COMMUNICATING ASTRONOMY with the Public 2005

EDITORS

Ian Robson (UK ATC)

Lars Lindberg Christensen (ESA/HUBBLE)

LAYOUT

Martin Kornmesser (ESA/HUBBLE)

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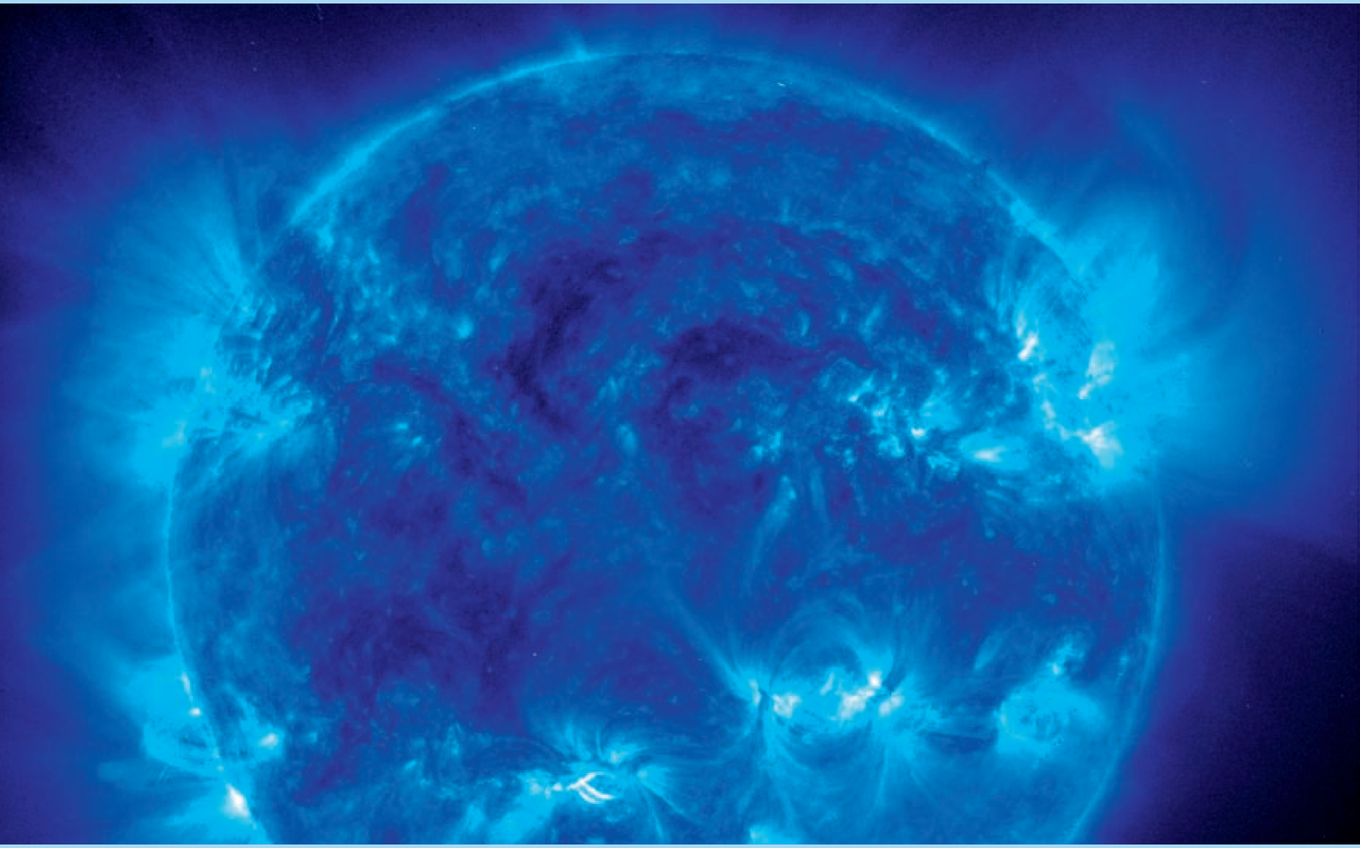
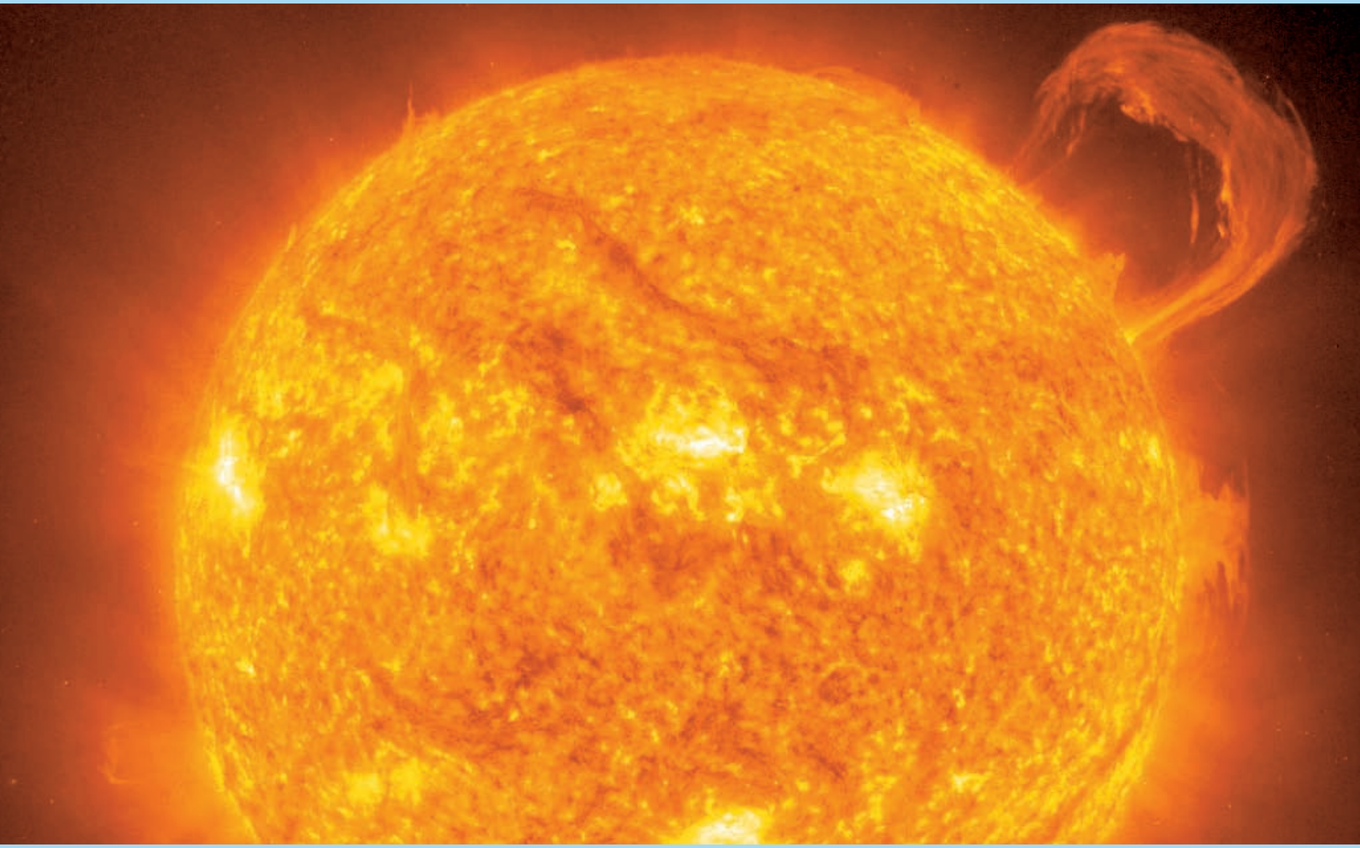


Credit: SOHO, ESA & NASA

OPENING SESSION:
Announcements, Business, Wider Issues



PREFACE

Over one hundred astronomers, public information officers, planetarium specialists and image processing gurus descended on ESO Garching in June for CAP2005 – Communicating Astronomy with the Public 2005. This was the third international conference addressing astronomy outreach; the previous venues being La Palma and Washington D.C. The main aim was to bring together specialists from the various strands of astronomy that undertake outreach in the broadest sense. The four-day conference was a resounding success, much was achieved and the work of ESO was better appreciated (especially from the non-European perspective) through a tour of the facility. Some of the highlights of the local environs were much enjoyed including the conference dinner at the Deutsche Museum's aviation museum "Flugwerft Schleißheim" (with cockpit tours of an F4 Phantom) and a splendid (somewhat liquid) evening at the Augustinerkeller, one of the largest Biergartens in Munich.

There were a number of key themes for the meeting covered in the plenary sessions. Each session began with talks by invited speakers and one of the main highlights of the meeting was the extremely high level, both in terms of content and presentational style, of all the speakers.

The sessions were: Setting the Scene; The TV Broadcast Media; What Makes a Good News Story?; The Role of the Observatories; Innovations; The Role of Planetaria; Challenges and New Ideas; Keeping our Credibility—Release of News; The Education Arena; Astronomical Images—Beauty Is in the Eye of the Beholder; Cutting-edge Audiovisuals; Virtual Repositories.

A most successful discussion on credibility and the general theme of communication ethics took place in the session "Keeping our Credibility", where we were delighted to field a star-studded panel, including the ESO Director General, Dr. Catherine Cesarsky.

Technology and the power of the web were much to the fore. All the PowerPoint presentations were posted online on the conference website:
http://www.communicatingastronomy.org/cap2005
on the same day as the talk took place. The conference was also broadcast as a live Webcast and thus available worldwide. If occasionally some of the speakers clearly forgot this and made controversial statements, there were some hasty interjections of the words "WEBCAST, WEBCAST" from the front row, to much amusement from the audience.

The “Hands-on” workshop sessions that ran in parallel in the afternoons were a huge success and a number were over-subscribed. This had been anticipated in the planning and so the more popular ones were repeated on subsequent days. The workshops were woven around the themes of image processing, interactions with the media and a communications toolkit.

The conference was summed up by Professor Paul Murdin (Cambridge) who brought together the various themes, tensions and links of the four days and also suggested a possible theme for the next conference which will be in 2007. It has been agreed that CAP 2007 will be held in Victoria, BC, Canada in September 2007.

Acknowledgements

The meeting was organised by Ian Robson and Lars Lindberg Christensen, supported by Scientific and Local Organising Committees. The contribution of the ‘FITS Liberator’ team was enormous in making the conference both successful and right up to the minute in terms of technology.

The organisers wish to acknowledge financial and infrastructure support from the European Southern Observatory (ESO), as well as support from the European Space Agency (ESA) and the International Astronomical Union (IAU).

Photos from the conference were taken by Lars Holm Nielsen and some of the participants. The astronomical images separating the Sessions were selected from the various image galleries on the web that were easy to find and which provided adequate resolution for the printed image size.

21. December 2005
Ian Robson (UK ATC, Edinburgh, UK) &
Lars Lindberg Christensen, (ESA/Hubble, Munich, Germany)

THE IAU WORKING GROUP ON COMMUNICATING ASTRONOMY WITH THE PUBLIC

Ian Robson

UK ATC, Royal Observatory Edinburgh, UK

ABSTRACT

The IAU Working Group originated as one of the outcomes of the 'Communicating Astronomy with the Public' meeting held in Washington D.C. in 2003. Its remit makes it an IAU-wide group, placing it in Division XII and distinct from Education (Commission 46). Since its inception a webpage has been developed, the Washington Charter adopted by a number of societies and agencies and this conference organised. In spite of this early success, there is still a great deal more work to be done and volunteers are actively encouraged to sign up.

INCEPTION

'The Communicating Astronomy with the Public' meeting held in October 2003 in Washington D.C. was the second international event; the first being held in Tenerife some eighteen months earlier. The Washington meeting was organised as a series of linked workshops and had specific outcomes (or charges) in mind. Two key items emerged from the meeting: the formulation of the 'Washington Charter' and the setting up of an IAU Working Group to promote astronomy outreach in the global sense. Dennis Crabtree and Ian Robson were proposed as Co-Chairs for the group with Lars Lindberg Christensen as the convener and Executive Secretary.

The group set themselves four early targets: promulgation to and adoption of the Washington Charter by societies, agencies etc; organisation of a webpage to promote the activities; organisation of some form of repository for data and organisation of a third conference in 2005. The Washington Charter will be discussed later by Dennis and Lars will discuss progress on what has now become the Virtual Repository scheme.

AN IAU WORKING GROUP OF DIVISION XII

From the outset it was considered important that this Working Group had the widest possible remit for astronomy outreach (and I use this term in the broadest sense) and that it should be distinct from the Education section of the IAU (Commission 46). With the blessing of the IAU, the newly formed group set out a range of activities and commenced work on a webpage hosted by ESO.

Paramount in the work of each activity is the belief that it is the responsibility of every practising astronomer to play some role in explaining the interest and value of science to our real employers, the taxpayers of the world.

Out of this came the Mission statement:

- To encourage and enable a much larger fraction of the astronomical community to take an active role in explaining what we do (and why) to our fellow citizens.
- To act as an international, impartial coordinating entity that furthers the recognition of outreach and public communication on all levels in astronomy.
- To encourage international collaborations on outreach and public communication.
- To endorse standards, best practices and requirements for public communication.

It is widely recognised that there are a number of barriers to communicating astronomy. Right up front is the fact that a number of professional astronomers do not feel comfortable with the very concept of talking with the public, either because they don't know how to communicate with the general public very well and/or suspect that they aren't very good at it. A second aspect is especially serious for the research astronomer, even if he or she is good at communicating. This is the hard fact that many employing organisations do not regard communication and outreach as a real part of the "job description". Hence, the researchers may not only be unrewarded for the time taken for public communication, they may even effectively be at a disadvantage if outreach is not perceived as a merit in the same way as grants, refereed papers and so on. The final hurdle is that a number of organisations (especially those outside the USA) have not yet integrated public communication (or "science and society") into their own structure by providing the necessary support—notably funding, training, infrastructure and personnel.

ACTIVITIES

Setting up the website was a very important step in providing a focus for the activities as well as an obvious means of promoting the group's existence and providing a key link for those interested in volunteering for work. Dennis and I are immensely grateful to Lars and his colleagues for designing and constructing the website (www.communicatingastronomy.org) and to ESO for hosting it.

The IAU is always keen to ensure that its activities span the globe and so the organisers canvassed colleagues (mainly astronomers who were IAU members) to become members of the Working Group Organising (or Executive body) Committee. Their names can also be found at the webpage.

The Washington Charter has its own section on the web and one of the key activities of the group was the promulgation of the charter to various agencies and societies, a number of whom have signed up.

One of the key areas for future efforts is a compendium of sites and information for those that wish to have access to sites that we know have high standards and promote professional information. This could be looked on as some form of 'one-stop' activity whereby enquirers can be passed on to other sites that have a 'kite-mark' of approval in the professional sense. This would then be an aid to those who seek astronomy information but do not have the knowledge to sort out the factual from the bogus.

Finally, excellent progress has been made on organising the third conference in the series, as we sit here now in CAP2005.

WHERE DO WE GO FROM HERE?

Looking firstly at this current meeting, the earlier Washington meeting had specific charges and followed a workshop theme to explore these. Here we have chosen a different path and are looking more towards consolidation and moving forward by sharing best practice, exchanging information and lessons learned, networking and, of course, enjoying ourselves. We have not completely forgotten the workshop theme, however. Originally we were intending to have an additional day aimed specifically at the image processing and virtual repository groups, but as the conference organisation got under way it became clear that we should roll it all into one. We now have a range of skills-based workshops covering image processing through press releases. I'm sure these will be a huge success and of benefit.

Finally, regarding this meeting, one of the key aspects for us is your input. This is most welcome and you are all encouraged to grab myself, Dennis or Lars at any time during the week.

Looking to the future, it is clear that there is an enormous amount of work to do, although having full-time day-jobs means that moving forward rapidly is rather a strain. We are very eager to have keen volunteers who are prepared to take on tasks and then go and deliver. As those who have responsibility for webpages will know only too well, maintenance of pages is a significant issue. We are looking to release funds to assist in this area as well as provide backup for the day-to-day activities of the Working Group. On the other hand, we are conscious that there is already a huge amount of excellent material and work going on 'out there' and so we are also working to ensure that we do not tread on others' toes and possibly alienate people in the process. We see our role primarily as facilitators and helpers, pointing people in the right direction rather than an end in itself.

We are also preparing for the input to the IAU General Assembly that will be held in Prague in 2006. I will be attending the Astronomical Society of the Pacific meeting in Tucson in September this year with the main aim of networking with the US amateur groups and seeing how they can help in spreading the word to the public and what the IAU can do for them. Finally, we are now looking towards CAP2007. We will review how this meeting has gone and what has come out of it and in so doing focus on a theme for the meeting to come.

In general there is much work to be done on promulgating the Washington Charter and we are actively seeking volunteers to promote this and have it adopted by their societies and agencies. In general we need to continue to encourage and support those who wish to undertake outreach by raising its profile and attempting to fight against prejudice. We also need to focus on bringing 'best practice' into the domain of those who will benefit and use the web as the medium. This does not only mean those that deliver astronomy outreach, but also funding agencies, for example. The need to develop a web-base of material is now obvious given the data explosion in astronomy. This leads naturally into the virtual repository etc, of which we will hear more during this week.

Finally, and this is aimed at all the audience, we need to develop an email list of 'supporters' and to issue regular updates of progress. So please, if you feel you can commit to this, sign up!

Enjoy the meeting.

PROGRESS OF THE WASHINGTON CHARTER

Dennis Crabtree

NRC-HIA, Victoria, Canada

ABSTRACT

The Washington Charter for Communicating Astronomy with the Public, usually referred to as the 'Washington Charter', has its origins in the 'Communicating Astronomy to the Public' conference held at the US National Academy of Sciences in Washington, DC, in early October 2003. The Charter outlines Principles of Action for individuals and organizations that conduct astronomical research and that "have a compelling obligation to communicate their results and efforts with the public for the benefit of all".

The IAU Working Group (IAUWG) on Communicating Astronomy with the Public has been active in seeking endorsement of the Charter from professional Societies and other bodies. The list of Charter endorsers currently includes:

- Astronomical Society of Australia
- European Astronomical Society
- British Astronomical Association
- Royal Astronomical Society
- Canadian Astronomical Society
- The International Union of Pure and Applied Physics, Commission 19 (Astrophysics)
- Danish National Committee (Astronomisk Udvalg)
- Royal Astronomical Society of Canada
- Particle Physics and Astronomical Research Council (PPARC)

Several of the above Societies, while endorsing the Charter, did have some minor reservations with the language. The reader may note a significant omission from the above list—the American Astronomical Society (AAS).

The AAS was approached to endorse the Charter in May 2004 but declined to endorse the Charter at that time. The AAS agreed wholeheartedly with the spirit of the Washington Charter and supported its goal to increase the amount and effectiveness of communication of astronomy with the public. However, the AAS felt that the broad language in the Charter amounted to an "unfunded mandate" and that its endorsement of the Charter would encourage other institutions to reallocate precious resources. They also felt that the language called for outreach to be associated with every activity in astronomy and that not every individual, department, program, or institution should necessarily be involved in outreach.

The IAUWG sees endorsement of the Charter by the AAS as critically important since the U.S. leads the world in efforts to communicate astronomy with the public through NASA, NSF and other programs.

We (the IAUWG) felt that minimal changes to the language of the Charter might allay the concerns of the AAS. Who should make these changes? Who had the right to make changes? The IAUWG believed that it was in the best position to make changes to the language as it was leading the efforts to have the Charter endorsed. However, we felt that the original group that had produced the Charter had ownership and that until ownership was transferred to the IAUWG no changes could be made in the Charter language. The original group was approached by email and all of those who responded agreed to transfer ownership of the Charter to the IAUWG.

IAUWG member Rick Fienberg skilfully crafted a modified version of the Charter that softened the language but which kept the spirit of the Charter intact. This language was refined further at the CAP 2005 conference to address a few remaining points. When polled about these changes several people at the conference noted that their national organizations had endorsed the original charter despite having reservations about some of the strong language, and that the new softer language eliminates the sources of those reservations.

The final revised version now sits with the AAS Council. We are hoping that they will consider this before their next Council meeting in January 2006 to give us a chance to respond to any final questions or concerns.

On a final note, the Astronomical Society of the Pacific Board (ASP) of Directors will consider endorsing the Washington Charter at its September 2005 meeting. Hopefully by the time you read this both the ASP and AAS will be listed as endorsers on the IAUWG website!

PROGRESS OF THE VIRTUAL REPOSITORY

Lars Lindberg Christensen

ESA/Hubble, Munich, Germany

ABSTRACT

When talking to other ‘communicating astronomy’ colleagues one issue always comes up: how can we share our resources more effectively? And ultimately, how do we allow the public better access to images, videos, news and other material? Imagine a kind of “Google Universe”. In 2004 a Programme Group called Virtual Repository under the IAU Working Group Communicating Astronomy was set up to stimulate work in this area.

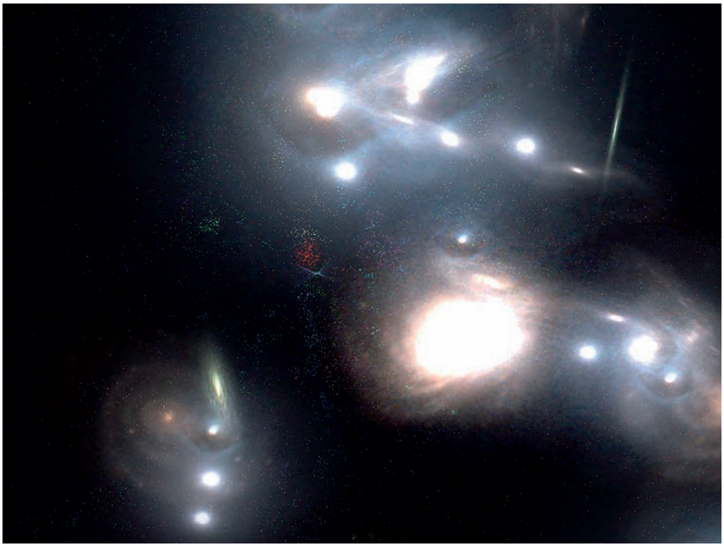


***Figure 1**. The dream of the Digital Universe is slowly becoming reality. Credit: Image from the Uniview application, property of Sciss AB Sweden, and the Digital Universe database, property of the American Museum of Natural History*

PROBLEM A – DATA IN EDUCATION

The coordinated exploitation of astronomical science archive data through the Virtual Observatory (VO) will have a major effect on the way astronomers work. The exploding volume of incoming data and the emergence of technologies and tools to mine the archives will inevitably also have a knock-down effect and result in significant changes for outreach and education as well. There is undoubtedly a great potential for exploiting ‘VO-data’ (meaning data in the VO era) and facilities in the educational context, but there is equally no doubt that this task is difficult and will need a coordinated worldwide effort.

An ultimate goal for us, as science educators, is to give the students access to real data in a "Digital Universe". There are many reasons for trying to use real data in the education process. Firstly the data are free. Secondly contact with real data and real science gives students a sense of adventure and discovery. In some cases there is the exhilarating feeling of breaking new ground and the chance to make genuine discoveries. Finally, astronomy projects that draw on real data can be a catalyst for learning about information technology.

Some small but significant steps in the direction of opening the data archives to educators, students and other interested parties have been achieved with our "ESA/ESO/NASA Photoshop FITS Liberator" (see http://www.spacetelescope.org/projects/fits_liberator and elsewhere in this volume) and "FITS for Education" projects. Using this free plug-in anyone can work with images and spectra from the NASA/ESA Hubble Space Telescope, the European Southern Observatory's Very Large Telescope, the European Space Agency's XMM-Newton X-ray observatory, NASA's Spitzer Space Telescope and many other major facilities.

However for a real "educational VO" the goal might even be the creation of advanced "Digital Universes" that can tap into science archives around the world and give access to all data at the click of a mouse. A beguiling vision, but probably not realistic in the near future? Giving access to real data is a major undertaking and quite possibly not worth the enormous effort involved. Scientific data are complex and inherently "dirty", and teachers may lack the background and training to understand many of the issues.

PROBLEM B – IMPROVING ACCESS TO EPO IMAGES, VIDEOS AND NEWS

At the same time as the scientists are experiencing a "data flood", we in Education and Outreach (EPO) are also experiencing, and participating in, a similar parallel development. Larger and larger amounts of "polished" audiovisual multimedia materials are being made available to press, educators and lay people on the web. The volume of digital products—outreach images, videos and news—is increasing all the time and the trend seems to be accelerating. Vast quantities of 'clean' outreach material are available on the web today. The problem is that they are not linked systematically, and it is therefore next to impossible for the press and public to search these resources in a simple manner. Or, as I expressed myself bluntly during the conference: *"Heck, if **we** can't even find each other's stuff, how can we expect other's to?"*.

Ultimately, how do we allow the public better, and more coordinated, access to images, videos and other materials?

HOW DID PROBLEM B ARISE?

The Internet and the World Wide Web have been determining technologies allowing efficient access to information and provide a fruitful environment for the creation of new information. Although very innovative search tools, such as Google, have been developed to search the textual parts of the available information on the web, similarly efficient tools for searching audiovisual content such as images and videos do not exist.

Today's search engines work by searching and indexing the textual information in html text-pages on the web. Existing audiovisual search tools, such as Google Images, can only search textual information that is placed around embedded images on a web page. This information consists largely of random pieces of text that often have little to do with the actual images and furthermore only images embedded in html pages can be searched. All audiovisual content in image or video archives, or databases, cannot be searched in this way and thus excluding a large majority of existing audiovisual content by far. In addition, real archives are the preferred storage method for the highest quality content, i.e. the content closest to the scientific and cultural sources.

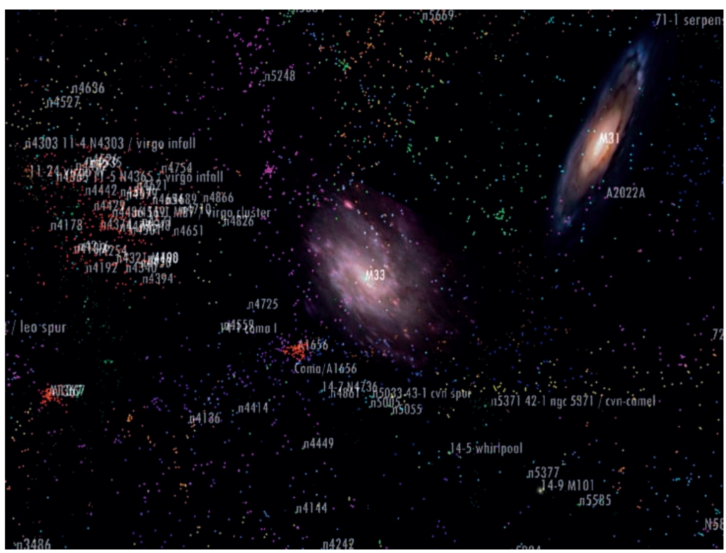


***Figure 2**. Placing EPO images in the right context within Digital Universe models in different environments such as the planetarium domes or on the desktop, may well be one the hottest issues in EPO over the next decade. Image from the Uniview application, property of Sciss AB Sweden, and the Digital Universe database, property of the American Museum of Natural History*

THE VIRTUAL REPOSITORY

What is needed is a framework that enables seamless searching in archival databases on the web—the Virtual Repository (VR). Here repository is used in the meaning of a 'place' where outreach and education resources are 'collected' and 'virtual' in the sense that no physical movement of data should take place—only a framework whereby the data can be accessed seamlessly in a sort of 'Virtual Observatory-style' is required.

The search should be advanced, and allow users to specify search criteria such as quality, size, popularity and more. The Virtual Repository project is dedicated to improve the accessibility and usability of digital astronomical material in a multilingual environment. The VR will coordinate collections in astronomical audiovisual archives worldwide and enhance the quality of the audiovisual material using well-defined metadata. The project will reinforce cooperation between digital content stakeholders such as the existing image archives at the large observatories. The aim is to give access to the unique resource that is the sky—a vast laboratory of science that is always in operation and accessible at all times to everybody.

A few possible applications of such a VR are:

1. Search engines (such as a “Google Universe”)
2. Interactive click-and-point experiences in the planetarium dome (“let’s look at the Orion Nebula in different wavelengths”)
3. The sky on your home desktop: Links with existing commercial planetarium software (Redshift, Starry Night, The Sky etc.)
4. AstroKiosk (exhibition kiosks that automatically tap into, and exploit the daily stream of astro-news, provided they are coded with the right VR-metadata).
5. Educational material

There are no limits to the potential applications when a VR framework is in place, interlinking multi-wavelength images and videos and placing them in the right context.

On the technical, or implementation, side, the Virtual Repository is in essence a framework consisting of four components, namely:

1. Resource metadata tags attached to images, videos, news etc. (see Christensen, 2006, this volume)
2. A centralized organiser or controller (for instance the IAU Working Group Communicating Astronomy with the Public).
3. A list containing the data archives, i.e. a “telephone book” or a registry that contains metadata about data resources and information services
4. A definition of a protocol for communication between the physical repositories and the users. For instance through the Registry with the help of a VO-style Data Access Layer, such as the Simple Image Access Protocol (SIAP)

THE IAU VIRTUAL REPOSITORY PROGRAMME GROUP

The International Astronomical Union (IAU) Virtual Repository Programme Group was set up during 2004 and business meetings were held at the AAS meeting in January 2005 and at the CAP 2005 meeting in June 2005. The purpose of the group is: *"To construct the framework for a virtual repository to allow outreach resources across projects and country borders to be 'catalogued' in a virtual repository and accessed by educators, press, students and public through specialised visual tools combined with search engines."*

So far progress has been made in three different areas:

1. Concept: The concept of the Virtual Repository has been thought out, discussed and improved to such a degree that real implementation can start.
2. International collaboration: Contacts have been established with the group lead by Frank Summers at the Space Telescope Science Institute in the USA working on metadata tagging the outreach images from the Hubble Space Telescope.
3. Funding: A proposal is currently being worked on for the EC. The goal is to give *"European-wide access to the treasure trove of celestial images from anywhere, anytime; moving astronomical images into the 21st Century"*.
4. Implementation: A student from the University of Copenhagen, Kasper Nielsen, is currently studying the practical issues related to ways of realising the Virtual Repository.

The Programme Group's web page is:
http://www.communicatingastronomy.org/repository/virtual_repository.html
containing background material and a list of members.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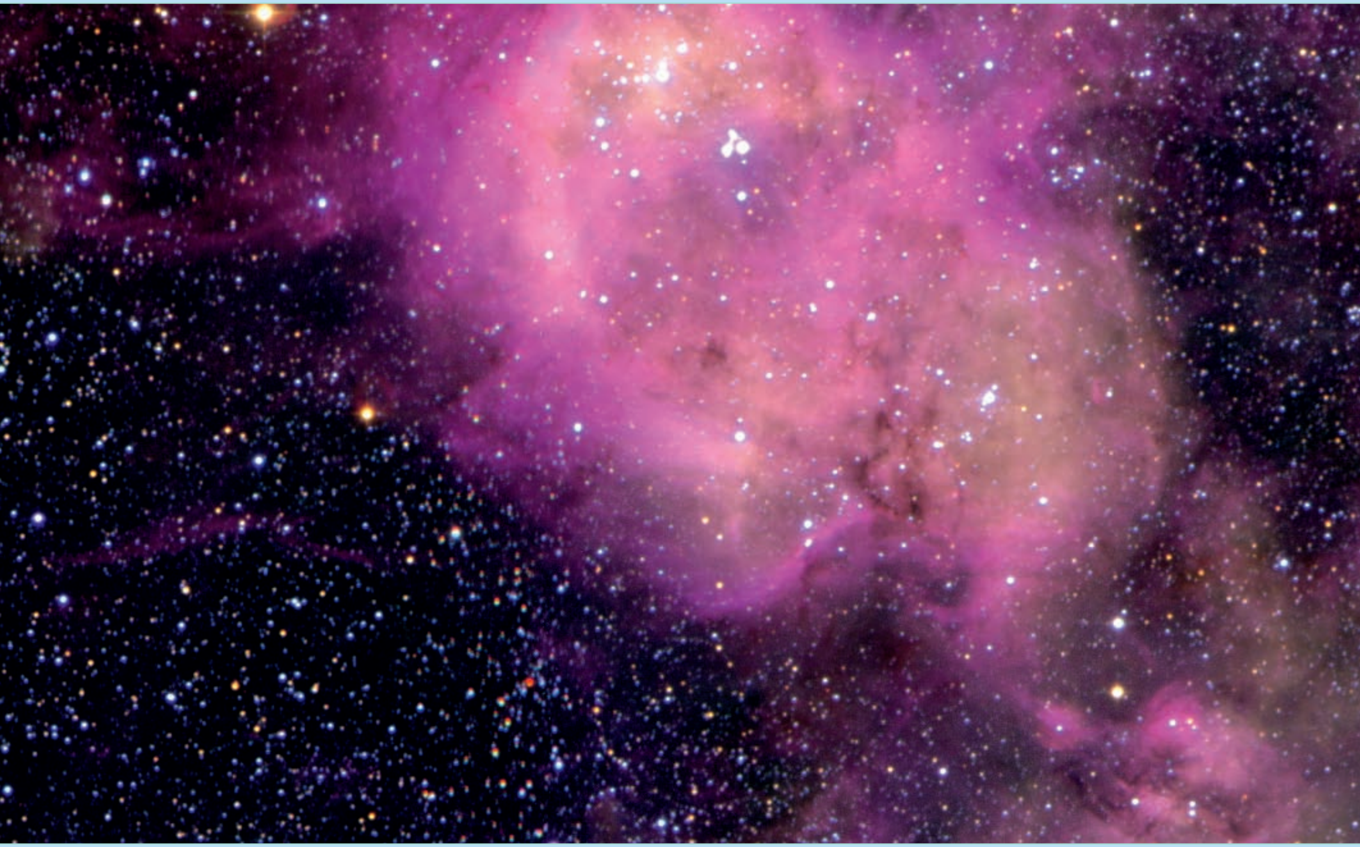

Credit: ESO MPG WFI

PLENARY SESSION 1:
Setting the Scene

WHAT SCIENCE IS *LIKE* AND WHAT SCIENCE *IS*—NON-PROFESSIONALLY EXECUTED ASTRONOMY AS A MEANS OF COMMUNICATING SCIENCE

Paul Murdin

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ABSTRACT

Astronomers and media professionals have formed very successful partnerships to communicate astronomy to the public through communications media of all sorts. However these efforts communicate what science is *like*, subject to the constraints of the communications medium. They do not communicate what science *is*. The missing and essential ingredient is public participation in an investigation, starting from uncertainty and proceeding to lesser uncertainty by means of organised enquiry. Science is a medium itself, and the medium is the message. We have started to communicate what science *is*, but the systems for doing so are sophisticated and we are only just beginning to implement them.

COMMUNICATING SCIENCE

The interaction between the scientist and the public usually takes the form of a dialogue in which the scientist tells what he has done and discovered and the member of the public says 'These are my concerns about your work.'

The dialogue is asymmetric. The scientist is, in other circumstances, a member of the public and can readily exchange his roles. In the laboratory (or observatory, or computer room) a scientist can take the point of view of a scientist whereas in his home and in the street he is a lay person, perhaps someone who is informed in general about scientific matters but not an expert on topics outside his field. By contrast a member of the public usually finds difficulty in being a scientist.

Of course this conference is dedicated to breaking down this barrier, and to generating as many opportunities as possible for lay people to taste being a scientist. The opportunities are most often the following:

- The lay person learns about science in the media.
- The lay person hears the scientist lecture.
- The lay person simulates scientific enquiry.
- The lay person learns what science is *like*.

SCIENCE IN THE MEDIA

Communicating science through the everyday communications media is very important. The media provide channels by which busy and unique people can speak to huge audiences. The science is presented by interpreters skilled in communicating simply, clearly and interestingly. The science that is presented can be culled from the whole world, so everyone can learn about extremely important results no matter where they originate—the media have truly created a 'global village' of universal understanding.

Astronomers, in partnership with savvy media professionals, have done a really good job in accessing the media in order to tell about science. We owe a debt of gratitude to the astronomy media pioneers and to the sheer professionalism of groups like the HST Office of Public Outreach.

However, wonderful though I think these efforts have been, are and will remain in communicating some of the features of science, they are not enough. They do not communicate some absolutely essential features of science. The global village of universal understanding is incomplete.

The media communicate what they *can* communicate. They select what they communicate for reasons that are non-scientific, e.g. to attract viewers or to sell copies of newspapers. We, as scientists, have to learn how to cast our science into a form that is set by the media. The science is selected as a 'story' and is edited by the media. The story has to have a beginning and an end. It is an advantage if it has an associated dramatic picture, humour or some sort of record breaking fact. It has to have news value, perhaps to show an implied threat—that asteroids might destroy the world, for instance. It has to be important in news terms, for example to come from some expensive and politically relevant facility, or to have been carried out by a well-known person, or perhaps to contradict one. It has to have human relevance, a person or people with whom we can identify.

We as astronomers are learning how to cast our science into the form required by the communications media. In particular we are lucky enough to have both pictures and people who know how to display them, and we gain the front pages. If the launch of our spacecraft is successful or hits the target, our people are savvy enough to cheer, whoop, punch the air and jump up and down and show the emotion that gets our project on the TV news. Our press releases start with the superlative and carry witty turns of phrase. Our scientists show enthusiasm and make themselves into characters.

But it is difficult to get access to the media to describe an incremental advance, or one that is abstract, or one that is still uncertain. As we have heard people say at this conference, press releases can have no ‘wiggly lines’—no graphs, in other words, even though the business pages are full of them and this is the language of quantitative presentation. What is presented of science through the media is too literary and ‘too neat’.
Science as portrayed in the media may often be a distorted version of the real thing.

Lectures describe an authentic experience by a scientist, either talking about their own work or their understanding of other people’s work. Listening to a lecture is listening to an expert, and what is being said is ‘right from the horse’s mouth’.

However, the lecture is also edited science. Just as with a scientific paper, history is rewritten (for reasons of logic and understanding). The context in which the science is placed is selected to illuminate the science. As in a scientific paper or a media story, the lecture is too neat. It is also passive for the audience and they have to listen. Of course, lectures teach (but experience teaches better).

SIMULATED AND TAUGHT SCIENCE

Simulated science is an experience. The public can simulate science under controlled conditions relatively easily. School students do this every day in classroom learning experiences. In a science lesson they are given an instruction sheet and a selection of apparatus. Following the instructions they conduct an experiment, making measurements. In the data analysis phase of the lesson they may plot this against that, and attempt to replicate a result, for example to ‘Prove Ohm’s Law’.

The experience of simulated science is memorable. And simulated science teaches some of the methodology of science. However, the classroom is not the laboratory. A lesson is an activity that is similar to science, but it is not ‘real’ science. As students sometimes accurately sense, it may be boring. A lesson is what science is like, not what science is.

Science in education is an authoritarian structure of books, laws, right answers and proofs. As a result students have negative impressions of science. It is:

- Difficult
- Mathematical
- A long haul
- Impersonal
- Cautious.

They are told that science is certain: they are taught things discovered by dead people who were right. Simulated science misses out the essential feature of science, that it is a learning process of reducing uncertainty, not a learning process about what has already been discovered by hard work. The result is that science appears unattractive.

To counteract these impressions, teachers (including scientists themselves) may teach science as:

- Fun
- Visual
- Snappy
- Biographic
- Contains dramatic 'eureka moments'.

(However, teachers still pretend that science is correct.)

Science does indeed contain these features—but not only these features, so taught science and simulated science is certainly incomplete or possibly actually false.

WHAT SCIENCE *IS*

So: real science is different from simulated science. Science is only in part a commodity to be traded through the media. Science is, more importantly, a process. It is a medium in its own right. In science communication, the medium is also the message.

In science, the 'answer' is unknown. However, a working hypothesis comes before the results and the method of the study is defined by the scientist's anticipation of the results. In the data reduction phase, the scientist draws a conclusion about the result on the basis of incomplete data. Science is inherently uncertain, but it is post-validated by being reframed according to rules of 'scientific method'. Science is a method of thinking, not just a collection of commodities to be traded.

The reality of scientific enquiry, with its uncertainty and its human interaction, is at odds with common perception. Science is neither certain, nor completely reliable. It is constructed by people —who have, however, tried to remove themselves from it. To view science as infallible or certain is to misunderstand science.

HOW CAN WE OFFER A MORE REALISTIC SCIENTIFIC EXPERIENCE TO THE LAY PUBLIC?

The most direct way to experience science is through observational science. Observation often both was and remains a feature of non-professionally conducted natural history. Bird watchers and fossil hunters are examples of present day naturalists who still have the opportunity to make scientific discoveries. And of course amateur

astronomers still exist in large numbers, viewing the sky through small telescopes or binoculars.
Observation need not be more than looking, seeing and recording. At some stages of science this might be enough of an end in itself. Robert Hooke looked through his microscope and drew a magnified and magnificent flea. James Nasmyth looked through his telescope and recorded and reconstructed the lunar mountains and craters in model form. But being a spectator is not really enough. What is missing is the flash of the idea, the progress of an investigation and the achievement of understanding.

In astronomy we do have scientific investigations through organised amateur astronomy, following the tradition of the great amateurs of individual astronomical research. I know those from Britain best, like the Herschels, Carrington, Rosse, W.H. Smyth, Lassell, Huggins... Societies like the British Astronomical Association and the American Association for Variable Star Observations continue to coordinate programmes of observations of variable stars, planetary features, etc. Some professionally run astronomy projects offer and manage real science opportunities that include amateurs, such as The Global Telescope Network, which is an optical backup programme for satellite gamma ray astronomy and the Small Telescope Science Program (STSP) of comet photometry for the Deep Impact mission. The Virtual Observatory and National Virtual Observatory projects make access to professionally archived data easy, so amateur scientists can make genuine astronomical discoveries, in the same way that the SOHO images of the Sun were used by an amateur astronomer to make discoveries of Sun-grazing comets.

Two exciting new projects that communicate astronomy beyond the community of amateur astronomers into the wider community of school students are the National School Observatory and the Faulkes Telescopes. Both use 2-metre class robotic telescopes. In the NSO, images are taken to order by a telescope on La Palma. In the Faulkes Telescope project, opportunities on telescopes on Maui, Hawaii, and Siding Spring Observatory, Australia, are offered for real-time observations. The essential point, however, is that both telescopes coordinate with scientific/educational projects. Example FT/NSO projects are:

- determining the light curve of a BL Lac object or gamma ray burster that has gone into outbreak,
- determining the size of an extrasolar planet from the light curve of its transit across its parent star,
- measuring and classifying the light profiles of galaxies for a catalogue
- determining the orbit of an asteroid to see if it will crash into the Earth.

These observations are of members of a population so large that professionals have found it impractical to devote enough time to them. Or they are of events that are transient, in the sky only briefly so that the student might be the lucky person with the telescope in the right place at the right time. This is democratic science.

Preparation for such projects is extensive and in particular the teacher training is pretty serious. A recent Faulkes Telescope teacher training course covered:

- Waves, optics, refraction, reflection, electromagnetic spectrum
- Colour imaging, human eye, colour pictures
- Photons, electrons, CCDs
- Mathematics, coordinate systems
- Robotics, weather, sensors, IT systems
- The scientific process.

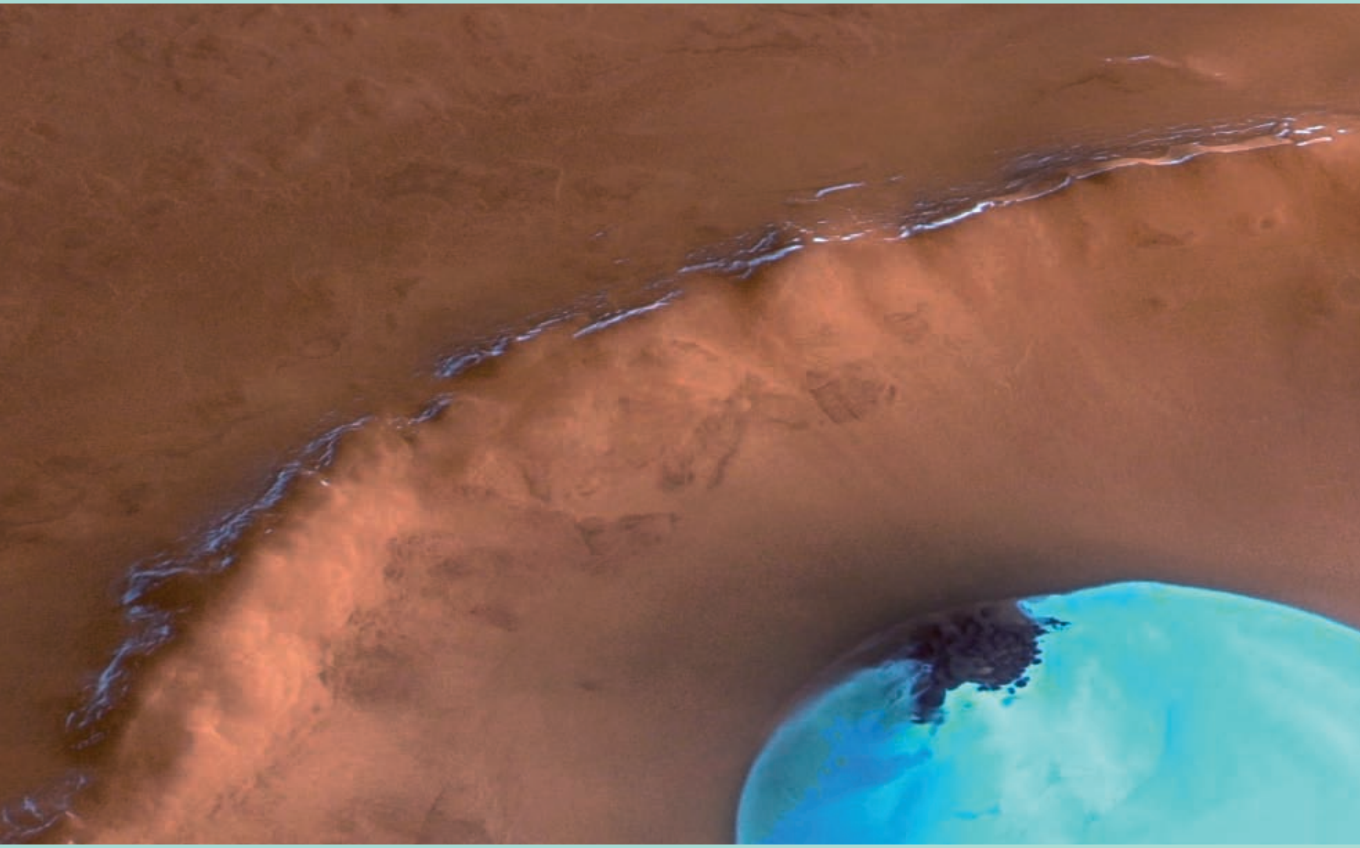
It is easy to see the size of the task to communicate what science *is*. The NSO and FT projects consist of:

- A facility
- Some projects
- As few nerdy astronomy techniques as possible
- As much cool astronomy science as possible
- Some scientific principles
- A programme that maps onto ability-related educational objectives
- Knowledgeable and confident teachers
- Enthusiastic students, young or young at heart

Only the last is guaranteed: the rest has to be worked at. The promised outcome is that the telescope rises beyond being an optical instrument. It becomes an instrument for communicating science fully and generating human understanding.

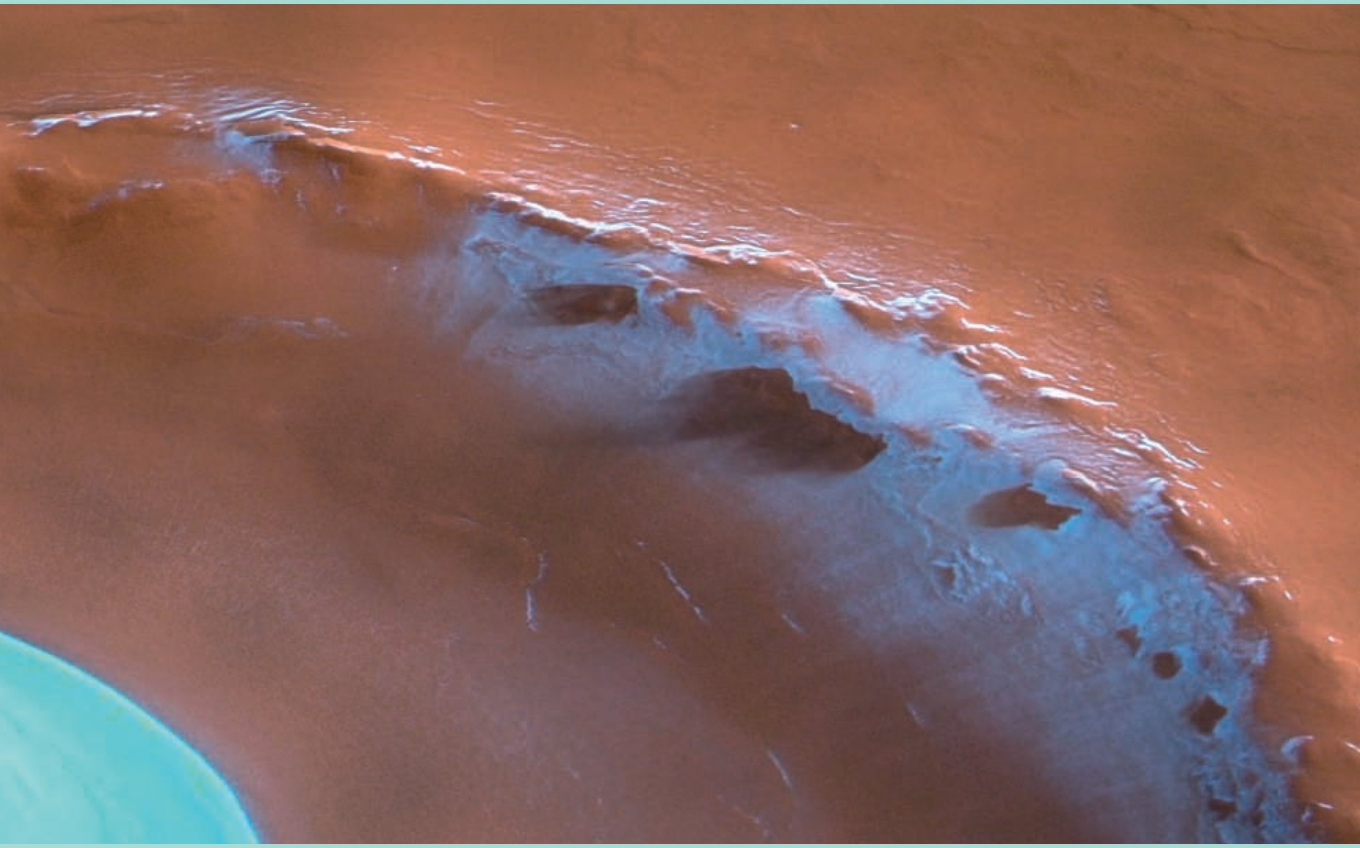
CONCLUSION

The essential characteristic of science *is* not to hear stories about science that fit a predetermined media requirement or even to learn what is known. It is to enquire. The purpose of science communication is not only to teach facts or ‘laws’, or to entertain. It is to change heads. Coming to terms with what science *is*, not what it is *like*, is one of the biggest issues in science communication. It is a key to the public development of a realistic attitude to science. The challenge is to put entire systems in place to communicate science realistically in this way. Astronomy has the power to do it.



Credit: Mars Express, ESA/DLR/FU Berlin (G. Neukum)

PLENARY SESSION 2:
The TV Broadcast Media



ATTRACTING THE MEDIA

Nigel Henbest

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ABSTRACT

The media provide the essential conduit for the mass communication of science. Yet the factors that contribute to a successful media production are not necessarily those regarded as most important by the astronomy researcher. Taking television as the prime example of a medium of mass communication, I examine some of the elements that are involved in the creation of a successful and influential astronomy programme.

These include persuading the "gatekeepers" who control the media that they should screen a programme on astronomy; choosing a riveting topic; writing an absorbing script; selecting the right human interest; and creating visuals—including graphic sequences—that are compelling to watch.

INTRODUCTION

Astronomy communication is, at its basic level, simply a supply problem. A researcher has an insight into the Universe. "Out there" lies the public. As astronomy communicators, we are concerned with facilitating the delivery of the message from one to the other. Fig. 1 shows this ideal.

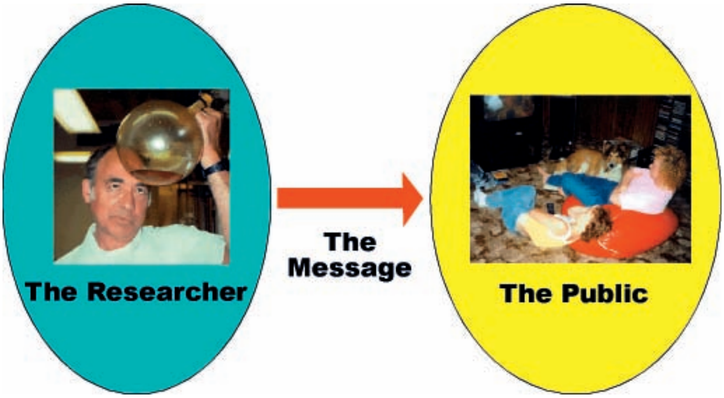

Figure 1. *The prime role of the astronomy communicator is to facilitate the delivery of the "message" from the astronomy researcher to its audience.*

The message is both overt and covert. At the obvious level, we want to involve the larger population in what astronomers are doing—to excite them about our unfolding knowledge of the Universe. We may also feel that they, as taxpayers, are entitled to know how their money is being spent. And we may hope to influence those members of the public who are opinion formers and decision makers that they should plough more money into astronomy and space research.

On a more subtle level, I believe the message should also convey astronomy as a sugar-coated pill for the harder sciences. In my experience as a communicator, it is difficult to interest the public in physics, chemistry or mathematics. By using astronomy to lure them in, we can introduce them to topics in other physical sciences.

There are many ways to convey the message. They include formal education, public outreach programmes, science centres, planetariums and dedicated websites. Here, I will focus on the role of the mass media—and take television as my primary example.

THE BIG CHALLENGE

In the real world, the situation is a lot more complicated than Fig. 1 suggests—as summed up in Fig 2.

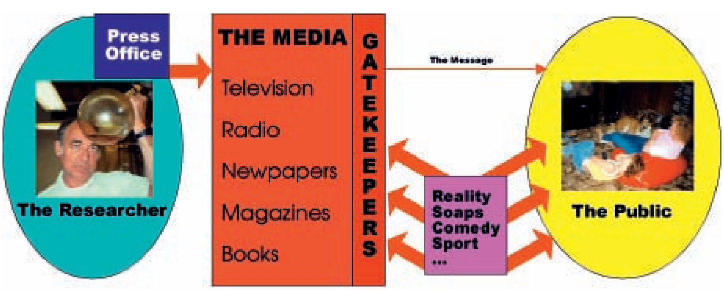

Figure 2. *In the real world, conveying the astronomy message by means of the mass media is far from simple!*

On the positive side, the researcher is generally not isolated. A Press Office, or Public Information Office, is at hand to amplify the message—primarily by means of the press release, but also using more targeted methods of contacting the media.

Between the researcher and his/her organisation lies the media—the “meeja” as it’s known in the trade. This includes television channels, radio, newspapers, magazines and books. And controlling the media are the “gatekeepers”.

Gatekeepers control the output of the media. They go by titles such as Senior Editor in print publishing, and Commissioning Editor in the broadcasting media.

These gatekeepers are under constant pressure to fill their pages or air-time with many topics other than astronomy. These include soap operas, sitcoms, “reality shows,” sport, news and current affairs, chat-shows, drama and so on. These topics squeeze our initial message down to a trickle that may be fairly imperceptible!

So our big challenge, as astronomy communicators, is to enlarge that final link in the conduit, and allow more astronomy through to the public. In practical terms, this means persuading the gatekeepers to commission an article or documentary on astronomy, rather than, say, the latest reality show or an investigation into the life of a sporting superstar.

THE TELEVISION WORLD

Television is the prime example of today’s mass media. It has the maximum penetration of any medium. In every country of Europe and North America, 96-99 percent of households have at least one television set. The most widely screened astronomy programme of all time, Carl Sagan’s Cosmos, has been seen by 500 million viewers in over 50 countries.

Today, though, the TV world is far from homogeneous. At one end of the spectrum are the relatively new cable and digital channels, usually with a specialised agenda. Astronomy finds a natural home on channels that specialise in documentaries, such as Discovery Channel and National Geographic.

The downside of cable channels is that they command only a small share of the viewing public. Even their highest rated programmes—such as Supervolcano (Discovery) and Unlocking Da Vinci’s Code (National Geographic)—were viewed by less than three million households, out of a total of 105 million in the United States. In contrast, the finale of the sitcom Friends (NBC) attracted 52 million viewers.

Television ratings are still dominated by the terrestrial broadcasters such as ABC and CBS in the United States, the BBC and ITV in the United Kingdom and the ABC in Australia. Here we face the problem that the channels are all chasing the high ratings—30% or more of the total viewing public.

Commercial terrestrial channels need high viewing figures to attract advertisers, and set high advertising rates. There is a more subtle pressure on public service broadcasters, such as the BBC and the Australian ABC, to achieve high ratings. The BBC is funded by a licence fee, paid by everyone who has a television set: if the ratings are too low, critics of the public-broadcasting service call for the licence fee to be abolished.

Looking at ratings for the British terrestrial channels, we find that, typically, the top 30 places are taken by soap operas, reality shows, sport, drama and light entertainment. The highest-ranking documentaries are placed no higher than number 40 in the ratings.

The challenge we face in putting astronomy on television thus becomes a quest for high ratings. We must not think of this as being merely a matter of pandering to the gatekeepers. A documentary that is seen by a million viewers is preaching largely to the converted—the readers of New Scientist or Scientific American. If we can reach 3 million or more, then we are delivering our message to people who would normally choose not to be exposed to science.

FORMULA FOR AN ASTRONOMY PROGRAMME OR SERIES

Here are some of the empirical criteria used by the gatekeepers when evaluating a television documentary:

- Television is primarily an entertainment medium; it is not an ideal conduit for factual knowledge (as compared, for example, with books or a website). A viewer will retain less than five facts per hour of viewing.
- The typical audience attention span is three minutes. After that, the viewer's finger starts reaching for the remote control.
- To keep the viewer's attention, the programme must include a "wow" visual every three minutes or so.
- To keep the viewers stimulated, every 90 seconds we must introduce a "f***-me fact" (actual words of a senior television commissioning editor!). The gatekeepers hope that at least one of these facts will be so astounding that the viewers will be discussing it in the pub the following evening.

So a factual programme must be as absorbing and entertaining as it is informative.

My formula for a successful astronomy (or science) programme goes as follows:

- Choose a riveting topic.
- Craft a gripping storyline, with a clear script.
- Take great care over the human element – the presenter (if used) and interviewees.
- Create stunning visuals, to use the television medium to its full advantage.

TOPIC

Some of the most successful astronomy series on television have taken the very wide remit of covering the entire Universe—for example, Carl Sagan's Cosmos (PBS) and Universe (Channel 4/ TLC). When it comes to individual topics, though, the gatekeepers are often tunnel-visioned. The same subjects keep recurring in various incarnations. Cosmic impacts, extraterrestrial life, cosmology and black holes probably cover around 90 percent of the astronomy shown on television.

The gatekeepers are also notoriously wary of taking risks. This is true of all types of programming: think of all the "look-alikes" that come along after a successful new format of reality show or quiz.

To persuade the gatekeeper to commission a programme on science, it helps if you can point to a successful book on the subject, and preferably one that's had glowing reviews in the more literary newspapers! A leading article in Scientific American or New Scientist, or a front page story in a national newspaper can also prove persuasive.

SCRIPT

With an interesting and topical astronomical result in hand, the next challenge is to structure a programme that will keep the viewer watching this documentary, rather than channel-hopping.

The key element is a script that both enthrals and guides the viewer. We must tell a story that has a beginning, a middle and an end. And it must be fairly linear. Flashbacks may work in novels, and to some extent in movies, but when we are asking viewers to follow a plot that contains plenty of unfamiliar concepts, simplicity is essential.

Science, of course, doesn't progress this way. But a documentary that follows the true of course of scientific advance would be a difficult programme for viewers to follow. That's particularly true of the cut and thrust of rival hypotheses in the quest to fit theory to the observations. Although trained as a scientist myself, I have to accept that television programmes are generally going to show the end result of scientific research, rather than the true process of research.

For the same reason, it's difficult to present complex ongoing controversies on television. Once a viewer has understood, for example, the significance of the iridium anomaly in connection with the death of the dinosaurs, it's too much to present them with another bunch of scientists who dispute the cosmic impact hypothesis, by presenting a totally different interpretation. The viewer is left floundering. And a floundering viewer quickly becomes a channel-surfing viewer.

One way round this particular dilemma is to make several programmes, each featuring one of the leading theories in a controversial area. At Pioneer Productions, we have made three separate documentaries on the death of the dinosaurs over the years: one implicated general climatic change, a second the super-eruption of the Deccan Traps and the third cosmic impact!

HUMAN INTEREST

Television is a very person-driven medium. Viewers quickly latch on to the people they see on screen, even if they are merely delivering the news bulletin or the weather forecast.

So a major component in making a compelling astronomy programme is human interest. Science aficionados may be happy to watch a television documentary that deals only with facts. But to extend the reach of our programmes to a wider public, we must include people on the screen.

Sometimes a presenter can be crucial to the success of a series. Carl Sagan's Cosmos comes once again to mind. Britain has the remarkable phenomenon of Sir Patrick Moore, who has presented his series The Sky at Night (BBC) every month since 1957.

With the current trend towards more international co-productions it is becoming increasingly difficult to find a presenter who is equally acceptable in different territories. Where these include countries with different languages, it's almost impossible to use a presenter.

The human interest in a programme, then, usually devolves on the interview subjects. Sometimes, a single individual can carry a whole programme, even when it's on an abstruse subject. The BBC produced a highly successful documentary on Fermat's Last Theorem, which made gripping television because it focused on the emotions of mathematician Andrew Wiles as he struggled to solve the long-standing mathematical problem.

Generally, a television documentary relies on several interviewees. Ideally, there should be no more than half a dozen major figures, so the viewers can "get to know" them. These interviewees must be carefully researched. They must be able to explain complex topics in an accessible and understandable way and with passion.

This means that a television producer may not necessarily use the astronomer who is perceived to be the leader in a particular field if that researcher is inarticulate or unemotional. Remember, the viewers are seeing our interviewees in the intimacy of their living room, so it helps if the scientist is the kind of person that the viewers would like in their homes!

VISUALS

"Location, location, location" is as critical to the programme-maker as it is to the estate agent. Fortunately, astronomy is not short of stunning locations—virtually any observatory will form both a pleasing background and a facility where the viewer can see a scientist in action.

Real images of the Universe are also stunning—as stills. But stills are unfortunately of limited use in television. Viewers expect action on television. And the rate of action has been increasing: watch a classic series from the 1970s, and it seems slow-paced today. Lingering shots are out; rapid cutting is in. Even a wonderful image from the Hubble Space Telescope—such as the Eagle Nebula—will hold the viewer's attention for maybe 20 seconds.

In addition, many of most exciting topics in the Cosmos are impossible to image in the detail that viewers expect—examples include extrasolar planets, black holes, alien life and the Big Bang.

The answer lies in graphics sequences. The graphic may depict how an astronomical object would look close up, or it may create a voyage to—and around—an exciting cosmic scene.

Such recreations may offend the purists in the astronomical community. How can we justify the detail we put into an alien landscape, or into the flow of gas into a black hole? Such concerns, incidentally, apply to many areas apart from astronomy: the producer of a documentary on dinosaurs will have to make a largely arbitrary choice of skin colour for the great beasts.

I believe that TV graphics are entirely justifiable as long as they represent a consensus view of the object we're depicting, they violate no laws of physics, and they square with the observations that have been made so far.

But we do have to be concerned that the viewer can differentiate real images from graphics. The clumsiest method is to insert a caption saying “simulation”. In almost every case it’s entirely possible to do the same job with some well-constructed scripting.

For example, in our production On Jupiter (Discovery/Channel 4), we created a graphics sequence that depicts a journey down to the heart of the giant planet. The script line reads “if we could make the impossible journey to the heart of Jupiter”—the words “if” and “impossible” clearly showing this is not a real observation.

In Black Holes (Discovery/Channel 4/ABC), we created a graphic of a “starship of the future”, which investigates the environs of black holes. By dropping a sub-probe into the gravitational well of the black hole, we can demonstrate the distortions of space and time in a way that would be extraordinarily difficult to describe otherwise.

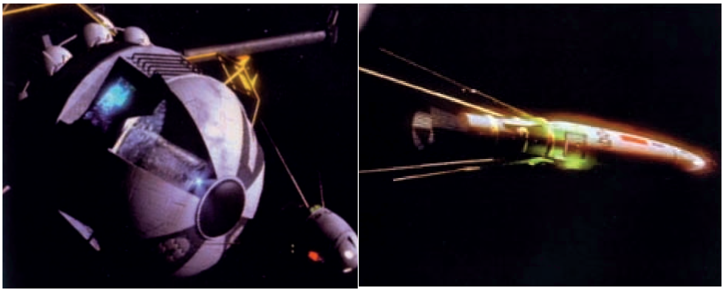

Figure 3. *Graphic sequences allow us to demonstrate the dangers posed by the gravitational field of a black hole. A sub-probe released from the mothership (left) is increasingly spaghettified (right) as it drops into the gravitational well.*

CONCLUSION

If a TV viewer with little previous interest in science comes away from a programme with a little more understanding of the Universe around us, and something of a feeling for the excitement of scientific research, then I feel that we have played a significant role in the communication of astronomy.

ESA ON RAINEWS24

A Case Study of Television Communication

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ABSTRACT

In May 2000, ESRIN, the Italian establishment of the European Space Agency (ESA), started a collaboration with the television channel Rainews24. Rainews24 is the “all-news” channel of Italian public television (RAI) and is now about 10 years old. It transmits 24 hours a day and is the most watched all-news satellite channel in Italy. Each Thursday an ESA representative (Stefano Sandrelli) is interviewed by a professional RAI journalist in a 5-6 minute long slot that follows the 5 pm news bulletin. The broadcast is repeated late at night or in the early hours of Thursday and Friday. Interviews are strictly linked to the weekly news and are prepared on the morning of the same day by the ESA representative in collaboration with a RAI journalist. The subject is chosen from the most topical news items of the week: video, images and animations are provided by the ESA television service and by press agencies (Reuters etc.). The interviews are largely informal and resemble a dialogue rather than an academic discussion “from space”. Even though they focus on ESA activities, they are not advertisements: space science and research is dealt with as a human activity, so both the positive and negative aspects of space exploration and exploitation may emerge. Although this outreach activity began as an experiment, the ESA interviews have become a fixed feature. As a result of five years of uninterrupted collaboration, over 200 interviews have been recorded, with about 30% of the interviews dedicated to pure astronomy. A welcome positive feature is that the interviews are seen by Rainews24 as an open source of daily news.

ESA: A TOTAL ECLIPSE OF COMMUNICATION

The European Space Agency (ESA) has 16 Member States, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Luxembourg is expected to join ESA in 2005, while Canada, Hungary and the Czech Republic participate in some projects under cooperation agreements—for an official presentation of ESA, see www.esa.int/esaCP/SEMX8CXLDMD_ index_0.html.

ESA is an organisation of international standing and importance that was founded in 1975. However it neglected communications with the citizens of its member states in its early years. The purpose of the Agency is “to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems" [http://esamultimedia.esa.int /docs/SP1271En_final.pdf]. In the mid-seventies these issues were among the top three in the field of mass communication as a result of the recent success of the Apollo missions. However, as a consequence of the political weakness of the newly formed European Union, and in striking contrast to NASA's communication policy, ESA's communication efforts were directed mainly at the scientific community and at European politicians.

The big sleep came to an end at the end of the 90's, when a broad-based survey [Sandrelli, S., Talevi, M, "ESA: un nuovo orizzonte per la comunicazione scientifica", Giornale di Astronomia, 2000] was conducted in the countries that were then ESA members, aimed at investigating ESA awareness among Europe's general public. The survey was conducted in June and July 1998 by telephone calls from a market research company with native speaking interviewers in all 14 ESA member states (Portugal joined ESA in 2000 and Greece in 2005). Altogether 8,350 interviews were recorded, which made a percentage confidence level of around 1.1% of the total sample possible.

The results were clear but chilling. Although 42% of the general public showed some interest in space exploration (very interested 7%; 35% interested; 35% not so interested; 25% not at all), only 12% of the general public knew of ESA spontaneously, while 54% of the same sample knew of NASA spontaneously. What is more, 63% of the sample thought that European Space Programme was important and almost the same percentage (64%) wished that "Government would continue to support European Space exploration programmes financially".

The implication was obvious: ESA was not a forgotten agency. People were simply not aware of it! Also, individual interest in space was much higher than the rate of ESA awareness might suggest. ESA's low profile was clearly due to a total lack of communication on its part.

ESA ON RAINEWS24: THE CONTEXT

As a consequence of the poor results from the survey, a Science Programme Communication Service was set up and the ESA portal was launched within a couple of years, in October 2000 [ESA's gateway to space, in ESA Today n.8]. Interestingly enough, the second published web story is dedicated to the Hubble Space Telescope [A unique test for Hubble's new solar arrays, 19.10.2000, www.esa.int/esaCP/GGG97TVTGEC_index_0.html], in which European participation was (and partly still is) largely ignored. The communication strategy underlying the portal was clear: information was target-driven. Five main themes were selected so that non-specialists, students, and any other curious people would be able to find what they were interested in: Life in Space, Expanding Frontiers, Improving Daily Life, Protecting the Environment, Benefits for Europe.

Besides the main site, there are also national sites with translations, original web stories and local news. As part of the effort to increase ESA awareness in Italy, the opportunity for a strict collaboration with RAINEWS24, a young digital channel launched by the Italian public TV broadcaster presented itself in the first few months of 2000. The first ESA interview was broadcast as early as 18 May 2000—a chat about the European astronauts. The second broadcast (1 June) was dedicated to a difficult mission—XMM-Newton, the ESA X-ray telescope [www.esa.int/esaCP/ESA-PORGBCLC_Italy_0.html (Italian), 1.06.2000]. Interviews are broadcast live at 5:12 pm each Thursday and re-broadcast late at night or in the early hours of Thursday or Friday.

Right from the beginning, it was clear that the interview should not be an academic harangue from on high, but more a warm and friendly dialogue between a curious but decidedly not space-oriented journalist and an ESA expert, who was basically talking to an interested friend. However, the ESA representative was an official member of the Agency, so he should be compatible with the image of the Agency itself. This had a certain impact on the way he was supposed to dress, move and talk.

WHAT IS RAINEWS24?

RaiNews24 (Director: Roberto Morrione) is the first Italian all-news channel [www.rainews24 rai.it] and the most technologically advanced division of RAI TV (Italian public TV broadcaster). It broadcasts digitally 24 hours a day, 7 days a week, via satellite on the Internet and on digital terrestrial television (Multiplex 2 Rai). Besides satellite transmission, it takes part in the Rai 3 nightly schedule from Monday to Friday. It covers all of Europe, part of North Africa and the Middle East and it is totally free. As suggested by its name, RaiNews24 is an all-news channel. It has a very simple but challenging editorial strategy: putting news in the spotlight. The editorial framework is made up of half-hour modules, consisting of news (10 minutes), weather forecasts and traffic conditions (2-3 minutes), in depth analyses of top stories (5 minutes) and a magazine (10 minutes), which is a daily or weekly programme on various issues, from sports to entertainment, from geopolitics to music, from education to foreign affairs (see figure 1). Thanks to its staff and the many experts who take part to the in depth analyses, RaiNews24 is an authoritative and reliable source of information.

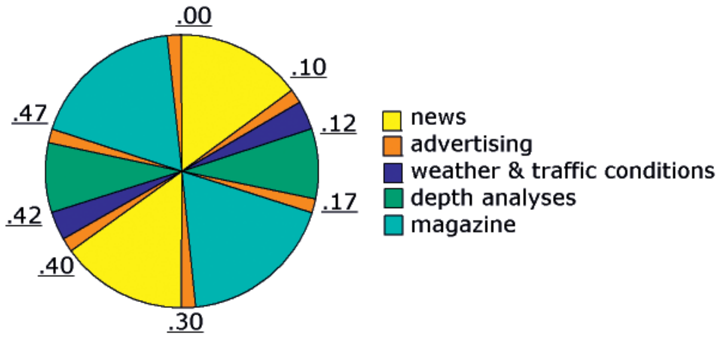

Figure 1. *The clock-timing of RaiNews24. ESA is classified as an in depth analysis of a weekly story.*

Recent independent surveys (Eurisko-Audistar [www.eurisko.it/english/english/euris2inglese/index.htm] and Auditel, [www.auditel.it/html/index.html]) confirm that RaiNews24 is the Italian leader among satellite news channels (Data Eurisko-Audistar, 2004; Data Auditel, 2004). The same surveys identify the audience as predominantly male (both young and adults) and of medium to high cultural level. This feature is also linked to the sophisticated multiscreen interface of the channel (figure 2).

Figure 2. *The multiscreen feature of RaiNews24 selects an audience with a high cultural background. There are several independent areas: as well as the main and the secondary areas, there are banners with the main news from the last few hours, financial information, internet links related to the main news and, finally, the date and time.*

As the clock-timing shows, everything revolves around the primary function of the channel: news.

Although one might expect the ESA interviews to be part of a weekly magazine, RaiNews24's editorial board decided to consider them as in depth analyses of weekly news items from the start. This is a key point in understanding the role of ESA in the context of RaiNews24, given that it is not a science channel.

ESA ON RAINEWS24: HOW DOES IT WORK?

At the beginning of each month, the ESA representative (S. Sandrelli), together with ESRIN's Public and Institutional Relations Office (Desk Office), plans the topics to be covered by the broadcasts, taking into account the Agency's priorities, e.g. an upcoming satellite launch, a wide-interest science workshop, an expected scientific release and so on. The ESA representative is based at INAF-Osservatorio Astronomico di Brera, in Milan. ESRIN Desk Office is located in Frascati, Rome.

For every subject, one or more of ESA's expert staff are interviewed by phone to collect the necessary information, while ESRIN's Desk Office selects suitable video clips from ESA television services, recording satellite transmission or by ordering beta tapes from the ESA television centre in ESTEC. Taking into account items in the weekly news, the final subject is chosen on Thursday mornings by the ESA representative and the RaiNews24 journalist. A beta tape covering the subject is sent by car from ESRIN (Frascati, Rome) to the RAI TV studios, in Saxa Rubra (Rome). The ESA representative prepares the Italian text of the interview (questions and answers) and submits both to the ESRIN Desk Office and the RaiNews24 journalist, who chooses the sequence of images to illustrate the subject. At 5:12 pm, the live interview is performed as a video conference, with the journalist in Rome RAI studios (Saxa Rubra) and the ESA representative in the Milan RAI studios. On Friday the text of the interview is then published on the Italian webpage of the ESA portal. As well as the interviews, the ESA representative has been supporting the Italian webpage by writing additional web stories or press releases, producing translations from English into Italian and checking the Italian translations made by others since 2005. This guarantees a consistent quality of the outreach service of the Italian webpage.

Last but not least, it is worth stressing that the ESA representative works in Milan, while the main studios of RaiNews24 and the ESRIN Desk Office are located in Rome. The work is mainly carried out by email and internet exchanges, supplemented by additional face-to-face meetings four or five times a year.

FACTS AND FIGURES OF 5 YEARS

An impressive total of 196 different interviews were broadcast between May 2000 and June 2005, each typically repeated twice, giving an estimated total broadcast time of over 3000 minutes and an estimated total broadcasting mean time of 15-20 minutes per week throughout this collaboration.

Although ESA manages a large number of different activities (from telecommunications to satellite navigation, from technology transfer to human spaceflight, from space science to launchers, from Earth Observation to enterprises support programmes), space science accounts for a significant 31% of the interviews broadcast (figure 3), which means it ranks first in the "top-of-the-pops" of topics, followed by Earth Observation (23%) and Human Spaceflight (16%). Telecommunications account for 9%, mainly thanks to Artemis's troubles in finding the right orbit in 2001 and, above all, to various telemedicine activities. Let us look at the topic distribution within Space Science in closer detail.

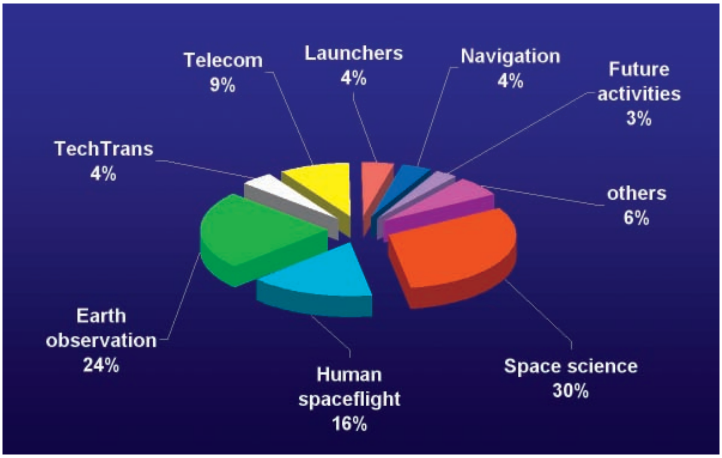

__Figure 3.__ Percentage distribution of the 196 ESA interviews broadcast by RaiNews24 in the years 2000-2005.
The overall leader of this "television space tour" is Solar System exploration, which accounts for 22.4% of the total. Mars Express, Cassini/Huygens, Rosetta and even the technological mission Smart-1 awakened significant interest in the media. While it is not surprising that the astonishing images coming from Mars and the Saturn system (both from ESA and NASA) make frontpage news, it is interesting to observe that both the Rosetta and Artemis stories arose from the technical troubles of these missions and how scientists fought against these problems until they succeeded in solving them. Smart-1, for its part, was interesting because it linked together a technological challenge and a scientific return in terms of moon images, which awakens interest in the amateur astronomy community primarily rather than in the general public. The launch of the Aurora programme is aimed at a manned expedition to Mars and catches even more interest, despite being a vision of the future.

Deep space accounts for a significant 9% of the total, thanks to the Hubble Space Telescope and the ESA's high energy telescopes, XMM-Newton and Integral—launched in 2002. The violent collisions between galaxies or the odd behaviour of black holes or neutron stars are very well known, widely requested astronomical themes, even if they require non-optical astronomy concepts.

Figure 4 shows the differential and integral evolution in the percentages of the three main interview topics: as is evident, increases and decreases are caused by specific events such as Mars Express' arrival on Mars or the descent of the Huygens probe on Titan. However the drop in the interviews about human spaceflight is due to the perceived stagnation of the project, even though the number of European astronauts is actually increasing mission by mission. The increasing relevance of the Earth Observation projects and the GMES Programme is also evident in the growth of environmental themes selected for our TV chat.

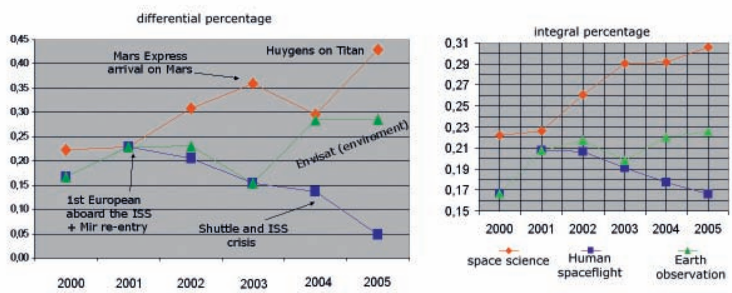

Figure 4. *Interest in Space Science is increasing because of several successful projects, including Mars Express' arrival on Mars, Rosetta's launch, the excellent results from XMM-Newton, the continually astonishing data from HST, the Huygens probe's descent onto Titan, the Smart-1 insertion into a Moon orbit. As an increasing differential percentage of Space Science, the integral percentage increases steadily too.*

RaiNews24 is a non-scientific all-news channel. So the question is: why is the discovery of a hot spot on a neutron star a relevant news item?

WHAT IS AN ASTRONOMICAL NEWS ITEM?

To a science communicator, the question of the intrinsic nature of a news item is very similar to the famous fundamental question about "Life, the Universe and Everything" [Adams, D.: The Hitchhiker's Guide to the Galaxy, 1979]. As "42" is clearly not a satisfactory answer, the original question has to be restated. Obvious cases such as a satellite launch or a new astonishing image from Mars suggesting that water was present on the planet hundreds of millions of years ago can be discounted.

As far as RaiNews24 is concerned, as wide a definition as possible of exactly what is newsworthy has been used: an astronomical news item about a phenomenon or object is anything that changes (be it a little or a lot!) the common perception of that phenomenon or object.

It does not matter if the news is related to a small visual phenomenon or if there are no spectacular images or videos. It is important to start from the general public's accepted understanding of that phenomenon or object (usually a misconception) and then to move on and illustrate that scientific understanding is a fluid entity that changes as our knowledge develops.

The key is to stress that science is a human activity that evolves continuously. The ESA representative can share his surprise for the new aspects of a phenomenon with the audience. This does not mean that scientists are at a loss, but that they may still feel that a changing vision can be confusing or even moving.

The aim is to help people understand that scientists are often as surprised (or confused or moved) as non-scientists are when facing a new aspect of a phenomenon. In a sense, the broadcasts allow people to tread gingerly along the most recent path taken by scientists, by modifying their original more naïve view of the phenomenon and adding a new scientific element. The most obvious criticism is that people are so full of misconceptions that trying to correct them all within a 5 minute interview is a “mission impossible”. That is completely true, of course. On the other hand, a 5-minute interview is enough to arouse doubts about pre-existing ideas and to let people try and imagine something different. It is a challenge to common perceptions. To be successful the piece of information should be broken up into 2-3 fundamental new concepts, since it is not politically correct to crush TV viewers!

Let’s see how it works with an example: the case of Integral looking for gold in space (see Space delivers the Philosopher’s Stone: http://sci.esa.int/science-e/www/object/ index.cfm?fobjectid=30256, 11.07.2002 for the ESA original story about Integral and the gold, and La corsa all’oro nello spazio, www.esa.int/esaCP/ESA4FATHN6D _Italy_0.html, 12.09.2002 for the interview, a couple of months later). When someone thinks of a stellar explosion, they understand and think something primarily about the explosion itself. If they have a basic scientific background, they also know that a stellar explosion produces chemical elements by nucleosynthesis (“we are all made of stars”, says Moby metaphorically in a recent song). But it is rare to find someone who actually knows which elements are created in the explosion. In this case, the possible creation of gold is the news element that has a good chance of catching people’s imagination and stirring up their curiosity. Linking a stellar death to the birth of one of the most precious metals on Earth underlines that the explosion is simply one mechanism of evolution in the Universe.

This success of this approach relies on the collaboration with RaiNews24 journalists, who are willing to take the risk that some minutes may be wasted talking about objects which seem far from reality. However, it is now an established fact that astronomy and space as a whole are seen by Rainews24 as a possible source of daily news, with the Solar System in particular as a window onto outer space.

It is far beyond the scope of this contribution, but anyone who wishes to read something about the subject in the context of radio may enjoy the recent article of Jergovic [Jergovic, B., Choices that Make Radio Science Stories, in JCOM 3 (4), 2004, jcom.sissa.it].

LOOK AND LANGUAGE

Science programmes are still extremely underrepresented on Italian television, despite the astonishing materials that are produced day after day by the major international scientific institutions. Notable exceptions are the traditional weekly programme Superquark (RAI1), which is strictly associated with the journalist Piero Angela, a veteran of science television programmes [www.superquark.rai.it/HPprogramma/0,4520, 76,00.html], Gaia (RAI3), a weekly programme on environmental issues presented by a CNR (Italian Research Council) researcher, Mario Tozzi [ww.gaia.rai.it/R3_popup_ articolofoglia/0,6844,44%5E942,00.html], and TG Leonardo (RAI3), a daily science magazine [www.leonardo.rai.it/tgr/HP_TGR/0,8248,22,00.html].

Reflecting this situation, it is hardly surprising that a thorough analysis of the format and style of television programmes seems to be lacking. The only fixed rule is that one can speak about science only in well-defined niches: this puts science in a dead end, since it isolates it from other cultural activities. On the other hand, recent surveys [Brandi, M., C, Cerbara, L., Misiti, M., Valente, A., Youth and Science in Italy: between enthusiasm and indifference, jekyll.com, 2004] show that the interest in scientific subjects is high, especially among people between the ages of 18 and 29. The traditional approach seems to be a waste of resources: it should be possible to feed interested young people a scientific news item directly given so many TV channels.

Moreover, an old, but still prevalent idea is that scientists know the truth, so that a modern version of the principle of authority emerges in that very field of human knowledge where it was rejected in Galilean times. The situation is rather different as regards the radio, since Italian radio science programmes are very modern both in spirit and approach, thanks especially to the pioneering work carried out by Sylvie Coyaud, who is now at Radio24. Moreover, serious analyses of interactions among scientists, science journalists and the public are conducted [Merzagora, M, Coyaud, S.: Conversations between scientists and the public in radio PHONE-INS: an experimental approach to analyse public perception of science, jekyll.com, 2002]. I will just quote a conclusion that should be widely shared: “it clearly emerged that the arrogance of science (and of ourselves, the science journalists) is largely responsible for the poor success in fighting the spread of irrational fears”.

The collaboration between ESA and RaiNews24 allows us to push science to the core of human activities, since it is regarded as one in depth analysis of the news among many others during the day. On the other hand, it is one of the very few fixed programmes on the channel, so that the ESA representative's face has become somewhat familiar to the audience.

This overview gives a sense of our communication strategy, which has been modified over the years after some initial communication mistakes. The ESA representative is a spokesperson of the Agency: if a mission is in trouble, he is usually well informed, but any comments he may or may not make on the issue are strictly limited by the official version decided on by Headquarters. He must also take into account the image of the Agency itself, the communication plan which is usually prepared by ESA officials, the priority of some specific messages that ESA wishes to transmit and so on.

On the other hand, I also believe that: a) interviews must be largely informal, that is, the ESA representative should not simply be a spokesperson, strictly associated with official correctness; b) the ESA representative must be allowed to have his own vision about space; c) the ESA representative must not necessarily be the top authority in any given field, but he must be highly reliable and well informed; d) the journalist need not be an expert, merely interested; e) the language used should be simple, but rich and correct.

The interviews are necessarily a balance between what an ESA representative should be according to the Agency and what a good science communicator really is. This ambiguous sentence means that the last five years have been a kind of revolution for us. As an example, look at figure 5. In the top left corner the second broadcast of 1June 2000, on XMM-Newton; all the other images refer to the first few months of 2005. The evolution of the look is evident, going from a formal tie-dominated look to a shirt-dominated one.

Figure 5. *Compare and contrast the upper left image with the others. Where is the red tie?*

PROBLEMS AND LIMITS OF THE COLLABORATION

RAINEWS24 is a dedicated news channel, with a very well-defined audience, selected both by the use of satellite technology (recent surveys indicate about 19 million dishes in Italy) and the use of a complicated interface.

The interview format is not changeable: the ESA representative must sit in front of a camera and talk: he cannot move around or show objects. The resulting interview format is too institutional and rigid: a more informal approach is needed. Besides, it is impossible to use any props during the interview, such as a scale model of a satellite. Whereas the text of the interviews is published on the Italian site of the portal, the video interviews are published neither on the ESA site nor on the RaiNews24 site. Finally, despite the successful collaboration with ESA, the ESA portal (www.esa.int) is not linked from Rainews24 channel website.

CONCLUSIONS

As far as astronomy is concerned, the main result of our activity is that space is now seen by Rainews24 as a possible source of daily and weekly news. Moreover, I wish to underline that from May 2000 to June 2005 about 60 interviews about astronomy were broadcast, giving an estimated total time of more than 1000 minutes dedicated to the field, with an estimated total broadcasting time of 5-7 minutes per week, with additional time given to repeats. Full texts are published on the ESA Italian site, which is now a repository of about 200 style-homogeneous interviews about space activity, together with other contributions.

As regards the communication of astronomy, ESA seems to be moving towards a less formal, modern and up-to-date communication style. ESRIN, in particular, recognizes and promotes the professionalism of a scientific communicator, not only as a communication consultant but as a selected ESA representative.

In a well-known comic strip, Felix the Cat grabs the Moon and uses it as a cradle to calm a crying baby: is Felix an astronomer, a poet or just a guy who has succeeded in understanding what culture means?

Acknowledgments: G. Celsi for providing RaiNews24 information; M. Talevi for providing information about the ESA's 1998-survey. A. Sandrelli for revising the English text.

Credit: Davide De Martin (http://www.skyfactory.org/), Digitized Sky Survey 2 & the ESA/ESO/NASA Photoshop FITS Liberator

COMMUNICATING ASTRONOMY

A Reporter's View

Govert Schilling

Freelance astronomy writer, The Netherlands

ABSTRACT

Reporters and editors are the intermediaries between scientists and the general public. So if you want to reach your audience through the print media, you'd better have a good understanding of how the newspaper and magazine world works. Here I present a reporter's view of the communication between astronomers and the press: what do the news media expect from scientists, how do you maximize your chances of media exposure, and what are the pitfalls and golden rules of communicating with journalists.

HOW DO THE NEWS MEDIA WORK?

It's all about money

News media are commercial organizations. They need to make money. If something doesn't sell, they won't run it. In the end, this means that they won't run a story, if they don't think their readers are interested in it. Of course, the readership interest is very much dependent on the type of publication—the New York Times may run stories that would never make it into USA Today.

Types of publications

Whether a story runs in a particular news media outlet (and in which form) or not depends heavily on the type of publication. Daily newspapers may run brief, newsy items; weekly magazines (or weekly newspaper sections) are more likely to run longer stories with some background; monthlies may even decide to run a feature story if there isn't a particular news peg.

No obligation to be complete

Since news media are not scientific publications, they have no reason or obligation whatsoever to be complete in their coverage of a particular field of science. The upshot is that the most 'sexy' topics will prevail; some technical topics within astronomy will always have a hard time to make it in a newspaper or magazine, no matter how important they may be to the scientists involved.

Always in a hurry

Remember how grant applications are always submitted just minutes before the deadline? It's the same in journalism: everything happens at the last possible moment, so in general, there's very little time for detailed discussions with interviewees, and—unfortunately—for fact checking. There's little hope that this situation will ever improve: it's the nature of journalism.

Ignorant about science

In general, editors of newspapers and general interest magazines are pretty ignorant about science. Expect them to have the same biased attitude as the population at large. In some senses this is good, since they aim to reach the public, which is also scientifically illiterate. On the other hand, lack of insight can often lead to strange decisions, for instance, in the choice of topics to cover.

WHAT DO NEWS MEDIA WANT?

News!

They're called news media, after all. In general, if there's no news, there's no story. But news can be many things: a scientific observation, a rocket launch, a publication, a talk at a conference, a new book, an exhibit, a visiting scientist and so on. At all costs make sure that the title and the lead of a submitted story or a press release has a news component.

An exciting story

Black holes are exciting. Extraterrestrials are exciting. The Big Bang is exciting. But many more astronomy-related topics can be exciting to a general reader. If it isn't for the research itself (which may be too abstract), the excitement can be generated by the scientists involved, or the new instrument they used. Any story that fires the imagination of the reader stands a better chance of ending up in a newspaper.

Human touch

You wouldn't expect to see it in The Astronomical Journal, but talk about people is an important aspect of journalism. Readers want to have some mental image of the protagonist of a story: how old is she, what does she looks like, how did she end up in this job? A teaspoonful (or more) of the human touch may make a story on a challenging topic easier to digest for the outside reader.

Conflict

People like conflicts, especially if they're not involved themselves. Also, conflict is what science is all about. Two groups with different views on a particular topic (like the formation scenario of giant planets) may not feel much personal animosity toward each other, but there's nevertheless a conflict that will make a story on the topic a more interesting read for a general audience.

Pictures

If you want to enhance the survivability of your story, make sure you include pretty art in the form of photographs, artist's impressions, and explanatory diagrams. Also, make sure that editors will actually see the prettiest picture(s) during their first casual glance over your submission. Remember: they're in a hurry, and may not have time to read all of it at first, but a nice picture will catch their attention.

HOW TO IMPROVE YOUR EXPOSURE

Know your press contacts

I'm not suggesting you send Valentine cards to newspaper editors or science writers. But if you know each other just a little bit (by making the occasional phone call, or having a chat at a conference), it will be easier for you to stand out from the crowd (dozens of press releases arrive at the desks of editors each day after all). Also, you will be recognized if you plan to make follow-up calls after sending a press release.

Be concise

It's an old saying: you never get a second chance for a first impression. News editors may make a first selection on the basis of reading just titles and first sentences. A brief lead paragraph should contain the whole story in a nutshell. If you can't explain the importance of the story in a few sentences, the topic may be too difficult or too arcane for a general readership.

Be patient

Your first submission may be ignored. Your second submission may be ignored. Your third submission may be ignored. Don't give up; be patient. Many, many factors are at play—it probably has nothing to do with the quality of your stories. Also, if a publication decides to run your story, they may bother you with numerous dumb questions. Again: be patient.

Be cooperative

Editors or reporters may have many requests after they decide to write on the topic of your press release: contact information for scientists, pictures, fact checking, et cetera. Don't expect your job to be finished after the release has been mailed. Being cooperative will be valued and remembered; next time around, your submission will ring a positive bell.

Be available

It happens all too often: media contacts and scientists mentioned at the bottom of a press release are unavailable (sometimes they're even on holiday). Make sure that your spokespeople understand that they should be at their (cell) phones almost all day for the first two days or so after the release has been issued. Also, in case of a great story, they should not expect to do much 'real' work in these first few days...

PITFALLS AND GOLDEN RULES

You're not a writer

Although large institutes have professional writers to produce press releases, smaller organizations rely on their scientists to do the public relations. They should realize that a newspaper article is not the same as a scientific paper or a poster. Leave the actual writing to the writers. You may not agree with their choice of topics, their phrasing and their use of metaphors, but it's their job, not yours.

They're not scientists

In communicating with news media (or even with science journalists), remember that they may not have an academic science background. Try to avoid the use of jargon (mass function, apo-centre), unfamiliar units (parsec, erg), general science concepts unknown to most people (3-sigma, power spectrum) and the like. You are the one who has to take the first steps on the bridge between science and the public.

K.I.S.S.

Keep It Simple, Stupid. Don't complicate things with too many unnecessary details and qualifications. Spend some time thinking about good metaphors and analogies to illustrate what you want to convey. Also, since the topic of your story is usually pretty unfamiliar to your readers, keep your language simple. This will make the story easier to digest.

It's all about the reader

In the end, the goal of your efforts is to bring science to the general public. Don't forget that members of the general public are all around you (you're part of it yourself!). How would you explain the topic of your story to your aunt or your greengrocer? Why not ask them for advice? After all, you would also like them to be able to read it, right?

Reporters are nice people

They may have a slightly different agenda from scientists, but in general, editors, reporters and writers are nice people. Don't be too suspicious of them, especially since you need them. After all, you are partners in getting the message to the audience. If in doubt, make solid agreements about matters like embargos, quote checking and so forth beforehand.

Credit: Subaru Telescope, National Astronomical Observatory of Japan (NAOJ)

PLENARY SESSION 4:
The Role of the Observatories

THE ROLE OF THE OBSERVATORIES

Ian Robson

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ABSTRACT

Observatories are the engine room of astronomical outreach. They provide the tools that allow research discoveries to be made in addition to employing many of the research astronomers and public information officers (PIOs). Where accessible, they provide a natural venue for public visits and centres of excellence. They engage in a wide variety of outreach activities in their own right with varying degrees of success, often linked to funding. In all of this, the enthusiasm and high calibre activities of individuals can never be overestimated. We review the above and report the results from a 'health of stock' survey conducted of a large sample of mainly ground-based observatories reflecting their overall activities and experiences.

INTRODUCTION

When considering astronomy outreach in the broadest context, three categories can be identified:

- Producers, comprising astronomers, observatories, facilities etc
- Mediators (sometimes termed distributors), comprising PIO professionals, PR departments, planetaria, etc.
- Deliverers, comprising astronomers, enthusiasts (including amateur astronomers) agencies (through sponsored programmes), planetaria, etc.

Of course, in reality, many of these boundaries are blurred and individuals can switch through all the categories as part of their normal working day—this kind of flexibility is a good thing and is to be encouraged.

We must all realise that observatories are the bedrock for the production side of outreach material. Even though it is the individual astronomer or team of astronomers who makes a discovery, then the basis is an observation, and that requires facilities and instruments (unless the work is in theoretical astronomy). [One can always argue about the standing of a theory without experimental verification, but one way or another it can generate significant public awareness through spectacular press releases.]

THE ROLE OF THE OBSERVATORIES

It is important to realise just how fundamental the observatories are in the overall astronomy outreach process. Naturally space platforms and satellites/missions are included in this context, but throughout this talk I will focus on the long-lived, ground-based observatories that serve the very widest astronomer base, rather than the one-off space mission that is limited to the instruments carried up on launch (the HST being the notable space-based example that can update its instrumentation and hence prolong scientific excellence).

Observatories provide the necessary infrastructure that allows observational astronomers to produce the exciting scientific results in the first place. They also provide employment for many people in the second category—the Public Information Officers. Many observatories provide a local focus for direct outreach in the immediate geographical area and a venue for members of the delivery category—especially enthusiasts and amateur groups. Finally, although perhaps not directly linked to outreach, but certainly a valuable resource, they are often the repository of the history of observational astronomy.

We acknowledge that ground-based observatories span a wide range of capability in terms of their delivery of 'outreach'. This may be dictated by a variety of reasons, including, for example, the standing of their competitive research activity, funding, location, and mission requirement. Let us take a look at each of these in turn.

RESEARCH ACTIVITY

Research activity for an observatory can range from a cutting edge, state-of-the-art, cut-throat occupation in a highly competitive environment, whose very reason for existence is to maximise the scientific impact, to old, 'historical' observatories that essentially undertake no research with the observatory equipment (although they may employ astronomers who pursue fine research using modern facilities worldwide). My own observatory in Edinburgh is a prime example of the latter. And there is of course everything between these extremes. It is not clear if there is a correlation or an anti-correlation between different types of research activity and deliverable outreach, where each is competing for staff time and resources. Many, if not most of the major observatories in the world have very active outreach programmes and there are excellent examples of high calibre outreach from the older and non-research driven facilities. The one thing that does seem necessary is that for a major observatory to maximise outreach commensurate with its 'status', PIO professionals need to be employed, given the competition for research staff time.

LOCATION

Location matters greatly when considering outreach in the context of public visits and lectures, a venue for gatherings and meetings of enthusiasts, provision of public viewing nights, or a visitor centre and shop. Telescopes that are close to major conurbations have obvious advantages in terms of visitor attraction and a potential public market, in the optical waveband light pollution tends to limit these to older observatories with conventional telescopes (e.g. Mt Palomar). However radio observatories can do well in this situation—Jodrell Bank is a prime example, with the major cities of the northwest of England close by. Jodrell has an extremely active visitor centre and planetarium and has become a local attraction featured on tourist maps. A few observatories happen to be adjacent to popular tourist destinations, especially ski resorts. Notable examples of these are the Observatoire du Pic du Midi in the French Pyrenees, Nobeyama Observatory in northern Japan and the two telescopes (TIRGO and KOSMA Telescopes) at the spectacular Gornegrat location on the ski slopes surrounding Zermatt. However, in most of these cases, other obstacles prevent or limit visits by the general public.

Figure 1. *The Lovell Telescope at Jodrell Bank provides a spectacular magnet for attracting visitors to this popular location. (Image courtesy of Ian Morison)*

Kitt Peak is probably one of the best examples of a modern observatory located relatively close to a major population centre and continuing to do frontline optical research. Tucson has been very careful with light pollution, but it is noticeable that the city has grown enormously since the blossoming of Kitt Peak in the 1970's. Where public access is readily accessible and there is either a major local centre or good reason for a financial subsidy (for more rural environments) visitor centres spring up and flourish, acting not only as tourist attractions, but as educational centres (e.g. Greenbank Radio Observatory). Something to remember is that gound-based solar astronomy is done in the daytime and so in principle provides a ready-made possibility for an 'easy' visitor attraction, as visitors can see observations made in real time. While many of these solar observatories are in remote locations, a number of them have realtime webcasts of observations for public viewing.

For the more modern optical/IR/submillimetre facilities, very high and remote mountain tops or high and remote dry plateaus are the name of the game. These are typified by La Palma, Mauna Kea and the sites in northern Chile (with Antarctica at the extreme). Access can be difficult because the sites are remote, or because they are so high that there may be serious health and safety hazards for the general public, or both. In such cases, visiting the actual telescope is very difficult, and where it is possible special care needs to be taken to ensure that members of the public are forewarned of possible hazards and dangers and that the observatory is protected from resulting lawsuits in case of incident. This is not a trivial question when weighing outreach and openness against business liability. In this context the Subaru Observatory deserves special mention for recently instigating a visitor programme for the general public (see poster by Ishida). It will be interesting to see how this develops.

Most of these very remote facilities have operational bases at a sea-level (or lower altitude) site, and this provides the potential for engaging in similar ventures to the more urban observatories in the previous category (e.g. the talk by West). It also enables 'remote' visits to the telescope, where the general public tour in cyberspace with various levels of interactivity. We will see a prime example of this in the Gemini Virtual Observatory talk by Peter Michaud later.

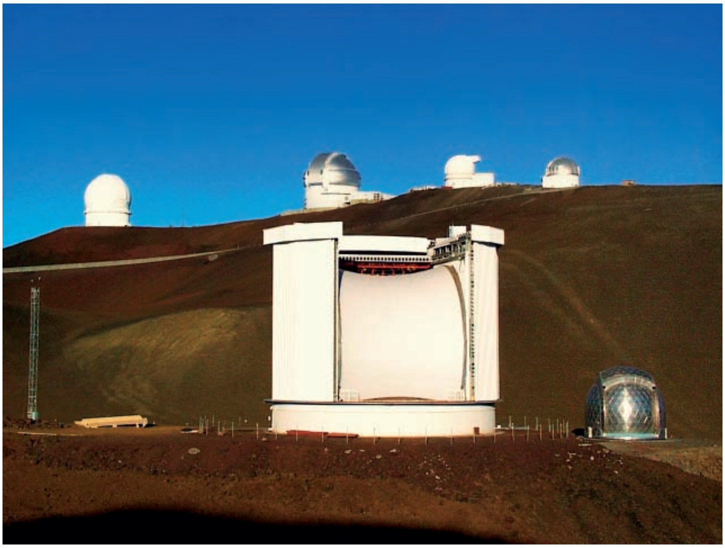


Figure 2. *High and remote observatories like Mauna Kea pose a variety of challenges for public viewing and tours of telescopes. Nevertheless, a number of commercial tour companies have cottoned on to the observatory as a tourist attraction and many vanloads of visitors are taken to the summit of Mauna Kea to see the sunset each evening.*

The challenges are different for facilities in space as there is no opportunity for public visits etc, but these observatories and facilities have produced an explosion of material for astronomical outreach and educational purposes through webpages, special events, promotions and control centre visits. One special case to be remembered is the Kuiper Airborne Observatory, which did such a lot for outreach/education by allowing teachers to fly in the airplane during observing sessions and produce lesson plans and generally excellent educational outputs from their experiences. The same is currently planned for its successor, SOFIA.

Some space missions work in wavebands that are alien to the general public and many have done a splendid job of education through some amazing innovations on their websites. We'll see examples of this during the meeting. Finally, there are the astroparticle experiments, some of which are buried deep underground. These have even greater problems at trying to explain the science to the members of the public, let alone confronting the access problem. I wish them the best of luck. Cosmic ray telescopes also have limited opportunity for public access, while not needing to be on extremely high sites, they do need very dark skies and so tend to be very remote by nature.

FUNDING

In many respects funding is the key to outreach success in terms of global reach. However, we should also remember that while funding may be necessary it is far from being sufficient. There has to be the 'added-value' provided by the key professionals and enthusiasts, many of whom are present at this meeting. Funding can be from the national government as part of a clear policy on outreach and education and/or from foundations and donations. In these cases funding is often generous. Many government agencies now require that all new major projects must devote a fraction of their total budget specifically to outreach. This is often manifested through webpages and activities (especially for the space missions). On the other hand, many observatories spend a significant amount of time applying for funds and grants just to be able to maintain a barely adequate level of outreach activity, and often at a level far below that which the individuals would like to be able to offer the public.

MISSION

Many observatories and facilities undertake outreach as part of their 'mission requirement'. This is to be greatly encouraged and is an example of good practice from sponsoring agencies. Being in such a situation is clearly a great asset for fundraising. The opportunity to subsequently increase this funding through demonstrable outcomes tends to be built into this model. I know of at least one major research facility from personal experience that has had a very significant increase in outreach funding over the past few years by demonstrating the need in the community and the effectiveness of their delivery methods and outputs.

On the other hand, many observatories operate outreach because of their inbuilt mission, rather than as an externally imposed mission. They do this because the observatory staff themselves feel that they should be and would like to be providing outreach. This is a highly altruistic viewpoint and is almost always driven by individuals. It is incumbent on all professionals and organisations to encourage and support this wherever possible. A key message of this entire talk is that INDIVIDUALS MATTER, whether it is the enthusiastic staff members who do the organising, the charismatic front-persons, the fund-raisers or the volunteers. Key people make a difference. Cherish them wherever you can.

THE EDUCATIONAL ASPECT

It needs to be recognised that many observatories undertake educational programmes that are directly linked to their local or national school curriculum. This is of tremendous benefit to the usually hard-pressed teachers and provides an ‘out of classroom’ experience for pupils that all of those who have been involved in such events know works extremely well. This is another aspect of good practice, but it has to be recognised that to do it well it is extremely labour intensive. And frankly, if it is not done well then it is almost certainly better not to do it at all. So for those thinking of such ventures, it would be well worth learning from those who are already successful, or maybe even better, from those who have tried and then given up.

Because of limited resources (usually staff time) some observatories have focused their efforts not on teaching the pupils, but on teaching the teachers—the continued professional development of teachers. If this is done well then the overall payoff is very high, as cascading knowledge into the teaching profession means that many more pupils can be reached with the same amount of staff input resource.

A number of observatories have visitor centres that have introduced clear educational themes that are either directly related to a curriculum, or, have very clear educational aspirations. Most observatories participate in the general educational theme by giving lectures to school children with a clear educational content rather than merely ‘gee whiz’ shows. So, all in all, it is clear that observatories are playing a notable role in helping science education at a time when it needs all the help it can get.

A COMMON DENOMINATOR

When assessing all the above factors in terms of sizing up observatories, they all have one thing in common; the ability to reach out to the public through the web. Because this is so obvious the question arises as to why I even mention it. And the reason is that web-browsing is similar to television channel surfing. As we have already heard, research shows very clearly that unless the TV audience attention can first be captured and then continually stimulated, it will be lost to surfing for all but the dedi-

cated viewer. Just translate this to web-browsing and you will see the drift.
Anyone who has ever been responsible for maintaining webpages knows only too well that it is extremely demanding in terms of staff time. Maintaining content so that it is always fresh and up-to-date with links that always work when pages are moved or linked to external sources and changing names of staff to contact is a nightmare and very resource intensive if done well. Even with the resource in place, the next question is how the general surfer views the webpages. As part of the questionnaire that I will discuss in the next section I visited the webpages of over 70 observatories and facilities to get an overview of what was ‘out there’. The results were very varied, from the excellent to the ‘I give up’ syndrome. I should be clear in this statement: I was looking for outreach and information about astronomy or the observatory for the public and nothing else. The question for me was, how easy the information was to find, and did it inspire further reading or investigation. There were some excellent sites with abysmal public outreach pages, and vice versa, but the good news is that most were making a decent stab at informing the public about what they were engaged in at least.

So, for the PIO audience present, take a look at your webpages as if you were a complete stranger and member of the public—or have your non-astronomy friend/partner do it for you. Questions you could ask include: is it attractive or exciting on first viewing? How easy is it to locate the ‘information for the public’ section? Is the directory tree sensible or just confusing? Are the images all much bigger in size (pixels) than they need to be and is the download time is just too long (think of those who are not on broadband)?

The web is a huge and valuable tool; we all use it to promote our institution as well as a means of conducting much of our work. But we also need to be aware that it needs to be customer-focused, much more so for members of the public than for research scientists. The latter are committed, the former may just be curious, so make sure that their curiosity is stimulated, not stunted at the first opportunity. Here endeth the sermon on the web for the morning.

OBSERVATORIES—THE BIG PICTURE

In trying to get a handle on where astronomers stand worldwide in terms of communicating with the public through the role of observatories, I attempted to contact most ground-based observatories and offer them the opportunity to answer a simple questionnaire. As noted above, I started by viewing a large number on the web. Some then were rejected as the web-content was in a language that I could not translate (altogether reasonable if the focus is on the local populace), some had contact points that never worked, and some were so complex to navigate that I got fed up and called it quits before getting to where I might have found a contact name.

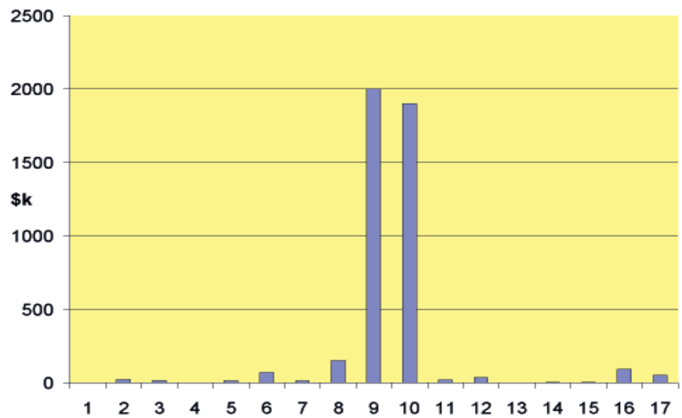
The final list comprised 58 ground-based observatories plus 2 space-based facilities (STScI and ESA Hubble). Their prime contact information (web) was taken from the Strasbourg data centre on: http://cdsweb.u-strasbg.fr/astroweb/telspace.html. I attempted to locate each observatory from the web and then contact their PIO or named contact person, as well as obtaining primary information (health of stock) and a 'gut feeling' for how well we are doing in terms of outreach to the public. This method also served to test the effectiveness of the webpages, and subsequently, the level of customer service in responding to the questionnaire. Up to the time of this meeting, 18 replies have been received so far. While in some quarters this could be seen as a high ratio of reply, I suspect most of us find this rather disappointing. A number of non-respondents are represented in this audience, and you should know who you are.

The questionnaire was as follows:

- Total Outreach Funding per annum:
- Major source of funding:
- Number of 'permanent' staff employed on outreach:
- Number of part-time helpers:
- Number of visitors per year:
- Number of school children visits:
- Do you have a formal programme of education?
- What are your attractions?
- What do you feel has worked well in terms of outreach success?
- What has not worked well?
- Number of research press releases per year:
- Do you have good contacts with the local media?
- Do your stories get well covered and if so, what is the secret?
- What proportion (%) of research workers actively participate in outreach?

As might be expected, the answers revealed the wide range of activity that is undertaken. In what follows I should note that the statistics are rather small and a number of the major players in the game are so far in the 'non-respondent' category. Nevertheless, given these caveats, the picture is that the total outreach funding ranges from $2M per year to zero, the straight average being $290k. As might be anticipated, the major source of funding is government and state. The replies are shown graphically below, where two large and famous observatories dominate the funding picture. It should be pointed out that some of this funding comes from visitor centre income as these are run on strict business lines:

Figure 3. *The annual gross income in $k as reported by 17 ground-based observatories from the survey sample of 58.*



The number of 'permanent' staff employed on outreach varied from 20 down to zero and the number of part-time helpers varied enormously. Taken overall, the number of direct visitors to the observatory locations was around 300,000, which, when you think about it, is not that many at all, in fact ridiculously small, and I'm sure will be completely dwarfed by numbers from museums/planetaria as we'll hear later. It is not clear that when the remaining figures are in, this total will increase significantly.

I was very keen to tease out 'what worked' and more importantly, 'what didn't' in order to pass this on to the community. While this generated a wide range of replies, some specific themes could be identified. 'Ask the Astronomer' was definitely top of the pile, and all those observatories that ran this commented very favourably on it. This is a hint for those that have not yet embarked along this line, it always seems successful and even those astronomers who might not be very good at standing up in front of the public and giving a talk, seem to do better at just answering questions and being available. It was also noted that it was not only the professional astronomers that were in this top category, but the keen amateurs as well. The public seem very responsive to meeting those who actually 'do' astronomy.

Open days/nights and opportunities to look through telescopes also rated highly, although a number of responses noted that the weather was a damper and that planning was fraught with problems—finding things to do when it turned cloudy was challenging. The general use of and hands-on interaction with telescopes also scored highly, even when cloudy—just seeing the enormous magnification that even a small telescope provides when focused on a terrestrial scene was a positive experience. I remember many years ago my university had a science exhibition in the local shopping centre and we took a number of telescopes. I had one set up and focused on the solitaire diamond on a ring in a jeweller's shop some 200 feet away and one floor up. Asking people to look and identify what they were seeing turned out to be an amazing turn-on. Virtually all could just not believe that something they could not even make out with their unaided eye (some could just about see the trays that the rings were on) could be revealed in such huge detail. It was just mind-blowing. The moral: simple things work.

Figure 4. *Staff from Jodrell Bank with their portable planetarium at a local school.*

Finally in this section, everyone who had portable planetaria reported excellent feedback. This is clearly a worthwhile venture, although success was very dependent on the quality of the presenter. Last in the list of common agreements was that visits to schools worked well, although once again, the quality of presenter was the key to the success.

And now, to the 'what didn't work well' category. While this was even more varied than the previous list, top of the pile was 'talks that went on for too long'. Presenters who lost empathy with the audience and did not have the ability to change pace or content were a clear turn-off for the public and need to be guarded against. 'Enthusiasm and entertainment' virtually always score over 'thorough but boring'. Following this in the list were what might be termed management issues. These centred on issues such as always having to fight for resources, along with not knowing the place of outreach in the management train, or, where the place was far removed from the action or the Director. Next was the difficulty of obtaining high quality exhibits for visitor centres, and even when funding was available, actually getting exhibits that were attractive, robust and that worked were all problems. Finally, and not unexpectedly, completing the list, was the perennial problem of the unpredictability of the weather for many locations.

CONCLUSIONS

We have seen that observatories make a huge input to astronomical outreach. The scale and scope of their activity varies widely; from very large organisations with flourishing visitor centres run on business lines to small observatories that occasionally open their doors to the public. All have their place and it is important that all are encouraged to do what they can in fulfilling the mission for astronomical outreach. Better to undertake a small number of activities well than to try and extend too much at the expense of quality. The public are discerning and competing markets for attention are huge in this day and age. Remember this when designing or updating webpages. Observatories are doing a great job, but it is certain that they can do more. Funding will always be an issue, but astronomy is incredibly fortunate in having highly enthusiastic staff engaged in outreach and a general public that is receptive to the message. We need to capitalise on this by whatever means possible and encourage observatory directors, funding agencies, sponsors and the like to continue to invest capital and time to this part of the mission, to both repay what we have enjoyed in our professional careers and to ensure that scientific literacy is not only continued but enhanced for the coming generations.


PAULANER

COMMUNICATING CHANDRA'S X-RAY ASTRONOMY TO THE PRESS AND PUBLIC

Megan Watzke & Kim Kowal Arcand

Chandra X-ray Center, Cambridge, Massachusetts, USA

ABSTRACT

As one of NASA's "Great Observatories" along with Hubble and Spitzer, the Chandra X-ray Observatory detects and images X-ray sources that are billions of light years away and provides insights into the Universe's structure and evolution. Since its launch in July 1999, Chandra has probed regions around black holes, traced the debris of exploded stars, and helped outline the enormous structures of the cosmos. But does the public know the name "Chandra" and do they know the field of X-ray astronomy exists? Conveying Chandra's exciting, though often complicated results to the media poses certain challenges, while offering significant rewards. This talk will cover some of the successes the Chandra team has encountered in this endeavour, while outlining areas that need improvement. Finally, we hope to discuss specific ways that Chandra might be able to collaborate with other telescopes and observatories to promote the excitement of astronomical research to the media and public.

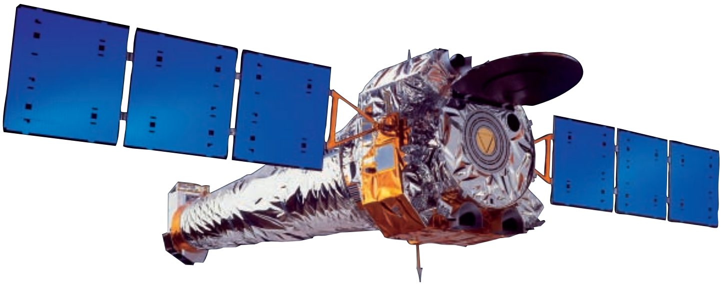


Figure 1. *Artist's Conception of the Chandra X-ray Observatory*

ABOUT CHANDRA

Chandra is NASA's flagship mission for X-ray astronomy, launched aboard the Space Shuttle Columbia on July 23, 1999. After completing its nominal 5 year mission, NASA extended the Chandra mission through 2010. If the spacecraft continues to be in good health, the hope is that Chandra could continue to operate well into the next decade.

Unlike most other NASA missions, the Chandra Science Center and Operation Control Center (i.e. "Mission Control") are located at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Chandra's managing NASA centre is the Marshall Space Flight Center in Huntsville, Ala. The Education and Public Outreach group (EPO), which includes both formal and informal education efforts as well as Chandra's Press Office, is also based in Cambridge, Mass. The EPO group consists of about 12 fulltime employees. The rough breakdown of duties is the following: press-3 people; web-3; education-3; multimedia-3. The responsibilities of the EPO group range from issuing the latest press release to maintaining the website to conducting teacher training. This presentation focuses almost exclusively on the press and media efforts of the Chandra EPO group. For more information on any of the other activities, please contact mwatzke@cfa.harvard.edu or kkowal@cfa.harvard.edu

GOALS FOR CHANDRA PUBLICITY

In an idealized situation, the outcome for Chandra press efforts would result in the naming of "Chandra", X-ray astronomy, and the specific research that was the focus of the release. Again, in a perfect situation, these articles would appear in prominent locations (preferably the front page) in such influential outlets such as the New York Times, Washington Post, and USA Today.

Figure 2. A collection of literature featuring Chandra articles and images—the ideal situation!

This, of course, does not happen with every Chandra press release. In fact, it probably happens only a small fraction of the time. Even if we are able to get coverage in these media outlets, only some of the information is used. This means that often "Chandra" or even "X-rays" are not mentioned.

CHALLENGES IN NON-OPTICAL ASTRONOMY

There are certain issues that non-optical astronomy must face. The first is that most of the general public is not even aware of the concept of "other" types of astronomy. To most people, astronomy is something done by looking through an eyepiece in a backyard or at the local planetarium. Of course, most of them have heard of Hubble, but this is largely an optical telescope they can easily relate to as a special, bigger version of familiar telescopes.

Another major hurdle for Chandra is that the images, while a great improvement over previous generations of X-ray telescopes, are not as obviously compelling.

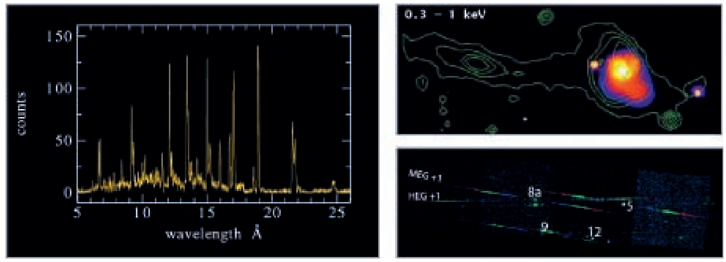


Figure 3. Challenging X-ray images, including a spectrum, x-ray contours and grating images. X-ray images are often starved for photons and, by definition, must employ false colours. Occasionally, X-ray images will awe the public by aesthetics alone, but this is usually the exception and not the rule.

Finally, many of the topics engaged in by X-ray astronomy imply high-energy physics. Therefore, the results often involve intense, complicated physics that can be very difficult to distil into a soundbite or headline.

CHALLENGES FOR ALL OF ASTRONOMY

While X-ray astronomy faces certain unique challenges, there are, of course, issues that any piece of astronomical publicity must confront. For example, the best news stories are discoveries, but true discoveries are rare. The “eureka” moment comes infrequently if at all. Especially in today’s era of large collaborations working on fundamental problems, most research papers describe incremental advances. While ubiquitous, incremental advances are difficult to make into news stories.

Also, astronomical press offices must deal with the difference of opinion between what they know to be of interest to the public and what scientists think is fascinating. It can be difficult to explain to a scientist who has spent months, years, or even a professional career on a topic that it is not something that makes news.

Lastly, astronomers are often not great communicators with the public. They are usually well seasoned in giving scientific talks to their colleagues, but there is a very different lexicon required when speaking to a reporter, especially one from TV or radio.

DESPITE THE OBSTACLES, SUCCESS IS POSSIBLE

It is not all dire news. In fact, many people do connect with X-ray astronomy, even if they do not even know it. That is because many of the topics covered best by X-ray astronomy—black holes, supernovas, cosmology, the Milky Way Galactic Centre—are gobbled up by the press and public. These areas seem to excite and interest the public, if we are able to present them in a way that is accessible.

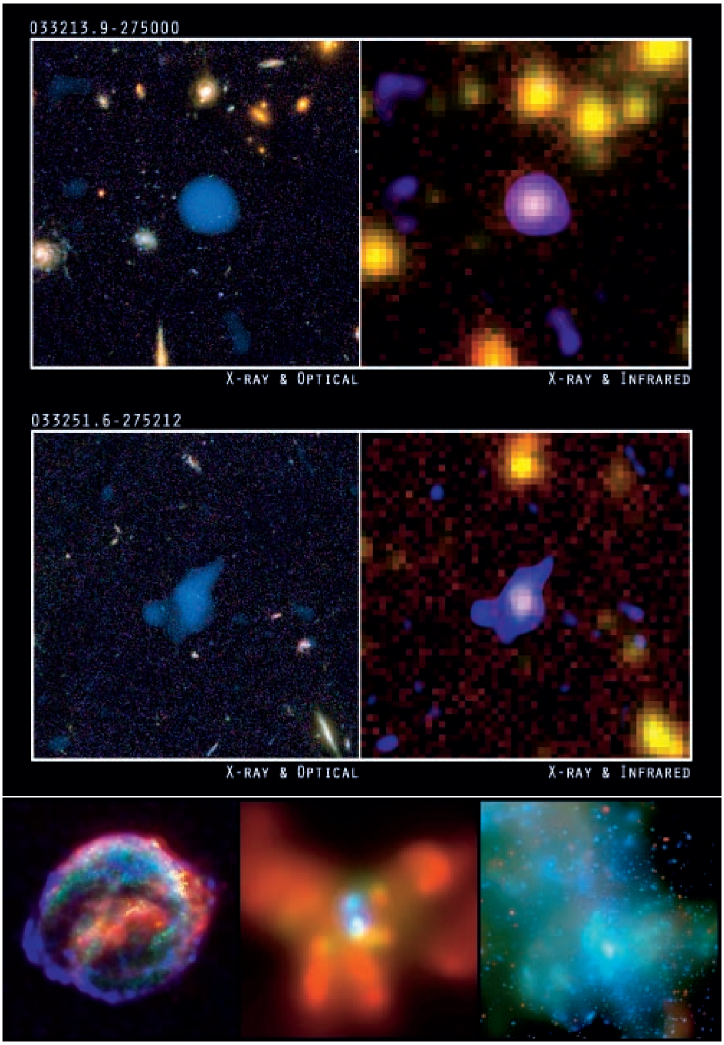


Figure 4. *Successful Chandra examples include GOODS and Kepler's SNR (both multi-wavelength features), NGC 6240 (botton the merger of black holes, and the Galactic Centre.*

One of the greatest benefits of publicizing astronomy today is the wide range of possibilities of multi-wavelength images and results. One could argue that we are currently enjoying a "golden age" of astronomy with the Great Observatories, with advances in adaptive optics and other technologies for ground-based optical telescopes, and improvements in radio, submillimetre and other regimes. The public, whether they understand it fully or not, seems to relish the idea of seeing the "whole picture". With X-ray and other types of astronomy, we can hope to "fill in the blanks" and enable a more complete view of the Universe.

HOW WE FIND STORIES

It is the responsibility of the Chandra Press Office to coordinate every bit of publicity that comes out about the mission or its research, including all of the results from astronomers worldwide who use the telescope. This stems from NASA's policy of having "first right of refusal" on any result. In other words, NASA wants to have the opportunity to publicize results if it so chooses to. It is the task of the Chandra Press Office to make sure all astronomers using Chandra know the procedure and follow it. To that end, we take several parallel steps:

- We contact every scientist who received Chandra observing time at certain key intervals (6 months, 1 year after they receive their data, for example.)
- We monitor astro-ph, as well as commonly used journals (ApJ, ApJ Letters) to see what papers are being published and by whom. For the best stories, we would prefer to get to the scientists before the papers are published on astro-ph, which is one of the reasons for the contact at key intervals. This can be very difficult, however.
- At least one member of the EPO group attends most major astronomical meetings, especially the AAS. We also try to listen to workshops, colloquia and any other accessible talks to get a feel for the latest research.
- Perhaps one of the most important efforts is the collaboration with other PAOs. For example, we frequently talk to both the Hubble and Spitzer News Offices to see what they are working on. If there is a question on a result involving another institution, or even a topic we know has been covered well by another observatory, we will contact that PAO. These informal conversations often provide the best handle on a story.

WHAT WE DO WITH THEM

As a NASA mission, we follow their guidelines and practices for media efforts. The following is a list, in descending order of scope that describes the different categories we use. In other words, the "biggest" stories will go out as NSUs, while a slightly less-newsworthy story would be a media telecon, and so on, i.e.:

- NASA Science Updates (NSUs): formerly SSUs. These are televised press conferences that are held in the NASA auditorium. Each NSU must be approved by a group within NASA HQ. The goal for NSUs is largely for TV coverage as well as high-profile print articles.
- Media Telecons: These are phone-in teleconferences where reporters can ask scientists questions and follow presentations posted on the web.
- NASA HQ Press Releases
- CXC/MSFC Press Releases
- Local Institution Press Releases
- Web-only posting

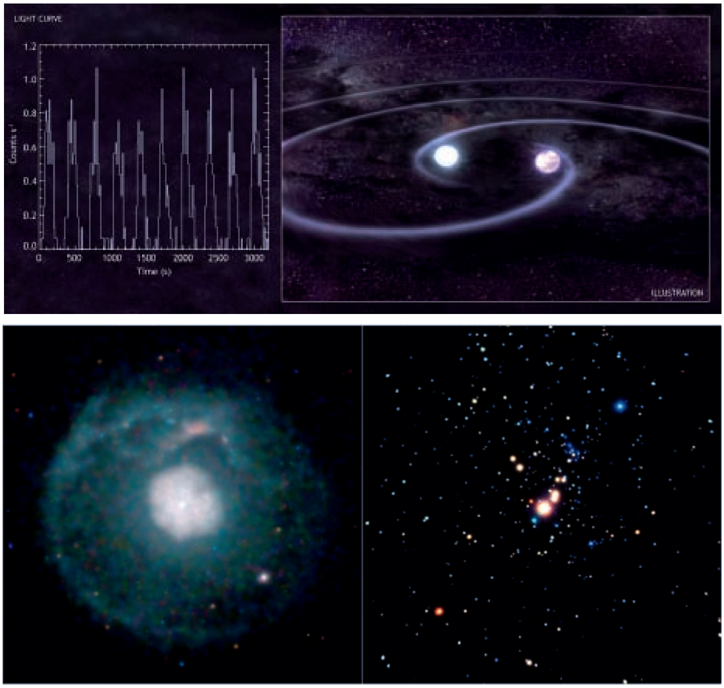


Figure 5. *Recent examples from left to right include J0806 (a NASA press release), G21 (a web-only posting) and Orion Nebula (a media telecon). A note about the review process for every press release: Each release to the media must be reviewed by the principal investigator, CXC (EPO staff and key scientists), MSFC, and NASA HQ—a total of at least 10 people!*

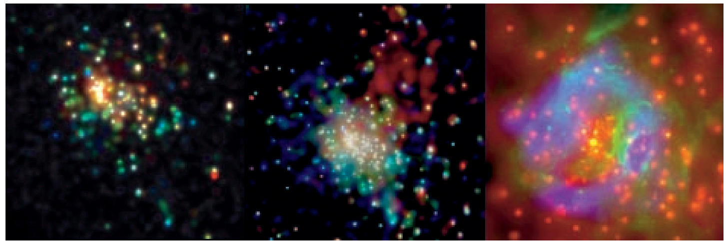
VISUALIZING CHANDRA RESULTS

The following section discusses the various means the Chandra EPO group employs in order to communicate the research from the mission visually. These range from using the Chandra-data-only image to multi-wavelength composites to artist's illustrations and animations. Because graphics are essential for the media and public to "see" what Chandra does, this is a considerable effort on the part of many people and resources in the group.

CHANDRA DATA: BLACK & WHITE PIXELS TO…PICASSO?

When preparing a Chandra image for public consumption, the first step is to collect information from the researchers involved with the result. Almost exclusively, the topics of Chandra press releases have already been submitted or are in preparation for a scientific journal. The EPO uses any images from the paper as a first step. We can also get a sense of the science that the image should convey from the paper. We try to factor this in, when possible, while trying to balance out the aesthetics. On occasion we can use the image directly from the scientist, but more often than not we need to reprocess it for our purposes.

__Figure 6.__ A low-resolution image from the PI; an image from the EPO group; a multi-wavelength version.
The original FITS files come directly from a member of the science team and we will then smooth, bin, flux, and separate the data into various energy bands, if needed. After processing with CIAO tools and displaying in ds9 (software packages used to handle Chandra data), the image is transferred to Photoshop. Once there, various aspects can be changed, sometimes utilizing FitsLiberator. For example, we can emphasize certain features, work with layers of energy cuts, adjust colour choices, change the field-of-view, etc. Also, if there are multi-wavelength layers to add, it can be tweaked in Photoshop as well.

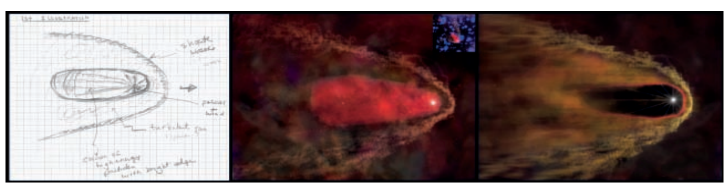


The entire process is iterative, with discussions among the scientists, members of the EPO group, and the image processor until there is agreement on a version for a main image. Often, we present more than one version of an image to fulfil both the wishes of the EPO group as well as the science focus. There is a convenient section of "More Images" on the website, which allows us to include many options while featuring the image we believe fits best for the press and public.

WHEN WE DON'T HAVE PRETTY DATA…ILLUSTRATIONS: PENCIL SKETCH TO SPACE ART:

Sometimes, the data from Chandra cannot be processed into something attractive. For example, the image could be a simple dot, or the data might only be spectral. In these cases, we often find it useful to create an artist's illustration (still graphic) to present as a primary graphic.

__Figure 7.__ Black Widow Pulsar: a pencil sketch from the PI; an early version, shown with the inset of the actual data; the finished product.



The steps for this process are:

- Review notes and sketches from the science team. (The seed for the illustration can come from the Chandra Science Spokesperson and/or Press Scientist, Principal Investigator on data or another scientist who works with the Media Coordinator of the EPO group.)
- Confirm the basic visual details (size, shape, texture, colour)
- Prepare a first sketch based on interpretation of materials (Photoshop, lots of layers)
- Continue drafts based on the feedback from the team until it is appropriate for the release (average number of revisions is about 7, but the record for versions is 14!)

There are times when a still graphic is not sufficient to tell the whole story of a Chandra result. For example, when Chandra does an NSU, we are required to have at least one animation. These artist's motion graphics are likely to be the most labour intensive but potentially most valuable product the EPO group creates. They cannot, however, be done quickly. A proper animation can take 6 to 8 weeks.

Here are the basic steps involved with creating a Chandra animation:

- Creation of a Storyboard: Like an illustration, the genesis for an animation can come from a scientist within the EPO group, a member of the science team, or some combination of the two. The creation of the storyboard requires strong visual communication between the scientists and the EPO group. Ideas are also gathered from existing data, simulations, still images, and other animations.
- Build 3D models and set the scene: We will create scene flow, the animation of objects, add lights and cameras—most often using Maya software.
- Add object textures and render the scene; the science team reviews for accuracy. The EPO group monitors visual appeal as well as tempo and flow.
- Iterations are discussed and changed to meet final expectations (not all changes requested are made, and often compromises are reached).

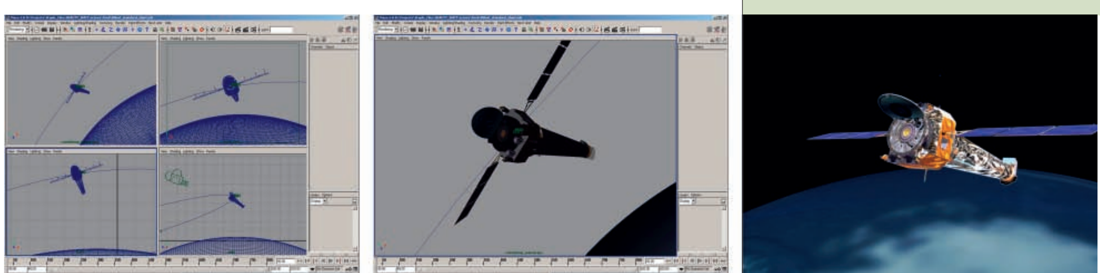


Figure 8. *Chandra beauty shot: modelling the spacecraft, adding texture and lighting; the final render.*

The final animation must be output in several versions, including betas for television, online (MPEG, QuickTime), and others.

When the press release goes out, the usefulness of these images and other visuals are not nearly finished. On the contrary, the Chandra EPO group "recycles" nearly every item for the press into a full array of products for the public. These include posters, lithographs, calendars, online exercises, CD-ROMs and more. Below is a sampling of these efforts.

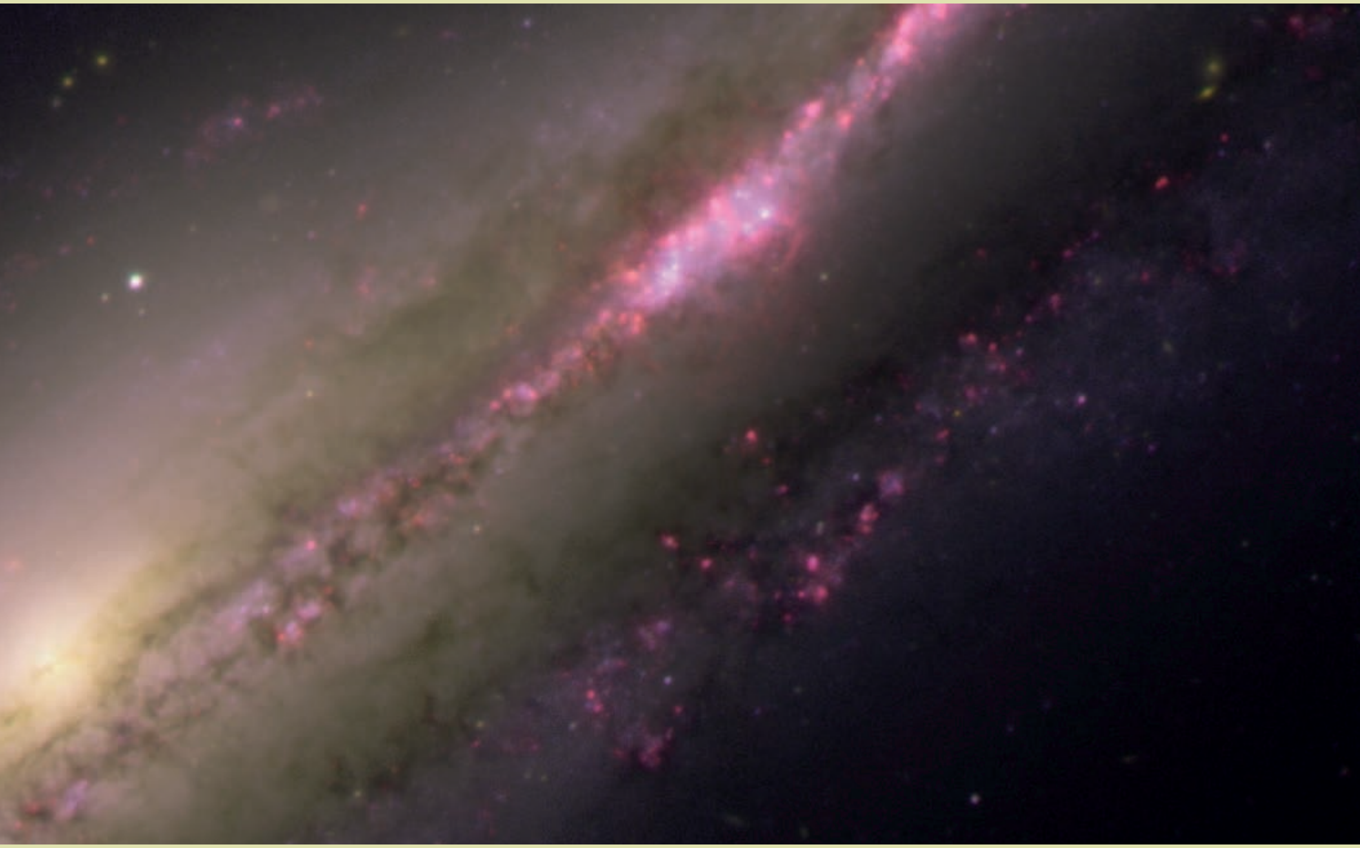
PUTTING IT ALL TOGETHER ON PAPER AND THE WEB

Figure 9. *Chandra images and release materials are recycled into calendars, posters, postcards and other print products. In addition, CD-ROMs, flash packages and other web/multimedia features are packaged up.*


the temptation for hype huge. Are comparisons
the sort "my scope is better than your scope" necessary? Do we really need
scientific results to be peer-reviewed in advance of their public dissemination?
Do we need internal political and scientific editorial boards – or is it just a kind
of double-refereeing? How do we handle the really BIG discoveries (e.g. exo-
Simpsons)? How do we treat the NEO threat? Why do press releases that are
later proven wrong rarely get withdrawn? Is the time ripe to make a Code of
Conduct for press releases that outlines recommended ethics and procedures
for conflict resolution, analysis and retraction?

Credit: Gemini Observatory/Travis Rector, University of Alaska Anchorage

PLENARY SESSION 5:
Innovations



USING THE NIGHT SKY TO CULTIVATE PUBLIC INTEREST IN ASTRONOMY

Richard Tresch Fienberg and J. Kelly Beatty

Sky Publishing Corp., Cambridge, Massachusetts, USA

ABSTRACT

To many people, the word "astronomy" means "science, math, difficult". They do not understand science or how it works, and some even fear it. Yet whenever there is a bright comet, a rich meteor shower or a lunar eclipse, members of the public come out in droves to see it. And when they do, they want to understand what they are seeing. Widespread interest in the night sky therefore offers many "teachable moments" during which amateur and professional astronomers can share the wonders and methods of science with the public.

There is actually no need to wait for an eclipse or other significant astronomical event. The Moon, bright stars, and one or more planets are visible almost every clear night, even from light-polluted cities. The key is to get people outside to look at them.

As one step toward this goal, the publisher of *Sky & Telescope*—the world's leading monthly magazine for serious astronomy enthusiasts—has created a new bimonthly magazine, *Night Sky*, especially for beginners and casual stargazers. We will relate some findings from our market research done before and after the launch, explain our editorial formula, and describe some of the things we are doing to maximize the magazine's impact.

An estimated 2 million small telescopes are sold worldwide each year, but many of them go unused. We want to see more of them outside collecting starlight rather than inside collecting dust.

INTRODUCTION

Sky & Telescope, the Essential Magazine of Astronomy, has been published monthly since November 1941. It has always featured articles about both the science and the hobby of astronomy to appeal to a broad range of enthusiasts. In its early days *S&T* was a 24-page black and white "journal" read by several thousand subscribers, mostly in the United States. Today it is a modern consumer magazine with a global readership. Each issue typically contains 136 full-colour pages, and its paid circulation exceeds 100,000. Two thirds of these readers take the magazine by subscription, while the remaining third buy it on the newsstand. Three out of four copies are sold in the USA or Canada, while the rest go to more than 130 other countries across the world.

We survey our readership every few years to make sure we know who is buying the magazine and how they are responding to it. Reader demographics have not changed much in several decades. The breakdown in skill level looks like this: 10% beginners, 50% amateur astronomers, 35% advanced amateurs, and 5% professional astronomers (plus or minus a few percent from survey to survey). The average reader owns at least two binoculars and two telescopes, the latter typically of aperture 15 to 20 centimetres (6 to 8 inches). He's male, middle-aged, well-educated, and active in the hobby, observing the night sky at least several times a month. And he likes *Sky & Telescope*—a lot!

Figure 1. *Sky & Telescope magazine (September 2005 issue).*

But there's another side to the story. In recent years, *Sky & Telescope*'s circulation has stopped growing. The average age of its readers has climbed faster than the average age of the general population and now tops 51 years. Meanwhile, the percentage of young readers (age 20 or less) has plunged to near zero. Yet at the same time, some 2 million small telescopes are sold annually worldwide, many of them as gifts for youngsters. And astronomy clubs and planetariums report record attendance at public observing sessions.

EXPANDING THE MARKET

When publishers talk about expanding their magazines' circulation, they refer to growing readership "horizontally" and "vertically." The former refers to reaching a wider swath of their traditional market, and the latter to reaching out to new markets. Sky Publishing Corp., the parent company of *Sky & Telescope*, decided to pursue both strategies at once.

To expand horizontally, Sky embarked on a program to create international editions that would appeal to our core market—amateur astronomers—in countries with large numbers of hobbyists but low sales of *Sky & Telescope*. To date we have forged licensing arrangements with publishers in three countries. Spektrum der Wissenschaft, the publisher of the German edition of *Scientific American*, publishes *Astronomie Heute* ("Astronomy Today"), with about 60% of its content translated from Sky & Telescope and the rest prepared by a local staff of astronomer-editors. Paragon Media publishes *Australian Sky & Telescope* to serve amateurs in Australia and New Zealand, where there was no monthly astronomy magazine focusing on the southern sky. Again, about 60% of its content is drawn from *Sky & Telescope* and the balance produced locally. The Italian publisher of the high-end *Le Stelle* and more popular *Orione* translates several articles from *Sky & Telescope* to include in each of these monthly magazines.

In combination, these magazines reach several tens of thousands of amateur astronomers that *Sky & Telescope* was not serving before. Counting these readers, *Sky & Telescope*'s circulation is higher than at any point in the magazine's history—and growing. We have licensing negotiations under way with publishers in several additional countries, so we anticipate that we'll continue on this growth track.

To expand vertically, Sky decided to reach out to the burgeoning market of casual astronomy enthusiasts and newcomers to the hobby. But we knew we couldn't do this with *Sky & Telescope*. After decades of honing its editorial and graphical formula to appeal to devoted hobbyists, we knew that if we were to reengineer the magazine to make it appeal to "newbies" we'd inevitably make it less appealing to our core audience. So we set about finding another approach.

Our first order of business was to get a good handle on the nature of the beginner's market. We did this in several different ways. First, we conducted a blind survey of buyers of beginner's telescopes. We rented lists of customers who had bought starter scopes by Meade Instruments or Orion Telescopes & Binoculars and mailed a survey to them without identifying either the manufacturer or *Sky & Telescope* by name. We visited numerous astronomy vendors, either at their offices or at star parties where they were exhibiting, to discuss their perceptions of the beginner's market. And we conducted informal surveys of visitors to telescope dealerships and public star parties.

BEGINNERS IN ASTRONOMY

From all this research a consistent picture emerged. Most small telescopes are bought as gifts during the holiday season, and the recipients—often children—may not have any interest in astronomy. But a significant number of first telescopes are purchased by astronomy enthusiasts for their own use. These buyers tend not to be children. Rather, they are typically middle-aged adults (predominately male) who match the demographic of Sky & Telescope's traditional readership. Many of these beginners in astronomy had an interest in the hobby when they were kids during the heyday of the Space Age but detoured to other pursuits as they reached adulthood, established themselves in a career, and built a family. They are getting back into the hobby now that they have more free time and discretionary income. They often buy expensive, gizmo-laden telescopes rather than cheap department-store fare. They're interested in science, but not in and of itself; the more familiar they become with the night sky, the more they want to learn about the science behind the celestial objects they can see in their telescopes. In short, in the early 21st century beginning amateur astronomers are a lot like traditional 20th-century Sky & Telescope readers, but at the origin of the learning curve.

Not surprisingly, we learned that these newcomers to the hobby have a lot of trouble operating their telescopes and finding their way around the sky. Consequently they experience a lot of frustration. For help, they pick up magazines, visit online astronomy sites, and buy beginner's books (in decreasing order of preference). But they find *Sky & Telescope* and other astronomy magazines intimidating—too costly, technical, and time-consuming. This is consistent with the results of surveys of former *Sky & Telescope* readers who've let their subscriptions lapse; the main reasons people stop reading the magazine are that it is too expensive (\$42.95/year for a subscription, or \$5.99/copy on the newsstand), they don't have time to read it anymore, or it's over their head.

ENTER *NIGHT SKY*

To respond to the underserved market of beginning astronomy hobbyists, Sky Publishing decided to launch an entirely new magazine especially for them. It would be written and illustrated for adults, but be inviting and accessible to interested kids as well. The main ingredient would be stargazing—navigating the sky with the naked eye, binoculars, and telescopes—with science added for spice. And it would appear bimonthly, to keep the cost to consumers low ($17.99/year for a subscription, or $3.99/copy on the newsstand) and to avoid overwhelming them with too much material too fast.

Night Sky premiered with its May/June 2004 issue. Its editorial and graphical formula can be summed up this way: "Astronomy is fun. You can do it, and we make it easy for you."

The new magazine meets the same high standards for accuracy as *Sky & Telescope,* but it is less comprehensive (a typical issue is 92 pages), less technical, and more user-friendly. In every article, we assume little or no prior knowledge on the part of the reader, defining every new term as we go. Text is written and edited with a welcoming, success-oriented tone. And only a few simple concepts are introduced and explained per article.

Each issue's featured celestial objects include a mix of naked-eye, binocular, and telescope targets—but only those visible from the suburban locations typical of our readers. We provide thorough, step-by-step instructions for finding them. Similarly, we provide thorough, step-by-step instructions for using popular telescopes and accessories—after first offering expert tips on how to buy the right equipment in the first place.

Straightforward, engaging text is augmented by lots of big, clear, simple illustrations, including sensibly labelled photos and diagrams. *Night Sky*'s charts are uncluttered by stars and deep-sky objects not visible in cities or suburbs and rendered to closely match the sky's appearance, especially the relative brightnesses of stars.

Most astronomy magazines, after opening with an editorial and some letters from readers, jump right in to news stories and feature articles on the latest discoveries. Star charts and other features for hobbyists come later. Because of its emphasis on stargazing, *Night Sky* opens (after the usual preliminaries) instead with all-sky maps and narrated naked-eye sky tours—one each for the two months covered by the issue. It then features a close-up of a single prominent constellation, including its naked-eye and binocular appearance and the historical myth or lore behind it. More observing-related articles follow, including a star-hop in a region of sky well-placed

Figure 2. *Night Sky magazine (September/October 2005 issue).*

during the months of issue, a scientific portrait of a single easy-to-find deep-sky target (how to locate it and what astronomers know about it), and a telescopic tour of the Moon or bright planet.

Additional features highlight timeless observing projects, such as tracking down colourful double stars or spying halos and other atmospheric phenomena, and then the magazine wraps up with a series of articles on choosing and using telescopes of various types, binoculars, star atlases, desktop-planetarium software, and the many other "tools of the trade" commonly employed by backyard astronomers.

Nowadays, no magazine is complete without a companion web-site, and *Night Sky* has one at http://NightSkyMag.com. At the moment of writing it's mainly a marketing site, giving prospective readers a taste of what's inside the magazine and making it easy for them to subscribe to it. Eventually the site will evolve to offer more astronomical content to supplement and complement what's in the magazine itself.

THE MARKET RESPONDS

After one year of publication, *Night Sky* is attracting a circulation of about 50,000 readers, split roughly equally among subscribers and newsstand buyers. This is immensely gratifying, as *Sky & Telescope* took some two decades to reach that level of readership! Even more gratifying, our first survey of *Night Sky* readers shows that only about a quarter of them read *Sky & Telescope*; as intended, the new magazine is reaching a new market of astronomy enthusiasts that we weren't serving before.

Readers aren't the only ones who've responded positively to the new magazine. We thought we might be able to attract only those advertisers who sell equipment "obviously" targeted at beginners. That has turned out not to be the case. Many of *Sky & Telescope*'s advertisers have booked space in *Night Sky* as well. After all, it was they who originally told us that modern beginners don't hesitate to spend lots of money on the hobby!

Although we didn't create *Night Sky* specifically for children, we were pleased to win a 2005 Parents' Choice Silver Award from the Parents' Choice Foundation. The honour recognizes publications that "entertain and teach with flair, stimulate imagination, and inspire creativity."

Early reviews of the magazine have been very encouraging. Here are two examples.

"This is a fine publication, another excellent tool for us to use and to recommend for those just starting out with more interest than knowledge, and a very good choice for your gift shop shelf."

– Jim Manning, *The Planetarian* (June 2004)

"We are not in the business of selling magazine subscriptions — it's just that this magazine is so good that we don't want you or your family to get involved with amateur astronomy without having it alongside."

– Celestaire, Inc. (March 2005)

Figure 3. *NightSkyMag.com home page.*

CONCLUSION

To enjoy stargazing you need just three things: curiosity, a clear view of the night sky, and a simple guide to lead you across the heavens. Plenty of people have the first two, but until the advent of *Night Sky* magazine they lacked the third. We hope that our new entry into the astronomy magazine market will nurture the growth of many new hobbyists and help educators and popularizers succeed in getting more people hooked on astronomy. Such an outcome would benefit the entire astronomical community.

It generally takes three to five years for a new magazine to firmly establish itself in the marketplace, so it's too early to say how this one will do. But the early signs are quite positive, so we'll continue to look up!

THE GEMINI OBSERVATORY VIRTUAL TOUR

Peter Michaud

Gemini Observatory, Hilo, Hawaii, USA

ABSTRACT

Because of their remoteness and the resultant difficulty of visiting the Gemini telescopes on Mauna Kea and Cerro Pachon, a virtual tour of the Gemini Observatory was instigated. This has been developed over the years and has received wide acclaim. This talk illustrates where we are now with the Virtual Tour and gives some examples of topics that have worked well and some idea of the costs involved in such an enterprise.

INTRODUCTION

During the past five years, the Gemini Observatory Virtual Tour (GOVT) has gone from a prototype project of limited scope to a broad initiative that has impacted a number of existing and new education and outreach programs at the Observatory.

Initially the GOVT was developed to address the problem of limited access to the summit area of Mauna Kea, and health, safety and staffing issues related to providing tours at Gemini North. Especially problematic is the fact that students under 16 years of age are not allowed on organized summit tours due to potentially severe health issues.

Figure 1. *The Gemini Observatory Virtual Tour "package"*

The GOVT was initially produced as a simple CD-ROM-based walking tour of the interior of the Gemini North facility, with interactive elements that allowed users to learn more about specific locations within the facility and to understand better how the observatory worked. With the initial success of this prototype, the GOVT has continually expanded to meet new needs, expanded rationales and educational objectives.

GOVT RATIONALES AND OBJECTIVES

Beyond providing a simple virtual experience to those wishing to visit the summit facilities, the GOVT has evolved to serve as a general informational package for anyone wanting to learn more about Gemini, its technology and scientific results. The content of the tour has also expanded dramatically and now contains dozens of modules covering most major aspects of Gemini's mission.

To meet the objectives set for the tour, it must be:

- Educational;
- Highly Interactive;
- Fun and Challenging;
- Bi/Multi-lingual;
- Current (updateable);
- Low-Cost (Distribution);
- Bullet-Proof for Kids and Kiosks;
- Accessible – MAC/Windows.

While most of these objectives have largely been met, some are still being developed, such as the bi/multi-lingual features. The next version (3.0) will contain Spanish translations, and additional languages are planned, incorporating all of the Gemini partnership languages within three years.

Making the tour current is an ongoing effort, but the ability to update it easily has been incorporated into the tour by developing an internet update feature into a "News" module. This module features current press releases and images in a lively newspaper-style format with updateable headlines, lead stories and an expanding archive.

PRODUCTION TECHNOLOGIES AND FEATURES

To meet the objectives of the GOVT, it was deemed that the most appropriate technology to use was a CD-ROM, due to low duplication costs and the almost universal accessibility of such drives in computers. Furthermore, with the relative ease of producing interactive content with multimedia elements and the relatively large data capacity of CD-ROMs it was determined that this combination would be the most appropriate for the tour. The final factor in choosing the CD-ROM format were our plans to “port” the tour to internet delivery eventually. Limiting the size to about 700 MB assured that eventual internet delivery would not be prohibitive.

The following key elements guided the selection of production technologies and features:

- CD-ROM/Hard Drive Delivery
- Interactive Media (QuickTime VR)
- Assembled with Macromedia “Director” for flexibility and interactivity
- Internet Enabled
- Mouse-driven Kiosk Mode
- Internal User Tracking (kiosk mode only - for evaluation)

CONTENT ELEMENTS AND FEATURES

The GOVT contains dozens of specific modules and elements. Many of these are part of larger themes that together make up an experience that allows users to delve as deeply or superficially as they desire. The following are some of the key elements that can be explored in Version 3.0 of the tour (see Figure 2):

- Simulated Observations (using real data)
- Gemini Images Screen Saver Maker
- Walking Tour
- Electromagnetic Radiation Explorer
- Adaptive Optics Game
- Active Optics Game
- Mauna Kea Explorer
- “Cosmic Times” News Updates
- Meet Gemini Staff
- Mirror Technologies

These and many subelements combine to provide an average of approximately five minutes of dwell time for visitors who use the tour at kiosks. For extremely interested users it is not uncommon for an experience to continue for 15 minutes or longer if “Simulated Observations” are completed.

Figure 2. *Various "screen shots" from the Gemini Observatory Virtual Tour showing several activities available on the CD-ROM*

While future expansion is possible, Version 3.0 nearly fills one high-capacity CD-ROM, so if new modules are added it will be at the expense of existing content. Note: capacity has been allocated for future language translations and news release updates.

EXPENSES AND RESOURCES

Production of the GOVT has been distributed over a period of about five years and many of the content elements have been produced for multiple purposes so determining exact costs is difficult. However, if the tour were to be produced as a stand-alone product the budget would be of the order of $200,000. Of this, the single most expensive elements are animations and programming. The following list provides rough estimates of expenses (all expenses in US dollars):

Programming:	$50K
Animations:	$100K
Graphic Design:	$25K
Photography (Staff):	~$20K (estimated)
Disc Duplication:	~$0.85/each (with packaging)

Annual duplication expenses for modest distribution rates of 10K/year are $8,500 excluding shipping and handling costs.

WHAT WORKED… WHAT DIDN'T:

Starting out as a modest "experiment" to provide a safe alternative to visiting the Gemini facility on Mauna Kea appropriate for all ages, the GOVT has been a tremendous success. This success is reflected in the fact that development of the tour has continued and expanded well beyond the initial scope of the project and it is now a fully developed interactive experience that has been tested and evaluated using multiple criteria and metrics.

Essential to the development process has been the use of internal counters and "dwell-time" monitors. These have provided essential data (not traceable to individuals) on where users of the kiosk version of the tour went and how long they spent on various activities (dwell-time). In addition, an opportunity for users to provide comments and suggestions has proved to be invaluable in modifying existing content and the development of new modules and content areas of interest to users.

Beta testing at public kiosks has also been extremely successful for identifying stability issues with the program and as mentioned previously for tracking usage patterns and navigation issues. Currently there are a total of 12 GOVT kiosks in Hawaii, Chile, Tucson and Canada.

Because this program has been under development for several years, the evolution of content and overall structure of the tour has never had a "front-to-back" review. This is a weakness of this approach and a plan is being developed to address the issue and possibly restructure the tour and re-work the navigation and story line of the tour to better match user interactions and educational objectives. This is discussed further in the "Future" section that follows.

Another element that remains to be addressed is the assessment of usage or "insertion rate" by end-users who receive the CD-ROM package. This is currently being addressed by including a "Customizable Screen Saver" module that will allow users to make a screen saver with the tour to encourage "insertion." In addition, several of the activities now allow users to email us a mailing address on successful completion of selected activities to obtain a Gemini Legacy Image set. This is designed to allow us to monitor increases in "insertion" rates as a metric of the GOVT's impact.

Annual distribution of the GOVT is currently at a level of about 10K/year which has been sustained over the past 3 years as the tour has been tested and developed. Future plans involve more aggressive distribution now that all stability issues have been addressed and an appropriate level of content has been achieved.

THE FUTURE

With version 3.0 of the Virtual Tour completed, plans are underway to address several issues for version 4.0. These issues relate to summative assessment strategies, educational implementation, distribution expansion, navigation assessment/modelling, integration into other education/outreach programming and additional language translations.

- Summative Assessment Strategies: a formal summative assessment strategy is being developed to assess the success of educational goals of the tour, "insertion rates," user interaction tendencies and the identification of improvements that can be made in future versions of the tour.

- Educational Implementation: adapting the tour for formal educational use will be pursued by assembling teacher focus groups to identify how the GOVT can be used effectively in the classroom to support national science standards and curriculum throughout the Gemini partnership. A redesign of the tour's navigation and emphasis will be considered to accomplish this objective.

- Distribution Expansion: expanding distribution of the tour to new audiences that include educators is a key objective. A sample of the tour will be made available on the web that will allow the public to sample the tour and upon successful completion of an activity they will be given the opportunity to receive a full CD-ROM copy. Outreach throughout the Gemini partnership will also be expanded as new language/translations become available.

- Navigation Assessment Modelling: as part of the summative assessment, user interactions will be studied for possible modifications to the navigation model currently used for the tour.

- Integration Into Other Education/Outreach Programming: the GOVT will be integrated into new and ongoing Gemini education/outreach programming like teacher workshops, a new prototype program call "Live from Gemini" and classroom visit preparation activities.

- Additional Language Translations: all of the Gemini partnership languages will be included in future versions of the GOVT. These will include English, Spanish, French, Portuguese and Hawaiian.

SUMMARY

The Gemini Observatory Virtual Tour project is a long term initiative that has been successful on many levels. All major elements in the programme are now complete, and a process of review, assessment and adaptation is now underway that is intended to broaden distribution to the public and educational users.

We encourage you to request the current version of the tour by sending an email with your mailing address to: geminivt@gemini.edu

Comments and suggestions for future versions of the tour are also welcome.

Credit: Spizer Space Telescope, NASA/JPL-Caltech/R. A. Gutermuth (Harvard-Smithsonian CfA)

PLENARY SESSION 6:
The Role of Planetaria

THE UNIQUE ROLE OF THE PLANETARIUM/ SCIENCE CENTRE IN SCIENCE COMMUNICATION

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ABSTRACT

This paper presents a very broad overview of the planetarium community. It is intended to present some basic facts about planetarium facilities, their distribution around the world, and suggestions for how education/public outreach (E/PO) and planetarium professionals (planetarians) can interact to bring astronomy to the public. These suggestions stem from an ongoing survey of planetarians, which asks what E/PO products they use and the effectiveness of such materials.

Planetarium facilities are among the most useful and attractive places members of the public can visit to learn about astronomy. Many astronomers recount vivid and fond memories of planetarium visits in their youth and these places remain staples for museum and science field trip visits. They reach out to a broad cross-section of society to bring astronomy to the public, often doing so despite low budgets and short staffing.

DEFINING "PLANETARIUM"

For purposes of this paper, a planetarium is defined as the theatre in which a star projector is used to recreate the night sky. In recent years, special effects projectors, sound systems, and video projectors have also supplemented the star projector.

Whatever the planetarium was in the past, in today's practice it has a multi-purpose function: it is a theatre, a classroom, and an immersive experience in which astronomy (and other subjects) are presented as learning experiences. Today's theatres are equipped with widely varying types of equipment, ranging from the familiar opto-mechanical "machine in the middle of a round room" projecting stars in combination with special effects projectors to state-of-the-art digital theatres showing full dome animations. Currently, the planetarium field is undergoing an evolution to a more digital realm, and planetarium professionals are re-thinking their older methods of show production and presentation.

HOW MANY PLANETARIUMS ARE THERE?

The worldwide planetarium community is growing, with more than 3,000 facilities spread across every continent except Antarctica. Roughly one third of these facilities are in universities and/or public venues, while the rest are associated with precollege schools. Many facilities use largely opto-mechanical star projectors with no or few auxiliary projector systems. Others contain arrays of projection systems that are used to create multi-media programs along with the star projector. Approximately 150 have converted to full dome video projection systems that project stars and video animations in a wide variety of programs.

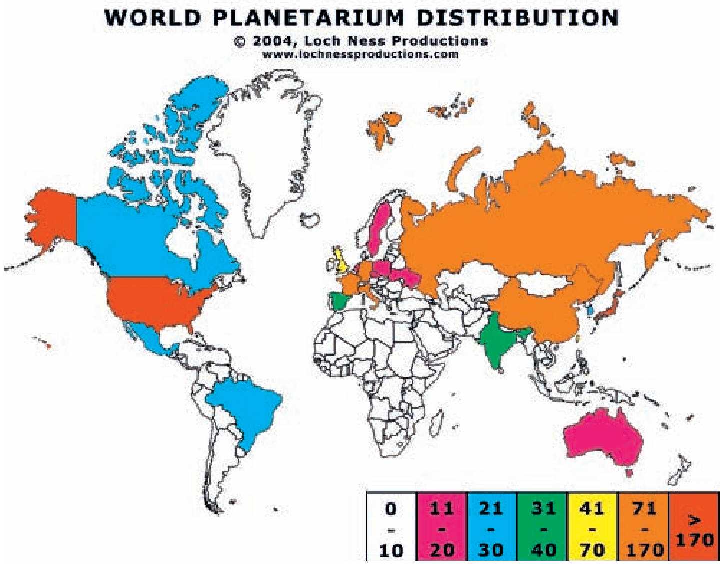


Figure 1. *This graphic shows the distribution of planetariums worldwide, colour-coded by number. Courtesy Mark C. Petersen, Loch Ness Productions.*

WHO ARE PLANETARIANS?

Planetarians encompass a broad range of professionals, including educators, producers, vendors, scientists, storytellers, artists, musicians, animators, writers, and narrators. Many facilities have only one or two full-time staffers assigned to "planetarium duty". We like to think of them as people who are interested in astronomy and motivated to share it with like-minded members of the public. Many planetarians are astronomers, whether amateur or professional, and with their own interests to share through lectures and shows.

WHO GOES TO THE PLANETARIUM?

While there are few rigorous studies of planetarium attendance, at least one informal and ongoing survey puts the total attendance at planetarium facilities around the world at 90 to 100 million visitors per year. This figure includes student field-trip visits as well as general public planetarium visitors.

WHAT IS A PLANETARIUM SHOW?

Today's planetariums and star theatres give a variety of presentations. They can be defined in three general categories:

1. Live "What's Up Tonight?" lectures are very popular and give audience and presenter a chance to interact. These programs are useful for teaching the sky and presenting the latest news from the field of astronomy.

2. Pre-recorded documentary-style programs presented with images, narration and soundtrack. These generally use slides and video coordinated with a soundtrack. More recent shows created for the full dome video community feature complete video presentations (including animations and other material).

3. Laser shows, concerts, weddings, and other assorted presentations.

Information from research institutions is often a vital part of many planetarium presentations. In this sense, planetarium theatres can function as a media outlet for education and public outreach offices at research facilities. In addition, these theatres are an effective magnet for the "motivated, interested public" that education and public outreach offices seek to reach.

HOW DO PLANETARIUMS USE MATERIALS FROM RESEARCH INSTITUTES AND AGENCIES?

Science education and public outreach offices make a wide variety of materials available to the public and educational institutions. These include:

- activity guides
- curriculum materials
- images and animations
- web-based materials
- posters
- printed material (press releases, images, newsletters, etc.)

These materials influence planetarium lectures and multi-media/image presentations in many ways. The most obvious is in content. Press releases, images with background interpretation, images and animations, and web-based material are the most useful to planetarians. They enhance the scripts and visual inventories of any given presentation. Planetarium professionals can choose material from these offerings for live lectures or for later use in pre-recorded presentations. Curriculum materials and activity guides are obviously most useful to planetarians who are associated with schools and must make much of their programming conform to classroom lectures and wider curricula. Posters are not useful for presentations, but may be useful for decorative or demonstration purposes.

The author is conducting a year-long survey of planetarium professionals to deter-

SURVEYING PLANETARIUM USAGE OF E/PO MATERIALS

mine the usefulness of E/PO materials in the community. As reported at the CAP 2005 meeting in Garching, about 100 planetarians had responded by mid-June 2005. The survey form can be viewed at: http://www.lochness.com/cap_survey.html until the end of 2005. A final report will posted on the same page in early 2006.

Early results point to some "best practices" for E/PO professionals to consider as they create materials for planetarium use. They are presented here binned into the categories that the survey covers:

Activity guides: most planetarians found them useful for student visitors.

Curriculum materials: most planetarians felt these were NOT targeted specifically for planetarium use and that they had to do some work to make them useful. The most often requested change was that E/PO products be more specifically targeted for planetarium use.

Animations: Free images are popular! However, most are not targeted directly for use in planetarium applications. Animations, in particular, are often criticized because many are created for TV use, which is not appropriate for the dome. As an example, a video clip of a spacecraft that goes out of frame does not work well on a dome against a backdrop of stars where the planetarian wants to have the spacecraft fly against the starfield. The result is often a grey, or blinding video rectangle blotting out the stars, with the spacecraft abruptly disappearing. However, some planetarium professionals will accept them anyway, and find a way to use them in certain applications. The most often-suggested "fix" for this problem is for E/PO producers to consider making two versions of particularly useful animations—one for broadcast and one that is more "dome-friendly". Most respondents to the survey have also suggested that E/PO's ask a local video-savvy planetarian for advice on what works best in the dome. Others have suggested that E/PO groups find experienced planetarium show producers and vendors to help create and distribute useful animations.

Images: For many planetariums, 35mm slides are still the visual distribution medium of choice. However, these are also getting harder to make as major film companies like Kodak scale back their film product lines and stop manufacturing slide projector systems. To replace slide projectors, planetaria are starting to use video projectors, with varying results.

This suggests a best practice from the digital realm: making high resolution, high quality visual material available in slide and/or digital format when possible, or CD and DVD for those who have the capability of transforming digital files to slide film. However, keep in mind that not all planetarium facilities have made the leap into the digital age and some cannot take digital images from CDs and DVDs and make slides from the data they contain.

Many survey respondents acknowledge specific vendors for their efforts to make materials available in both slide and digital format, and stressed again that maybe E/PO professionals should work more closely with such program producers at both planetarium and for-profit production companies to create packages useful to a wide variety of users.

Web sites: These are very popular and many E/PO sites (such as Space Telescope Science Institute's "Hubblesite" and ESO's outreach pages) are cited as outstanding examples of web-based outreach. The main complaints about many E/PO sites ranged from "not easy to access or navigate" to "not all sites make broadcast quality or high-resolution imagery available". The general suggestion was that web administrators need to make materials easier to find, and give more science background on the material they provide. Many planetarians have sufficient background to read technical background information (although most were not interested in reading academic papers) on events and discoveries described on E/PO Web sites.

Personal interaction: Many planetarians suggested that E/PO organizations make a personal point of contact available for planetarians. They cited such examples as John Stoke at STScI and various scientists at ESO and NASA who make themselves available to discuss discoveries. The Solar System Ambassador program was cited as an excellent outreach effort, as well as JPL's Museum Alliance.

CLOSING THOUGHTS AND COMMENTS FROM PLANETARIANS

This brief overview gives some insights into planetarium facilities, the professionals who work in them and the presentations they deliver. Planetaria are excellent outlets for education and public outreach professionals looking to leverage their "product" beyond the traditional classroom and media outlets. Planetarians are incredibly gifted lecturers and presenters, and the advice they can give you on reaching new audiences is valuable. This paper closes with a few quotes from survey participants:

"The most useful materials for planetarium presentation arise from awareness that a planetarium's "frame" is not rectilinear but hemispheric."

"As a full dome digital facility with three astronomers on staff and 200 volunteer interpreters, we need the best, latest, most scientifically accurate information that we can get."

"Kudos to: The ESA Hubble Anniversary Event organized by ST-ECF."

"Loch Ness Productions showed others how to use images and information from STScI best in their "Hubble Vision 2" show".

"We love using the ESO web pages!"

"The Space Telescope Institute and JPL "get it" when it comes to dealing with planetarians."

For more information about planetarians and planetarium practice, the International Planetarium Society journal, **The Planetarian** is a useful resource. It can be found in university libraries and at many planetarium facilities. The main website for the publication is: http://www.griffithobs.org/IPSPlanetarian.html

The main page of the International Planetarium Society
http://www.ips-planetarium.org/

For references on planetarium show production and practices
http://www.lochness.com/pltref/pltref.html

The ongoing planetarium usage survey page:
http://www.lochness.com/cap_survey.html

NEW PERSPECTIVES IN PLANETARIUM LECTURES

How to Tell Science under the Dome while Preserving the "Enchantment"

Gandolfi, G.[1], Catanzaro, G.[1], Giovanardi, S.[1], Masi, G.[1,2], Vomero,V.[1,3]

[1] Planetario di Roma, Italy
[2] II Università di Roma Tor Vergata. Italy
[3] Comune di Roma, Sovrintendenza ai Beni Culturali – Musei Scientifici, Italy

ABSTRACT

We discuss the philosophy and strategy of a modern planetarium lecture within the larger frame of the communication of astronomy. The planetarium is a peculiar medium that requires a creative and rigorous approach in order to balance the three motivating forces behind the 'planetarium experience': scientific knowledge (method and contents); technological 'sense of wonder' and a pre-rational (not necessarily anti-rational) sense of 'enchantment'. While scientific and technological resources are typically fully exploited in state-of-the-art domes, the latter concept—introduced by Max Weber in order to categorize the mystic/aesthetic impact of nature on the human mind—has not been sufficiently explored. To use it effectively demands an understanding of the public perception of astronomy, stressing the crucial role of professional communication skills for the effective communication of science. Rather than enforcing a narrow focus on pure science and/or a crusade against astrology, we believe that the planetarium experience should be a stimulating reawakening of curiosity and a holistic awareness of the sky and hence of the Universe. Fine tuning of the above three components makes the classical conflict between the boring academic lecture under the stars versus disneyish, supertechnological shows obsolete. We present some approaches for creating "fine-tuned lectures", with examples from our experience at the Rome Planetarium.

INTRODUCTION

Organizing a planetarium program using internally produced shows is a highly complex task. One should have a very precise set of objectives in mind and a well defined approach to science communication, while still trying to exploit the incredible potential of a state-of-the-art dome. The main problems are the search for an effective and clear narrative that both informs and entertains, the ability to mix the different media involved (video, sky projection, music, reading, etc.) while stimulating interest and fascination in scientific topics. The unique features of the immersive environment and the theatre-like structure of the dome point naturally to a possible solution: the audience is set under a stage where many stories of the sky and about the sky are told and the lecturer (or the recorded voice) is not an academic but a storyteller that "respects" the methods and truths of science. Such a storyteller, being the science communicator, puts astronomy and astrophysics in a broader cultural context, where science, history, humanities and art can meet and the general public rediscovers the sky as a common, familiar inheritance.

THE PLANETARIUM EXPERIENCE: A "PHILOSOPHICAL" APPROACH

Starting from this perspective we have developed a "philosophical" model of the planetarium experience that allows all planetarium ingredients to be mixed correctly and carefully balanced.

We identify three motivating forces at work under the planetarium dome: Science, Technology and "Enchantment"; striking different chords in the mind and imagination of the audience.

Scientific drive and the technological sense of wonder have been widely explored and exploited during the century-long adventure of the planetarium as a natural consequence of the dominant view about science communication. The traditional approach consisted in a top-down transfer of scientific contents through a high-tech, spectacular device—the sky projector. Essentially, a lesson was presented under the sky, with astronomical phenomena and accelerated motions explained in an educational facility for the masses. The technological sense of wonder, excited and continuously stimulated by cinematic special effects and videogames, has been well cultivated with an impressive escalation towards sophisticated all-sky digital animations, not always related to science or to the sky. The recent interest in PUS (Public Understanding of Science) has scarcely modified this scenario, still ignoring the third component of the planetarium experience: what we have called 'Enchantment' (following the suggestion of German sociologist Max Weber). This motivating force, while dealing with the emotions and the imagination of the public, is a precious tool that can inspire curiosity and interest for the world we live in, including the methods and results of science. The intimate pre-rational (but not necessarily anti-rational) connection with the cosmos above us is usually regarded with suspicion by scientists and assumed to be in opposition to the "correct" scientific version, so it is no surprise to find this sense of wonderment ignored in "academic" science popularization as well as in planetaria. We will try to highlight its importance and to show how it can be harnessed in the making of attractive and stimulating sky shows.

Figure 1. The dome of the new Planetarium of Rome

SCIENCE

Science is the key ingredient in a planetarium, and our efforts are aimed at conveying the excitement of the processes of reasoning, discovering and experimenting. All the many different cultural and scientific visions of the sky should enter the shows: the history of observation, cosmology, the astrophysics of celestial objects, the human exploration of space, speculations about extraterrestrial life and so on. Essentially we would like to transmit a way of looking at things and a methodology while still instilling just that final twist of uncertainty. Moreover, our objective is to create an awareness of the many connections between different disciplines and between science, culture and art, concentrating on the outline more than on details. The planetarium, being an independent institution, is best suited for a general review of the discipline without the pressure of the scientific propaganda typical of observatories and research institutes and without the usual jargon and technicalities given by professional astronomers occasionally involved in science communication.

TECHNOLOGY

It is impossible to deny the fascination of high technology, both in planetarium attendees and in science communicators. The wonders of an artificial sky and of celestial simulations are of paramount importance in the work of communication, but it is essential to exploit the best available resources without being dominated by the spell of the latest gadget or all-sky digital device. Hence, the real challenge is blending technology and artistic expression in a harmonic composition rather than just looking for the perfect, expensive solution for each effect.

THE WEBERIAN ENCHANTMENT

Max Weber (1864-1920) introduced the concept of “disenchantment” (Entzauberung der Welt) in order to describe the fall of the ancient cosmological traditions and at the same time to focus on the romantic and pre-romantic interest for the “sublime”, widely analyzed philosophically by Edmund Burke and Immanuel Kant. For Weber the disenchantment is the passage from the old “magical” way of looking at Nature and at the sky to the mechanistic vision that has dominated science since Galileo and Newton.

“The unity of the primitive image of the world, in which everything was concrete magic, has tended to split into rational cognition and mastery of nature, on the one hand, and into “mystic” experiences, on the other. The inexpressible contents of such experiences remain the only possible “beyond”, added to the mechanism of a world robbed of gods”. (M. Weber, Essays in sociology)

By gaining modern science we have lost the sense of wonder and of transcendental mystery, leading to an excess of rationalization and intellectualization. In other words, the origin of our technological success contains the roots of an unavoidable crisis as nature and technology collide.

There is still academic debate about the meaning and relevance of such a loss, but we are convinced that a useful and healthy side of the enchantment may be recovered, both in scientific and in communication practice. In fact, the aesthetic astonishment and awe experienced under a clear sky, imbuing the sense of an infinite Universe not amenable to complete calculability, are essential in recovering a positive relationship with nature. They make a holistic cosmological vision possible, in the sense of a vision of the Universe characterized not only by matter and physical laws, but also by mind, life and culture. So, rather than fighting against the fossils of the enchantment (astrology, new age, etc.), we should use their appeal to expand a controlled imagination and develop a knowledge filled with emotions and feelings. This approach, obviously, doesn’t necessarily mean justifying pseudo-science: it just consists of an attitude of “existential wonder” and humility, which helps to prevent scientism and instrumentalism, while recovering pluralism and sense of mystery.

For us the enchantment is a psychic dimension, a state of consciousness that professional astronomers dismiss as irrelevant for science too often. However their own "vocation" often came from "poetic fancy" and they tend to forget the emotive impact of a starry night on the human quest for knowledge. How many scientists started their careers with the enchantment of a dark starry night? It was certainly the case for Fred Hoyle, as he recalls in his autobiography:

"(..) When on top of a wall that perfect starlit night, I seemed to be in contact with the sky instead of the earth, a sky powdered from horizon to horizon with thousands of points of light, which, on that particularly dry, frosty night, were unusually bright. We were out for perhaps an hour and a half, and, as time went on, I became more and more aware—awed, I suppose, of the heavens. By the time I arrived back at the sandstone block, I made a resolve. I remember standing on the block and looking upwards and deciding that I would find out what those things up there were."
F. Hoyle: Home is Where the Wind Blows

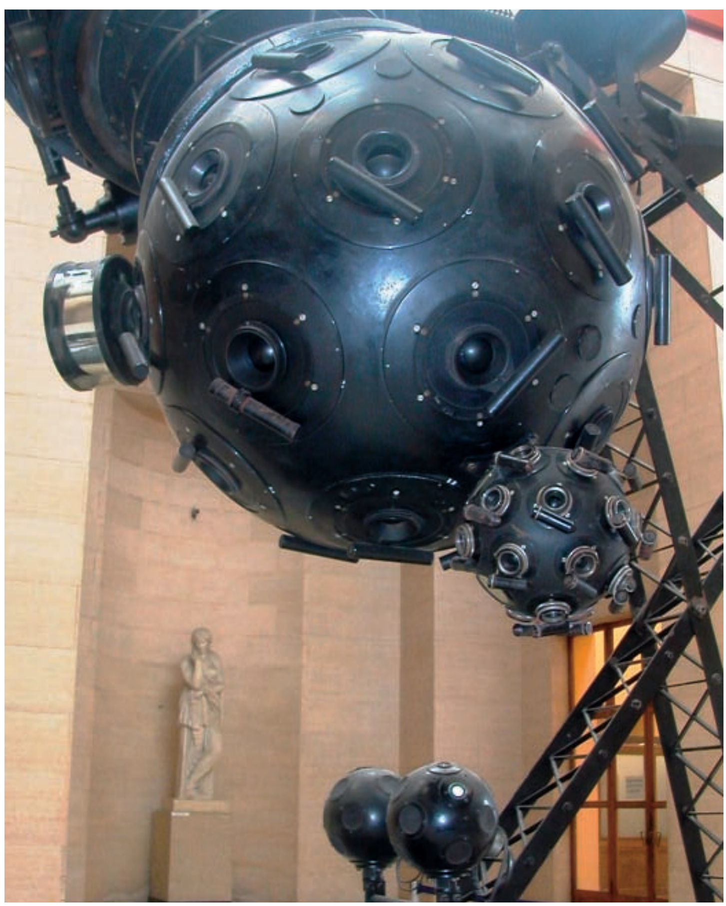


Figure 2. *The Zeiss projector of the old Planetarium of Rome in the entrance hall*

TOWARDS A FINE TUNING

The planetarium is one of the best places to blend the rational scientific with the mystic sense of enchantment, as everyone who has experienced the strong "wow effect" under a dark starry sky knows. Things that seem contradictory (science, technology, enchantment) may coexist in harmony, stimulating questions and thoughts. As we have already pointed out, the main difficulty here is a careful balance of the ingredients: a narrative that captures the attention of the audience and raises emotions with images; video and sky simulations presented at the right times in the right proportion while telling about science; its impact on history and human perception of the Universe. Usually, the best solution is a voyage in space and time, with a point of view oscillating between the earth's surface and the depths of space. Terrestrial interludes allow us to insert poetry readings, historical anecdotes, artistic inspirations, philosophical thoughts in the show and to provide the necessary connection to the observability of celestial phenomena. A possible alternative solution is a narrative based on contrasts: human culture presented in a celestial context and the influence of the sky as found in our daily environment (music, architecture, paintings).

THE PLANETARIUM OF ROME AND THE ITALIAN SCENARIO

Outside Milan and Rome there are only small or medium sized planetaria (less than 100 seats) in Italy. The Live Lecture (so defined here in contrast with the mainstream automatic show) has been the main format from the outset: few planetaria present automatic shows or multimedia productions. The planetarium is conceived almost exclusively as an educational facility, where a lecture is considered equal to a lesson, with a bonus of demonstrative simulations and/or still images.

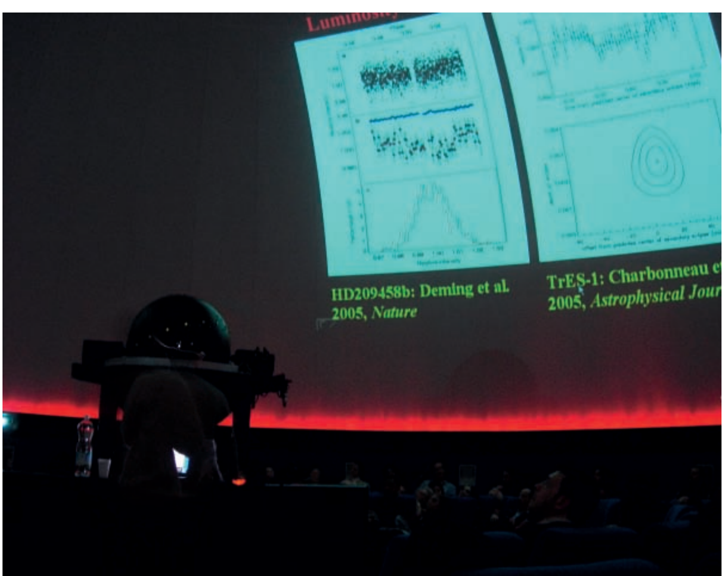


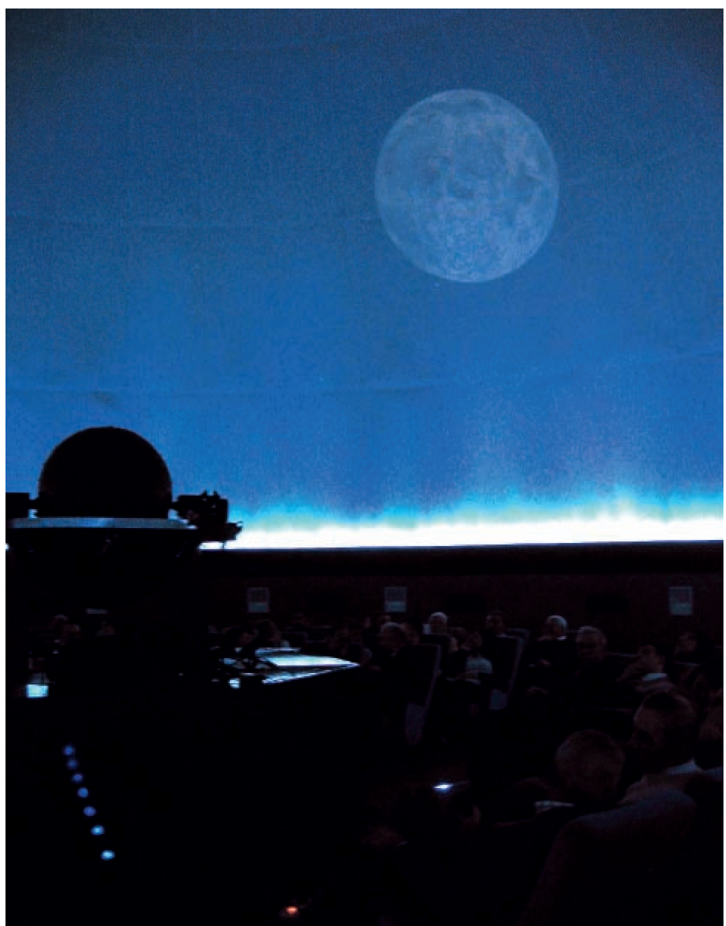
Figure 3. *Live shows under the dome*
The old Planetarium of Rome, one of the first in Europe, was closed twenty years ago, but had a longstanding tradition of such educational lectures. When it reopened in May 2004, we decided to start an intensive production of Live Lectures along with a few automatic shows, in order to retain the good values and the tradition of the Italian planetarium style, but also to update it. Our goal is to draw attention to science and the natural wonders in a city like Rome, which is dominated by an artistic and historical heritage, while trying to convey the message that the planetarium is a "house of the sky" where people can return and discover new things each time, a fascinating location where science meets culture and culture meets science.

Lecturers were scientists with a background in science communication or facilitators with a good scientific background. Our effort is aimed at delving into the public perception of astronomy, always keeping in mind the crucial role of professional communication skills for an effective communication of science. This is an objective that requires constant feedback from the public, stimulating debate, interaction and participation.

LIVE LECTURES AT THE ROME PLANETARIUM

During the first year of work we have implemented a very large catalogue of Live Lectures (about 50), with a variety of astronomical and para-astronomical topics. In keeping with our principles we design our lectures to focus on Public Awareness of Science rather than on PUS or on plain education. Our purpose is to inspire curiosity and to entertain, to leave the public with many questions, and with a desire to explore in more depth, rediscovering the Sky for themselves. We do not pretend to answer all questions or to be exhaustive in any sense. We consider the planetarium

Figure 4. *Live shows under the dome*



show to be an experience that raises interest in astronomy, an interest that other media (books, lessons, magazines) may fulfil more extensively later. In order to make our choice clear, we always call our Live Lectures “shows”. And they are actually shows in an astronomical theatre: the lecturers’ storytelling and the flow of images, simulations and videos are neither lesson nor “documentary”. The audience perceives the lecture as a multimedia theatrical performance rather than an explanatory sequence of information about the cosmos. As we usually say: “It’s a show, a stairway to the stars, not a lesson”.

Figure 5. *Live shows under the dome*

The Live Lectures are organized in thematic groups: Skyscapes, Open Universes, Impacts. Skyscapes describe the sky and its phenomena in general for a public of beginners and children, while Open Universes are single subject shows about astrophysical, cosmological or planetary themes. Impacts explores the connection between celestial objects and the humanities taking an interdisciplinary approach.

We have adopted the classic storyboard technique for the production of Live Lectures, maintaining a large degree of freedom as regards feedback and improvisation. Particular attention is given to technical and conceptual balance in the script.

THE GOLDEN RULES

Three golden rules summarize our productions (Live Lectures as well as automatic shows and events). The first rule is: “Rhythm, rhythm and rhythm again!” That not only implies the constant presence of music (and of silences considered as music), but also the right interplay between different media: images, sky projection, animations and all-skies. One can never have too many still images, or motionless skyscapes, or open-ended videos. Furthermore, the theatrical “presence” of the lecturer is fundamental, although his/her silhouette may fade frequently into the darkness.

Strong criteria in the selection of the staff are storytelling qualities, diction and voice control.

Paraphrasing Duke Ellington we might say: "It don't mean a thing if it ain't got that swing". Actually jazz is a very effective metaphor for Live Lectures: they have a strong improvisational side, the lecturer has many flexible solos on a fixed canvas (as in Ellington compositions), "mood" and "arrangements" may vary in different executions, depending on feedback from the public, and finally, as in a Jazz Orchestra, we have a conductor (the show director at the console) and a soloist (the lecturer).

The second rule is: "Give the public an emotional context, not just information!" Keeping that in mind means exploiting suspense, and the senses of wonder and humour at the right times. Narrative structures are also naturally charged with emotions and we vary them in different lectures, exploring the atmosphere with fiction, dialogues, time travels, musical journeys and explicit theatrical performances.

The last rule is perhaps the most trivial, but also the most constraining: "The Sky is always on the Stage". It implies that the "slide show effect" of a standard seminar must be avoided, while remembering that the planetarium is not cinema, but a show characterized by astronomical objects and phenomena 'up there'. Conferences and movies may be programmed in a planetarium hall, but they are definitely another kind of performance, which doesn't exploit the magic of a starry dome at its best.

SOME EXAMPLES

Live Lectures at Rome Planetarium are multimedia journeys, synthetic adventures that capture the imagination and try to paint several pictures of the cosmos with a touch of originality. It is difficult to convey the variety of experiences offered: they span from a trip around the Lord of the Rings of the Solar System ("Between the Rings of Saturn", a show with a fictional narrative and many 3D panoramas); to the romantic and multi-ethnic skylore of "The Sky of Lovers", full of mythology and poetry; to a flight in search of exoplanets starting with Giordano Bruno at the stake in Campo dei Fiori ("Towards Distant Worlds"); to the medieval saga of "Celestial Code of the Templars", a title referring to the atmosphere of pre-Copernican astronomy and at the same time debunking many inconsistent myths concerning the famous knights; to the ethnic music, sound effects and panoramas of "A Tour of the World in 30 Minutes", where celestial cartography is discovered along with terrestrial landscapes, observing the sky at different latitudes on the path of Jules Verne.

Some of our shows explore a two-voice option: that is the case in such successful lectures as "The Black-Holes, Monsters in Space", with several quotes from music, fantastic speculations and cinema (one lecturer takes care of scientific aspects, the other evokes emotions and fantasies), or “Travel in Time between Earth and Sky”, where cosmology faces geology in a journey through time, the far reaches of space and our planet’s history (one voice presents the appearance of Universe, the other the contemporary evolution of the terrestrial surface).

We also look for a strong connection with the historical background of Rome in “The Sky of the Romans”, a lecture characterized by original ancient music, text readings, recreations of the sky and a virtual archeo-astronomical walk through the ruins.

CONCLUSIONS

After one year of experiments our production of Live Lectures is still improving and expanding. We have noticed that initially many attendees expected a single standard show, but more recently people have become aware of the richness of our catalogue and are returning for other shows or events. The feedback from the public seems really positive: an active part of the audience asks for new specific topics and our mailing list (about 2000 subscribers) is growing constantly, with many messages of encouragement and appreciation. Criticism mainly addresses technicalities, not conceptual points. Presently we monitor impressions, comments and suggestions in a logbook, but we plan to conduct a more quantitative survey with focus groups and survey forms.

SEEING BEYOND THE NAKED EYE IN A PLANETARIUM

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ABSTRACT

I have a philosophy that the traditional naked-eye sky, as usually shown in planetariums, should only be an introductory step in portraying the Universe. Consequently, over the years I have produced 'inter alia' various versions of an enhanced Milky Way (the latest based on Axel Mellenger's panorama), the extragalactic sky and the radio sky for projection on planetarium domes. I also put together a three-dimensional planetarium show—the audience being equipped with ChromDepth™ spectacles—which stepped from the Solar System to the cosmic microwave background. The advent of digital technology now makes all this much easier. Currently, Labyrinth, a visualization program developed in-house, serves much the same function as the Hayden Planetarium's Partiview, but also permits rendering and fly-throughs of large-scale structures. It allows viewers to explore local cosmography. Labyrinth can produce images that operate with the 3-D spectacles; we have also produced a version of Partiview that does the same.

This presentation involved many slides and visualisations, including three-dimensional views for which the audience was equipped with ChromoDepth™ spectacles. Only three such images accompany this presentation, but the original PowerPoint presentation may be downloaded from:
http://www.communicatingastronomy/cap 2005/talks/day2/fairall/fairall.ppt
The following text provides the accompanying narration and explanation to that presentation.

INTRODUCTION

Human eyesight is probably the chief reason why members of the public understand so little about the Universe beyond their home planet. We are of course creatures of daylight, designed to see by day and sleep by night. While our eyes may adapt to darkness—and employ our rod receptors—our eyesight at night is nevertheless poor. We cannot see to walk around, and when we look upwards, we get a very shallow view of the Universe, and one that is very difficult to interpret.

As far as looking at the night sky is concerned, there are three basic things wrong with the human eye. The first is its insufficient aperture, never more than 6mm. In a galaxy of billions of stars, our eye can see less than ten thousand. In a Universe of billions of galaxies, we can barely see our own Galaxy and three others! The second is the limited wavelength range. The sensitivity of our eye has evolved to match that of the blackbody radiation of our Sun. Although the Earth's atmosphere is also transparent to portions of the near infrared and radio waves, our eyes cannot detect those wavelengths. Finally, the stereoscopic vision of our eyes is limited to distances of some 25 metres or less, and all astronomical objects lie way beyond that. There is no perception of distance, so small pebbles hitting the Earth's atmosphere a hundred kilometres up are confused with stars light years away. More obviously the planets in our Solar System are also mistaken for bright stars.

Surprisingly, things are no better in a planetarium! So much effort has gone into recreating the night sky as the human eye sees it that the visual image is no improvement. My personal philosophy is that the traditional planetarium sky should only be a starting point, and that a planetarium should be used to remedy the problems of human eyesight and show what the eye ought to see.

SEEING OUR GALAXY

From modern cities the glow of the Milky Way is completely overpowered by the overspill of artificial lighting. Even away in the countryside, a few artificial lights in the vicinity of the viewer are enough to rob our Galaxy of its lustre. It takes a dedicated individual to find a site where no artificial lights are visible and to glimpse one of the spectacles of nature. However impressive it may then look, it is still nowhere close to revealing the true structure of the galaxy.

In a conventional planetarium, the glow of the Milky Way is added into the starry sky by dedicated projectors. These are often simple shadow projectors, where the central lamp is surrounded by an appropriate mask, and no lenses are involved. To enhance the view of the Milky Way, such standard Milky Way projectors need to be switched off and alternative projectors used. In my case I have achieved this using a six-projector 'all-sky' system. Such a system is widely used in major planetariums (though it is currently being surpassed by fully digital systems). Each of the six projectors is a conventional 35mm slide projector, equipped with wide-angle (35mm) projection lenses, and suitable masks. Six pie-shaped segments are 'soft-edged' together, to form a static image over the entire hemispherical projection dome. The computer system that controls the projectors can also set the illumination level. The images of the six panels need to be pre-distorted (from pie shapes to gothic arch shapes) according to the geometry involved. The six projectors are mounted around the periphery of the auditorium and do not ride on the star projector, so the star projector must be suitably orientated to work in register with the all-sky projection.

Our first all-sky Milky Way (in 1989) was relatively crude and hand-painted by an artist. A couple of years later, it was superseded by an improved version, which our planetarium artist Margie Walter painted using an airbrush. It was based on the panoramic photographic montage put out by the European Southern Observatory (Laustsen, S., Madson, C. & West, R. 1987. Exploring the southern sky: a pictorial atlas from the European Southern Observatory, Berlin, Springer-Verlag), and like the original, it was in black and white.

By the mid 1990s we were producing a colour version, which separated the yellowish galactic bulge from the bluish spiral arms. It provided a technical challenge because, unlike the high contrast Kodalith emulsion used previously for the black and white rendition, colour emulsion cannot give a completely opaque black background, and specially designed masks had to be incorporated so that light did not stray into the dark sky outside the Milky Way. We also had to find a compromise level of illumination, where the eye could just see colour, yet still be completely dark adapted. We complemented the airbrushed star clouds with some ten thousand or so additional faint stars concentrated towards the plane of the Milky Way. These were added to the scene by a separate bank of slide projectors (the images being on Kodalith film). As before, the bright stars, those visible to the naked eye, were provided by the regular planetarium projector, working in register with the all-sky scene. The colour version also allowed us to include emission nebulae (though it would have been preferable to have employed a third bank of 'all-sky' projectors, so their illumination level could have been set independently). It was then possible to conduct the planetarium audience on a tour of the Milky Way, including, for example, the Orion Nebula and surroundings, the Vela and Gum supernovae remnants, Eta Carina, the Lagoon Nebula and the Galactic centre.

But better things were still to come. Many readers will be familiar with the magnificent colour photographic panorama of the Milky Way produced by the German physicist Axel Mellenger (see http://canopus.physik.uni-potsdam.de/~axm/images.html). It is the clearest exposition of the visual sky as the eye ought to see it, and has been widely reproduced. It shows exactly what we ought to be seeing of our Galaxy. It is of course possible, using the six-projector all sky system, to project a hemispheric view over the planetarium dome, as we have done. However, when so magnified, the images of the bright stars become unrealistically large and less realistic. Accordingly, we have created an edited version of the Mellenger Milky Way, where all stars brighter than sixth magnitude have been removed—see Figure 1.

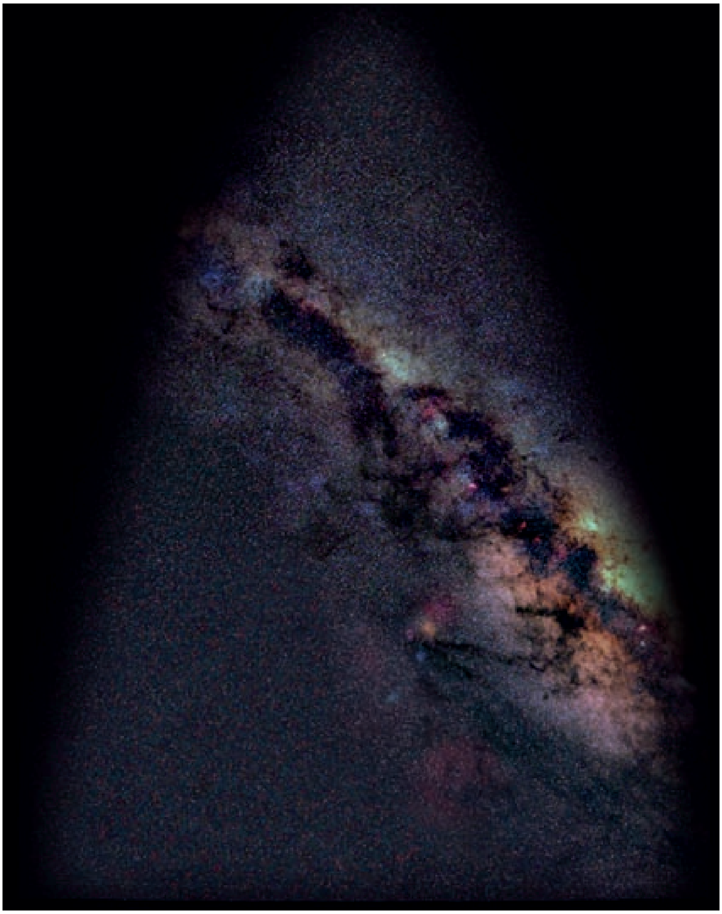


Figure 1. *The Galactic Centre is seen in this panel (rotated by 90°), one of six that are joined together seamlessly to form a single image over the hemispherical planetarium dome, via the 'all-sky' system. This image is derived from Axel Mellinger's panorama, but has been edited to remove stars brighter than sixth magnitude, which are inserted by the conventional planetarium star projector instead, working in register.*

This version then operates in register with the planetarium star projector, which provides the brighter stars. This has given us the best enhanced Milky Way to date, and most importantly, a means by which our audiences have been able to see the Galaxy in which we live clearly.

As planetariums make the transition to fully digital skies the six-projector all-sky system is rapidly becoming obsolete. However the new digital technology now makes it easier to combine an enhanced Milky Way, such as Axel Mellenger's digital image, with the conventional star-field.

THE RADIO SKY

An alternative view of the Milky Way can be provided by the radio sky. The Rhodes University/HARTRAO 2326 MHz survey image (Jonas, J.L., de Jager, G. & Baart, E.E., 1985. A&A, 62, 105) was similarly mapped to six all-sky panels by Wayne Pavard (then an M.Sc. student in the Department of Computer Science) in 1992 using a software recipe devised by the author. As a result we were able to dissolve from optical sky to radio sky. The views of the Milky Way are wonderfully complementary, the radio sky revealing the interstellar gas instead of the stars, while increasing the prominence of the supernova remnants. The radio sky also shows extragalactic sources, including the conspicuous outer lobes of Centaurus A.

THE EXTRAGALACTIC SKY

Perhaps my main motivation behind these all-sky projections was to create an extragalactic sky—since this is where my research specialty lies. Unlike the foreground stars of the Milky Way, which are scattered almost at random—thereby creating the patterns identified as constellations, galaxies concentrate into large-scale structures. I therefore used my Southern Redshift Catalogue (Fairall, A.P. & Jones, A., 1991. Southern Redshifts: Catalogue and Plots, Publ. Dept. Astr., Univ. Cape Town, No. 11) as a database. Although a handful of nearby galaxies are close enough to be seen as extended objects, all others have no discernable angular size. Accordingly I used the redshifts to grade the colour of the galaxies from white (near) to blue (distant). Almost by chance I experimented with viewing the scene with ChromoDepth™ glasses and was amazed to see large-scale structures in three dimensions emerge.

The projections have also served as a research tool in the mapping of nearby large-scale structures and voids. In particular they served as a means of identifying the ‘Centaurus Wall’ (also known as the ‘Hypergalaxy’), which in the extragalactic sky (to cz = 6000 km/s) is somewhat analogous to the plane of the Milky Way in the starry sky.

THE UNIVERSE IN THREE DIMENSIONS

ChomoDepth™ glasses work by means of chromostereoscopy. Their lenses disperse colours without overall deviation, and their design results in red objects appearing to stand out in front of the screen, while blue objects appear more distant. Intermediate colours of the spectrum appear at intermediate distances. They have the great advantage that only a single, appropriately colour-coded image is needed, from which the spectacles create their own stereoscopic pair. Disadvantages are the obvious false colour, and the fact that RGB monitors or projectors do not give a true continuous range of colours, and stop short of indigo and violet (they simulate violet by mixing red and blue). Furthermore, 10% or more people do not have true colour vision, and for them, chromostereoscopy does not work.

Following the success of viewing the colour-coded extragalactic sky with the 3D spectacles, I experimented with 'full-colour' (red to blue) versions, and finally I produced a sequence of images to convey the Universe in three dimensions, from the scale of the Solar System to that of the Cosmic Microwave Background. The images are circular, each covering half the Celestial Sphere, and can be viewed either as slides (as shown at this conference, and for example in Fairall, A.P. 2000. Cosmology Revealed. Praxis-Springer. Chichester) or extended onto the hemispherical screen of a planetarium.

This finally fulfilled my dream of being able to perceive relative distances in a planetarium, and provided the basis for what was apparently the world's first 3-D planetarium show, allowing planetarium audiences to interpret what they can see, when the conventional star-field is dissolved into the colour coded charts. Again, I used the 6-projector 'all-sky' system (described earlier) to project the images onto the planetarium screen. As before, the images work in register with the star projector. Mechanical-optical planetarium projectors do of course produce very realistic looking stars, with high intensities concentrated in almost pinpoint images (which is why such projectors are so expensive). The simple slide projectors of the 'all-sky' system cannot match such quality; experimentation showed that stars had to be portrayed as circular dots, larger dots for brighter stars. While not as realistic as pinpoint stars, I use it to remind the audiences that stars are really spherical incandescent bodies, rather than the misleading spiky shapes so many cultures have unfortunately adopted.

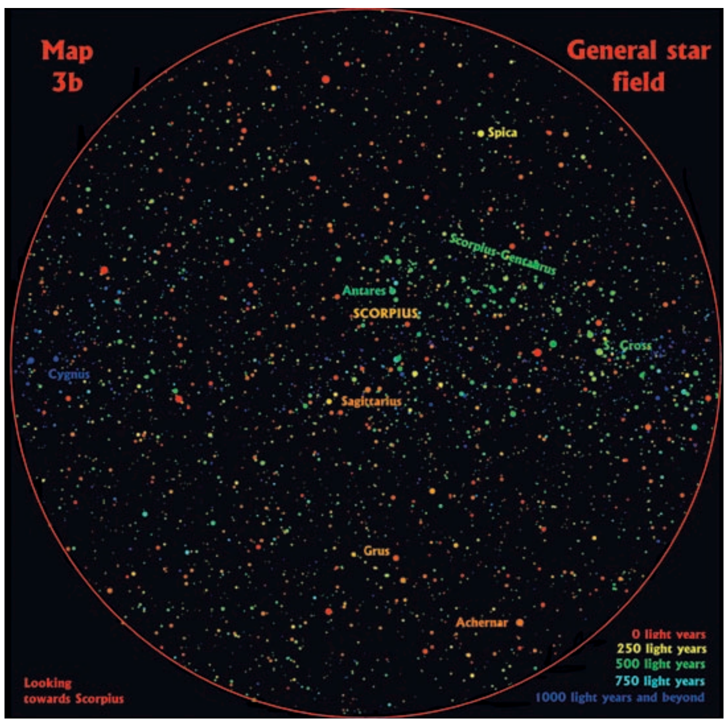
The mapping of stars to the all-sky panels has reasonable registration in that when both all-sky and planetarium star-fields are superposed, the pinpoint planetarium stars fall either within the corresponding coloured dots or immediately outside them.

The range of depth shown by chromostereoscopy can be set according to the need. My opening scene portrays the Moon and visible planets of the Solar System, and clearly separates the differing distances of the Moon, inner planets and outer planets, even when they lie in close proximity to one another in the sky. The star-field is colour-coded pure blue to provide the background.

For stars I selected all stars brighter than visual magnitude 6.5 from the Hipparcos database, which carries the most reliable parallax determinations to date. The great range in stellar distances necessitated dividing the star-field into two ranges. The first was 0 to 100 light years, where all stars beyond that range were colour coded pure blue. The pairs of images (each a hemisphere of the Celestial sphere) then show the local stellar neighbourhood, with the nearest stars clearly standing out. It is illustrative of stellar luminosities to point out that that the very closest stars include not only bright stars (Alpha Centauri, Sirius and Procyon) but also many faint sixth magnitude stars.

For the next set of images, the chromostereoscopic range has been set for 0 to 1000 light years, a range in which almost all visible stars fall. Such an accurate portrayal is only possible due to the Hipparcos results. In general, most well known constellations ‘come apart’ and are initially difficult to recognise when seen in three dimensions. While the general randomness of the stellar distribution is apparent, the portrayal does allow spatial features that are not otherwise easily discernable to be identified: particularly the extended Hyades cluster and the Scorpius-Centaurus Association – see the example in Figure 2.

Figure 2. ‘Map 3a’ is one of the images that convey the Universe in three dimensions. It shows a half of the Celestial Sphere, centred on R.A. 18h, Decl. -30d, with Scorpius central and the Southern Cross to the right. Distances to stars have been colour coded from 0 to 1000 light years. When viewed with ChromoDepth™ spectacles, the scene is seen in three dimensions.



For the next pair of images in a sequence of increasing depth, the chromo-stereoscopic range is set for 0 to 30,000 light years, with all visible stars coloured red to form the foreground. The view reveals the spiral arms of the Galaxy, one of the hemispheric views aimed towards the Galactic Centre, the other the anti-centre. License is taken by making the normally dark dust lanes luminous and colour-coded according to distance, as estimated from the foreground star density on the Axel Mellenger panorama. Thus, when looking towards the Galactic Centre, it is possible to discern dust clouds in the Local Spiral Arm, as distinct from those in the Sagittarius Arm, while the Galactic Bulge appears mainly blue (but a slight colour variation recognises its bar-like nature). The Magellanic Clouds and the Great Galaxy in Andromeda (all pure blue) are apparent.

Beyond the Galaxy, chromostereoscopic depth jumps from 0 to 350 million light years ($0<cz<7500$ km/s), the foreground Galaxy is omitted as the scene reverts to the extragalactic sky (much as already described). In recent years, the database for this has switched from the author's catalogue—which was discontinued in the late 1990s to that extracted from the NASA Extragalactic Database. A deeper view—to some 2 billion light years ($0<cz<50000$ km/s) — is provided by the distribution of Abell Clusters, using a database provided by H. Andernach (University of Guanajuato, Mexico).

The final scene, with chromostereoscopic depth running all the way to 15 billion light years showed a scattering of distant quasars superposed against the fluctuations found by the COBE satellite. Such a scene is now of course out of date, with the finer detail of the fluctuations found by WMAP (and a more probable distance of 13.7 billion light years) now available.

LABYRINTH SOFTWARE

Successful as it was, the Universe in Three Dimensions, just described, was of course no more than a sequence of static images; whereas digital projections today allow for animations, particularly fly-throughs. Such technology was exemplified in the opening production of the new Hayden Planetarium in New York. The software involved for that production has been adapted into a public version, released as 'Partiview', which enables 'fly-throughs' in a digital Universe, and is an alternative method of perceiving relative distances to stars and galaxies. Since its release, we have been experimenting with its use, particularly as we have also carried out such fly-throughs of galaxy databases since 1993 (thanks mainly to software written by Wayne Pavard), used mainly for research purposes and to a small extent in public presentations.

'Partiview' (from Particle View) is an impressive package, but it did not allow chromostereoscopy to be used, and although it operates with billboards, which, for example could carry galaxy images, it could not portray continuous structures such as the envelopes of the large-scale structures formed by the distribution of galaxies.

Consequently a package of software—now known as Labyrinth—was developed by Carl Hultquist and Samesham Perumal, originally as an 'Honours' project in the Department of Computer Science of the University of Cape Town, following the success of a programme by David Turner that identified and grew 'Minimal Spanning Trees' in fly-around visualisations.

Labyrinth also identifies Minimal Spanning Trees to specified criteria that compensate for the increasing incompleteness in the galaxy databases with increasing redshift. It then wraps a surface around each minimal spanning tree. I refer to these surfaces as 'Tully Bubbles', as they resemble those seen in visualisations of large-scale structures pioneered by Brent Tully. The three dimensional bodies so created may be visualised as solid or translucent—the degree of transparency may be varied.

Labyrinth has seen many further refinements from Carl Hultquist, and currently forms a multi-faceted visualisation tool. It is able to render individual galaxies as points, with or without full colour or white-blue chromostereoscopy. Alternatively galaxies can be shown as billboards, drawn randomly from a small library of galaxy images. Unlike some other extragalactic visualisations, which have the sizes of galaxies greatly exaggerated for effect, Labyrinth shows galaxies at approximately true size. As already indicated, Labyrinth portrays large-scale structures, with the ability to vary their transparency, and with either white-blue or full colour chromostereoscopy. Both galaxies and large-scale structures can be portrayed together, or one without the other; if need be galaxies outside the large-scale structures can be 'switched off'. For research purposes, Labyrinth can identify individual large-scale structures, or even just groups and clusters of galaxies, and catalogue the members of each unit.

The distance range of the chromosterescopy, whether white-to-blue or full-colour, can be adjusted. Similarly, the degree of fading of galaxies and structures with increasing distance can be varied.

While 'travelling' within the galaxy databases, a readout gives Supergalactic coordinates and direction of view. Labyrinth can be manipulated in real-time fly-throughs of galaxy distributions and large-scale structures. It can create animated fly-throughs along predefined tracks. By gradually increasing the percolation radius of its minimal spanning trees, it can show the 'growth' of large-scale structures from their densest cores outwards, as an animated sequence if required.

Such a sequence was shown as part of this presentation using state-of-the-art data from the 6dF survey. The 6dF survey (Jones, D.H. Saunders, W., Colless, M. et al., 2004. MNRAS, 355, 747), which will cover most of the southern sky, is by far the densest coverage of galaxy redshifts in the nearby Universe. It reveals details of the texture of the 'Cosmic Labyrinth' never previously seen. A sample frame is shown in Figure 3.

The final figure (3) shows a view of the Universe far removed from the experience of the layman. The average member of the public knows little more than the Solar System. Our enormous challenge is to extend his or her scale from a few light hours to billions of light years. Understanding our Galaxy first and then the realm of galaxies and their labyrinth of large-scale structures ought to be basic knowledge. Planetarium presentations that use visualisations to achieve this offer some hope that a small fraction of the Earth's population may yet get to know the Universe in which we live.

CONCLUSION

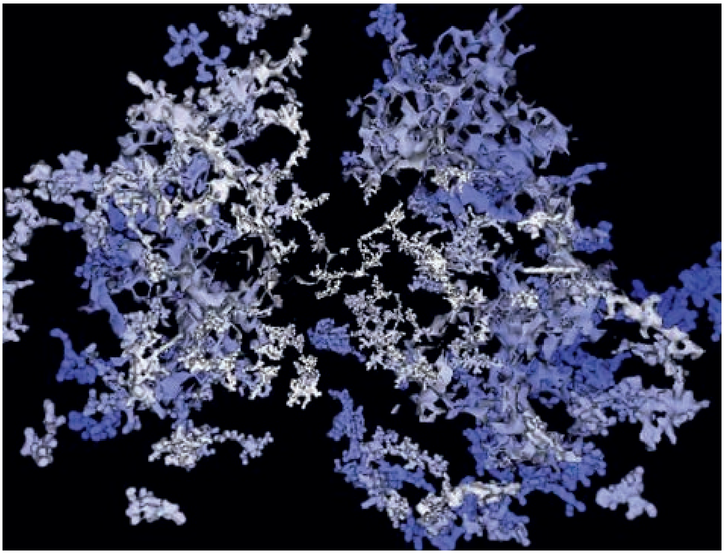
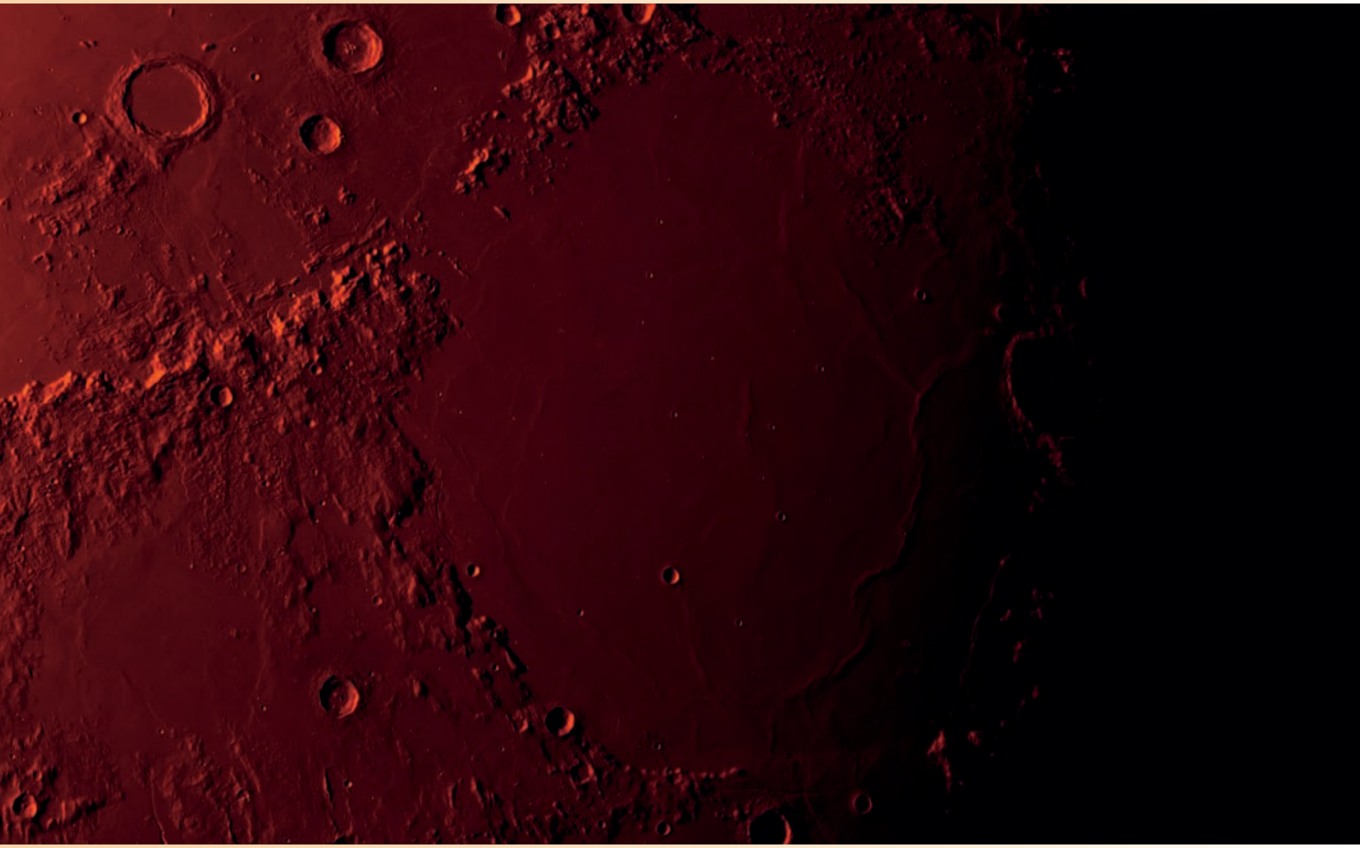


Figure 3. *The texture of the local cosmic labyrinth that surrounds our position (centre of diagram) in the Universe, to a depth of some 1.5 billion light years, using the 6dF data. Labyrinth software shows the large-scale structures in which the galaxies are concentrated. Numerous filamentary structures surround bubble-like voids, somewhat reminiscent of the filaments that surround the cavity created by the Crab Nebula supernova.*

Credit: Nordic Optical Telescope, M. Gålfalk, G. Olofsson,and H.-G. Florén, Stockholm Observatory

PLENARY SESSION 7:
Challenges and New Ideas



DIFFICULT CONCEPTS

Bob Fosbury

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ABSTRACT

Beautiful colour images of the sky are both a blessing and a curse for the communication of astronomy to the public. While undoubtedly attractive, they can obscure the fact that discoveries are often made in astrophysics using techniques and measurements that are much more difficult to grasp and certainly less appealing to view. Should we try to explain such concepts as spectroscopy, polarimetry and interferometry, or is it a lost cause? The most effective approach to this problem may be to lead the audience to ask the question themselves: "But how do you know that?"

INTRODUCTION

Astrophysics is 'hard science'. Astronomy has a tremendous advantage over most other hard sciences in that pictures of the sky are naturally appealing and can be appreciated and enjoyed by the lay viewer without the necessity of complex explanation. Following pioneering photographic work—most notably by David Malin—around 30 years ago, the technique of producing more-or-less true colour representations of astronomical objects and fields has flowered into the digital imaging age where now both amateur and professional astronomers can produce stunningly beautiful images from digital archives using the power of the FITS Liberator software.

Important discoveries in astronomy, however, are generally made by employing a broad range of observational, experimental and theoretical techniques that are subtle and/or intrinsically difficult for a non-scientist to understand. The use of such techniques can often reasonably be ignored or by-passed when presenting and explaining a result but sometimes their application is so crucial that explanation must be attempted. Some outreach operatives teach: "never, ever show a spectrum!" Such a dictum was voiced at this conference. I do not agree. How should it be done? Are there any general rules or guidelines? How do audiences react: is it a 'turn-on' or a 'turn-off'?

SPECTROSCOPY: THE JOY OF COLOUR

Spectroscopy is the science of colour. People react to colour; it can be beautiful and it certainly carries information. A greyscale image of M51 (Fig. 1, top) carries a great deal of information about what a galaxy is, but a colour image (middle) opens the door to understanding physical processes and the nature of the different components of such a complex structure. The addition of a colour image from outside the visible spectrum (perhaps a difficult concept itself) adds yet more insight into how things work. With this sequence of images we have already started doing spectroscopy without even mentioning prisms, gratings or slits!

Figure 1. *The path to spectroscopy. The monochrome image of M51 (top) from Hubble's Advanced Camera for Surveys (ACS) gives a wonderful insight into galactic structure. Foreground stars, luminous clumps tracing the spiral arms and dark regions of obscuration are clear. The addition of (roughly true) colour coding (middle) adds an enormous amount of information that can be interpreted quite directly in terms of the physical processes in young star clusters, the distributions of stars of different types and the absorption in dust lanes along and between the spiral arms. Moving to a different waveband, this time using the IRAC on Spitzer in its four filters from 3 – 8 microns (bottom), complements the optical physics by showing the dust in emission (fluorescence) and coding almost all the stars as the same shade of blue which represents the invariant 'Rayleigh-Jeans' part of the stellar spectrum. Just by using and explaining these beautiful pictures, we are well on the way to doing real spectroscopy! [credits: NASA, ESA, S. Beckwith (STScI), and The Hubble Heritage Team (STScI/AURA); NASA/JPL-Caltech/R. Kennicutt (Univ. of Arizona)/DSS]*

What about 'hard-core' spectroscopy: the source of the real information? There are many analogies of course (rainbows, radio dials etc.) and some of them are over-used, but all are effective in the right context. Contrary to most prejudice, some spectra have their own intrinsic beauty and immediately convey the idea of richness of information. A high resolution representation of the Solar spectrum, e.g., http://www.noao.edu/image_gallery/html/im0600.html, is visually stunning and a high redshift quasar showing a resolved Lyman forest will convince anyone that the Universe is trying to tell us something profound.

Try taking your audience back to the second half of the 19th century when the spectroscope was first being turned towards the Sun and the brighter stars and nebulæ. Imagine the orgy of intellectual excitement when it was realized that mankind had a means to analyse the physical state and chemical composition of remote, inaccessible objects throughout the visible Universe. The discovery of helium in the Sun and the first steps taken to interpret the signals from other objects gave us the science of astrophysics.

So, yes, do be ready to show spectra and explain what they mean. Science without spectroscopy is like civilisation without TV and radio (pause for the obvious response…).

OTHER TECHNIQUES

What else is encoded in a stream of photons? Polarization is a property that is not impossible to explain; but it is difficult, even for physicists (read the first chapter of Paul Dirac's "Principles of Quantum Mechanics). When Polaroid sunglasses were common, we at least had a chance to demonstrate what we meant. Polarization really tells us about the orientation in space of a source of photons or it can reveal something of the path the photons took to reach our telescope, i.e., it is a property that can be imprinted by 'reflection' (read scattering) from mirrors that allow us to see around corners. As for spectroscopy, there are analogies and easily visible demonstrations in nature: one just has to choose an appropriate one.

Figure 2. *Polarization of the blue sky. Sunrise on Hawaii looking south. The Sun is rising behind Mauna Kea on the left and a polarizing filter in a fisheye lens (the 30mm lens on a Hasselblad with a diagonal FoV of 180°) reveals the directional imprint of Rayleigh scattering: the process that creates the splendour of the clear blue sky.*

Figure 2 is an example of the kind of demonstration that I so often find useful in explaining astronomy. There are many sky phenomena visible with the (almost) naked eye that are directly related to the processes we study as astronomers. In this case, the use of a polarizing filter to photograph a clear sky at sunrise (it could be sunset with equal effect) reveals the next layer of depth in our understanding of why the sky is blue. The dark band arching through the zenith shows us the relationship of polarization with direction and orientation. You can explain how the filter is oriented and why!

Interferometry is also a challenge: there are fewer useful analogies and the process is intrinsically complex. We are driven to use it because of our desire to see fine detail in images and the physics behind it is one of the two reasons we are always trying to build larger telescopes. If you can explain this reason, you are halfway there. If we reach the stage of sketching fringes and talking about equalising paths, we may be stepping into quicksand.

So, having mastered spectroscopy, polarimetry and interferometry, where do we go next? These techniques all concern the properties of single quanta. Once we start bothering ourselves with the arrival times of individual photons, we get into the whole new game of quantum optics. We can see if they come in bursts or as a spatter of more evenly distributed events. We will need large telescopes to do this for faint astronomical sources, and we will need to count photons pretty fast, but it will tell us about natural lasers, phenomena close to black holes and the intricacies of the photon's journeys to us.

CONCLUSIONS

I believe that what we do as astronomers is explicable to lay audiences. In my experience, people love to hear about what we actually do: even if they don't understand the gorier details. I have no fear of showing (and explaining) spectra or polarization maps. But the audience have to be prepared first; they need to formulate the questions themselves. They should be ready to ask: "But how do you know that?"

We are fortunate as astronomers in having the Universe as our canvas. We have the intrinsic beauty of the night (and daytime!) sky above us. When we look closer with our expensive toys we can, unlike many scientists, convert our digital data streams into the most stunning images that everybody loves to see. Given this bonus of public interest, we can afford to put a little effort into revealing glimpses of a deeper understanding. But we have to tread gently: it is all too easy to kill interest.

EUROPE IN SPACE

Taking off without the Public?

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ABSTRACT

Europe is doing great in space, scientifically and technologically—but for some reason, this is not communicated. Can we change the attitude of scientists and agencies towards public communication?

January 4th 2004: The Mars rover Spirit has just landed on the surface of Mars. It transmitted the first colour images from the Gusev crater, presented in near real time at a major press event, headed by NASA administrator O'Keefe.

January 19th 2004, 16:30 h CET: The first image of Mars taken by the ESA spacecraft Mars Express is published: It pops up on the internet without any special treatment, despite an eager public anxious to see Europe's first Mars image and unappreciative of the delays. The spacecraft had already been in orbit around the red planet for several weeks. An official event with high level representatives from ESA and politics followed four days later.

November 2005: The Cassini spacecraft has been in orbit around Saturn for almost 18 months, publishing new and beautiful images from Saturn daily. More than 500 Cassini images are now online, but after almost two years of operation a mere 50 images from ESA's Mars Express are available online.

The Hubble Space Telescope—a joint NASA/ESA undertaking with a largely unsung 15 per cent share for Europe—publishes marvellous pictures almost on a weekly basis. Europe's premier organisation for astronomy, the European Southern Observatory (ESO), which operates the Very Large Telescope (VLT) in Chile, considered the world's most powerful astronomical instrument, published just five "Hubble class" VLT pictures in 2004.

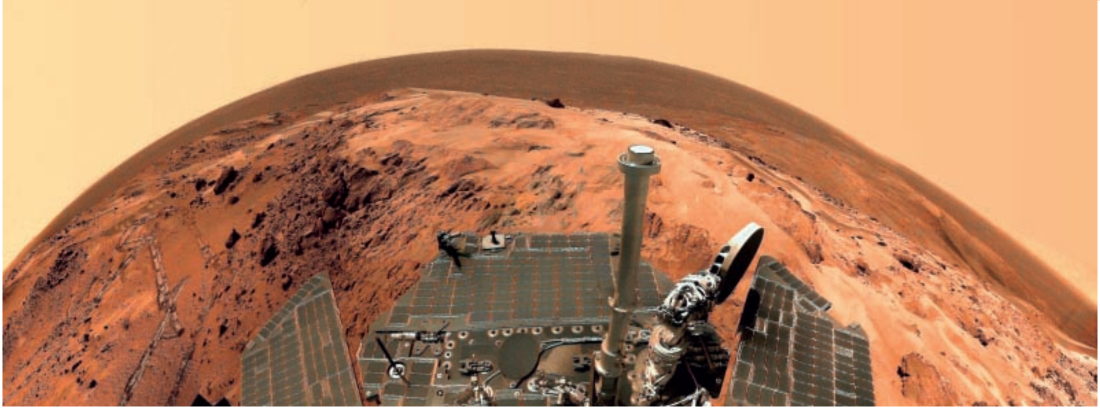
These are just a few random examples of the lack of proper science communication in Europe. Europe is doing great work in astronomy and space flight, but is not communicating it well. The bottom line is quite obvious: American scientists are more enthusiastic about communicating their research than most of their European fellows.

The big question is: Why? Is it a cultural difference? Is there more political pressure in the US to get the next project funded by communicating current activities? Are there more staff in outreach departments in the US than in Europe? Do US scientists enjoy sharing their work with the public more than most of their European colleagues? Is it an issue concerning the public perception of science—are US citizens more science minded than most European citizens, many of whom naturally consider Mozart, Voltaire and Michelangelo as culture, but not Kepler, Galileo and Newton ? It could be a mixture of all of these.

It is surely the scientists‘ job to leave their ivory towers and to spread the news of their achievements. Science matters, but if science doesn‘t matter to the public, the public will lose interest in it, which might even result in a decrease in funding in the long term. Linking funding to public perception could present a severe problem for important science with a boring image, but it should be a great opportunity for astronomy and space flight activities. Both are easy to communicate. Astronomy and space flight fire the imagination, they deal with extreme conditions and extreme numbers and are producing beautiful images (yes, just show them!)—a combination enough to fascinate anyone. But it seems that not many European scientists and engineers in these fields have realised it—or are hampered by political structures that constrain public relations work.

In a stroke of genius the team of the Hubble Space Telescope has devoted about one percent of its observing time to the Hubble Heritage Project. Its only purpose is to produce beautiful images that are presented primarily as artwork, not necessarily in the proper scientific orientation etc., but in the way that appeals most to the public. But is Hubble wasting valuable observing time? Would it be “better” to use this time for “real” science (even though most of these beautiful images do have some scientific value)? Hubble is the most famous scientific instrument in history today. To a

__Fig. 1__ Mars as seen from rover Spirit. Credit: NASA/JPL/Cornell & Marco Di Lorenzo et al, Aviation Week



great extent this is due to its almost perfect communication activities (carried out by a huge team, counted in dozens at times).

And Europe? The four VLT telescopes are used mostly in spectroscopic mode—splitting the light into different colours rather than taking conventional images. Spectroscopy is certainly more meaningful scientifically, but if we assume the four telescopes can be used 80 percent of a year on average, there are well over 1000 VLT observing nights. What would it really cost to devote ten nights per year for imaging just for PR purposes? ESO might end up with a few publications less in peer-reviewed papers. So what? Is the 115th article in a scientific journal really more important than a good picture that makes the front page of newspapers throughout Europe? There are many astronomical pictures taken by HST that are familiar to almost everybody. Many people will not know what the image shows or even that Hubble has taken it. But many of these pictures are almost scientific icons or symbols of our time. Where is ESO? There are very few well-known VLT images—and many people refer to them as Hubble pictures. HST will be history within the next five years. Astronomy will lose its picture machine. Is Europe willing to take over? A few dedicated nights per year could make all the difference, generating an avalanche of public outreach data, and enhancing public perception and reputation.

Communication is visual, mostly. Communication uses images, but it is made by human beings, i.e. PR officers and scientists. What's the pay off for scientists? Is it of any use to invest time in public outreach activities? Well, it may be in the spirit of science, but, a scientist doesn't benefit from any of his own outreach work immediately. However, in the long run outreach may increase his visibility and the public awareness of this particular research area. Is this something, a scientist should care about? Young scientists should. When applying for an academic position, everyone is expected to supply a publications list. However, if an applicant admits to fewer peer-reviewed publications because they have talked to journalists for two hours per week on average, have given public talks and have written a popular book, nobody is impressed. It doesn't count in the academic world. What's wrong with our science system?

The Principal Investigator of an instrument flying on a European satellite is in a very strong position. They virtually own the data in most cases. They decide whether specific data can be used for public outreach or not. They decide what to show the public early in the mission (later all the data are usually made public). How is it possible that a great deal of public money is spent on space and astronomy, but the scientists responsible for the projects are ultimately the ones to decide how much the public should see of it? Is scientific equipment the private toy of the responsible researcher? The press officers of various institutions can suffer from the ignorant behaviour of some scientists.

Why isn't public relations work an integral part of any project financed by the European taxpayer? FP6 public relation activities are mandatory according to all contracts granted by the EU, but nobody seems to really care about it. Nor is a certain share of the budget allocated for outreach purposes. Does anybody check how and even whether a specific project is communicated? It is quite hard (next to impossible) to judge whether PR activities have been done well or not. Success depends on many factors the players have no control over. But isn't it possible to ask any applicant for examples of their outreach activities and press coverage in former projects? We need a shift in attitude. Scientists need to realise that communication is necessary and that it has its benefits.

Astronomy and space flight have much more appeal to many people than many other areas of science and engineering. Space events have the potential to attract kids to follow a professional career in science and technology. There is a whole Apollo generation of scientists and engineers (and not only astronomers and space flight engineers!). In the era of the Lisbon process we can't afford to waste this potential any longer. We need action taken now. Excellent science and efficient event-driven communication are not mutually exclusive. A major discovery can turn out to be a hot shot for communication too. Superb pictures are excellent tools for communications even without any scientific value.

Europe is doing a great job in space. But its achievements rarely make headlines. Scientists, public outreach officers and journalists need a sound basis on which to live and work together. They need to collaborate and establish clear guidelines for their respective tasks. Europe may be surging ahead in space—but we all need a completely new attitude towards the communication of science.

THE ROAD LESS TRAVELLED

Non-traditional Ways of Communicating Astronomy to the Public

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ABSTRACT

In an age of media saturation, how can astronomers succeed in grabbing the public's attention to increase awareness and understanding of astronomy? Here I discuss some creative alternatives to press releases, public lectures, television programmes, books, magazine articles, and other traditional ways of bringing astronomy to a wide audience. By thinking outside the box and employing novel tools—from truly terrible sci-fi movies, to modern Stonehenges, to music from the stars—astronomers are finding effective new ways of communicating the wonders of the Universe to people of all ages.

INTRODUCTION

As a number of talks at this conference have emphasized, those of us involved in astronomy education and outreach face an uphill struggle to reach the public through books, press releases, images, and other traditional ways of communicating astronomy. Let me illustrate the challenges with two specific examples:

1. In July 1969, Neil Armstrong became the first person to walk on the Moon, an event that surely ranks as one of the greatest achievements in human history. Just three and a half years later, in January 1973, Elvis Presley's "Aloha from Hawaii" television special was beamed via satellite from Honolulu to over 40 countries around the world. Guess which of these two events was watched by more television viewers? It is estimated that more than a billion people around the world tuned in to watch the self-proclaimed "Hunk o' Burning Love" on television, compared to about 600 million people who viewed Neil Armstrong's walk on the Moon. When the Elvis special was shown on American television, more Americans watched it than watched the Apollo 11 astronauts walk on the Moon. It's a sobering reminder to those who wish to use television as a medium for communicating astronomy to the public that they face daunting competition from soap operas, reality television shows, sports, sitcoms, and other popular programming that captures the vast majority of television viewers.
2. Here's another depressing fact: according a recent survey by the U.S. National Endowment for the Arts, 43% of adult Americans read no books last year. Although that might explain a lot about the last U.S. presidential elec-

> tion, it's also hard not to lose the will to live if you're a science writer, because it means that you don't have a prayer of reaching those people, no matter how clever or informative your writing might be. It's not that those 43% didn't read any science book last year—they didn't read any book last year. And the reading rate is declining most rapidly for young people between the ages of 18 to 24.

The late, great Richard Feynman summarized the situation eloquently when he lamented, *"Is no one inspired by our present picture of the Universe? The value of science remains unsung by singers; you are reduced to hearing not a song or poem, but an evening lecture about it. This is not yet a scientific age."*

Given this reality, how can we effectively communicate astronomy to a public that often seems uninterested in science, frequently finds it difficult, and is becoming increasingly difficult to reach via traditional media such as print and television?

My goal here is to share some creative, non-traditional ways that are being used with great success to communicate astronomy to a wide audience. I don't pretend to be an expert on this topic, and the information that I will present here is by no means a complete survey. Rather, it is just a partial list that will hopefully inspire others to find their own new ways of bringing astronomy to the public.

COMMUNICATING ASTRONOMY THROUGH CULTURE

A key issue in astronomy outreach has always been how to address the general public's implicit question of "Why should I care about this?" To motivate people to want to learn more about astronomy, we need to make the subject interesting, understandable, and relevant to their lives. Culture offers a powerful "hook" to get people interested in astronomy and to make it more relevant to them. Every one of us comes from a place with a culture, with creation stories, and with legends about the heavens. Astronomers can use these cultural connections as a starting point to communicate the wonders of astronomy to audiences everywhere.

One place where science and culture come together is the Imiloa Astronomy Center, a $27 million dollar centre scheduled to open in Hilo, Hawaii in late 2005. Conceived as a unique interpretive facility to increase public awareness of the Universe and our place in it, the Imiloa Astronomy Center is a community project in the truest sense. With involvement from the astronomical community in Hawaii, the University of Hawaii, and the native Hawaiian community, the centre's content will reflect the reverence for Mauna Kea shared by Hawaiians and astronomers.

The goals of the Imiloa Astronomy Center are manifold, but there are two primary objectives. First, to weave together two seemingly disparate stories—one about astronomy and one about Hawaiian culture—into a compelling story of human exploration. Second, to provide a personal connection to science and culture. Why should visitors to the centre care about astronomy? Why should they care about Hawaiian culture? By tapping into universal themes that transcend science, culture and places of origin, it is possible to create a centre with a broad appeal.

Why build a world-class astronomy education centre in Hilo, a small town of only about 45,000 people? Mauna Kea, which is only about an hour's drive from Hilo and dominates the local landscape, is home to one of the greatest collections of telescopes in the world. Many people—local residents and tourists alike—have heard of Mauna Kea, and many are curious to learn more about the observatories on the "White Mountain." An estimated 100,000 visitors a year come to Mauna Kea, although most do not go to the summit to see the telescopes because of the hardships of high altitude. With more than a million tourists visiting the island of Hawaii each year, the Imiloa Astronomy Center has a tremendous opportunity to teach countless people about the exciting astronomical discoveries being made nightly by the dozen observatories on Mauna Kea.

In addition to the scientific attraction, the mountain is also a sacred site to many native Hawaiians and throughout much of Polynesia, so there is a cultural connection to Mauna Kea as well. Hawaiian culture is not just a thing of the past; it is a living, vibrant culture that is experiencing a renaissance today, and the Center aims to increase public awareness and understanding of the rich culture of the kanaka maoli (indigenous people) of Hawaii.

Figure 1. *Artist's rendering of the soon-to-be-completed Imiloa Astronomy Center in Hilo, Hawaii. Image courtesy of the Imiloa Astronomy Center and Durant Media Five.*

Visitors to the Imiloa Astronomy Center will encounter interactive exhibits, panels to read, a 3-D theatre, a planetarium, and live demonstrations and performances. The Center's exhibits are housed in four main areas that focus on the following themes:

Piko. The Center's introductory space is intended to be a place of wonder, where visitors first connect with Mauna Kea's special nature. Piko is the Hawaiian word for umbilical cord, and in Hawaiian lore Mauna Kea is the navel of creation, a place that connects Hawaiians and their culture back through time to their ancestral origins as descendents of the gods. This opening space attempts to recreate the feeling of enchantment that one feels on the summit of Mauna Kea, with the aim of piquing the visitor's curiosity.

Origins. The next space that visitors enter asks a basic question that people of all cultures have pondered and attempted to answer throughout history: Where do we come from? It begins with the Kumulipo chant, which tells an ancient Hawaiian legend of our cosmic origins, and then moves into our modern astronomical creation story, from the birth of the Universe in the Big Bang to the origin of stars, planets, galaxies and life. The goal is not to compare and contrast these two very different creation stories, or to pass judgment, but simply to show them as different expressions of the ages old human quest to understand our cosmic origins.

Voyages. This area of the Center asks: Where have we been? Where are we going from here? Here "we" can be many different groups—we astronomers, we Hawaiian people, we human beings, and the voyage may be literal or metaphorical. Visitors will learn what it was like to sail aboard a Polynesian voyaging canoe across thousands of miles of open ocean, navigating by the stars, the wind, the clouds, and other natural signposts. Visitors will also get a chance to try their hand at astronomical observations in an observatory simulator that will give a sense of what it is like to be an astronomer on a voyage of discovery into the unknown Universe. The intention is to show that modern astronomers and ancient navigators are kindred spirits, driven by the same spirit of exploration. The same curiosity to find out what lies beyond the horizon that inspired the ancient Polynesians to voyage thousands of miles across the Pacific Ocean is what motivates astronomers today to explore the cosmic ocean to learn about distant worlds.

Voices. In the closing space of the Center, visitors are given the opportunity to express their own views about Mauna Kea, culture, science, and what it all means to them. They will also have the chance to hear what previous visitors from around the world have said.

By using science and culture as partners, the Imiloa Astronomy Center has an opportunity to create one of the premier interpretive centres for astronomy in the world. A place that will help inspire children growing up in Hawaii to reach for the stars and to embrace the cultural heritage of the islands. A place where local residents and visitors from far away will come together to learn about our place in the cosmos. Ideally, those who come to the Imiloa Astronomy Center to learn about astronomy may also leave with more awareness and appreciation of Hawaiian culture. And those who come because they are interested in Hawaiian culture may also find that their interest in astronomy is sparked. More information about the Imiloa Astronomy Center can be found at www.maunakea.hawaii.edu.

Of course, Hawaii isn't the only place where people have gazed into the starry skies and wondered about their origins. Another place that has successfully linked astronomy and culture is Stonehenge Aotearoa, which is located outside Wellington, New Zealand. "Aoetearoa" is the Maori name for New Zealand. Built by a very dedicated group of amateur astronomers, the goal was to create a modern Stonehenge—not an exact replica of the one in England—but one that was constructed from modern materials and that reflects the lore of the sky in the southern hemisphere and the local Maori culture.

Stonehenge Aotearoa's clever idea is to capitalize on the fact that many people—whether or not they are interested in astronomy per se—are fascinated by the ancient stone circles found around the world. It's a magnet to bring people in. And once they are there, it's possible to teach them about the motions of the Sun and stars throughout the year, about Maori culture, and about the legendary ability of the ancient Polynesians to sail across the vast Pacific Ocean to New Zealand's shores by observing the stars. "Stonehenge Aotearoa is a fabulous teaching tool combining art, history, different cultures around the world, star lore and astronomy," says Jennifer Picking of New Zealand's Phoenix Astronomical Society, which built the structure with a government grant and over 11,000 hours of volunteer effort.

Figure 2. *Stonehenge Aotearoa, shown here, is a modern version of the ancient Stonehenge located on England's Salisbury Plain. Image courtesy of, and copyright by, Chris Picking.*

Stonehenge Aotearoa opened in February 2005, and has already proven to be a popular destination for visitors. It has a bright future as an innovative way of communicating astronomy by blending the ancient and the modern. More information about Stonehenge Aoetearoa can be found at www.astronomynz.org.nz/stonehenge/.

COMMUNICATING ASTRONOMY THROUGH NEW TECHNOLOGY

Another way of communicating astronomy to a wide audience is to take advantage of emerging technologies. There are many examples of this, such as CD-ROMs, webcasts, virtual tours, and portable planetaria, all of which have made it possible to bring astronomy to the public rather than requiring the public to come to museums, observatories, or other fixed locations. However, today's cutting-edge technology is often tomorrow's technological antique, and so those involved in astronomy outreach must be prepared to adapt quickly to opportunities presented by new technologies.

One of the newest technologies with great potential for astronomy outreach is podcasting. Whereas just a year or two ago weblogs or "blogs" were all the rage, allowing anyone to post their thoughts on the internet for others to read, the growing popularity of small, personal listening devices such as iPods has now made it easy to disseminate audio broadcasts over the internet for interested listeners. Such "podcasts" have rapidly become the technology du jour. Podcasting has been described as the next generation of radio, allowing listeners to find, download, and subscribe to any of thousands of free audio broadcasts that can be automatically delivered via the internet to the listener's portable audio player or personal computer. Anyone can create a podcast with only a modest investment of resources, and if the podcast is innovative then it has the potential to reach a huge number of listeners.

With this motivation, a group of astronomy enthusiasts named Aaron Price, Pamela Gay and Travis Searle quickly capitalized on this new technology to create the first astronomy-themed podcast, which they call Slacker Astronomy. Every week, they produce a five to ten minute podcast that discusses the latest astronomical news, along with occasional interviews, chat shows, and more. None of the Slacker Astronomy team is paid for their contribution, they see it as *"a three-person volunteer collaboration for fun, for you, and for the voices in our heads."* The shows have an irreverent sense of humour that makes them both entertaining and informative.

Figure 3. *Slacker Astronomy has been podcasting since February 2005 and already has nearly 10,000 listeners to its weekly shows. Logo courtesy of Slacker Astronomy.*

From its humble beginning in February 2005, Slacker Astronomy has grown quickly to over 9,000 listeners in August 2005, and that number will undoubtedly continue to rise. These are impressive figures, and demonstrate the great potential for reaching large audiences through this new medium. According to Aaron Price, such podcasting "is most effective as part of a greater effort in using new media. The grand strategy is to use the blogosphere, instant messaging, online portals, podcasts, etc. to get the word out online."

The folks at Slacker Astronomy are also eager to help promote astronomical research by creating podcasts on demand. Just send them a press release that you'd like publicized, give them two weeks notice, and they'll create a special Slacker Astronomy podcast, free of charge. They honour embargo dates, and also allow final script approval. It's a wonderful opportunity to reach the public in a new way, and shows what a difference a few dedicated individuals can make. More information can be found on their website at www.slackerastronomy.org.

COMMUNICATING ASTRONOMY THROUGH MUSIC

A number of talented people are combining their passions for astronomy and music as a way of bringing astronomy to the public. Here are a few examples:

- Jim Webb is an astronomer at Florida International University. He does research in the field of active galaxies such as quasars and blazers, and he recently organized an international conference on that topic. He's also a guitar player with a home recording studio, and to date he has recorded three astronomy-themed CDs that he gives away as gifts or sells at cost. "The songs deal with space travel, life in the Universe, black holes, and our place in the cosmic scheme of things," he says. To date his CDs have travelled as far as Hungary, Sweden, Mexico and California. More information can be found on his website at www.fiu.edu/~webbj/ASTROMUS.HTM

- Fiorella Terenzi, is an astrophysicist, author and musician who has been described as "a cross between Carl Sagan and Madonna." Her CD, Music from the Galaxies, takes VLA and Westerbork radio observations of the galaxy UGC 6697, converts the frequency and intensity of the radio signal into sounds audible to the human ear, and then blends these with computer-generated music to create a sound that Time magazine has described as "part New Age, part Buck Rogers sound track, played on an oscilloscope." More information is available from her web page at www.fiorella.com

- Astrocapella is a project that Sky & Telescope magazine has described as "an astronomy class set to music." Two Astrocapella CDs have been released to date containing original, astronomically-correct a cappella songs written and performed by a group of astronomers and educators who call themselves The Chromatics. The group's philosophy is that music can serve as a powerful memory aid, and so when one hears a catchy song with astronomy-related lyrics, it stays in the listener's brain. More information can be obtained from their website at www.astrocappella.com.

- In case you're thinking that a cappella astronomy songs might not appeal to teenagers, have no fear—there's always MC Hawking. Created by an American web developer named Ken Leavitt-Lawrence, his humorous premise is that Stephen Hawking has dual careers as a famous theoretical astrophysicist and a rap star. MC Hawking's CD, A Brief History of Rhyme, consists of rap songs sung by a synthesized voice that sounds remarkably similar to the one used by the real Stephen Hawking. The MC Hawking website features a biography of MC Hawking that blends fact and fiction, and includes digitally manipulated photos that purport to show the "Hawkman" hanging out with fellow rap artists, and a police mug shot to help establish the astrophysicist's street credibility as one tough gangsta rapper. But it's not all just for laughs; beneath the humorous approach there really is an underlying foundation of science, with songs about such topics as entropy, unified field theory, and the Big Bang. And in case you're thinking that this is in poor taste, don't worry. The real Stephen Hawking has said that he is "flattered, as it's a modern day equivalent to Spitting Image". MC Hawking creator Ken Leavitt-Lawrence says: "Despite the fun I'm having with it, I have tremendous respect for the man." More information, including a video for the MC Hawking song What We Need More of is Science, can be found at www.mchawking.com.

Figure 4. *The cover of Out in Space, one of three CDs of astronomy-inspired music that astronomer Jim Webb has recorded at home. Image courtesy of Jim Webb.*

COMMUNICATING ASTRONOMY THROUGH MOVIES

One of the earliest examples of cinematic fantasy was a pioneering short French film titled Le Voyage dans la Lune (A Trip to the Moon), based loosely on a Jules Verne story. In this 1902 silent movie, several astronomers travel to the Moon in a spacecraft fired from a giant cannon, rough up a few Selenites that try to capture them, and then return safely to Earth. It's a wonderful film, and was quite successful for its time.

Figure 5. *A scene from the 1902 silent film A Trip to the Moon, which was written and directed by Georges Méliès. This 14 minute film was one of the earliest science fiction movies, showing the great appeal of astronomy-related themes in cinema.*

Astronomy has always been an attractive subject for movies. Of the top five most successful movies of all time in the United States, three have themes related in one way or another to astronomy and space exploration: Star Wars, E.T The Extraterrestrial, and Star Wars: Episode I.

Capitalizing on the popularity of science fiction movies, the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, has hit upon a novel way of using them as a tool for teaching astronomy to the public. Sci-Fi Movie Nights is a monthly community outreach program based on the premise that "everything we know about science we learned from the movies." It is the brainchild of David Aguilar, who is Director of Public Affairs at the CfA, and it grew out of his frustration with the inaccurate way that science is often portrayed in the popular media. *"Science fiction movies have always been a motivator in sparking the interest of younger people,"* says Aguilar, *"so why not use an attention grabbing, off-the-shelf commodity to further the teaching of science?"*

The CfA shows the movies for free, and also provides free popcorn, free prizes, and free scientific discussion. Each movie is preceded by a brief introduction that explains why the movie was made, who is in it, great scenes to look for, how the special effects were done, and so on. “After the movie, the discussion now examines the science,” says Aguilar. “Good science, science and technology to come, misconceptions and the bad science. We may venture into particle physics, lasers, antimatter, space travel, biology, physics, botany, time travel, etc.”

Part of the appeal of Sci-Fi Movie Nights is the selection of movies, which include some of the campiest sci-fi films ever made—the ones that are so bad they’re actually good. Among the films that have been shown are the 1957 cult classic Plan 9 from Outer Space and Robot Monster, both widely considered contenders for the worst movies ever made. Plan 9 from Outer Space, for example, is advertised as “almost starring Bela Lugosi” because the famed actor died just four days after filming began, and so a stand-in was hired who spent the rest of the film with a cape over his face so that viewers wouldn’t know that it wasn’t really Lugosi. In the low-budget classic Robot Monster, Earth is visited by aliens played by actors wearing a bizarre combination of gorilla suits and diving helmets. The cheesiness factor is enormous, but that’s all part of the fun, and it keeps the audience coming back for more.

Beyond sheer entertainment value, however, these films are also a fun and effective way of stimulating public curiosity about astronomy. In Plan 9 from Outer Space, for example, Earth is invaded by surprisingly human-looking aliens who have come to our planet out of concern that we humans are developing a weapon that could destroy the Universe. This provides an excellent starting point for discussing a wealth of topics after the movie, such as interstellar distances, the challenges of space travel, and the likelihood that aliens from another world would look human.

Public response to the Sci-Fi Movie Nights has been incredible, with standing-room only crowds of all ages. The program has also been successfully taken on the road to Arizona, Colorado, Washington, DC and California, and would likely be a hit most anywhere.

Let me give another example of the power of film for communicating astronomy in a different cultural context. In 1998, I taught the first university astronomy course ever in the Gambia, an impoverished nation in western Africa. The introductory course covered the usual topics such as our solar system, stars, galaxies, cosmology, and the search for life in the Universe. My students were a delight to teach, and they asked many excellent questions. They also taught me much about western African cultures and Islam, and I learned as much or more from them as they did from me. Yet I have no doubt that the one thing they all remember from my course to this day is this: I showed them the movie E.T. The Extraterrestrial, which I had brought with me. Because of the extreme poverty in the Gambia—it is ranked as one of the poorest countries in the world by the United Nations—most of my students didn't have televisions and had never seen this movie before. And they loved it.

Toward the end of the film, E.T. and his young earthling friend, Elliot, are trying to escape from government agents when suddenly their bike flies into the air as if by magic, over a roadblock, over houses, and returns E.T. to his waiting spaceship. It's a wonderful moment in cinematic history—and my entire class burst into spontaneous applause. Steven Spielberg is, of course, a master at pushing those universal emotional buttons that people of all cultures can relate to. After showing E.T. The Extraterrestrial in my class, I had a captivated group of students for our ensuing discussion of the search for life in the Universe. The possibility of extraterrestrial life had suddenly been transformed from an abstract concept into an alien creature with a face, feelings, and a name—even if it was just fantasy and highly anthropomorphized, a personal connection to a scientific question had been created.

Finally, let me also mention the possibility of piggybacking on major Hollywood releases to increase public understanding of astronomy. When the new sci-fi comedy movie The Hitchhiker's Guide to the Galaxy was released, in which the Earth is destroyed to make way for an intergalactic hyperspace bypass, the University of Hawaii's Institute for Astronomy took advantage of the buzz generated by the film by offering its own free evening presentation titled "The Hitchhiker's Guide to the End of Everything" in which a panel of astronomers discussed the chances of surviving real astronomical dangers, such as killer asteroids, colliding galaxies, exploding stars, black holes, and the eventual fate of the Earth and the Universe. It was a timely and fun way of communicating science. New movies with some astronomical connection are released all the time (e.g., the recently released War of the Worlds), providing new opportunities for capitalizing on the free publicity to increase awareness of astronomy.

CONCLUSIONS

My goal here has been to showcase some of the many non-traditional ways that the astronomical community is reaching out to communicate with the public. Many of these are not expensive, and many can be quite fun. It is my hope that some of the ideas presented here will inspire others to find their own new and creative ways of communicating astronomy to people of all ages.

Acknowledgments: I thank the conference organizers for a most enjoyable meeting, and

DO THE STARS TELL YOUR LOVE STORY?

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ABSTRACT

A good alternative to traditional methods of passing on astronomical concepts is to use a 'collateral' story that catches the public's attention. It may also simultaneously give a vital opportunity to awaken the critical faculty that often seems so perilously close to extinction these days…. The recipe is simple: nothing but an actor or actress, his/her voice and hands, and a script on a topic of wide popular interest, with bits of magic and humour. A live example was shown during the Meeting (see the webcast). The text of that performance is presented in this paper, followed by an analysis and discussion of the proposed resource.

NO INTRODUCTION: WELCOME TO "THE COMEDY CLUB"

The Spanish TV program "The Comedy Club" consists of an actor or actress alone on stage, just with a high stool and maybe a drink, who performs a (usually very good) monologue. Although this author is not a professional actress and her mother tongue is not English, she welcomes you to "The Comedy Club", with the performance entitled "Do the stars tell your love story?"

"When the producer of the program called to invite me to perform, I expected to receive a wonderful, clever script, with plenty of humour and irony from the director … but, here I am, and I've been told that, due to late night spending cuts, I have to improvise. So, during the last couple of hours, I've been writing the exciting story of my love affairs for you.

My goodness… all through my life, I've been so unlucky with boyfriends… really, I'm not joking, even though I've always paid great attention to the compatibility of astrological signs. But, listen: I'm a Taurus. As soon as I became a teenager I carefully read the characteristics of that sign, checking that I was an authentic Taurus. You probably know that the 'Earth' signs are very stable, few circumstances can disturb us, we love the good things of life, and we take very good care of our money. In addition, my sign is governed by Venus, my metal is copper, my lucky day is Friday, my colour is green, my perfume is orange blossom, and my fortune stone is the emerald. But the most important thing is that, concerning relationships, we Taurans are really physical; sexuality and sensuality are very important for us and, when we decide to be faithful, boy, are we faithful.

Great: once this essential information was known, the next thing was to find a sign compatible with mine. It could be another Earth sign, that is, another Taurus, or Virgo, or Capricorn; or, a maybe Water sign, like Cancer, Scorpio or Pisces.

My first boyfriend was born on November 19th; as soon as we were introduced I thought: "wonderful, a Scorpio, a sign so passionate, apparently chaotic and destructive, but actually with mystique and deep feelings about sex!" So, of course, I threw myself into his arms, but we only stayed together a very short time. I just couldn't understand it - he was too well balanced and rational to be a Scorpio! Then, somebody explained to me about the true length of star signs.

Ah, don't you know this? Well, but, you do know, at least, what the Zodiac is, don't you? Mmmmm, I'd better start at that point: OK, very distant stars don't appear to move in the sky from Earth, and the Sun apparently travels among them on the vault of heaven - though it is actually because the Earth goes round the Sun in a year that the Sun seems to move. The Sun's apparent path is called the ecliptic, and is actually the line in which the plane of the Earth's orbit intersects the sky. The planets are always seen very close to the ecliptic because the planes of their orbits are close to ours. The Zodiac is a lane on both sides of the ecliptic, whose width is approximately the same as my open hand seen at arm's length.

You know there are groups of stars that, even if they may be very far away and have no relation to one another, seem to form drawings on the sky, called constellations. The ones lying on the aforementioned lane are the twelve Zodiac constellations: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces. The 360º of the Zodiac circle are then divided into 12 equal parts of 30º, each one corresponding approximately to one month of the yearly journey of the Sun. The most conspicuous constellation in each region gives its name to the astrological sign, starting at the spring equinox, March 21st. On that day, the Sun is on the intersection between the ecliptic and the celestial equator, rising exactly in the East, and, as indicated by the word equinox, day and night are of equal length.

So, the zodiac sign of a person is given by the constellation where the Sun was at the moment of their birth. But, in fact, the sections of the ecliptic occupied by the Zodiac constellations happen to be of different lengths on the sky, so the corresponding signs should also have different time spans; for instance, Virgo is enormous, and it should last for 45 days; Leo and Pisces are also quite large, with 37 and 38 days respectively; while Scorpio is actually tiny, corresponding to just one week.

Now I get it! My first boyfriend was not really a Scorpio, he was a Libra, an 'Air' sign, and they really don't get on with Earth signs, in particular with a genuine Taurus like me. That was probably the cause of the break up!

Some time later, I met another boy who I found really nice, and he had the gift of the gab… But, as you know, appearances can be misleading, and I wouldn't let myself be taken in. So, when I had the first opportunity, I asked him about his birth date. "December the 8th", he said. "Be careful!" I thought, "he is a Sagittarius, a sign of Fire - a very good communicator, with a way with words of course … but surely too impulsive and a ladykiller". So, I had to let him go, but I have to admit I was really sad.

Later on, I realised that I should have tried, at least. And this was because of another astronomical dirty trick that I didn't know. It happens that the twelve Zodiac constellations we know are the ones considered most striking by the ancients, but there are many more! In fact, the zone where the Sun and planets are always seen includes no less than 24 constellations. And if you include Pluto, whose orbit is the most inclined with respect to the ecliptic, you have to add another four constellations!

Anyway, there is at least one constellation officially accepted: it has to belong to the Zodiac no matter what. Its name is Ophiuchus, and it goes from the 30th of November to the 17th of December. Therefore, my second boy was actually an Ophiuchus, and that sign is not classified nor described: perhaps he might have suited me very well, so now look at the mess I'm in!

When I got to know the one who became my third boyfriend, I was already much more knowledgeable. Above all, I had asked around to find out that he was born on October the 20th, that is, theoretically, a Libra. I already had a bad experience with an authentic Libra (remember the first lad), so I was surfing the Net to get a good table giving the right time-spans of the constellations, and including Ophiuchus. That way, I realised that the boy was Virgo (astrologically speaking, I mean). Virgo is an Earth sign, like mine: "Fantastic", I said. And quoting an Astrology manual, "Earth with Earth may turn into a colossal mountain of faith and vigour… or to an arid desert, it depends on the direction followed. When shaken, the result can be an earthquake with volcanic repercussions. The option depends on both lovers". This latter part was dubious indeed, but the former still had promise. We started going out and, at the beginning, everything went really well, until, that is, somebody told me about the precession of equinoxes.

Doesn't this sound familiar? Listen: maybe you know that the North Pole on the sky, indicated by the star Polaris, however incredible it seems, has not always been in the same place. The Pole is the extension of the terrestrial rotation axis; and the Earth happens to rotate like a spinning top, that is, it swings very slowly. So, the North Pole describes a circle in about 26,000 years, making the cardinal points move and, consequently, so do the constellations "visited" by the Sun along a year. In particular, a backwards shift of more than one constellation has been produced since the Zodiac signs were "invented". Currently, the Sun doesn't rise any more in Aries on the 21st of March, but on Pisces and, soon, in Aquarius. And the same is valid for the rest of signs.

Coming back to the poor boy of the 20th of October, he actually was a Leo, a sign of Fire—compatible, but only with much difficulty with a Taurus like me… In addition, it is also said that the signs have much to do with the animal they represent and, can you imagine a bull with a lion…? I stood him up, of course, no need to suffer again.

The fact is that, later on, I stopped to think that my actual sign should be shifted backwards as well, and I started suspecting that maybe I'm an Aries, a sign of Fire. Then I looked for the description of Arians and, to tell the truth, I don't understand how I could have believed I was an authentic Taurus. Being Aries, I fitted in well with that theoretical Libra that, in fact, was a Virgo that should be a Leo… Pufffffff, this is making me to feel dizzy, and, finally, I don't know who to trust.

Anyway, it's better to be optimistic, and to think positively: just imagine if I'm only compatible with one single sign, whatever it is; there are about 6,000 million people in the world, and if these are essentially classified into twelve personality types, one per sign, there should still be about 500 million human beings, almost one half of them male, compatible with me. It will probably be a matter of time and patience to find the right candidate.

Otherwise, I can always change to the Chinese or the Indian Horoscope. At the end of the day, it seems to me that they have just as much validity as the occidental one…"

FOOTNOTE

The preceding text is the translation of the initial script of a live performance offered in a bar during a sceptical celebration of the 2003 summer solstice, in which several colleagues of the University of La Laguna tried to mimic "The Comedy Club". After the author's performance during the Meeting as a part of her oral contribution, it is presented in this paper as an example of a different way of popularising astronomy.

Before going into further comments and discussion, let me remark the on impossibility of a trustworthy translation, that is able to transmit the original sense of humour, as well as the many nuances, touches, and national or even local references. In fact, these cultural differences were apparent during the Meeting, as shown by some of the questions posed after the contribution. (ed's comment—and even this translation has been edited in some areas – so go see the webcast for the only true translation—and enjoy!)

NON-USUAL WAYS OF COMMUNICATING ASTRONOMY: A PROPOSAL

A number of basic astronomical concepts can be found by the reader (or spectator in the case of a performance) in the previous script:

- the ecliptic
- the planets' orbits and their inclinations
- the Zodiac
- the concept of angular extent
- the constellations, including the Zodiac ones
- the rise of the Sun at different points of the horizon along a year
- the Equinox, the North (and other) cardinal points
- the precession of equinoxes.

All are properly named, briefly defined, and simply explained, using ordinary words and the help of gestures and dramatisation, within a text which, apparently, is far from an astronomy lesson.

Several features of the example presented deserve a mention:

- The author claims that, in addition to dealing with spectacular instrumental advances and late news on astrophysics, an important part of outreach should be devoted to explaining the rudimentary notions of astronomy to the non-specialised public. We cannot forget that scientific literacy is still scarce in our societies, and its future development can only be founded on a sound understanding of the basics.
- It is frequently reported by the staff of science museums and planetariums that live shows are always very welcome (even considered the favourite) by the public. Therefore, in the middle of the current proliferation of sophisticated images, movies and all kinds of audiovisual facilities as resources to communicate astronomy, I would like to promote the authenticity and proximity of an actor or actress, and the immediacy of a classical theatre performance.
- It is a matter of fact that, among the multiple attitudes to science, going from blind faith to an open rejection, is fear. Therefore, a subject that does not "sound" exactly like science may make the audience feel more comfortable.

- My suggestion is to introduce astronomical concepts (no matter if they are basic or complicated, old or recent) using a collateral story, a topic of wide popular interest that is able to catch the public's attention.
- Everything related to magic or mystery offers the additional advantage of touching the human hopes, wishes, and emotions, making the speech closer to everyone's interests.
- Humour is also a powerful tool that contributes to demythologize the scientists and their activity, leaving aside the dogmatism, and helping to relax the atmosphere.

Astrology can be a good choice to satisfy this aim: it sounds similar to astronomy but, since it is not an actual science, it is perceived as easier and closer by the public; it uses astronomical terms, thus allowing us to explain their actual meaning. The speaker may easily approach the personal space of the listener, mixing up astronomical facts with the claims of astrology concerning the personality and future of people, most particularly about love. It is possible, by making use of humour and irony, to show how those assertions turn out to be ridiculed by their own contradictions; this is an added benefit that helps to educate the critical sense and to spread a healthy scepticism, both unfortunately in danger of extinction nowadays. Summarising, the proposed topic has the double aim of communicating astronomy with the public, and fighting against irrational beliefs that, like astrology, are sometimes presented as scientific knowledge.

MORE ON THE RESOURCE OF ASTROLOGY

As previously shown, astronomical outreach can be done on the pretext of discussing some astrological predictions. But astrology offers many other possibilities as well. For example, with the aim of finding the physical cause of the cosmic influences, "rankings" of gravitational attraction, tidal forces, emission of electromagnetic radiation or particles, and magnetism exerted by different bodies at the moment of birth can be elaborated. Of course, when carrying out the calculations, objects like the mother, the doctor, the hospital building, or the delivery room lamp must be taken into account, as well as satellites, asteroids, comets, and other bodies of the Solar System, including Quaoar, Sedna, and who knows how many more…

After demonstrating that none of the known physical influences is capable of explaining how astrology works, it is still possible to show statistical examples of clear astrological failures; for instance, a review of failed predictions concerning politics, economy, religion, society, or the absence of correlation between the sign and the profession, or the sign and certain personality characteristics. This would serve to popularise other scientific topics rather than astronomy, so I will not go deep into this point.

STILL ANOTHER ASTRONOMICAL EXAMPLE

In addition to astrology, let me present another astronomical topic that can also inspire a performance: the search for extraterrestrial planets. It has an undoubted scientific interest and, moreover, in the recent times it has appeared relatively often in the news, thus becoming a really 'hot' topic for the general public. The related young branch of science—Astrobiology—finally connects with the old human wish of finding (intelligent) life anywhere in the Universe, no less, so, attraction is guaranteed. There is a wide set of astronomical concepts that can be presented and explained within a text related to exoplanets:

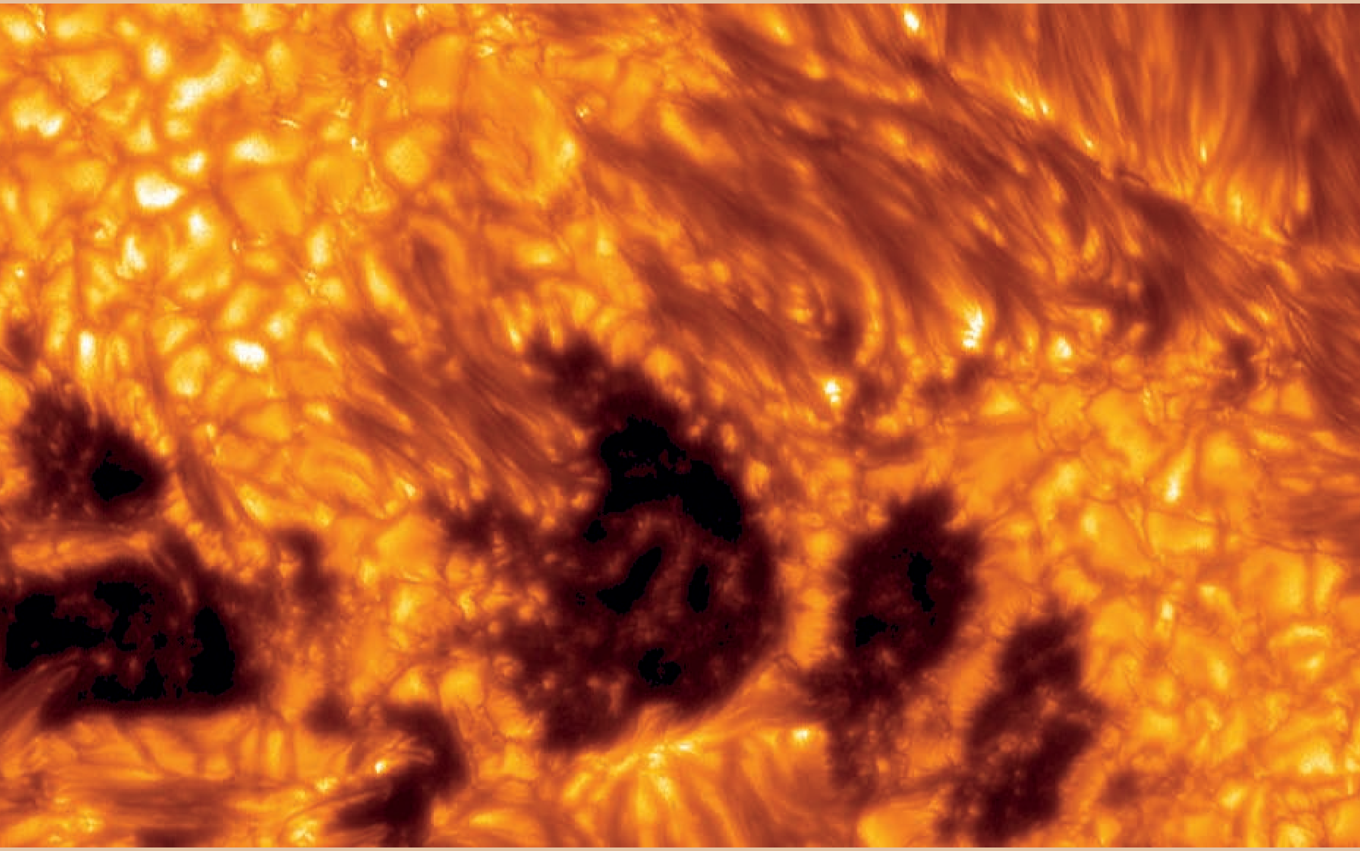
- the similarities and differences between planets of the Solar System and extraterrestrial planets
- the habitable zones in planetary systems, including concepts like stellar classification and evolution, albedo, planetary atmospheres, greenhouse effect, etc., and the conditions for life to appear
- the Drake equation, and the Fermi paradox
- the actual feasibility of intergalactic communications, discussed on the basis of the huge astronomical distances
- the enormous, but finite, speed of light
- its constancy, which results in the equivalence between time and space
- the concept that in looking at the sky, one is always looking at the past
- the feasibility of cosmic travel, which allow us to speak about actual space missions, their scientific goals and their technological development
- the SETI projects, its scientific foundations, and the multiple references in science-fiction literature, films, art, etc.

Rational discussion about the UFO phenomenon (misinterpretations of astronomical or atmospheric stimulus, ET visits, abductions, psychological and sociological aspects, etc.), may arise in a natural way. This is really necessary to compensate for the widespread dissemination of uncritical (and sometimes dangerous) information from journalists, writers, innocent 'witnesses' or not very scrupulous promoters, and even certain sects.

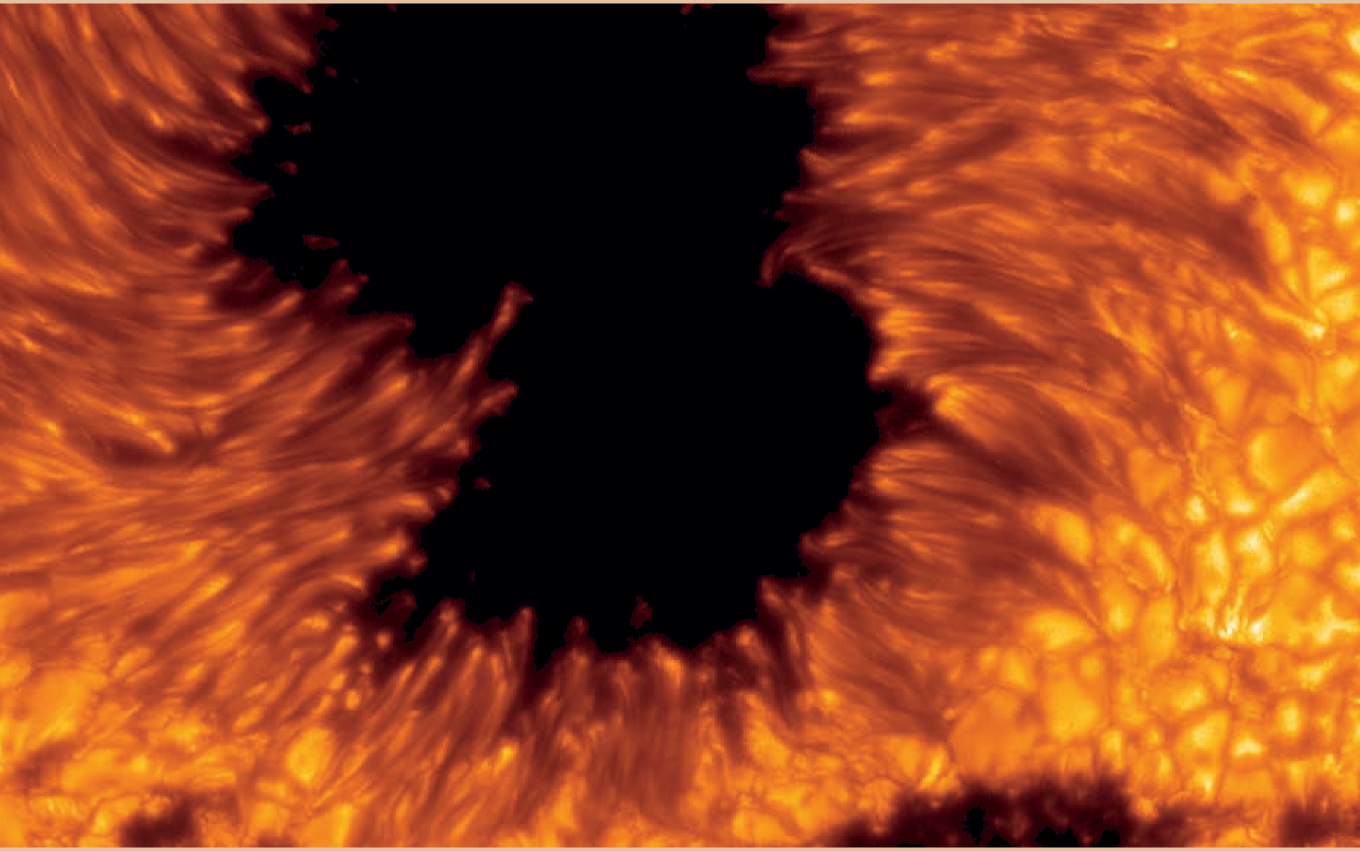
SUMMARY

Many astronomical notions can be presented by an actor/actress during a live performance based on an impromptu script. It should deal with a topic attractive to the general public, related to astronomy, but with a non-scientific dressing, with spots of humour, irony, and magic, hopefully contributing to the fight against the alarming persistence of irrational beliefs. Of course, these concepts could be presented in a very sophisticated documentary essentially based on spectacular images, with an explanatory text, but I suggest that this alternative type of communication, more unusual, but quite straightforward, appeals both to people's hearts and minds, and is also efficient.

Acknowledgements : I would like to thank my dear neighbour Jackie Zamora for her kind revision of the English translation of the original Spanish script.


Credit: The Swedish 1-m Solar Telescope, Royal Swedish Academy of Sciences

PLENARY SESSION 8:
Keeping our Credibility—Release of News



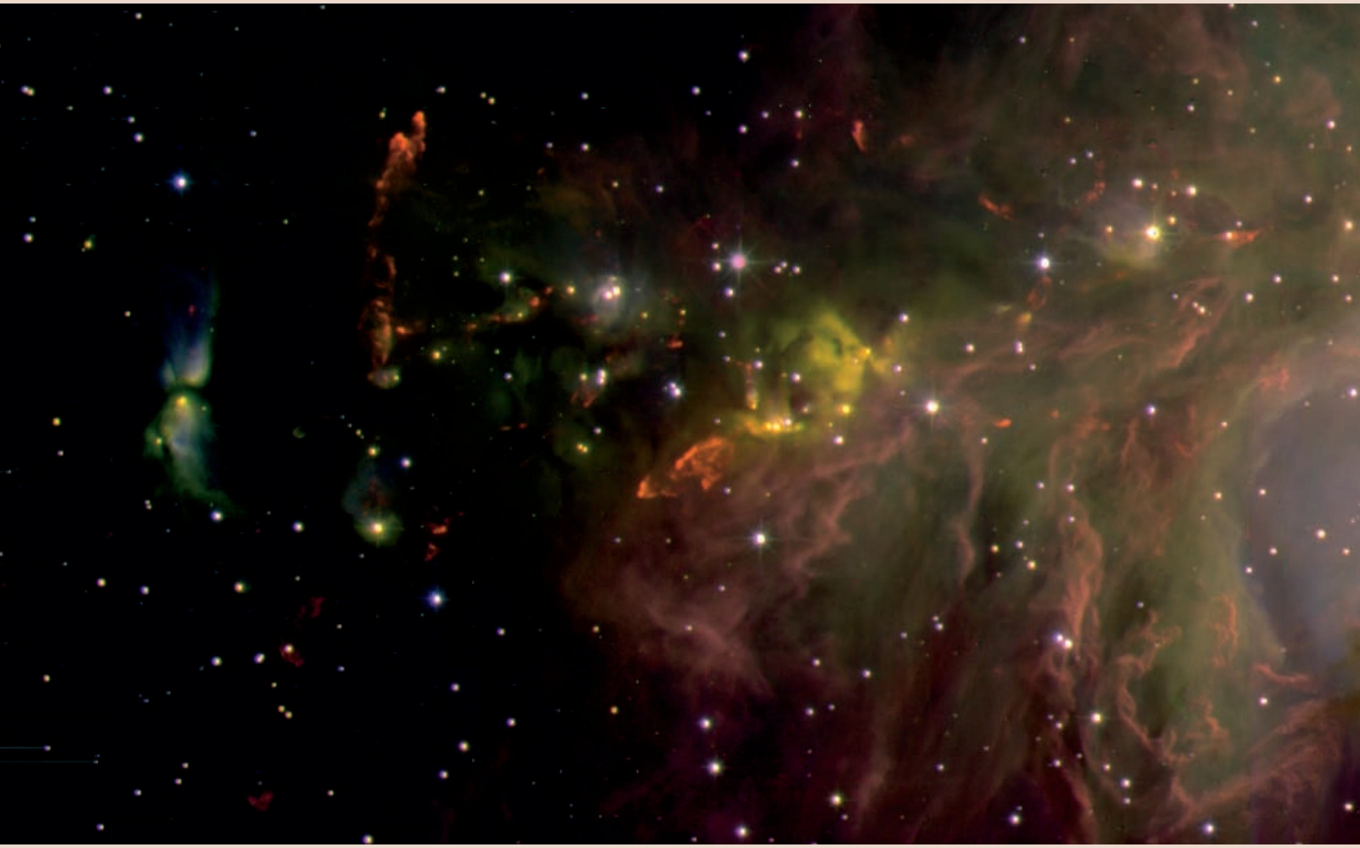
CREDIBILITY PANEL DISCUSSION

The Panel comprised Professor Paul Murdin (Chair) accompanied by Drs Catherine Cesarsky, Robert Fosbury, Claus Madsen and Dirk Lorenzen. To focus the discussion the following series of questions was posed at the outset:

How far can we, in the name of science communication, keep pushing, or promoting, our respective results or projects without damaging our individual, and thus also our collective credibility? The pressure is larger than ever, and the temptation for hype huge. Are comparisons between different projects of the sort "my scope is better than your scope" necessary? Do we really need scientific results to be peer-reviewed in advance of their public dissemination? Do we need internal political and scientific 'editorial boards', or is it just a kind of double-refereeing? How do we handle the really BIG discoveries (e.g. exo- Simpsons)? How do we treat the NEO threat? Why do press releases that are later proven wrong rarely get withdrawn? Is the time ripe to make a Code of Conduct for press releases that outlines recommended ethics and procedures for conflict resolution, analysis and retraction?

Catherine Cesarsky led off with a case study of an example of referencing (or not as the case may be) of data from earlier missions in papers and press releases, how that can cause conflict and how it should be undertaken. Bob Fosbury then discussed the differences in scientific language (and the use of caveats to show doubt) compared to the journalistic view that doubt is bad and certainty is a necessary requirement and gave a case study of how real scientific doubt is handled by an organisation in terms of a press release. Dirk Lorenzen considered how issues are handled, and how from his perspective as a journalist, he sees how the question, how big is 'big', is treated by scientists and press officers. One of the examples he discussed was the life on Mars issue. Claus Madsen looked at how information is distilled down into what finally appears in the media and in the event, what does 'accuracy' really mean to the public, as distinct to scientists. He gave an example of a totally inaccurate TV documentary programme that nevertheless went down well with the general public, who even got a reasonably correct overview of the subject in spite of it all. Paul Murdin then discussed the practice of science as a discipline and the body of knowledge that is science. He pointed out that the body of knowledge is far removed from the excitement of doing science, and the body of knowledge is now only understandable by the expert. Therefore human values need to be added back in when communicating with the general public and mistakes and errors need to be either taken on the chin or renounced, but that deliberate deceit must never be sanctioned.

A wide-ranging and lively discussion then ensued and can be enjoyed at the conference webcast:
http://www.communicatingastronomy.org/cap2005/programme.html



Credit: UKIRT, Joint Astronomy Centre

PLENARY SESSION 9:
The Education Arena

ASTRONOMICAL PILLS

One-shot questions about the Universe

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ABSTRACT

In the last two years, the Public Outreach & Education office (POE) of the INAF-Osservatorio Astronomico di Brera (Milano, Italy) has carried on an extensive survey (over 1300 tests) on the instinctive ideas that junior and secondary school students (aged 13-19) use when facing astronomical concepts. Students were asked to answer nine closed-answer questions and an open-answer one. They were only allowed a few seconds to make their choices. Our goal was to take a first step into the exploration of the naïve view of the Universe developed by students in the different age ranges. In particular we explored the evolution (if any) of some misconceptions with respect to age and other educational factors. In this talk we present a critical review of our work, highlighting the following points: "lessons learned", "what works and what doesn't" and "what can be learned" from our personal experience.

INTRODUCTION

The Public Outreach & Education office (POE) of the INAF—Osservatorio Astronomico di Brera (Milano, Italy) began a survey on the astronomical ideas and concepts held by junior and secondary school students in 2003. Two years of data collection and over 1300 tests have enabled us to take a first step into the idea of the exploration of the Universe as developed by school-age youngsters. We now present the preliminary results of this survey, stressing some aspects of our own personal experience.

Our goal was to explore the naïve view of the Universe developed by youngsters in different age ranges, mainly focusing on the general perception of the Universe, on distance and size, and how gravity works. In particular, we looked for the evolution (if any) of some misconceptions with age and at the role of socio-educational factors. We would like to stress that we did not aim to investigate the students' knowledge of science, but, rather, the spontaneous schemes and concepts used by youngsters when facing some basic astronomical ideas. We tried to rebuild the image of the Universe developed by youngsters over time using these schemes.

THE ORIGINS OF MISCONCEPTIONS

Why are we so interested in misconceptions? From childhood onwards, people create their own representation of the environment. These representations are based on perception, they are affected by social relationships and they are described by using informal language. This is what is known as the common-sense framework. For instance, if we rely only on our perception alone we would say that it is the Sun that moves around a still Earth.

However, schooling teaches us a very different representation of the environment. This is the rational scientific framework, based on logical abstraction, hypothetical-deductive reasoning and the use of formal language. Misconceptions are born when people try to combine common and scientific sense together. The process involves not only content knowledge, but, most importantly, thinking structures as well. New knowledge does not erase the pre-existing ideas by merely replacing them; rather, it modifies itself to fit the older conceptual scheme. This is a mostly subconscious process due to the fact that common-sense knowledge is more intuitive and more useful for solving daily problems than is the scientific sense. Furthermore, the process involves the emotional sphere: people simply like familiar ideas.

Misconceptions hamper the correct assimilation of new learning. By studying misconceptions, it is possible to understand better how people's minds work during the learning process and to improve educational strategies to provide a better assimilation of new concepts.

It is only in the last hundred years that the first analyses of children's misconceptions have been carried out following Piaget's theory about the phases of cognitive development. According to this theory, misconceptions are just a phase that depend only on the age of the child, and disappear from adults' minds at the end of cognitive development. However, modern theories provide a more complex framework. First of all, cognitive structures interact with learnt contents and produce resistant conceptual schemes which are almost completely unknown and ignored by teachers and educators. Moreover, social framework and educational level as well as age are involved in the process. This means that misconceptions do not disappear with age and, in fact, some studies highlight the fact that some misconceptions are difficult to eradicate and fairly predictable (e.g. Cavallini, 1995). This was confirmed by surveys that have been carried out to investigate teenagers' and adults' misconceptions since 1970 (e.g. Mayer, 1990).

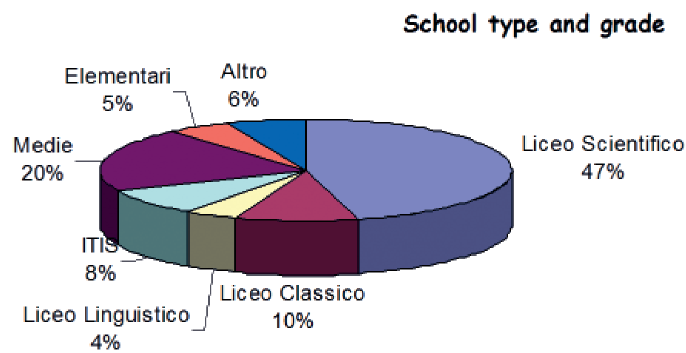
SAMPLE AND TEST FEATURES

Our work follows this line by studying misconceptions in the domain of astronomy. We think that astronomy is a useful field to highlight several misconceptions and to develop the capacity for abstraction essential for scientific knowledge.

We collected more than 1300 completed tests over a period of 2 years (2003-2005), consisting of 10 questions on astronomical topics, concerning the students' perception of the Universe, distance and size in the Solar System, properties of light and how gravity works. The study sampled students in different age ranges (13-19 years old) and from different types of school (see Fig 1).

To study the possible evolution of misconceptions with age, we considered three groups: 13-14 years old (last year of junior school) 14-16 years old (first two years of secondary school), more than 16 years old (last three years of secondary school). We also looked for differences between males and females for each age group.

Figure 1. *More than half of the schools involved were secondary schools (14-18 year-olds): 47% science-oriented, 10% literature-oriented, 8% technical-skills- oriented, 4% language-oriented. Then, junior schools (11-13 year-olds) follow with 20%.*



There were two versions of the test, administered at different times, so the same topics could be compared, and to see what bias (if any) is introduced by question structure. Therefore, the test consisted of closed-answer questions with multiple-choice on common- and scientific-sense and open-answer questions.

Students took the test as soon as they arrived at the observatory. We tried to put the students at ease by explaining the purpose of the test and by pointing out that it was not like a school test, starting with the fact that it was anonymous and was not going to be marked. Then, we asked them to answer questions as quickly as possible to let their spontaneous imagination come out. To allow their imaging to emerge more easily, questions were posed during informal conversations with students; moreover, in the open-answer questions we let students choose their favourite method of expression: images, words or both. We now present the results analyzed so far.

DATA ANALYSIS

Let us start with the question about the perception of the Universe. The analysis revealed the presence of similar answers, which were therefore grouped in categories. The most frequent answers were “infinity” and “objects”. The older the pupils, the higher the rate of “infinity” with respect to “objects”. In addition, we studied what kinds of objects and adjectives were chosen to describe the Universe and we found that the Universe consists mainly of planets, stars and galaxies and that it is perceived as big and dark (see Fig. 2).

We also collected drawings about the Universe. Their number is small compared with the whole set of data (about 15%), but we think they are representative of the perception of the Universe because they are consistent with the results previously described. Since the drawings do not vary between age groups, we could think of three possible age-independent scenarios.

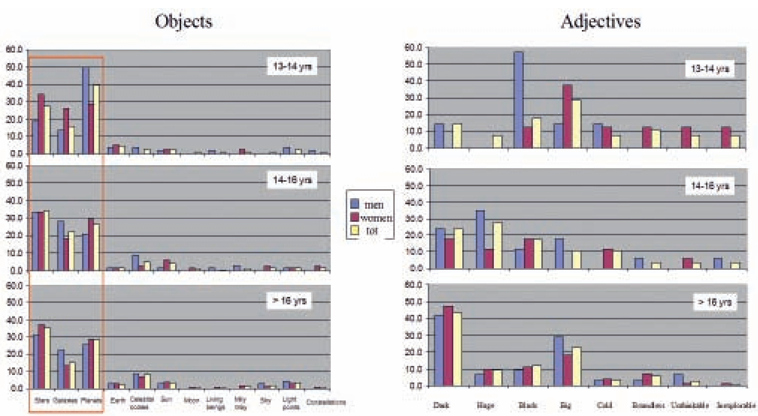


Figure 2. *Objects and adjectives used to describe the Universe in the open-answer question about the Universe perception*

1. The so-called “Cosmic Box” in which the Universe is perceived as a box of stars (point-like or traditional 5-pointed) and planets in a space, sometimes encircled by an edge. It’s worth noting that the Sun and stars seem to be perceived as two different types of objects.
2. The so-called “Solar System”, in which the Universe is perceived as equivalent to a Solar System with very small distances between same-sized planets. This is consistent with the literature: the Solar System as a sort of all-

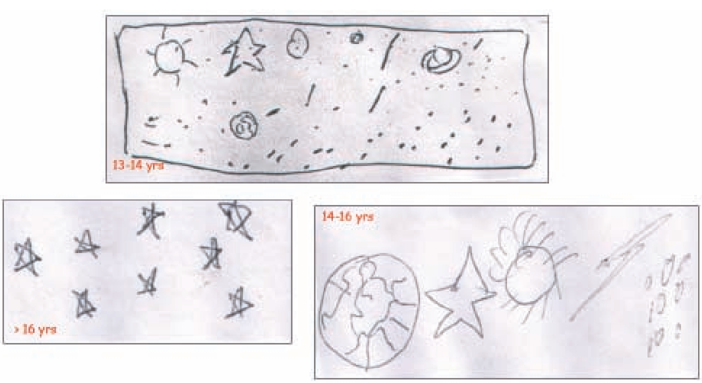


Figure 3. *The “Cosmic Box”. It is worth noting that the Universe is sometimes encircled by an edge and that the Sun and the stars are per**ceived as two different kinds of objects.***

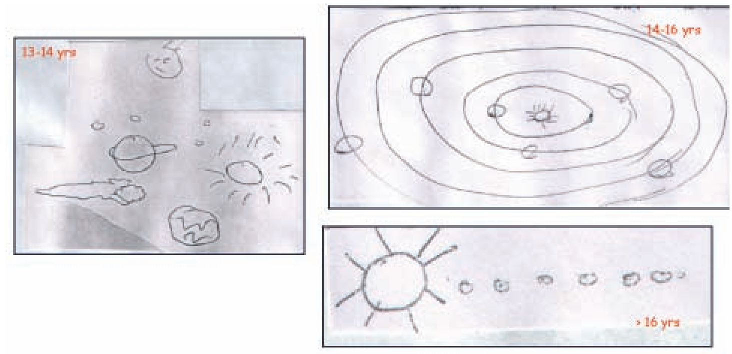


Figure 4. *The "Solar System". It is worth noting that all the bodies have the same size and that distances between them are very small.*

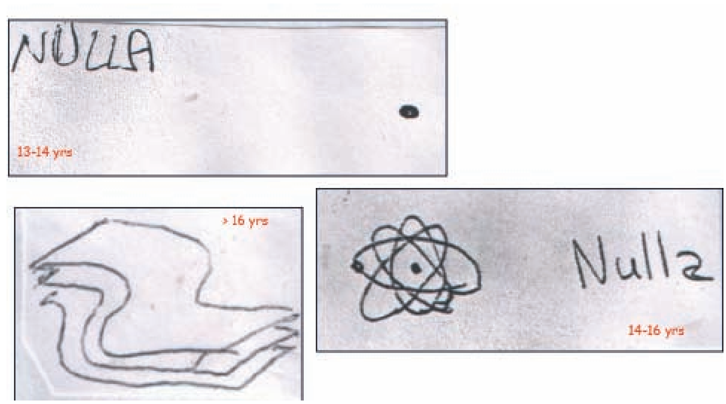


Figure 5. *The "Empty Expanse". In Italian nulla means "nothing".*

purpose astronomical box in which people put everything known about the Universe (Dussault, M., 1999, "How do visitors understand the Universe? Studies yield information on planning exhibitions and programs, *Association of Science-Technology Centers Newsletter*).

3. The so-called "Empty Expanse" in which the Universe is perceived as an empty space without any evidence of stars, planets or other features.

Then, we investigated the students' perception of distances in the Solar System and in the Universe with an open-answer question. For the size of the Solar System, the students had the correct idea about the order of magnitude; in particular, the majority of them indicated numerical values remarkably close to the correct one. On the other hand, there was a wide range of answers concerning the size of the Universe. We found this was true particularly of the older students, while the younger ones indicated values very close to the size of the Solar System. This is consistent with the "Solar System" scenario. Furthermore, we compared these results with those of the analogous closed-answer question and we found they were very similar. Therefore, misconceptions on distances do not depend on question structure.

Other misconceptions were not as difficult as we had thought. From the analysis of the open-answer questions described so far, students seem to know nothing about hierarchy in the Universe. Nevertheless, when they were asked a properly formulated closed-answer question, almost all of them were pretty sure that the Solar System belongs to a galaxy. The difference is striking because they seemed completely unaware of the discrepancy, even when we asked them to consider their different answers.

What is the cause of this discrepancy? There could be several causes. We think the use of specific language forms in a given framework plays an important role. In particular, the presence of keywords significantly affects the answers more than the actual knowledge the students have. Furthermore, subjects do not understand when discrepancies arise in comparing common- and scientific-sense frameworks until they are forced to combine them together in a common framework.

We investigated if students knew what gravity is by using formal language, such as the language that they might find in their textbooks (see Fig.6). As shown in Fig.6-A, three of the four answers on gravity are partially right. Except for the 10% of students who answered wrongly, most people seemed to have assimilated the concept of gravity. Moreover, the older the student, the more often the correct definition of gravity was given. Therefore, formal language affects secondary school students more than junior school ones. This result is consistent with the literature (e.g. Calcidese, P., 2002, L'Universo che non c'e'. Preconcetti e misconcezioni degli studenti in età adolescenziale nell'ambito della fisica e conseguenze sulle idee riferite all'origine ed evoluzione dell'Universo, *thesis*).

A

The gravity force is:
a) the force which makes the Sun attracts the Earth
b) the force which makes us fall
c) the interaction force between two massive bodies
d) the energy of a falling body

B

Bodies are near spherical because:
a) they spin around the Sun
b) the sphere is the perfect geometric shape
c) they spin around themselves
d1) all men stay with feet on the ground and head up
d2) make up your own answer

Figure 6. *Formal (A) and informal (B) language used in the question about gravity.*

On the other hand, another question about gravity, formulated in informal language (see Fig.6), showed the opposite result. In this case, very few people seemed to have assimilated the concept of gravity. The majority of them answered that bodies are nearly spherical because they spin around themselves. Furthermore, in an ensuing conversation, when asked whether the Earth was a perfect sphere, students immediately answered that it is not, because it is squeezed at the poles as a consequence of the Earth's rotation. Students were not aware of the discrepancy until they were made to pay attention to both their answers. So, it seems necessary to conclude that the use of formal and informal language in a given framework causes differences in the resulting answers. For instance, if the framework was perceived as school-like, students would choose an answer in formal language, like that required in classes, notwithstanding its contents.

However, the two questions about gravity were too different in structure to allow a direct comparison on language bias only. We tried to isolate the language bias by omitting just one single keyword in the correct answer statement. The compared results showed a completely opposite trend, as shown in Figure 7. In the test version containing the keyword (namely wavelength), the students seemed to know the correct answer confidently, whereas without the keyword they were totally confused. Therefore, we obtained evidence that language formalism significantly affects the subjects' answers irrespective of school grade.

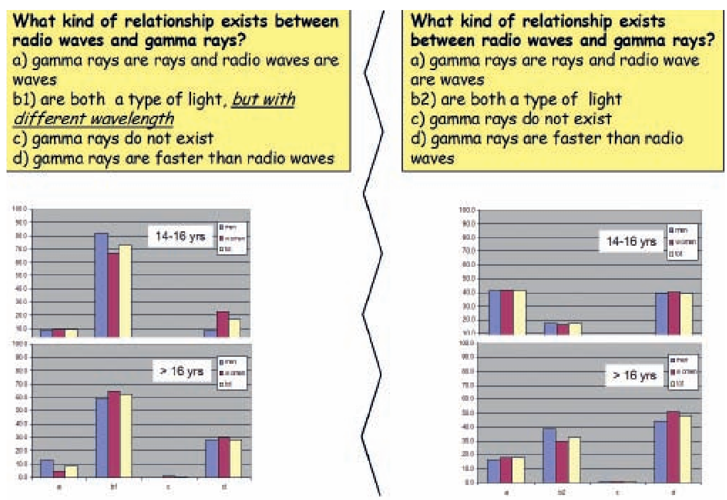


Figure 7. *Language formalism significantly affects the subjects' answers irrespective of school grade.*

LESSONS LEARNED

What have we learnt from our experience? The obtained results suggest that age and schooling do not modify the most basic ideas regarding the Universe. Moreover we did not find any significant difference between boys and girls.

Some misconceptions were demonstrated to be difficult to eradicate, while others are affected by the use of a specific language form. In addition, misconceptions are resistant to time: our results are very similar to those of surveys carried out 10-15 years ago (e.g. Cavallini, G., 1995, *"La formazione dei concetti scientifici. Senso comune, scienza, apprendimento", Firenze, La nuova Italia Editrice; Mayer, M., 1990, "Conoscenza scientifica e conoscenza comune. Analisi dell'incidenza di fat-*

tori scolastici ed extrascolastici nell'apprendimento della fisica", Roma, I Quaderni di Villa Falconieri, CEDE). Of course the method used to investigate common-sense knowledge could be improved, for instance, by considering smaller groups of students and by differentiating the test framework from the school framework. In fact, we had some evidence that the environment was perceived as school-like: for instance, some pupils tried to cheat by looking at their neighbour's answers. This was also probably due to the presence of their teachers or to the fact that the activity took place during school-time, even if located at Brera Observatory.

Finally, we are convinced that consistency in data collection and the method used is essential to make progress in the study of misconceptions and cognitive knowledge. In particular, it is important to enable educators to have access to sufficient data to make general theories, which are far more useful than isolated case studies based on individual surveys.

SUMMARY

The aim of this test was to study any spontaneous schemes and concepts about the most relevant ideas of the Universe developed by youngsters. In particular, we looked for evolution of some misconceptions over age and socio-educational factors.

We paid particular attention to concepts that seemed not to change with age and school grade, such as distances in the Universe. Moreover, no significant differences emerged from the comparison of males versus females.

Using a list of the main ideas about the Universe found in a school-age public, we tried to bring their background knowledge to the surface and see if it blocks the correct assimilation of new learning. We found that the use of formal or informal language in a given framework significantly affects the subjects' answers, by introducing socio-educational and emotional factors. In particular, this result has highlighted the fact that scientific and non-scientific knowledge are not combined together in our cognitive structures and that age and school grade do not modify pre-existing ways of reasoning.

Acknowledgments: A. Sandrelli for revising the English text.

SPACE EDUCATION:

A Lifeline to the Skills Shortage

Ian Jones

Orbit Research Ltd, UK Space Industry Best Practice Club, UK

ABSTRACT

There is a crisis in education relating to science, technology, engineering and maths (STEM). In the UK, universities are closing physics and chemistry departments in favour of subjects such as media studies. Astronomy and space science may hold the key to engaging and captivating new audiences who may go on to be the scientists and engineers of the future. Orbit Research Ltd is carrying out practical research and development to work cooperatively with teachers and pupils in schools, colleges and universities, and industrial partners such as ESA, the National Science Learning Centre and the UK Space Industry Best Practice Club to rekindle the sense of excitement that space science can bring. The research includes the development of a 'space education centre' where the aim is to link elements of current national curriculum science to contemporary space research and space missions.

INTRODUCTION

This paper addresses the issue of how space education might be a way forward to encourage more students to choose science, engineering and maths subjects for their studies both at university and in school. Analysis has already been carried out, in particular in a report, "SET for Success" by Sir Gareth Roberts. Relevant findings of this report are reviewed.

It is generally agreed that the subjects of space and astronomy can be used to engender a spirit of interest and learning in young people, and indeed these subjects are already covered within the formal curriculum in many countries. However, the material is often covered superficially or repetitively year on year—particularly because of the lack of specific knowledge of teachers, most of whom are non-physics specialists in primary or lower secondary schools. This in turn exacerbates the problem, and many potential engineers, mathematicians and scientists are turned off the subject by the age of 13 or 14.

To counter this problem, a new pilot project aimed at supporting both formal and informal education providers is proposed. The aim of the project is to develop links between education providers and industry to showcase space related careers as exemplars of exciting options for young people who are making subject choices. At the same time, we are developing a space education centre which is aimed at not only covering UK National Curriculum aims, but pushing new boundaries in interactive activities on space related themes.

UK NATIONAL SKILLS STRATEGY

In 2001 the Chancellor of the Exchequer in the UK commissioned a report into the supply of people with STEM based qualifications into the UK economy. It is considered to be a vital component of both the European and UK strategy to ensure that we remain competitive especially in relation to emerging technology regions.

Sir Gareth Roberts, Chair of the Science Council, undertook the review, and whilst he found that overall there was a small increase in the number of university places in these subjects, a more detailed analysis showed that the increase was in specific areas, such as microbiology and bio-engineering. Physics, traditional engineering subjects and maths are declining at an alarming rate. This is reflected through a wide age range with, for example, A-level physics entrants down 21% between 1991 and 1999, and PhD Physics degrees awarded down 9% from 1995 to 2000.

In the UK there is a shortage of specialist teachers in Physics and Maths and in general it is considered that the teaching laboratories for these subjects are inadequate. Courses fail to inspire students—particularly girls—and careers advice in these areas is poor. There appears to be a lack of correlation between young people's expectation of career prospects for these subjects and the actual situation. Physics, maths and engineering graduates are amongst the top economically active group. Many young people seem to believe that these subjects will limit their choice of employment and opt for more 'vocational' sounding degree subjects. In fact employers are very keen to employ STEM graduates because of their special understanding and capabilities.

For many young people, physics and maths are considered to be difficult options, which they feel will yield lower grades for them in their exams. When they consider that any degree will improve their prospects for getting a well paid job, they do not always receive advice that physics and maths would actually be a better option, because of the enhanced job opportunities such degrees bring.

A number of recommendations of Sir Gareth Roberts' report are now beginning to be implemented to address the falling number of STEM graduates, and space education projects can easily be seen to meet the requirements of these recommendations.

THE CASE FOR SPACE

Space and astronomy capture the imagination. People, young and old, retain a fascination with a quest for understanding of these subjects. Astronomy and cosmology push the boundaries of our understanding of the Universe, whilst space engineering and science provide our daily weather forecast, guide our holiday or business flight, warn us of an impending speed camera, and for many hundreds of millions, provide TV images to our living rooms from remote parts of the world. Space probes make discoveries about our solar system, and help us to understand and support our own planet.

Yet, the vast majority of the population now take all of this capability for granted, and have collectively forgotten about the technological achievements that have made it all possible. There are hundreds of niche technology areas, with highly rewarding (intellectually and financially) prospects for bright new graduates. Space Education is not just about the Sun, Moon and Earth; the motion of the planets and their generic properties; day and night; the seasons; or about the difference between geostationary and LEO satellites. It can be used to demonstrate many scientific laws, to explore ecosystems, to understand heat, cold, water, light, waves, communication, cooperation, languages, programming, planning, design, materials, and so on across many multilinked curriculum areas.

An excellent example of a space education project is the Starshine satellite project. Young people, from the age of 6 to 18, at schools and colleges throughout the world took part in polishing over 1,000 aluminium mirror blanks from their original rough cut to achieve an optically flat surface with a measured accuracy close to a single wavelength. The task in itself was exciting and informative, requiring precision work to be undertaken. Then the optical flats were sent to be assembled onto a satellite to create a super-reflective 'disco-ball' which was launched from the US Space Shuttle. Students were able to track the Starshine satellite as its orbit decayed in the rarefied upper atmosphere. Further science was carried out by determining the rate of decay in relation to solar activity—which has the effect of increasing the density of the upper atmosphere.

The students involved in this project will never forget their experience, and for those lucky enough to be involved, it will hopefully positively influence their outlook in relation to science and engineering.

The lessons learnt from this experience were that hands-on science is an excellent way of learning, and although the task of polishing a mirror is repetitive and laborious, the fact that the end-product would become part of a space mission added an incredible sense of awe in the minds of the participants. It enabled them to achieve far more than would normally be expected, and they were fully prepared to learn more too.

PARTNERSHIP APPROACH TO SPACE EDUCATION

Many organisations exist in the formal or informal education sector that can provide access to projects that promote science, engineering and maths through a range of space-related projects. Orbit Research Ltd has been working to build a relationship between some of these organisations to test out novel ways of developing solutions to inspire young people to want to find out more about STEM subjects.

Initially we were invited to take part in a programme funded by Yorkshire Forward, a UK government regional development agency, entitled 'Constructive Partnerships'. This project linked young people to local businesses, challenging gender stereotypes. We trained a group of Girl Guides and Scouts to take part in an international space competition.

Following this success, many other organisations wished to capitalise on the interest raised, and a number of other education partners joined the project. These included: local education authorities, where space-club activities were developed and supported; further work with Girl Guides and Scouts organisations, links with Science Discovery Centres such as Eureka were developed; the Children's University, where children can enhance their learning experience with fun, non-compulsory, after school activities. We also engaged with Aim Higher (an organisation promoting access to undergraduate courses), with teacher CPD (continued professional development) providers and SETNET (an organisation developing links between professional scientists, engineers and schools).

Within the space industry, we found that the European Space Agency and the Russian space programme had education programmes in their infancy, whereas NASA had a huge education machine with extensive resources (mainly aimed at the USA). It remains a challenge to engage with private industry to any significant degree, but we are exploring ideas for encouraging better links. Many organisations are happy to participate in low impact activities, such as site visits.

Astronomy, and visits to observatories is a challenge in the UK, but several excellent public outreach observatories exist, and new projects such as the Faulkes robotic telescope provide real time access to the night sky during school hours. The concept of developing loose partnerships between these organisations has worked extremely well so far, as many enthusiastic individuals see the huge potential that space education has to offer. Pilot projects carried out by partner organisations with their students have been universally successful and appreciated. There now remains a task to consolidate and expand these relationships, whilst maintaining the overall level of interest.

STAR CENTRE – A MODEL FOR REGIONAL SPACE EDUCATION

We developed the concept of a regional space education centre to provide a focus for the space education ideas we were developing, and a location to engage directly with our young audience. Working again with Yorkshire Forward and Keighley College (a further education college), we have created a relatively compact and low cost area containing a Mars floor, mission control room, science/engineering lab, teaching room, radio room and science dome (planetarium). The centre is fitted out to look like a space scene in order to enhance the visual impact.

The mission control room is seen as a key element of the centre. Software is being developed which, rather than being a tightly scripted system like some existing space education simulators, is based around elements including mission time line segments and timers, underlying spacecraft ephemeris data and telemetry data. This in turn can control open source planetarium software, orbital tracking visual displays and individual telemetry screens. The aim is to create a broad range of mission simulations to cater for a wide age range audience by means of diverse graded interface screens. As different education scenarios are needed, then new mission segments can be easily added to the software library.

On the Mars floor, remotely controlled robotic rovers will carry out experimental work under the guidance of students in the adjacent laboratory. The radio communication room contains amateur radio equipment capable of communicating with astronauts and cosmonauts onboard the International Space Station, and we have also made contact with former cosmonauts in Star City, Russia. This radio facility has sparked considerable interest in electronics and communication, and the centre has been able to apply for status with the Radio Society of Great Britain (RSGB) as a training and examination centre.

Over the next year, the plans are to encourage as many groups as possible to trial and test the space education resources that are being developed; to use this feedback to improve the range and specifications of the programmes, and to develop plans for new centres.

Funding and sustainability are always significant issues in any project such as this. We are carefully selecting low cost solutions that can be maintained by a body of existing teaching staff and technicians. We believe that this approach will have a highly positive impact on the long term survivability of any such centre.

CONCLUSION

Space Education is a potential key to reversing the alarming trend of declining student numbers studying physical science, engineering and maths subjects. Space and astronomy are perceived as exciting subjects, and so can also be enabling subjects linking other cross-curricular studies.

There are a wide number of organisations already engaged in space education, and a larger number who, judging by the enthusiasm we have encountered, will readily accept well developed education resources. They are willing to undergo professional development courses to enhance their skills in leading these activities. As government initiatives move to fill the well reported issues relating to skills shortages in STEM subjects, there will be opportunities to build better links between the education providers and industry.

The STAR Centre at Keighley College, UK is one such initiative that is seeking to develop new and innovative solutions to this problem which can be replicated in other regions with low start up and operational costs.

THE ROLE OF THE POPULAR ARTICLE IN ASTRONOMY COMMUNICATION

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ABSTRACT

Over recent decades there has been a proliferation of special-interest magazines dedicated to astronomy. In spite of the undoubted market for specialist feature articles on astronomy such articles appeal to a restricted sector of the general public and rarely appear in the daily or weekly press. I argue here that, apart from television documentary programmes and series, the general public's main exposure to astronomy-related stories is in the form of news reports, which carry too much information in too condensed a form for the general reader or viewer to absorb. I propose that, apart from education, trade books and documentaries, the only way to engage the serious interest of the public in astronomy is through feature articles published in wide-circulation newspapers and magazines. I further propose a generalized model for science communication and distinguish between *outreach* (to the general public), *midreach* (to astrobuffs) and *inreach* (the raising of awareness of the importance of outreach among the research community). Much of what is currently called outreach falls under midreach.

INTRODUCTION

In a standard text for documentary filmmakers Rabiger (Directing the Documentary, Boston: Focal Press, p. 9, 1998) states, 'At a higher level is a discourse—and this is equally true of narrative fiction—that aims not at conditioning or diverting but at sharing something in all its complexity.' Rabiger contrasts discourse with the coercive efforts of advertisers on the one hand and "binary" communication (the noncommittal coverage of "both sides" of every issue) on the other. Much of what Rabiger has to say in his general discussion of the role of the documentary can be applied to the popular article. In particular, he emphasizes the concept of authorship, the seeing of an issue through an author's eyes, as a way of engaging the audience in active discourse rather than feeding it fact after fact. "Complexity" is a tricky topic in astronomy communication. Some areas of research are so arcane that only a small group of researchers dedicated to that topic can really understand the issues. But most topics in astronomy need to be carefully explained if a general audience is to grasp the basic ideas. Astronomy communication takes place on many levels, and the intended audience must be identified and addressed in a way that is suited to its level of understanding. I begin with a review of audience types.

OUTREACH, MIDREACH AND INREACH: SOME USEFUL DISTINCTIONS

This conference—along with CAP I (Washington, D.C. 2003), the Arecibo meeting (2003) and the second half of the Tenerife meeting (Mahoney, T. J. [ed.] Communicating Astronomy, La Laguna: IAC, 2005)—has as its brief to find ways of improving our astronomical outreach efforts. To achieve this goal we need to be clear at all times at whom outreach is being aimed. To make progress it is essential to differentiate outreach from what is here called *midreach*; an outreach audience needs every technical term and concept explained, whereas a midreach audience (i.e. one that has some understanding of science in general and of astronomy in particular) will not. Hence, in popularizing astronomy, the communications techniques applied must be adapted to the level of astronomical awareness of the audience concerned.

In this paper I identify three broad audiences for astronomical communications: i) the general public, ii) the astronomically aware sector of the public and iii) the community of astronomers (professional and amateur). The three audiences are not mutually exclusive; for example, a professional astronomer will, to some extent be included in the first two groups by watching news coverage of science-related issues and reading such magazines as *Sky & Telescope* or *Astronomy Now.* I ignore audience (iii) communications, which are restricted to research papers, conference proceedings and observational reports in amateur journals, since these cannot be classified as either outreach or midreach. Instead, I shall consider this audience only as the target of inreach efforts (described below). I further identify three tasks that all of us dedicated to the communication of astronomy need to address: a) popularizing astronomy to the public (outreach), b) providing astronomical news reports and feature articles for the general astronomically aware audience (midreach) and c) convincing the community of research astronomers of the necessity to communicate the results of their work to a general audience (inreach).

OUTREACH: GETTING THROUGH TO THE PUBLIC

At meetings like this, we talk a great deal about outreach in the sense of getting the astronomical message across to the general public. I argue here that much of what we call outreach should really be classified as midreach since it is mainly for consumption by those who already have a keen interest in astronomy. Astronomy programmes on radio and TV, planetarium shows and star parties are undoubtedly outreach since they are consciously aimed at a non-astronomical public and their treatment often presupposes no previous knowledge of astronomy, but their effect is largely transitory since they provide no lasting means of raising the general level of public knowledge concerning astronomy: that is the task of education, popular books and feature articles. I discuss here the feature article in the context of other forms of outreach and midreach.

The term “general public” covers a wide range of audiences so it is useful to identify at least some of the subgroups that form this vast assembly of individuals. The public varies according to medium and genre. Prime-time TV programmes have a high entertainment content with an emphasis on spectacular graphics and images flashed on screen at a dizzying pace. But what about university-educated members of the public, graduates, say, in fields other than the sciences? These form a small but potentially powerful group. In the media, they will constitute the gatekeepers (Couper, H. Communicating Astronomy, La Laguna: IAC, p170, 2005,) —the people who decide what gets broadcast and published. They also make up the bulk of programme-makers, editors and journalists. Flashy graphics and breathtaking images alone will not impress such an audience, who will demand something to *think* about, something that challenges its intellect rather than non-stop audiovisual stimuli. For this public astronomy must be made to appeal to the mind and not merely the senses.

Whatever the kind of public, any initial interest sparked by a news report or television documentary, if it is to make a lasting impact, will need to be quickly followed up by the reading of feature articles and books, genres that allow the reader to mull over new and occasionally difficult concepts at leisure. As Rees (2001, Pantaneto, 1 http://www.pantaneto.co.uk/issue1/rees.htm) points out, ‘The place of science is in features and documentaries, rather than news.’ But an important point needs to be stressed here. Before the 1980s, the public depended exclusively on TV broadcasting companies and cinema distributors for the availability of audiovisual programmes and films. With the advent of the video recorder, internet and DVD recorders, the public have full control over what they view and when they view it. There are now instant pause and replay facilities; there is also software to edit and blend text, images and video sequences into personalized databases. Hence television, hitherto regarded by many as a poor information medium (Watts, H. On Camera: Essential Know-how for Programme-makers, London: Aavo, p. 18, 1999; Henbest, N. in Communicating Astronomy, La Laguna-IAC, p165, 2005), can now—by virtue of replay and editing facilities—make much more information available that can be supplemented by other media according to the viewer’s wishes. Viewing is no longer the serial experience it was a quarter of a century ago.

Members of the public who become hooked on astronomy in this way swiftly move into the midreach market, but they are a minority: for the great majority of the public astronomy outreach has but a brief impact. Increasing the general awareness of the public in science is a slow process ultimately involving the educational establishment. Outreach can enhance education but is no substitute for it.

MIDREACH: TALKING AMONG OURSELVES

While astronomical outreach, as defined in this article, still leaves much to be desired, I think it fair to say that what I am calling midreach has been considerably more successful, especially in recent decades. There is now a plethora of popular astronomy magazines on the market in many languages. Without a doubt, pride of place must go to *Sky & Telescope* with a global circulation of more than 100,000 (Fienberg, private communication). Since April 1987, the UK popular astronomy market has been served by Astronomy Now. Both magazines offer a similar blend of brief news items, monthly star charts and ephemerides, feature articles, book, equipment and software reviews, opinion columns and letters to the editor. Both magazines also have useful websites.

INREACH: GETTING THROUGH TO THE RESEARCH COMMUNITY

Two reasons often put forward to urge scientists to engage in outreach are the right of taxpayers to see how their contributions are being spent and the need for a scientifically literate electorate to decide on political issues involving science in a democratic society. Both reasons are praiseworthy, but neither is convincing. Taxpayers are rarely consulted on how their taxes are spent, and a scientifically literate population benefits almost any form of government, including dictatorships (to give just one example, the first artificial satellite was launched by a communist regime and was followed with great interest by the Soviet public (Kaplan, S. A. Kak uvidyet', uslyshat' y sfotografirovat' iskusstvenniye sputniki zyemli, Moscow: State Publishing House of Physico-Mathematical Literature, 1958)). Advocating outreach activities in the interests of good citizenship, then, will not cut much ice with overworked researchers busily seeking project funding or tenure. A completely different approach is necessary. The relatively recent exponential increase in the number of working scientists has led to the rise of overspecialization and consensus thinking (Kuhn's "normal" science; Kuhn, T. S. The Structure of Scientific Revolutions, 3rd edn, Chicago: UCP, 1996). Ulam (Adventures of a Mathematician, New York: Scribners, 1976) made the following interesting observation that could apply equally well to present-day astronomy: 'In mathematics one becomes married to one's own little field. Because of this, the judgment of value in mathematical research is becoming more and more difficult, and most of us are becoming mainly technicians.' Rees (2001) makes a similar point about the blinkered outlook engendered by overspecialization.

This tendency towards overspecialization makes it imperative for astronomers to describe their work – not only as outreach, but also in departmental reports, funding applications and even observing proposals—in terms that a non-specialist can understand. That's *mid*reach! It is equally incumbent on researchers to keep abreast of what is going on in other fields related to their own and in astronomy generally. Research journals are far too specialized for this purpose, although a small number of journals, such as *Nature* and *Science* offer a fairly highbrow form of midreach.

No researcher's astronomical reading would be complete without regular perusals of such magazines as *Scientific American*, *New Scientist*, *Sky and Telescope*, *Astronomy*, *Astronomy Now*, etc. But unless at least a small proportion of specialists address themselves to the task of doing midreach and outreach, there is a far from negligible risk of misrepresentation or oversimplification of the science under discussion. Who better to write about cosmology, say, than a working cosmologist?

Scientists need to realize the necessity of adequately publicizing their work and passing it into the public domain; however, 'The Washington Charter' (http://www.communicatingastronomy.org/washington_charter.html) places the responsibility for providing the wherewithal, time and training to do midreach and outreach on research centres. The Charter does not distinguish between outreach and midreach as is done here, but it is essential to be clear as to the type of audience being addressed.

MARKETS FOR POPULAR ARTICLES

Popular astronomy articles for the midreach audience have a wide range of outlets, ranging from the review columns of *Nature* to popular magazines such as *Sky & Telescope* and *Astronomy Now*. The readership ranges from research astronomers wanting to keep abreast of progress in other branches of astronomy to the astronomically aware general reader. Outreach, however, is an entirely different matter. Apart from news coverage, there are relatively few outreach articles on astronomy in the periodical press (Rees 2001; Madsen, C. in Astronomy Communication, ed. A. Heck & C. Madsen Dordrecht: Kluwer, p. 67, 2003).

NEWSPAPERS AND GENERAL-INTEREST MAGAZINES

In a study of the coverage of astronomy and space-science in the European print media, Madsen (2003) divides astronomy-/space-related articles into four categories: i) *space articles* (mainly coverage of space missions), ii) *'bona fide'* science articles (with an emphasis on new research results), iii) *'planetarium-type'* articles (principally covering positional astronomy and celestial mechanics), and iv) *other* (scientific controversy and the interface between science and other disciplines). My main concern here is with the last category, about which Madsen makes the following illuminating comment: 'In some sense, it is in this category that science "meets" other major human activities, and it is indicative that very few articles fall in this category.' In other words, precisely those areas where science connects with other disciplines and activities is where printed media coverage is weakest: in the quality press, then, the Two Cultures seem to be as divided today as they were when Snow gave his famous Rede Lecture (Snow, C. P. The Two Cultures, Cambridge, CUP, 1959). The feature article has an enormously important role to play in getting astronomy and the other sciences to cross the cultural divide and earn their rightful place in mainstream intellectual thought. I discuss this disastrously neglected issue in a later section.

THE VANISHING MIDREACH FORUM IN PROFESSIONAL ASTRONOMY

In recent years astronomy has suffered the irreplaceable loss of three culturally invaluable midreach journals with the disappearance of *Vistas in Astronomy*, the *Irish Astronomical Journal* and the *Quarterly Journal of the Royal Astronomical Society*. *Vistas* was transformed into a no-nonsense refereed research journal (*New Astronomy*) and *QJ* was supplanted by its glossy successor *Astronomy & Geophysics* (later abbreviated to *A&G* – attention span diminution, it seems, has become a problem even among the learned!). The forum for the discussion of astronomical culture has shrunk correspondingly. *A&G* articles are shorter than their more expansive *QJ* predecessors, and the mission statement in the first issue the new magazine (A&G 1997, 35, 5) expresses an increased demand for formality on the part of its authors and an emphasis on authoritativeness (i.e. consensus thinking) in comparison with the more relaxed requirements for *QJ* (see Bondi, H., Ovenden, M. W. & Dewhirst, D. W. QJRAS, 1, 3, 1960).

PUBLIC ATTENTION-SPAN ATROPHY: MYTH OR REALITY?

A small digression on the supposedly ever narrowing public attention span will provide a useful insight into the potentially destructive influence of purely profit-motivated market forces on the communications media. Once again, the type of audience must be taken into account. British television perfectly illustrates the full spectrum of programming content and style. At the top end are the excellent Open University (OU) programmes that provide audiovisual support to the OU's wide range of undergraduate courses. A maths programme, for example, might take the student through a lengthy derivation. The viewership is tiny compared to those of soaps and shows, and the audience is credited with a sufficiently long attention span to be able to follow difficult mathematical arguments.

The *Horizon* programme, the flagship of the BBC's science broadcasting, is midreach in style but has recently moved more downmarket. Scientists are encouraged to put their story across in a way that will interest their peers and appeal to a thinking lay audience at the same time. Audience attention span used not to be considered a problem, although the pace of some recent programmes has deliberately been made snappier.

Henbest (2005) informs us that a well-known American TV channel insists on a "wow" fact every 90 seconds and a stunning visual every three minutes, the reasoning being that failure to stimulate continuously will prompt the audience to zap to another channel. How justified is this assumption? It is worth pointing out (Henbest, N. in Astronomy Communication, p. 55, 2003) that Carl Sagan's 13-hour long *Cosmos* series, in which Sagan presents lengthy chains of verbal and visual reasoning, often with not a single wow fact or stunning visual in sight, has been seen by 500 million viewers in 50 countries. Indeed the series is still available on DVD. While Henbest recognizes the continued impact of the more traditional science programme (the BBC's *Horizon* being perhaps the supreme example), he cites the pressure on makers of programmes for commercial TV from the high-impact visuals and graphics in cinema films, TV adverts and the superb images and graphics being generated by the astronomical community itself. Henbest further cites the apparent truism that television is not an information medium.

But is television really such a poor communicator of information? Soaps are among the most popularly viewed television series worldwide. Couper (1995) reports that in 2001 the average British viewer watched 99 hours of soaps (almost the equivalent to watching Sagan's *Cosmos* series seven times in a single year). There is undeniably a dearth of wow facts and stunning graphics in the average soap, yet multitudes of viewers are hooked and forget to zap. What is it that draws so many viewers to this sort of programme, but that causes them to zap continuously for others?

Couper claims that viewers are drawn by human interest stories. In soaps the plots can have many evolving story lines involving numerous individuals and events. Yet multitudes of dedicated viewers seem to be capable of following all the complexities of character and plot during individual episodes and throughout entire series. Soaps contain a wealth of information – admittedly all fictional and non-technical, but information none the less. Even so, in spite of the high fictional information content of soaps, there does not seem to be an attention span problem. Couper is undoubtedly right in her claim that television viewers are largely attracted by programmes that tell a human story. People possess an enormous store of knowledge concerning people.

Such, however, is certainly not the case for science, mathematics, economics, politics or law. Unless we pay close attention to the contents of a news bulletin, we are not very likely to retain more than a scrap of the barrage of information thrown at us in a very brief period of time (although news stories involving scandals or tragedies are more easily retained since we process them with reference to our personal experiences and knowledge of human society). Successful outreach must therefore emphasize the human interest that is inherent in the profoundly human activity of science. This was brilliantly done in the dramatization of Dava Sobel's *Longitude*, which, far better than the book itself, gave an extremely moving account of Commander Rupert T. Gould's struggle to restore Harrison's timekeepers (Gould, R. T. Q. J. Soc. Naut. Res., 21, 1935: Sobel, D. Longitude, London: Fourth Estate, 1996).
It is important to stress that even the most elementary terms, such as light year,

must always be explained as though the reader or viewer had never heard of it before. Strong use must be made of simile and metaphor (see Rodríguez Hidalgo, I. 2005, in Communicating Astronomy, p. 172, for an interesting discussion of the problems of radio outreach). The distinguishing feature of outreach is that we must always start from the beginning.

THE IMPORTANCE OF THE FEATURE ARTICLE IN BRINGING ASTRONOMY TO THE PUBLIC

News reports provide the greatest source of astronomy-related stories. The impact of Comet P/Shoemaker-Levy 9 on Jupiter in July 1994 and the transit of Venus on 8 June 2004 both produced a flurry of intense media coverage. Regular celestial events such as meteor showers and eclipses also draw considerable media coverage, which instantly dies down when the event has passed. Nearly all the coverage, although variable in quality, is sympathetic towards astronomy.

Much rarer are feature articles and programmes dealing in depth with an astronomical issue. Background stories are occasionally produced in conjunction with major celestial events such as transits of Venus. Feature articles not related to specific celestial events are very much less frequent, a recent exception being a feature that appeared in the *Sunday Times* News Review on 5 June, 2005 (Appleyard, B. Sunday Times News Review, 5 June, 7, 2005). The story dealt with a simulation of the formation and evolution of galaxy and quasar clusters reported in *Nature* (Springel, V. et al. Nature, 435, 639, 2005). The article describes the small-sample problem of cosmology (only one universe to play with) and the resurrection of Einstein's cosmological constant in the guise of dark energy. The treatment is light but a genuine attempt to put the basic scientific case across in the 1500 words of text. Unfortunately, the 390-centimetre squared colour image of the simulation has a brief one-line caption that talks about Einstein's greatest blunder possibly being his greatest triumph but does not explain the meaning of the image, which looks more like synapses linking the neurons of the brain than anything to do with galaxies or quasars. A puzzled reader might well wonder whether the editor has got the illustrations mixed up. How much more informative might the image have been had it been slightly reduced in size to allow for a quarter of a column of useful description of the way in which galaxy clusters distribute themselves into vast filaments and sheets. Sadly, in an otherwise informative and interesting article, a large, unexplained image succeeds only in conveying zero information to the general reader. The article is introduced by a trite headline ('By Jupiter, the scientists were right') and a cryptic introductory sentence ('The simulated universe has confirmed a dark truth, says Byan Appleyard'. However, these elements are designed to be eye-catching rather than informative (the same principle is used in magazines such as *New Scientist*).

According to Madsen & West (in Astronomy Communication, p. 3, 2003), *'In terms* *of public communication, images may sometimes be self-explicatory or at the most demand a short and simple caption.'* Yet astronomical images have a long tradition of misleading even astronomers. When Sir William Herschel discovered Uranus he mistook it for a comet. Herschel also discovered planetary nebulae, but at first took them to be distant congeries of stars (Herschel Phil. Trans., 75, 213, 1785): *'We can hardly find any hypothesis so probable as that of their being Nebulae; but then they must consist of stars that are compressed and accumulated in the highest degree.'* Further observations eventually persuaded Herschel to change his mind and declare planetaries to be true nebulosities (Herschel, Phil. Trans., 81, 71, 1791). Herschel was, of course, working at the limits of ocular detectability and customarily used extremely high magnifications, making his images blurred and faint. The point being made here is that even Herschel, widely recognized as the greatest telescopic observer in astronomical history, occasionally failed to interpret astronomical images correctly. The Kant's "island universe" hypothesis regarding what are now known as galaxies was not finally established until 1924 when Hubble observed Cepheid variables in three spiral "nebulae" (see Hubble, E. The Realm of the Nebulae, New Haven: Yale Univ. Press, p. 28, 1936). Pre-photographic telescopic observations of spirals had previously given rise to the suggestion that they might be gaseous whirlpools in the process of forming planetary systems (see North, J. D. The Measure of the Universe: a History of Modern Cosmology, Oxford: Clarendon Press, p. 7, 1965). Astronomical images must *always* be adequately captioned and fully explained in the narrative. Images that do not receive this treatment are simply a distraction.

The basic problem with astronomical images is our lack of depth perception on the cosmic scale: what in reality occupies vast expanses of space appears to us in two dimensions with depth projected on to the flat surface of an image. To borrow a term from photography, in astronomy everything is "at infinity". In a terrestrial context, humans have a well-known capability of deprojecting two-dimensional images of three-dimensional objects and even possess the ability to rotate a projected image mentally by comparing two images of the object taken from slightly different angles (Shepard, R. N. & Metzler, J. Science, 171, 701, 1971). In astronomy, however, deprojection can normally only take place, and then only indirectly and not always unambiguously, with the aid of spectroscopic analysis. The position and motion of parts of an object along the line of sight are often difficult to ascertain; for example, Oort (Ann. Rev. Astron. Astrophys., 15, 295, 1977) interpreted various expanding neutral hydrogen features within a few kiloparsecs of the Galactic Centre as being the result of a central explosion, although he admitted that the effect could be caused at least in part by some sort of resonance effect. Nowadays this phenomenon is generally recognized as gas streaming brought about by the gravitational potential of the Galactic Bar.

The Universe beyond the Earth's atmosphere is entirely alien in nature: the distances involved dwarf the imagination: the extremes of temperature, density and gravitational attraction are entirely beyond our everyday experience on the surface of this planet. Astronomical images can therefore sometimes be extremely uninformative (or even misleading) when presented in the absence of context. Most astronomical images – however spectacular and eye-catching they may be—will need a great deal of verbal support from a communicator if their content is to be made at all comprehensible to the public. A stunning telescopic image by itself will often convey little useful information to the uninitiated: in astronomy, it is words—not pixels—that do much of the painting.

A GENERALIZED MODEL FOR SCIENCE COMMUNICATION

Models are useful in understanding methods of communication. A useful model should be capable of describing a given situation and suggesting the possible results of various strategies. Several communication models are described by Madsen (2003), including Madsen's own sophisticated model, which consists of overlapping constituencies, the overlaps representing the actual communication process, set against a background of public discourse. This model may be taken further to provide a generalized model of science communication with both descriptive and predictive power. A generalized model (for which no claims to originality are made) works as follows:

Each *constituency* (astronomers, peers, funding agencies, media, public) is represented by a *node*, which is part of a *network*, and which is joined by *bidirectional channels* to all the other constituencies.

- The topological properties of this setup enable any constituency to be placed at the centre of activity, thus adding flexibility to the model and allowing communication to be viewed from the perspective of any given constituency.
- The entire network is set against a *shared cognitive background.*
- Shaded *area* of *activity*, or *focus,* encloses the communications activities of the central constituency, the intensity of the shading indicating the level of activity.
- The area of activity will have its own *communal cognitive background*.
- There is one *medium of communication:* language. The "media" (i.e. the commonly used term for newspapers, magazines, TV, radio, the internet, etc.) may be represented either as individual nodes or generally by a single node; they are regarded in the model as constituencies rather than channels).
- Acts of communication occur among constituencies via interlinking channels.

This model has the advantages of a non-hierarchical structure (i.e. it makes no prejudgements concerning the relative importance of the various constituencies), flexibility of perspective, bidirectional flow of communication (the constituencies may be seen as sharing information), no periphery (no node is really central) and a common cognitive background for all the constituencies. The number of nodes may be varied in different studies, ranging from general outreach to detailed analysis of, say, research publishing. The common cognitive background will vary accordingly. For descriptive purposes, reality is injected into this idealized picture by placing a given constituency in the central node and adjusting the directionality of the channels. The gradually shaded area of activity describes a given constituency's communications profile for different types of communication.

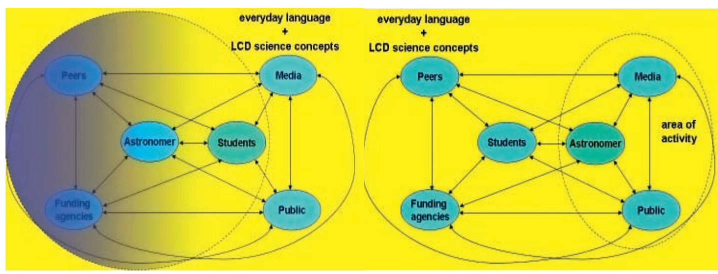


Figure1: *Right: An astronomer's professional communications tasks; right: An astronomer's outreach and midreach communications tasks.*

Figure 1 left shows the research communications profile of an astronomer; the area of activity indicates a large burden of research and a lighter PhD student supervisory load. The communal cognitive background will be the language and practice of astronomical research. The bidirectionality of the arrows suggests genuine communication among all the constituents. The perspective is that of the astronomer, but any other node could be made the central one to find the perspective of any given constituency (for example, from a PhD student's perspective the astronomer-student arrow might be perceived as uni-directional, indicating a little feedback to the student, a situation that would need to be remedied). If the astronomer engages in outreach and midreach, his focus will be shifted (Figure 1 right) to denote a different set of constituents (this time including the public and the media). The communal cognitive background will approximate very closely to non-numerate, non-scientific general knowledge.

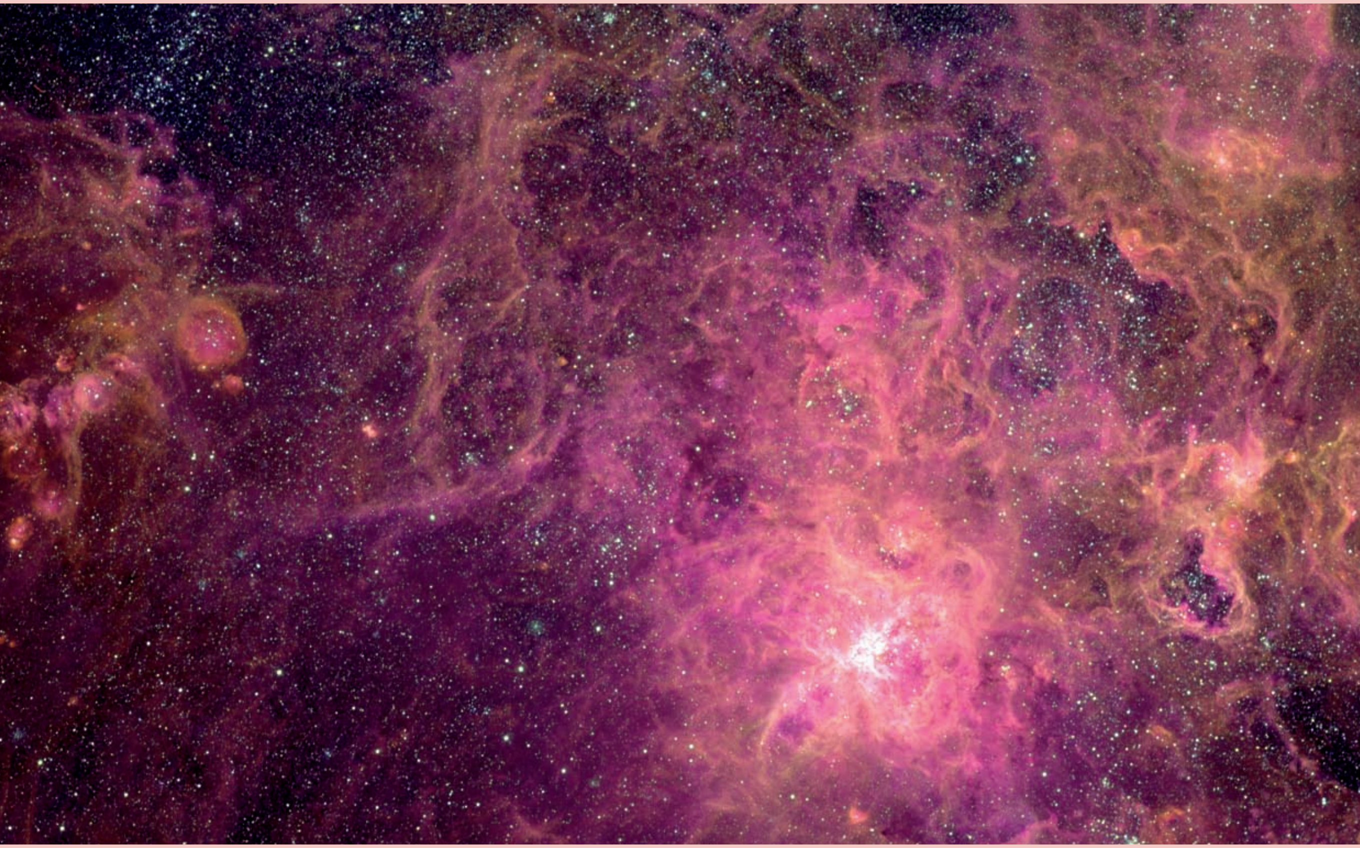
The model shows why outreach and inreach are different in degree and kind. An outreach audience will need every scientific concept described afresh since the common cognitive background does not reach beyond the lowest common denominator of general knowledge in questions of science. However, for an audience educated in areas other than science, the common cognitive background will include a sophisticated level of reasoning, so that the level of discourse may be correspondingly higher (as might be done, for example, in a trade book or feature article). Two examples of influential trade books aimed at this level are *The First Three Minutes* (Weinberg, S. London: André Deutch, 1977) and *The Selfish Gene* (Dawkins, R. 2nd ed, Oxford: OUP, 1976). For a midreach audience the discourse is at a higher level with a shared background of basic scientific knowledge and numeracy. The history of astronomy provides a fairly high level common cognitive background, interfacing as it does with many aspects of the humanities and is an area that could be developed much further.

CONCLUSIONS

A useful rule of thumb for the use of images and graphics in astronomy communication would seem to be to accompany every image/graphic with a brief explanatory caption to be followed up in detail in the body of the narrative. Uncommented imagery often mystifies readers and viewers and diverts attention from the message of the narrative. The aim of a feature article or documentary should always be to engage minds, rather than just fill the collective cranium with glitz and decibels.

The educated sector of the public is ill-served by the outreach community, as has been identified by Rees (2001). The dearth of feature articles needs to be addressed; trade books, feature articles and documentaries that tackle issues in depth and seriously would undoubtedly find a market. At least some of this outreach must come from the professional community and preferably not in the form of press releases.

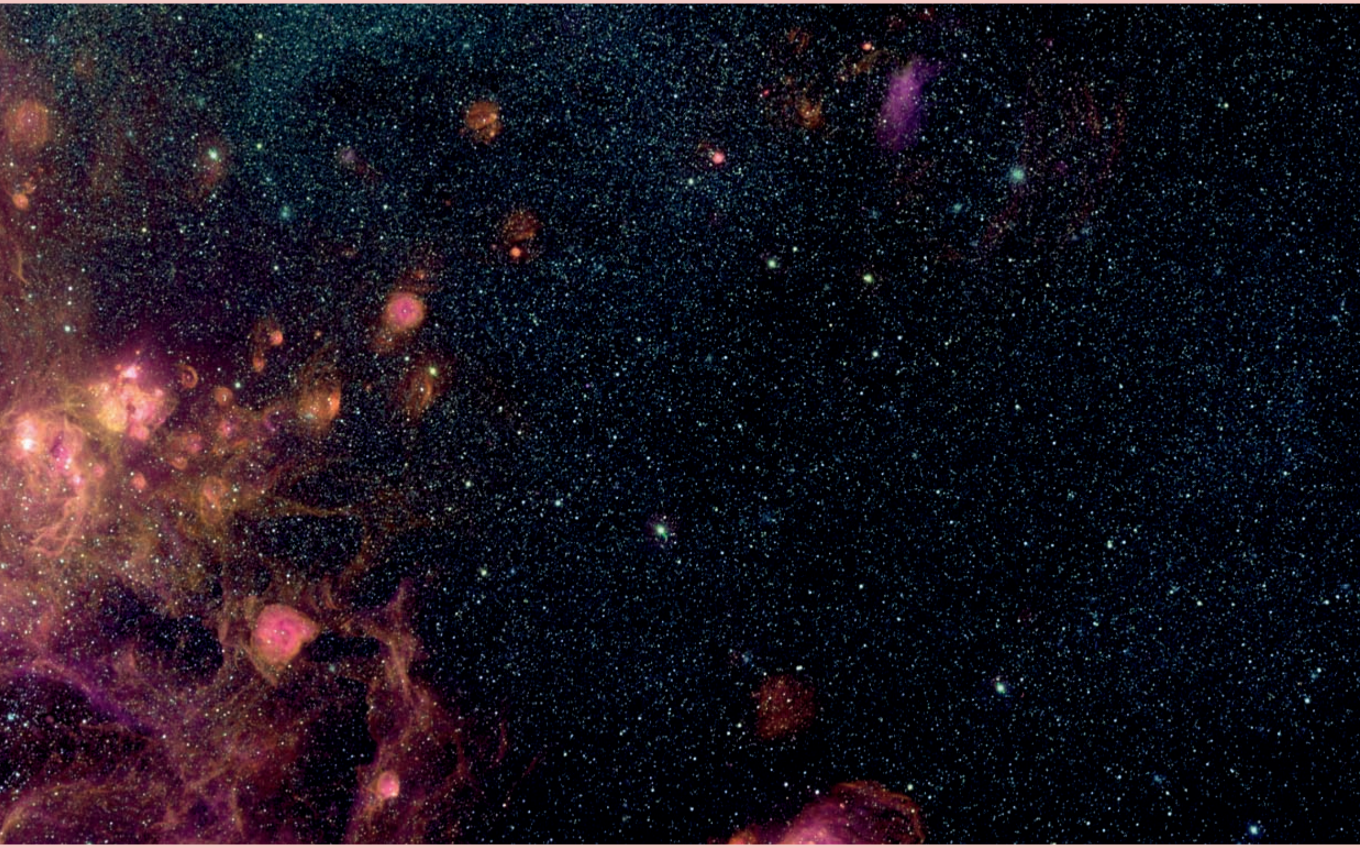
The generalized model suggested here provides a flexible way of describing communication setups and identifying problem areas and will be developed in a future paper. It makes clear the necessary distinction between outreach and midreach.



Credit: Curtis Schmidt Telescope, S. Points, C. Smith, R. Leiton, C. Aguilera and NOAO/AURA/NSF

PLENARY SESSION 10:

Astronomical Images—Beauty Is in the Eye of the Beholder



PHILOSOPHY FOR THE CREATION OF ASTRONOMICAL IMAGES

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ABSTRACT

The quality of modern astronomical data, the power of modern computers and the agility of current image-processing software enable the creation of high-quality images in a purely digital form. The combination of these technological advancements has created a new ability to make colour astronomical images. These programs use a layering metaphor that allows for an unlimited number of astronomical datasets to be combined in any desired colour scheme, creating an immense parameter space to be explored. A philosophy is presented on how to use scaling, colour and composition to create images that simultaneously highlight scientific detail and are aesthetically appealing. This philosophy is necessary because most datasets do not correspond to the wavelength range of sensitivity of the human eye. The use of visual grammar, defined as the elements that affect the interpretation of an image, can maximize the richness and detail in an image while maintaining scientific accuracy. By properly using visual grammar, one can imply qualities that a two-dimensional image cannot show intrinsically, such as depth, motion and energy. In addition, composition can be used to engage viewers and keep them interested for a longer period of time. The use of these techniques can result in a striking image that will effectively convey the science within the image to scientists and to the public. Details of the pictorial examples used are presented in the conference web-proceedings and webcast.

INTRODUCTION

For many decades astronomical colour images have been generated using large-format photographic plates and traditional darkroom techniques, (e.g. Malin, D. Royal Astron.Soc.Quart.Jrn. 33, 321, 1992). In the early 1980s, charge-coupled device (CCD) detectors began to replace photographic plates as the instrument of choice for astronomical research. However CCD arrays lacked the number of pixels necessary until recently to compete with the fine grain of photographic plate emulsion. In recent years CCD detectors have grown in size, the physical size of pixels has decreased and mosaics of CCD arrays have been implemented in many instruments. The large numbers of pixels in these cameras now allow high-quality optical images to be generated in a purely digital form.

Furthermore, the continuous improvement of imaging capability in non-optical windows of the electromagnetic spectrum has enabled the creation of high-quality images at other wavelengths as well. Historically, astronomical images have been made by combining greyscale images taken through red, green and blue optical filters. But often images are made from datasets that are either outside the optical window or do not match the characteristics of the colour-detecting cones in the human eye.

The development of advanced astronomical instrumentation has been contemporaneous with the advancement of computing power and, in particular, digital image-processing (IP) software for commercial applications. These IP programs, e.g., Adobe Photoshop, Photoshop Elements and The GIMP, offer unprecedented power, flexibility and agility in digital image generation and manipulation. The combination of these technological advancements has led to a new ability to make colour astronomical images. And in many ways, it has generated a new philosophy in the creation of these images. No illustration of this is more apparent than the "Pillars of Creation" image of the central region of the Eagle Nebula (M16), with the *Hubble Space Telescope* (HST) [Hester, J. & Scowen, P. 1995 "Embryonic Stars Emerge from Interstellar 'EGGs,'" STScI Press Release 1995-44.]. This image demonstrated the tremendous resolution of the HST Wide-Field Planetary Camera 2 (WFPC2) camera. It also showed how narrow-band imaging can change our view of an object. It also demonstrated how colour schemes can be used to imply depth, motion and texture in an astronomical image. Just as importantly, it illustrated how effectively such images can inspire the public and generate enthusiasm for astronomy in general.

PROCEDURE

Generating a colour image can be distilled into the following steps: (1) intensity scaling and projection of each dataset into greyscale images; (2) importing the datasets as layers into an IP software package; (3) assigning a colour and intensity rescaling to each layer; (4) fine tuning the image, which includes overall colour balance, the cleaning of cosmetic defects, and orientation and framing; and (5) preparing the image for electronic distribution and print production. Prior to image generation, it is also very important that your monitor is colour calibrated and a colour management workflow is established. These techniques are described in detail in Rector et al. (http://arxiv.org/abs/astro-ph/0412138).

More than one dataset, and preferably at least three, should be combined to produce a colour image. A dataset is defined as a two dimensional image of a particular waveband, polarization or other distinct characteristic; e.g., an optical image through a single filter, or a radio image at or in a particular waveband and/or polarization. These techniques are designed to take advantage of the distinct structural information in each dataset for which they were obtained. For comparison, a popular technique among amateur astronomers is known as the LRGB method, (e.g., Gendler, R. “Astro Imaging—Creating High-Resolution Colour CCD Mosaics with Photoshop,” Sky & Telescope, August 2003, pp. 130-134 2003), wherein an image is first generated in the traditional “natural colour” scheme from datasets obtained through red, green and blue filters. To improve the image quality, an unfiltered, “luminosity” image is added that lacks colour information but has a higher signal to noise ratio. This technique is well suited for small aperture telescopes because most objects are limited by relatively poor signal to noise. The LRGB method is effective for decreasing the noise in an image, but results in a loss of wavelength-specific structural information. This method is not well suited for use with scientific data, which is rarely obtained unfiltered. Indeed, narrow-band observations are obtained specifically to increase the contrast between emission-line and continuum-emission regions of an object. Thus the quality of an image can actually be improved by the exclusion of particular wavebands.

PHILOSOPHY OF IMAGE CREATION

Historically, a small percentage of telescope time has been used to create public outreach photographs to appear in the news, textbooks and magazines. However photography is now rarely used; and currently two other sources for outreach images dominate. One source is images from research data that are directly provided by individual astronomers or by image-making teams. These images are created with the specific intention of being released to the public. In the other case, institutional news and public relations teams appropriate images and figures that were created by scientists with the sole intention of communicating to their colleagues. These images are often released to the public stripped of their captions and therefore lack a guide as to how to understand them. It is particularly this latter case that makes the issue of how images are constructed, and subsequently interpreted by the non-expert, of relevance to astronomers.

In general, the lay person has little understanding of how astronomical images are made. And inevitably astronomers and image processors are asked about the authenticity of the representation, with such questions as, “is that what it really looks like?” and, “is this what I would see if I were standing right next to it?” It is beyond the scope of this paper to discuss the physiological and psychological response of the human eye to the intensity and colour of light, however it is worth noting that the answer to the above questions is always "no," regardless of how the image was generated. Images can be generated that do render the "intrinsic" colours of an object as closely as possible by using a set of filters that cover a wavelength range similar to the human colour-vision range and by photometrically calibrating the filters relative to each other. And yet these images also differ from human perception for several reasons, including the eye's poor sensitivity to red light and its inability to detect colour from faint light. Additionally, contemporary astronomical images tend to display observations in selected, limited-wavelength ranges; and these ranges are distributed throughout the entire electromagnetic spectrum, not just the optical. Thus, an image serves as an illustration of the physical properties of interest rather than as a direct portrayal of reality as defined by human vision. After all, the reason for using a telescope is to show what the human eye cannot see.

This is not to argue that one is free to perform any image manipulation, as the intention is to retain scientific accuracy. To move, modify or delete structure within the data for aesthetic reasons is not allowable if the goal is to portray the true nature of the object. What manipulations are then allowable, and even desirable? Colour and intensity scaling schemes that maximize the richness and detail within the object should be used to convey the most information about the source while retaining the visual qualities that make it naturally intriguing. In particular, "visual grammar," defined as the collection of elements that affect the interpretation of an image, can be used as a guide for finding a composition and colour scheme that highlights aspects of the astronomical object while retaining scientific accuracy.

The employment of visual grammar when choosing the intensity scalings, colour scheme and composition is crucial for producing an image that is clear without a legend, thereby making it legible to the public, and sufficiently engaging. The process is similar to that used by 19th-century painters who portrayed the newly-explored American West for a public that was as unfamiliar with it then as they are now with the far reaches of space (Kessler, E., Ph.D. dissertation, University of Chicago 2004). The challenge is to create an image that accurately conveys the nature of an unknown world in a way that is both exotic and inviting. While this may appear to be a conflict between art and science, it is the contention of the authors that it is possible, and indeed worthwhile, to address the aesthetics of the image while simultaneously articulating the scientific content of the data. The use of colour and composition to achieve these goals is discussed below.

It is important to generate an image that focuses on the astronomical content and not on the method of data acquisition or image construction. In this regard, it is important to note that the public does have expectations based upon past experience;

e.g., spiral galaxies are expected to have bluish disks because most images of spiral galaxies are that colour. From prior experience the public has developed a mental link between the colour and morphology of spiral galaxies. Thus, an image of a green spiral galaxy can be distracting. In contrast, the public does not necessarily expect nebulae to have a particular colour because each nebula has a unique morphology. And few nebulae are well known to the public, although notable exceptions do exist, e.g., the Horsehead Nebula. Therefore, if the public is not likely to be familiar with previous images of a nebula, one is allowed greater freedom in choosing the colour scheme, scaling and framing. Datasets outside of the visual regime, e.g., radio, IR and X-ray, are also cases where colour schemes are less constrained.

CHOOSING A COLOUR SCHEME

When working with optical data, a traditional approach to colour assignment, often referred to as natural colour, is to assign to each dataset the "visible" colour of its filter. The visible colour is essentially the passband of the filter as perceived by the human eye; i.e., what one would see if one looked through the filter against a bright, white light. For this approach to work well, several filters that cover most of the visible range of light must be used (Wainscoat, R. J. & Kormendy J., PASP 109, 279, 1997). However, datasets in enough filters may not be available. And the overall colour of the image can become skewed if the colours of the filters aren't balanced; e.g., an image that is created from V, R, I and H-alpha datasets would contain too much red because the three of the four datasets would be assigned a reddish colour. Furthermore, modern images often include data from wavelengths outside the visible regime. Thus, there is a need to define a more generalized methodology for colour selection.

Choosing a colour assignment will depend on the datasets to be combined, the science to be illustrated, and personal aesthetic. When choosing colours it is also important to consider the fact that our eyes, and indeed our senses in general, function by detecting relative differences; e.g., a line appears to be long only when a shorter line is present for comparison. Colour in an image is similarly intensified or weakened by the contrast of a colour's properties with other colours in the image (Itten, J. The Elements of Colour, John Wiley & Sons 1970). Thus, contrasts between colours can be used to highlight or de-emphasize elements of the image. Black and white images have only one contrast scheme, that of light to dark. However, there are seven contrasts in colour images. To produce a striking image, attention to these contrasts is strongly encouraged.

In this section, the different colour contrasts are noted as recommended colour assignment schemes are described. When assembling an image, notice which contrasts can result after the initial colour assignment. And then adjust the colour scheme, either by choosing different colours or by swapping the colour assignments amongst datasets, to achieve these contrasts. The next section describes examples of colour schemes and their resultant contrasts in astronomy images.

In general a good starting strategy when assigning colour is to space the colour assignments evenly around the colour wheel; e.g., if creating an image with three datasets, assign undiluted colours that are 120° apart on the colour wheel. This is known as a triadic colour scheme and is the simplest example of hue contrast. The traditional RGB colour scheme falls into this category because the primary colours red, green and blue are separated by 120°. This selection represents the extreme instance of the hue contrast in the same way that white-black represents the extremes of the light-dark contrast. Similarly, the secondary colours cyan, yellow and magenta are also separated by 120° and may be used. However, one is free to use any colours that are separated by 120°. Similarly, if there are four datasets, space them at 90° intervals around the colour-wheel, which is known as a tetradic colour scheme. Note that white and black can be included as colours in the contrast of hue scheme, so any pure whites and blacks that appear in the final image will strengthen this contrast. Three or more adjacent colours, i.e., within 30° of each other on the colour wheel, also create a contrast of hue, although the effect is subtle.

By choosing colours that are evenly spaced on a colour wheel, the sampling of the colour space is improved; i.e., there will be a wider range of colours within the image. Also, for this reason, it is important to assign fully-saturated colours to each layer, because only fully-saturated colours can combine to produce all of the colours available in the colour wheel. Unfortunately it is impossible to produce an image that fully samples the colour space with only two datasets. However, this limitation can be overcome by creating a third dataset that is the intensity average of the existing two. This technique has been successfully used in several images, including an HST/NOAO image of the Helix Nebula (Hubble Heritage 2003).

Alternatively, if there are only two datasets one can assign colours that are separated by 180°, which is known as a complementary colour scheme. The complements are used in two contrasts: complementary and simultaneous. It is worth noting that selecting exact complementary colours and mixing them together, creates what are called compensating tones. When combined, they will produce neutral grey in the CMY subtractive system or pure white in the RGB additive system. Two or more colours are defined as mutually harmonious if their mixture yields a neutral grey. However if the colours are not exact complements then a brown is produced; this defines the case which is considered non-harmonious. A harmonious combination of three colours can be made by splitting the complement. For example, if yellow is chosen then its complement, blue, can be split by instead selecting two blues, one that is more purple and one that is more cyan.

The simultaneous contrast is particularly important since colours are affected by their surrounding hues. When a colour is viewed, our physiology produces its complement as an afterimage. One can experience this phenomenon by staring directly at a colour for several seconds. After looking away one will see an after image of the complementary colour. Hence if there are two non-complementary colours, physiologically four colours are seen, two of which are after images. If there is a sharp common border between the two actual colours, it becomes ill-defined and appears to “vibrate”. The same physiological colour mixing also occurs if daubs of colour are adjacent, rather than mixed. Although the resultant hue will be the same, it will appear more luminous. This method was used by the Pointilist school of art.

Therefore, based upon the number of available datasets, one should attempt to distribute the hues assigned to the images in a manner that maximizes the usage of the colour space. And, of course, the effect should be pleasing. If, after the initial assignments, the overall colour of the image is unattractive, try swapping the colour assignments given to the layers. Also, try changing the initially assigned hues overall; e.g., instead of starting with red, green and blue (RGB) assignments, try using cyan, magenta and yellow (CMY). Once approaching a scheme that appears to be close to attractive, adjust the hues for the individual layers separately. Even changes of only a few degrees in hue can have a significant impact on the appearance of the image. Choosing the colour assignments for each layer is perhaps the most important step of the process, so attempt multiple schemes and weigh decisions carefully.

Aside from its aesthetic aspect, colour can be used to imply physical characteristics, such as depth, temperature and motion. For example, our minds perceive hues that contain blue, collectively known as cool colours, to fall into the background while hues that contain red, known as warm colours, jump towards the viewer. This is a result of our everyday experience, wherein distant objects, such as mountains, appear to be bluer because of scattered light from the foreground airmass (see Lynch, D.K. & Livingston, W., “Colour and Light in Nature” Cambridge University Press, 2001 for examples). Thus, the warm-cool contrast can be used to create an image that has a three-dimensional feel by selecting colours for data layers which, when combined, produce warm colours for the objects that should come forward and appear closer, and cool colours for those that that should fall into the background and thus appear farther away. In addition, our mind perceives cool colours to be literally colder than hues which contain warm colours. This is a result of our experience with reddish flames and bluish ice. Of course it is in contrast to the Planck spectrum, wherein redder objects are cooler and bluer objects are hotter.

Note that a given contrast can be supplemented using other contrasts. For example, if an image contains the colours of orange-red and cyan, it has the complementary contrast as well as a warm-cool contrast wherein the orange will appear in the foreground. Since dark colours in a light background also jump forward, one can use the light-dark contrast to further create depth by darkening the red-orange and surrounding it by a light cyan. Both colours should be equidistant in value from neutral grey to maintain a harmonious relationship.

Colours and colour combinations can also evoke emotional responses (e.g., Whelan, B.M. "Colour Harmony 2", Rockport Publishers: Rockport, Mass. 1994); e.g., red is synonymous with the powerful emotions of love and hate. Thus, colour combinations with red are often powerful and forceful. The colour yellow, associated with the Sun, often implies life and motion. Blue is often associated with calmness; and violet is often synonymous with magic, mysticism and the extraterrestrial world. Trendy colours, such as the pastels that were popular during the 1980s, give a contemporary feel but may appear dated in the future. Colour schemes which include conservative colours such as dark green and royal blue convey a sense of strength and stability which may allow the image to age better. The contrasts of saturation and extension may used to balance or enhance emotional responses. For example, surrounding red by dull colours causes the red to saturate and hence dominate. If a large area contains greenish colours this area may be balanced by a small area of red or pink using the contrast of extension.

It is important to emphasize that this approach does not advocate hard and fast rules of colour assignment. Indeed, it is recommended that a favourite colour scheme is used as a starting point. Then by using colour contrasts and the other factors discussed above, produce a harmonious and powerful composition. The next section discusses some of the different colour schemes commonly used and indicates in more detail how colourizing a layer can produce a colour contrast.

DEFINITION OF COLOUR SCHEMES

Unfortunately terminology is not used consistently when describing the different colour schemes used in astronomical imaging. A traditional colour scheme, often called "natural colour" or "true colour," is a specific colour scheme intended to match the three colour photoreceptors in the human eye. In the natural colour scheme, data are obtained in broadband optical red, green and blue filters (e.g., Johnson R, V and B) and are assigned red, green and blue colours respectively. In addition, the datasets are scaled photometrically, i.e., with calibrated data, identical transform functions and maximum and minimum values that reflect the transmission and sensitivity functions of the filters and telescope. Note that if the datasets in an image are subsequently rescaled the resulting image is not technically a natural colour image. In the natural colour scheme, emission nebulae tend to appear as a deep red due to the strong H-alpha emission line at l6563Å, a wavelength of light which is perceived as a deep red by the human eye. It is worth noting that the natural colour scheme does *not* accurately match the eye's sensitivity to colour; e.g., the Orion Nebula (M42) is a deep red in most natural colour images due to its strong H-alpha emission. However, M42 actually looks greenish when seen through a telescope due to the human eye's poor sensitivity to faint red light.

By deduction, the term "false colour" therefore applies to all images which are not made with the above colour scheme. In this paper the term "representative colour" is used when describing images assembled from multiple datasets of different wavebands, but in a manner that does not meet the criteria of natural colour. This term is used because each dataset encodes properties of a physical phenomenon and colours are assigned to properly represent it. Most astronomical images generated from professional data fall into this category because the datasets are not necessarily obtained through broadband optical red, green and blue filters. And these datasets are usually scaled and projected to maximize detail. A representative-colour scheme is said to be in "chromatic order" if the filters are assigned colour based upon the wavelength of their passbands. If the datasets are not assigned colour in order of wavelength, it is known as "composite order."

Here the term pseudo-colour is used to refer to a distinct technique wherein a monochromatic image is converted into a colour image by mapping grey levels into colours according to a previously-defined colour lookup table (LUT). In a pseudo-colour image, the colour changes as a function of the value of a single physical property represented in the image, e.g., polarization, velocity or monochromatic flux density, thereby creating a multicoloured image. Note that the pseudo-colour image itself is not monochromatic unless all of the colours in the LUT are of the same hue; e.g., the popular "heat" pseudocolour scheme is not monochromatic because the LUT contains red, yellow and colours of intermediate hue. Images generated from natural, chromatic and composite colour schemes are fundamentally different than pseudo-colour images. Examples of different kinds of images may be found in Rector et al. (2005).

THE COMPOSITION OF AN IMAGE

One of the goals of a composition is to keep the viewer engaged with an image. That is, the goal is to keep the eye trained within the borders of the image. Human perception of images is complex but includes seeing "bilaterally," that is, dividing the page into left and right halves, and perceiving the bottom part of an image as closer than the top part, e.g. Bloomer, C.M., Principles of Visual Perception, 2nd Edition, Design Press. 1990. Simplifying this, for 95% of those in western cultures the eye will enter from the left edge of the image, roughly one-quarter of the way up from the bottom. Travelling horizontally for a short distance, the eye then moves along a diagonal up to the right and exits close to the upper right corner. If a picture doesn't redirect this travel onto a different path, that is, onto a trail that winds within the frame, then the viewer spends little time apprehending the content and the picture is neither memorable nor engaging.

A visit to an art gallery will illuminate the tactics used by artists to redirect the eye towards the centre of the image plane. For example, they use vertical structures and upper-left-to-lower-right diagonals to block the eye's default path. Additionally, they will redirect the eye back towards the point of entry, close to the left edge, by using a spot of high contrast either in terms of brightness or of colour.

Cropping can be used to remove high contrast spots, like stars, that would drag the viewer's eye quickly out of the picture plane. It can also be used to place naturally occurring diagonals and verticals in the correct position in the picture plane for slowing down the eye's motion and to change its trajectory. Care should also be taken in selecting the picture's centre. If the midpoint of the target of interest is placed dead centre, then the target will appear to be sliding down when the image is viewed vertically, e.g. on a monitor or on a wall. Instead, the target midpoint should be placed above the horizontal centreline of the image to keep it from appearing as if it is about to fall out the bottom of the image plane. The target's midpoint should also be offset from the vertical centreline in order to ensure that the image appears dynamic rather than static. A static image risks allowing the eye to follow the default path in from the lower left of the image and then rapidly out via top right corner.

SUMMARY

The quality of modern astronomical data, and the technologies now available to manipulate them, allows high-quality images to be created in a purely digital form. Many groups are now exploiting this fact to create attractive images intended for scientific illustration and outreach. The success of these images in public outreach is responsible for much of the popularity that astronomy currently enjoys.

A practical guide is presented in Rector et al. (http://arxiv.org/abs/astro-ph/0412138) as to how to generate astronomical images from research data by using powerful image-processing programs such as Photoshop and The GIMP. These programs use a layering metaphor that allows an unlimited number of astronomical datasets to be combined; and each dataset can be assigned any colour. This is an improvement over traditional methods, wherein only three datasets can be combined, and only with the primary colours of the colour space, usually red, green and blue. In the layering metaphor, each dataset can be individually scaled and colourized, creating an immense parameter space to be explored. These IP programs offer excellent flexibility and agility in the creation of images, allowing easy exploration of this parameter space.

A philosophy is presented here on how to use colour and composition to create images that simultaneously highlight the scientific detail within an image and that are aesthetically appealing. Because of the limitations of the human eye, it is fundamentally impossible to create an image of an astronomical object which shows “how an object truly appears”. This is particularly true for datasets outside of the optical window and for datasets with limited-wavelength coverage, e.g., emission-line optical filters. Indeed, the goal of many of these images is to show what the human eye cannot see.

Thus, by properly using visual grammar, i.e., the elements that affect the interpretation of an image, it is possible to maximize the richness and detail in an image while maintaining scientific accuracy. With visual grammar one can imply qualities that a two-dimensional image intrinsically cannot show, such as depth, motion and energy. A basic primer has been included on some elements of visual grammar, such as the seven colour contrasts, including examples of these contrasts in astronomical images. In addition, composition can be used to engage and keep the viewer interested for a longer period of time. The effective use of these techniques can result in an appealing image that will effectively convey the science within the image, to scientists and the public alike.


NO
FUMAR

HUBBLE AND THE LANGUAGE OF IMAGES

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ABSTRACT

Images released from the Hubble Space Telescope have been very highly regarded by the astronomy-attentive public for at least a decade. Due in large part to these images, Hubble has become an iconic figure, even among the general public. This iconic status is both a boon and a burden for those who produce the stream of images flowing from this telescope. While the benefits of attention are fairly obvious, the negative aspects are less visible. One of the most persistent challenges is the need to continue to deliver images that "top" those released before. In part this can be accomplished because of Hubble's upgraded instrumentation. But it can also be a source of pressure that could, if left unchecked, erode ethical boundaries in our communication with the public. These pressures are magnified in an atmosphere of uncertainty with regard to the future of the mission.

INTRODUCTION

Hubble Space Telescope images have been very highly regarded by the astronomy-attentive public for at least a decade. Due in large part to these images, Hubble has become iconic, even among the general public. Have we become a victim of our own success? Can we continue to produce images and science results that still generate interest among the media and the public?

Certainly we have been fortunate to have many Hubble images reproduced widely in various media and used to further formal and informal education. However, we do work with a broad continuum of types of images from the Hubble Space Telescope, ranging from the pictorial to the illustrative. Of course none is purely pictorial. The images are derived from data as part of science investigation, after all. By the same token, none is entirely a purely technical science illustration either, as any visual representation has pictorial, even emotional content. One would hope that even images intended for technical illustration would be pleasing to look at. After all, if the picture repels the viewer, the intended message will never get across.

Sometimes an image illustrating a science finding is just not very attractive. This usually happens when the observation pushes the capabilities of the instrumentation. The image will be noisy, the object of interest just a smudge amid other smudges, perhaps with no significant colour information. This can largely be accepted because often a cutting-edge science result depends on taking an instrument to the limits of its capabilities. The inherent technical content of the image may be quite significant nevertheless. The original Hubble Deep Field and subsequent surveys come to mind. The HUDF has more visual appeal than the earlier surveys, mostly because it was made with the Advanced Camera for Surveys (ACS), which is a more capable camera than the older Wide Field Planetary Camera 2 (WFPC2).

There are ways to present such an image effectively and to use it to support the announcement of a science finding, for example, we can smooth and colourize or otherwise enhance the image. We can also include an artist's rendering or a model for comparison or in place of the actual data. Though there is always some danger that the more attractive rendering will be taken as an actual image.

Careful presentation can add value to a marginal science image, making it more understandable to both scientists and the public. These annotations draw attention to the relevant parts of the figure and add an explanation that helps guide the viewer to understanding the illustration. Such figures are intended to accompany an announcement of a science finding. As such, the figure serves to explain part of the story, but need not tell everything about the story. At the same time, the figure should communicate its point clearly and succinctly. Nothing should be included in the figure which might distract from the main point.

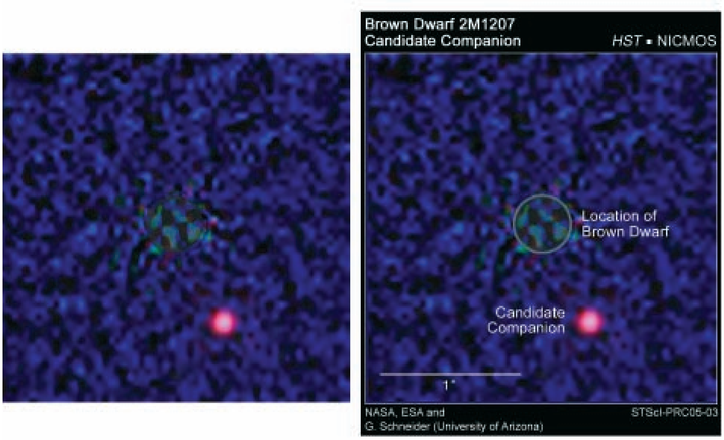
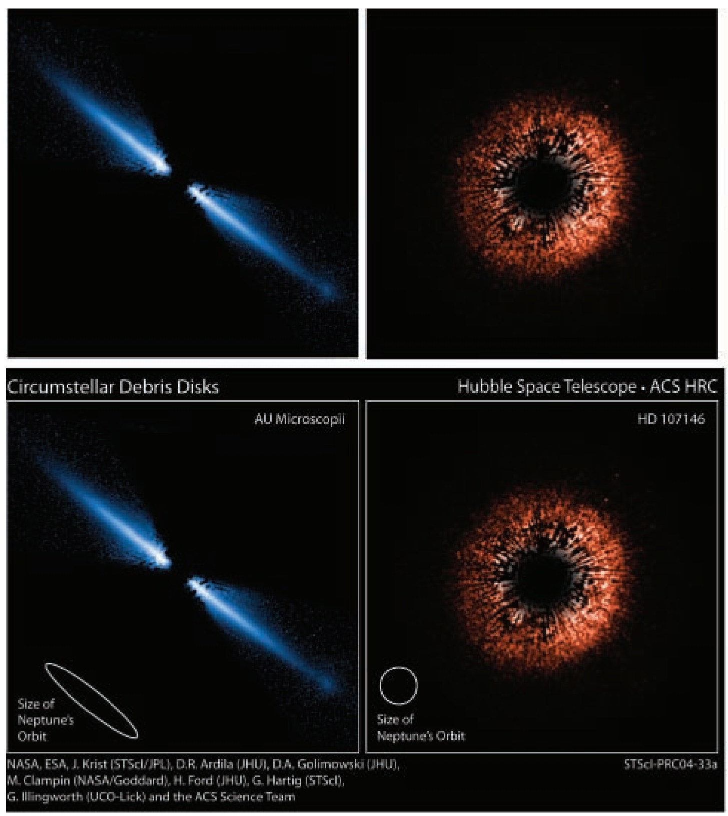


Figure 1. *HST/NICMOS image of Brown dwarf 2M1207 with a candidate planetary-mass companion. On the left is the image as obtained from the science team. On the right is the released photo, including some explanatory annotation. NASA, ESA and G. Schneider (University of Arizona).*

In the first example (Fig. 1), the science team provided an image of a brown dwarf 2M1207 thst was found to have a planetary-mass companion (http://hubblesite.org/newscenter/2005/03/). We felt some annotation was needed to make this image understandable as there was very little context otherwise. In most cases, titles, captions, credits, etc., are kept off the image itself.

The second example (Fig. 2) is similar, but includes two images of related types of object, circumstellar debris disks (http://hubblesite.org/newscenter/2004/33/). At the top are two images made from data provided by the two science teams. Some processing in the images themselves also served to make the story a bit clearer. Light from the relatively bright stars has largely been removed in the instrument, but much residual scattered light remains in the original images. Some of this has been masked here to prevent misunderstanding. At the bottom is the release photo combining the two observations. Again, minimal annotation identifies the objects and provides some context in the form of a scale to show the physical size of what appears in the images.

__Figure 2.__ Circumstellar debris disks, HST ACS/HRC. NASA, ESA, J.E. Krist (STScI/JPL), D.R. Ardila (JHU) et al.



One final example (Fig. 3) shows an image that says very little by itself but represents a quite profound science result. Supernova 1997ff was discovered in the Hubble Deep Field and turns out to be one of the most distant known supernovae (http://hubblesite.org/newscenter/2001/09/). So distant in fact that it helped strengthen the reality of Dark Energy. Unfortunately, the most important image, provided by the sci-

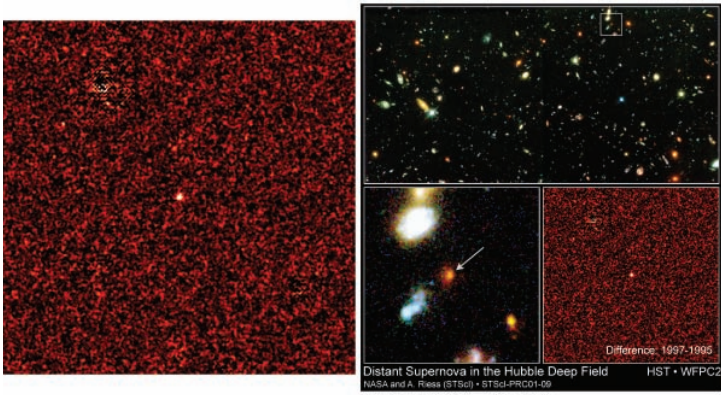


Figure 3. *Supernova 1997ff in the Hubble Deep Field, HST WFPC2. NASA, ESA, and A. Riess (STScI)*

ence team, was what I might consider an image "only an astronomer could love." It is the difference of images from after and before the supernova outburst, so is largely noise with a single brightish dot.

We combined the science ("discovery") image with a detail showing the supernova host galaxy and a larger piece of the HDF showing the location of the host. This provides enough context, along with the more extensive explanation in the caption, to appreciate what appears in the illustration.

Sometimes there is a happy confluence where science relevance comes together with visual appeal. Perhaps the most recognized example of this is the iconic Eagle Nebula image, recently updated with a new view of a different detail in the same region (Fig. 4, http://hubblesite.org/newscenter/newsdesk/archive/releases/2005/12/).

Figure 4. *Eagle Nebula (M16) detail, HST ACS/WFC. NASA, ESA, and the Hubble Heritage Team (STScI/AURA)*

At times it does require a bit of background to really appreciate the dramatic significance though. A little understanding of the nature of the scene can enhance the appreciation of an image to a level beyond the simply pictorial. This is not unlike photographs of landscapes in which an understanding of the geology can heighten our appreciation of the view.

The images all do tell some story. For a largely pictorial image the story may be simply that this is something stunning that we want to share. For a technical illustration, the image may serve to convey some aspect of the science. One expects that the image conveys this idea more succinctly than a number of words. Most of the Hubble images fall somewhere along this continuum. The overall visual appeal of a figure, be it a technical science illustration or a more aesthetic image, need not sacrifice the accuracy of the content.

This distinction is something like the difference between representational visual art and conceptual art. Representational art portrays recognizable objects and scenes straightforwardly. Conceptual art portrays ideas, with symbols and icons represent-

__Figures 5__ Tadpole Galaxy, HST ACS/WFC. NASA, ESA, H. Ford (JHU) et al.

ing those ideas. Therefore, the viewer needs some background to understand the symbology in order to interpret the image, though in many cases a highly symbolic painting may also still be appreciated for its more literal, aesthetic appeal.

An example of a Hubble image with both visual and deeper appeal is the Andromeda Galaxy Halo (Fig. 5, http://hubblesite.org/newscenter/2003/15/image/a). This is perhaps not the most visually appealing image for many, though I find the dense scattering of faint stars visually compelling, combined with a few smudges of other recognizable features. But thinking about the nature of this image makes the significance become immediately apparent and quite profound. A few bright stars, from our galaxy, relatively close by, provide foreground context. The bulk of the visible features are at the distance of Andromeda some million light years away, including a fine globular cluster. Then, as with most deep ACS images, we can see numerous background galaxies at cosmological distances. The whole result shows the entire depth of the cosmos in a single image.

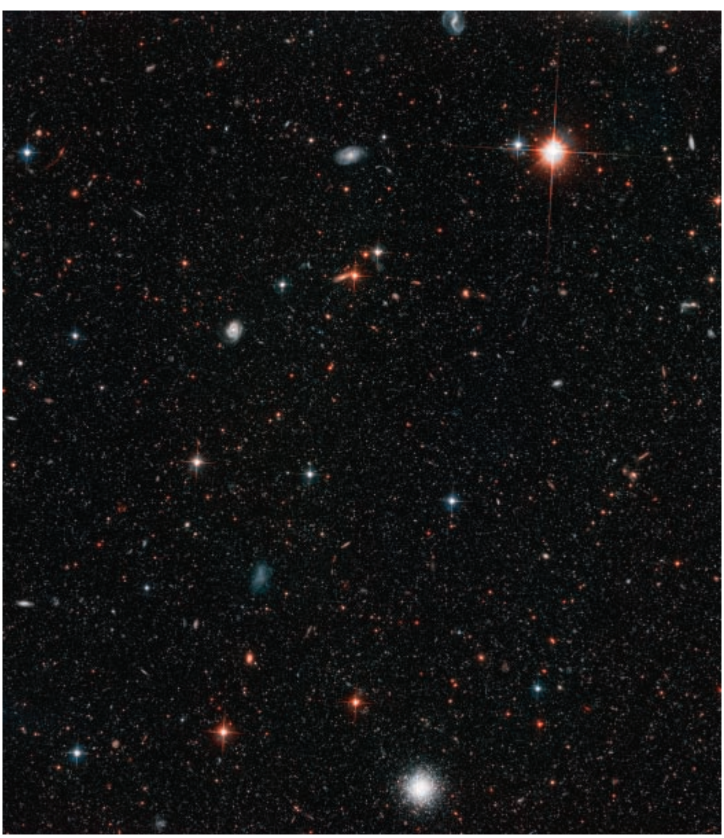
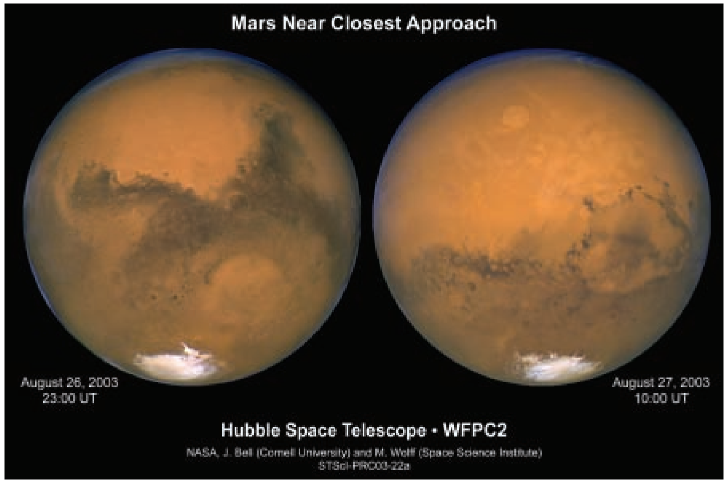


***Figure** 6: Andromeda Galaxy (M31) Halo, HST ACS/WFC. NASA, ESA, T. Brown (STScI).*

Figures 7 Mars at opposition in 2003, HST ACS/WFPC2. NASA, ESA, J. Bell (Cornell) and M. Wolff (SSI)



Another example of this is the Tadpole Galaxy (Fig. 6—http://hubblesite.org/ newscenter/2002/11/image/a). This was one of the first images made by the Advanced Camera for Surveys. One of the goals of producing this was to demonstrate that the new camera worked and that it is indeed better than the older instrument, WFPC2. This is a much more visually compelling image overall. There is a strong graphic element with the main galaxy in the upper left corner with tidal tails streaming down to the lower right. As with the M31 Halo, numerous galaxies appear in the background, some quite striking and detailed themselves, lending visual balance to the image, and there is a scattering of foreground stars. We can then understand that we are looking simultaneously at relatively nearby objects (the brighter stars), an immense galaxy as the main subject, and unimaginably distant background galaxies. When we realize this, the image suddenly becomes more than a two-dimensional image and pops into a third dimension, if only in our perception of it.

CASE STUDY: MARS

Sometimes practicality versus communication becomes extreme. The closest Mars opposition in many years happened in 2003. There was a great deal of emphasis in the media of the excitement of this “once-in-a-lifetime” event. A sceptical scientist might point out that there was no real scientific value in this particular (or perhaps any) opposition. And certainly Mars would be pretty much in the same place in the sky and very close to the same distance for some weeks around the opposition, so the actual time was fairly irrelevant. Many people recognized the value though in publicizing the event as an opportunity for the recognition of science.

In fact, a great deal of effort was expended at STScI to try and release a Hubble image of Mars as close as possible to the actual time of opposition. We could have made the image days before and released it on the day of opposition, likely with no-one any the wiser, or we could have waited to release the image some days after the opposition. Of course, the former approach would have opened us up to charges of misleading the public, while the latter would have left us behind the news cycle, playing catch-up.

As it turned out, this event was widely publicized around the world, to the extent that the STScI network was overwhelmed for some time (mostly because some news outlets published a direct link to our content rather than hosting content locally). In this case, capitalizing on the public's interest and careful timing "worked" in some sense, providing a great deal of attention to science, and to astronomy in particular. Was it misleading to imply that this was a significant, time-critical event? I don't know the answer to that.

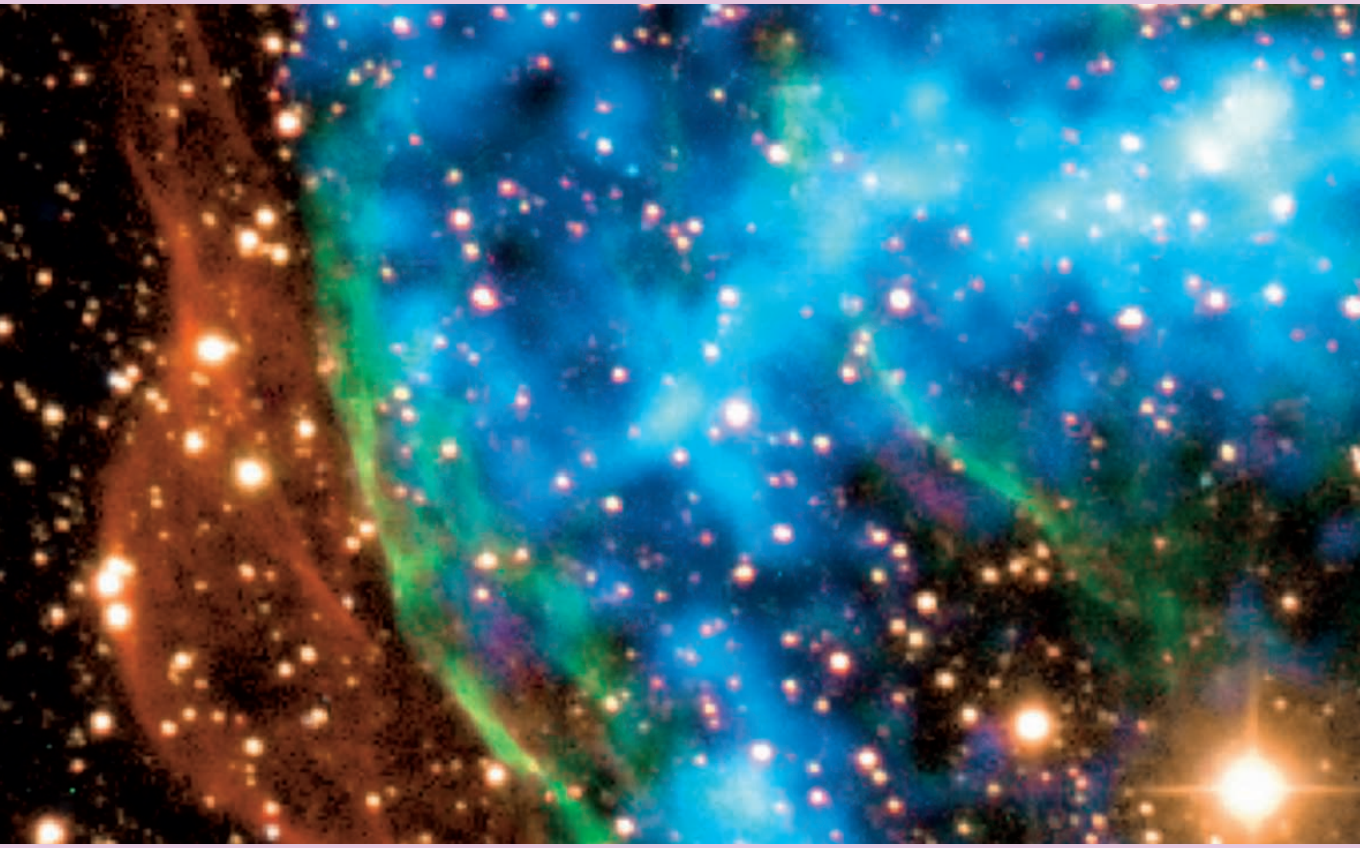
CONCLUSION

We have certainly been fortunate during the Hubble mission so far to have periodic updates to the instrumentation. In every case the improvement has been quite dramatic. So there is some expectation among mission insiders at least that we need to improve the quality of the images, even regardless of any enhancements to the instrumentation. There is some danger then that this expectation may lead to some pressure to produce exciting news, which in turn might lead to publicizing some results that may not deserve it, or to enhance images beyond their inherent content in order to continually produce more exciting results.

In the past, we have capitalized on upgraded instruments to provide improved capabilities, better data and spectacularly better images. Certainly the installation of WFPC2 was dramatic and produced stunning results. And the upgrade to ACS continued this trend and provided a dramatic enhancement in the quality of Hubble images. Now the Hubble mission is in something of a steady state. While new instruments are built and ready to fly, we have no certain servicing mission scheduled, and the constant danger that a hardware failure will be fatal. It can be a challenge to continually improve on our previous results. Fortunately, the observing community continues to devise challenging programs such as HUDF that do push beyond what has been observed before. And with a fortuitous convergence of opportunities, we have been able to produce images such as the Whirlpool Galaxy ACS mosaic.

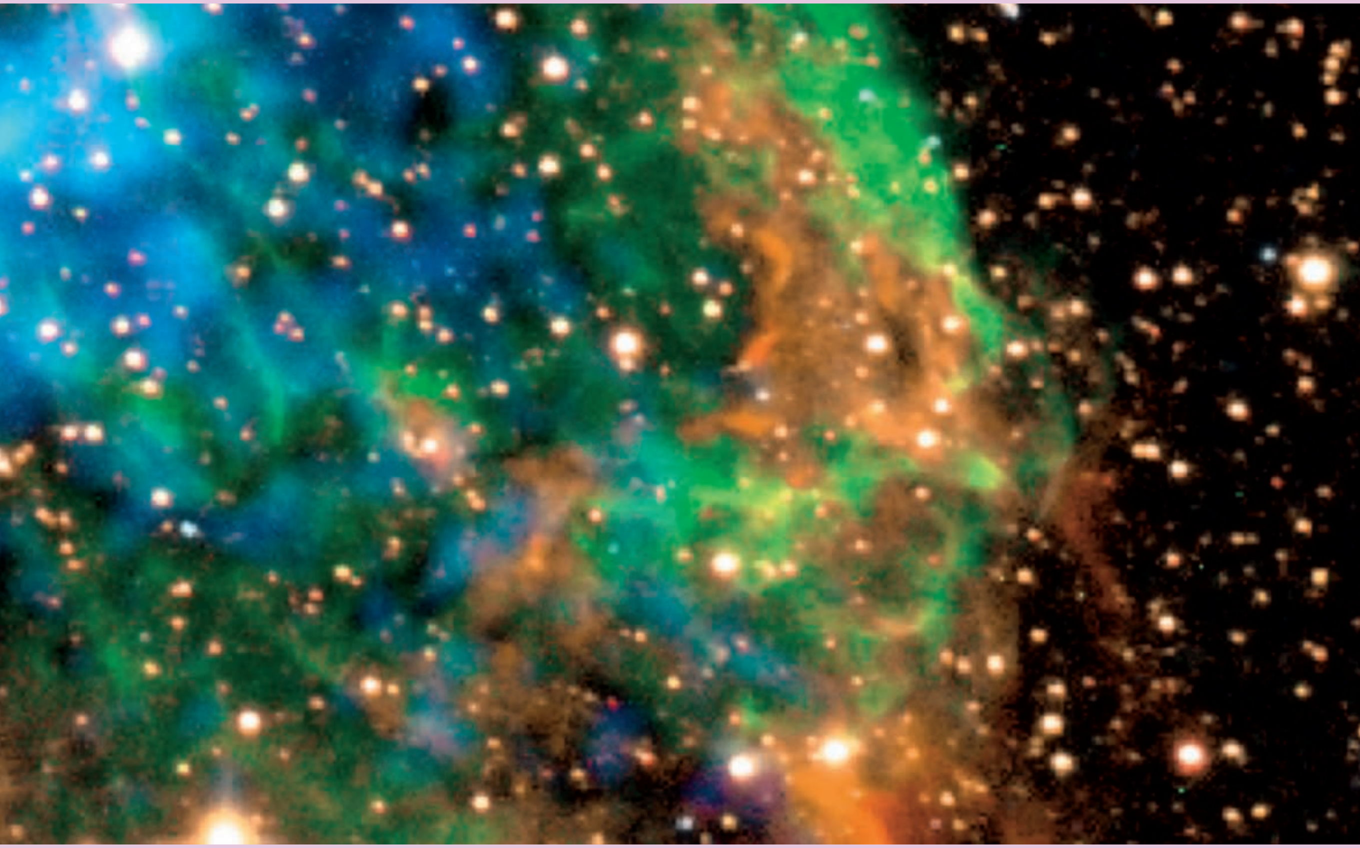
We do face the rather daunting challenge of getting the message of science across in a cacophony of voices competing for media attention. An "arms race" mentality in media attention fuels a need to constantly produce more interesting, exciting images and words. For better or worse, in today's media-saturated culture, one must shout to be heard above the din. To attain our goals of informing the public, we must get the attention of viewers and readers. It is increasingly difficult to craft a message that matches the increasingly loud, exciting messages seen and heard in all media.

The urge is to make the images and the stories more and more interesting and exciting, regardless of their inherent value or content. Techniques now available make it relatively straightforward to enhance the images in just about any way we wish. Colour may be added, changed, made more saturated. Selected regions of the image may be brightened, darkened, their contrast changed to emphasize an area as the significant region of interest. Noise can be reduced or removed. Detail can be sharpened. All of this is legitimate and used by any photographer. Of course presenting an artificial image—artist's drawing or model render—as actual data is inaccurate and misleading. Any significant alteration to the data without disclosure is also misleading. Certainly subjective choice is involved in this process, from deciding which images to publicize, how to transform the data into pictures, and of course how to "manipulate" the images to produce the visually most interesting and pleasing result.
On the other hand, there is understandable pressure from scientists not to stray too far from straightforward, accurate images or prose. Scientists sometimes complain that clever, over-the-top leads mislead the reader and cheapen the presentation of the science. It may be prudent to craft a message that is absolutely precise and avoids any misrepresentation, exaggeration, or superlative. But if we put out such a story and nobody listens, the message doesn't get across. We repel viewers by presenting overly technical, unintelligible or ugly graphics. So we need to find a balance between hype and fact.



Credit: Chandra X-Ray Telescope, NASA/CXC/Rutgers/J.Warren & J.Hughes et al.

PLENARY SESSION 11:
Cutting-edge Audiovisuals



VIRTUAL TOURS OF THE UNIVERSE

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ABSTRACT

Although primarily an astrophysics research group, the Swinburne Centre for Astrophysics & Supercomputing has placed a strong focus on providing quality public education in astronomy. Two of our biggest success stories have been the interactive AstroTour that uses stereoscopic (3D) projection to immerse the public in the Universe, and Swinburne Astronomy Online (SAO)—a nested online degree program aimed at a graduate level that is available to students from all over the world. We discuss our experiences with both of these programmes and how we have approached our goal of "inspiring a fascination in the Universe".

INTRODUCTION

The Centre for Astrophysics & Supercomputing at Swinburne University of Technology, Melbourne (hereafter, "The Centre"), is one of Australia's newest and most rapidly growing astronomy research groups. Swinburne's original astronomy group formed when Professor Matthew Bailes was recruited from the University of Melbourne in late 1997, bringing with him one postdoctoral researcher and three PhD students to join with Dr Margaret Mazzolini. The Centre was born out of this group the following year, when it became one of several strategic initiatives to receive start-up funding from the University.

A goal of the Centre was to achieve growth at a time in Australia when several physics research groups were shrinking, with the hope of reaching a "critical mass" of high-quality researchers capable of generating ongoing funding from competitive grant schemes. An opportunity was seen to add to this growth by seeking non-traditional (for an astronomy group) forms of funding through commercial projects that might take advantage of the Centre's supercomputing and scientific visualisation resources. By mid-2005, the Centre had reached 42 staff/students, comprising 8 academics (in tenured or ongoing positions), 11 postdoctoral/contract researchers, 15 PhD/Masters students and 8 support/technical staff (including administration, computer support and computer animators).

Contributing to this rapid growth was the strong emphasis on public education and outreach, captured in the Centre's mission statement: *The Centre for Astrophysics & Supercomputing is dedicated to inspiring a fascination in the Universe through research and education.*

Somewhat strangely for a University-based astronomy group, the Centre does not undertake any undergraduate or service teaching. Instead, its two main education activities are:

- Swinburne Astronomy Online: a fully online graduate degree program in astronomy by coursework, reaching ~250 students per semester resident in over 30 countries per semester; and
- AstroTour: a school program presented in the Centre's Virtual Reality theatre, where the audience is immersed in a 3D universe.

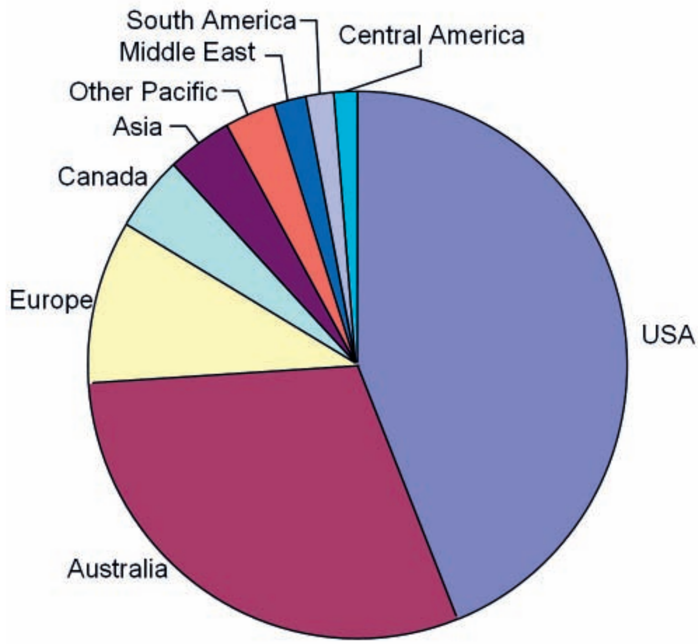
The remainder of this paper will describe these two teaching initiatives in more detail, looking at how they work and the lessons we have learned from their operation.

SWINBURNE ASTRONOMY ONLINE

Swinburne Astronomy Online (SAO) is a fully online graduate astronomy program that began in 1999. SAO concentrates on the fundamental concepts and key issues in contemporary astronomy, rather than its mathematical basis, and as such it is not a training program for professional research astronomy. Instead, SAO units are designed for amateur astronomers, science educators and communicators, people working in astronomy related fields, and anyone with a love of astronomy. SAO concentrates on building a student's skills at communicating their science knowledge. Having just completed its thirteenth semester, SAO is a success story in new techniques of online education.

SAO is a nested graduate degree program, offering a Master of Science (Astronomy), a Graduate Diploma of Science (Astronomy) and a Graduate Certificate of Science (Astronomy). SAO uses high bandwidth course content and supplementary multimedia material delivered via custom CD-ROMs, each of which contains over 1,500 animated slides written by a variety of professional astronomers. There are 16 units to choose from, 12 of which are accompanied by their own CD-ROM, as well as 3 major project units. The latest unit, *HET618 Astrobiology and the Origins of Life*, offers its slide presentations (~1-2 MB each) via download over the internet. The internet is also used for communication, research, and assessment purposes. The SAO community consists of professional PhD astronomers who teach into the program plus ~250 students resident in more than 30 countries (see Figure 1).

Figure 1. *SAO Students by country of origin. Australian students make up ∼30% of the student body, while ∼40% are from the United States.*



Students interact with instructors and fellow classmates via asynchronous newsgroups and email, allowing them to study at a time that suits them. This is particularly advantageous for a course where the students and instructors are all in different time zones! The 14-week semester is broken up into seven two-week blocks, with fortnightly newsgroup discussion forums focusing on specific parts of the syllabus.

The SAO assessment mix includes computer-managed tests, an essay, project work and newsgroup contributions (Mazzolini, M., 2000, PASA, 17, 141). The development of good communication skills in astronomy was one of the key aims of SAO, and so the ability of students to communicate astronomy concepts effectively to non-specialist audiences, as well as being capable of researching a topic in depth, were built into the assessment criteria for SAO projects and essays from the start. There are over 100 project topics to choose from and each unit has a choice of at least five essay topics. Considerable thought and research has also gone into designing appropriate assessment for the asynchronous discussion forum component of SAO. It was also necessary to provide online, open book assessment tests to give credit to students who master the overall bulk of the course material.

SAO instructors are professional astronomers, some of whom are Swinburne academic staff, but a number of whom are employed full-time at observatories, universities or research institutions around the world. Depending on the student enrolment numbers, there are about 12 instructors per semester. SAO also uses between 30 and 35 project supervisors including PhD students, postdoctoral fellows and academic staff from Swinburne, as well as professional astronomers and amateurs from outside of Swinburne. Distance education provides flexibility for the instructor—instead of being locked into a regular lecture and tutorial schedule with office consultation times, our astronomers are able to continue research activities such as observing or attending conferences with minimal impact on teaching. The students appreciate reports sent back from astronomers while they are observing at major international facilities, as they can share in the excitement of the research process.

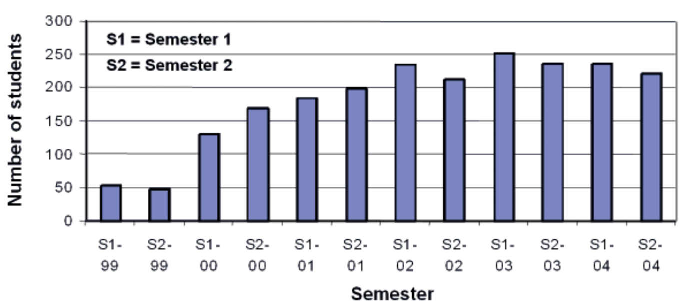


Figure 2. *6 years of semester-by-semester student enrolments in SAO Units from 1999 to 2004.*

Figure 2 shows the semester-by-semester student numbers from 1999 to 2004. The marked growth in student numbers from 1999 to 2000 coincided with the release of the "Clear Skies" CD-ROM on the front cover of the January 2000 edition of Sky & Telescope http://astronomy.swin.edu.au/sao/clearskies/clearskies.html. "Clear Skies" provided a sample of the introductory Units, acting as a self-contained educational tool along with acting as a "teaser" to attract students to the program.

THE IMPORTANCE OF GOOD COMMUNICATION

One of the key distinguishing features of online education, as compared to other forms of distance education, is the opportunity for instructors and students to interact via online asynchronous discussion forums. Asynchronous discussion forums are used to a varying degree in different online academic programs, and in widely different ways. Discussion forums are a key feature of SAO units, initially designed to help build a learning community within distance education, and specifically to encourage active learning (Maddison, S.T., Mazzolini, M., Effective Teaching and Learning of Astronomy, 25th meeting of the IAU, Special Session 4, 24-25 July, 2003 in Sydney, Australia, meeting abstract; Mazzolini, M., 2002, PASA, 19, 448).

In SAO discussion forums, students are divided into groups containing up to ~30 students per instructor, and each group has its own set of discussion forums, with a new forum opened every fortnight during the semester. In each of these forums students can discuss the course material currently being studied, and relevant astronomy press releases can also be channelled into the forums. Students are required to post questions and/or comments about the current course material, and attempt to answer each other's questions. Instructors act as 'guides on the side', aiding the discussions by contributing extra information and follow-up questions. They intervene in discussion threads that have 'gone off the rails', but avoid dominating the discussions. In this approach, it is vital that the students see each other as a resource to obtain answers to their questions, rather than rely on instructors as oracles.

The discussion forums contribute 30% of the total assessment marks, comprising a component for regular participation, plus a mark awarded for three postings nominated by the student as being their best contributions over the course of the semester. Counting forum contributions towards the final grades recognizes the time and effort put in to researching forum contributions, and encourages contributions from all students, not just the most confident.

The discussion forums operate in asynchronous mode, where students make postings at times to suit themselves. Necessity was the initial motivation for the use of asynchronous forums, given the truly international nature of the program. In online synchronous chat room discussions involving more than a few participants, it is easy for the various discussion threads (topics) to become hopelessly entangled. In contrast, in asynchronous forum discussions, each discussion thread is clearly identified under its own heading, which is an important consideration with thirty or so contributors. Discussions conducted via asynchronous forums can be surprisingly flexible and engaging, providing a form of peer group contact so frequently missing in distance education. The asynchronous nature of the discussions also gives participants time to research and reflect before they post answers to each other's questions. An additional benefit exists for students who do not have English as their first language, as these students have time to compose their answers (which may include translation from their native language) and contribute equally, whereas in a real-time discussion forum, they may get left behind.

In SAO, the forums are delivered using newsreader technology. When necessary, this allows participants to download discussions, deal with them offline, and then resynchronize and upload postings on their next login. Students also participate in the discussions through a variety of well known browsers. A recent development is the use of video introductions of unit instructors, available for viewing by their students. The videos are about 90 seconds in duration and allow the instructor to describe themselves, their research background, and discuss specific or interesting aspects of the upcoming unit and assessment items.

At the end of each semester, students are invited to provide feedback on the course content, quality of teaching and other aspects of SAO delivery. This feedback is provided to the unit instructors, and problems are discussed within a subject panel consisting of the instructor, the SAO coordinator and typically an instructor of another unit. The Centre holds an annual SAO planning day, and the progress of the SAO program is reviewed by an external advisory committee. Prior to the start of each semester, the CD-ROMs go through an intense period of revision to include recent discoveries. Unlike traditional textbooks, the SAO content is continually evolving to cope with advancements in astronomy and the changing requirements and interests of our students.

Further details on Swinburne Astronomy Online can be found at the program's home page http://astronomy.swin.edu.au/sao.

FROM ASTRONOMY VISUALISATION TO ASTRONOMY EDUCATION

As part of the transition from informal Astronomy group to strategically-funded research Centre in 1999, funding was made available to develop an immersive, stereoscopic (3D) visualisation facility. While existing commercial products were investigated, such as the SGI Reality Center (http://www.sgi.com/products/ visualization/realitycenter/) and the WEDGE (http://wedge.anu.edu.au/) developed by the Australian National University, a decision was made to use local expertise to design a stereoscopic theatre with `off-the-shelf' components. The Mark I Virtual Reality (VR) Theatre comprised a CRT projector (modified to project with a refresh rate of 120 Hz, rather than the usual 60 Hz), a Dec-Alpha computer and graphics card, and several pairs of wireless electronic shutter glasses. The projection equipment was installed in part of Swinburne's old film and television school, in a room with a ~6 m high ceiling providing a projection area of 4.8m x 3.6m. The final important ingredient was the hiring of Paul Bourke as visualisation researcher to develop software tools and provide visualisation support to the Centre and the wider Swinburne research community.

As an early demonstration of the VR Theatre's capabilities, a basic, interactive solar system program was developed that would show each of the planets and allow the user to fly from one planet to another. Additional content included interactive tools to display and manipulate datasets generated by the Centre's astronomers, such as the Swinburne Intermediate Latitude Pulsar Survey (Edwards, R.T., Bailes, M., van Straten, W., Briton, M.C., 2001, MNRAS, 326, 358) and cosmological N-body simulations. The VR Theatre soon began a regular stop for the Vice-Chancellor when showing visiting dignitaries highlights of the campus.

Following a letter from an 8-year old boy to Professor Bailes, the first school group presentation was made in the VR Theatre in 1999—a very successful event, that was greatly enjoyed by all of the students. The Centre saw an opportunity to provide a unique educational program to Victorian school students, and successfully applied to the Victorian State Government for money to purchase 30 pairs of shutter glasses and a programmer to develop content. Swinburne contributed to the costs of installing seating and the *AstroTour* program was up and running. Along with providing content that met with the curriculum requirements of Victorian students from Grades 3 to Year 12 (final year of high school), the Centre wanted to challenge and inspire students by incorporating its own research work.

ASTROTOUR

The AstroTour school program is targeted at students from primary school (Grades 3-6) and secondary school (Year 7-Year 12). At each school level, we aim to cover the requirements of the Victorian Curriculum Standards Frameworks (CSF) and the Victorian Certificate of Education (http://www.vcaa.vic.edu.au). The AstroTour content is sufficiently flexible that we can use the same interactive demonstrations for all age levels, and simply change the information the AstroTour guide provides.

AstroTour sessions are presented by PhD students and researchers from the Centre. As each researcher has their own particular area of specialisation, the AstroTours are also able to adapt to reflect the presenter's interests. We feel that it can be very rewarding for a student to hear about discoveries in cosmology, planet and star formation or pulsars from researchers who actually work in those fields. It is also an excellent training ground for PhD students to improve their own science communication and teaching skills.

A typical AstroTour (http://vr.swin.edu.au/content.html) lasts for 50 minutes, with at least 5 minutes of question time. We find that younger students (Grades 3-6) are very uninhibited when it comes to asking questions about the content we have shown, or other areas of astronomy and space that they are aware of. The level of questioning drops off sharply around Year 9 & 10, particularly when dealing with students from general science courses. The situation improves again at Year 11-12, as the groups tend to be specialised physics or chemistry classes. Sessions include a mix of interactive and pre-rendered (movie) content and we encourage questions from the students at (almost) any time. Worksheets are available for primary school teachers to use in follow-up activities in class. AstroTours are usually scheduled by schools at the beginning of teaching the astronomy portion of the curriculum to provide a solid introduction to the topic, or at the end of the course so that it provides a conclusion to the ideas they have been studying in class.

As the Swinburne VR Theatre is only able to hold about 30 students at one time, we are limited in the number of sessions that can be offered throughout the year. On average, we have $\sim$1500 students through the Theatre each year. In addition to the school program, we provide regular professional development sessions for teachers. These can consist of either a version of the AstroTour program that we would show to their students, or a more in-depth discussion of a particular area of the curriculum that can be supported by the 3D demonstrations. During school holidays, the Centre offers family sessions, which are usually sold out, with a large number of repeat visitors who come back to see new content.

To date, the Centre has not undertaken any formal evaluation of the effectiveness of the AstroTour program as a method for astronomy education. However, we are encouraged by the very positive responses from students and teachers during and after AstroTour sessions. Another indicator of success and popularity of the program is the number of schools that bring back students every year. Audiences of all ages regularly attempt to jump out of their seats and catch stars and galaxies as they come whizzing towards them—it is clear that we are engaging with the students, which is an important step towards helping them learn more about the Universe. As anecdotal feedback, consider the following responses from teachers:

- *Just a Big Thank You for the time you gave us the other day. It was greatly appreciated. Students commented very positively –"inspired"* (by one to his mother), *"I'll never see the night sky the same way again"* (from another). *They are reasonably smart and tuned in students and I think the level of presentation was just right. A good base that they had already encountered, but also significant extension of ideas.* (P-12 Teacher)
- *… a wonderful excursion and start to our unit of work on the Solar System. This is the second visit for me and I still don't know if I am more impressed with the way you can manipulate the display to make a point or just blown away with the information about the vastness of the Universe.* (Primary school teacher)
- *…fascinated and enthralled…the subject matter you discussed is just the kind of exciting, up-to-date material which will motivate my students…*
- (from a Teacher Professional Development session)
- *... the kids want to come back and see more!* (Secondary school teacher)

TAKING 3D ASTRONOMY EDUCATION TO THE WORLD

At the completion of a study mission in late 2000 by Dr Christopher Fluke to explore virtual reality technologies in the US and the UK, including their potential use for education within museum environments, a decision was made by the Centre to produce a 20 minute long stereoscopic movie. While this would add to the content of Swinburne's own AstroTour program, a version was also to be installed at the Parkes Observatory Visitors' Discovery Centre in New South Wales. An important change to the projection system was required—due to the expensive nature of the electronic shutter glasses, and the risks of damage and theft, the Parkes VR Theatre was to use polarising glasses. This meant a change from a single CRT projector to two DLP projectors and the addition of a polarisation preserving projection screen. The topic chosen for the first production was the life cycle of the Sun and other stars. With a script written by Dr Sarah Maddison and Fluke, "Our Sun: What a Star!" was completed over a period of six months, opening at Parkes at Easter 2001, and in the upgraded Swinburne VR Theatre shortly afterwards. Following the success of "Our Sun: What a Star!" and the Parkes Observatory installation, with approximately ~10,000 visitors in the first six months after opening, the Centre began to explore other opportunities to take its 3D astronomy education to Australia and the world.

The next major project was the creation of a futuristic flight to Mars, using data from Mars Orbital Laser Altimeter (MOLA) experiment on Mars Global Surveyor. Working with Melbourne animation company, Act3Animation, and co-producer Bob Weis (Weis Films Pty Ltd), the Centre produced "Elysium 7" for the major national exhibit "To Mars and Beyond" staged by Art Exhibitions Australia. The exhibition ran for eleven months (December 2001 to October 2002) at the National Museum of Australia in Canberra, followed by four months at Melbourne Museum (December 2002 to April 2003), with more than 100,000 visitors seeing the 3D show. "Elysium 7" continues to be a popular component of AstroTours.

While the museum VR theatres were temporary installations, two permanent theatres opened at the Jodrell Bank Observatory Science Centre (UK) in October 2002 and at the Sydney Observatory (New South Wales, Australia) in December 2002. Both Parkes and Jodrell Bank were equipped for movie-playback only (although both are in the process of upgrading), whereas Sydney Observatory had a full system with interactive content and movies, allowing the Observatory to run its own version of AstroTour. Additional installations are summarised in Table 1 below.

Location	Country	Opened	Seats
Mahidol Wittayanusorn School	Thailand	May 2005	200
Papalote, Museo interactivo Infantil (theatre installation by Spitz Inc.)	Mexico	Oct 2004	–
CosmoDream	South Korea	July 2004	20
Melbourne Museum: To Mars and Beyond (temporary)	Australia	Dec 02-Apr 03	25
Sydney Observatory 3-D Space Theatre	Australia	Dec 2002	25
Jodrell Bank Observatory Science Centre	United Kingdom	Oct 2002	25
National Museum of Australia: To Mars and Beyond (temporary)	Australia	Dec 01-Oct 02	25
Parkes Observatory Visitors Discovery Centre	Australia	May 2001	25
Swinburne University of Technology	Australia	Dec 1999	40

Table 1. *Swinburne Virtual Reality Theatre Installations.*

The Centre has continued to produce at least one new stereoscopic movie each year, and was heavily into production of the fifth show at the time of writing. A brief synopsis of these movies is given in Table 2.

***Table 2**. Swinburne Stereoscopic Movies*

Show	**Year**	**Synopsis**
Our Sun: What a Star!	2001	The closest star to the Earth is the Sun. Where did it come from, and what will happen to it and the Solar System in the future? This 3D movie tells the life-story of the Sun and other stars: from birth to sometimes violent death.
Elysium 7	2001	Take a futuristic tourist flight to the Red Planet on board Elysium 7. Produced for the exhibition To Mars and Beyond, this 3D journey uses NASA's Mars Orbital Laser Altimeter (MOLA) dataset to reconstruct the actual surface features of Mars.
The Little Things	2003	Comets. Asteroids. Kuiper Belt Objects. This is the story of the amazing little things in the Solar System, and the incredible space explorers that have visited them.
After Stars	2004	Red supergiant star MB-8782 is about to end its life - but when the star explodes, will it produce a black hole or a pulsar? Join Margus, Dr Jozalin and WLR-309 as they find out...
Spinning in Space	2005	An astronaut on-board the International Space Station is helping to install a new galaxy-finding telescope. With the help of his temperamental robotic assistant, he starts to learn about spiral galaxies – their features, origin and evolution.

CONCLUSIONS

Through Swinburne Astronomy Online and AstroTour, researchers from the Centre for Astrophysics & Supercomputing at Swinburne University of Technology (http://astronomy.swin.edu.au) have been able to share their passion for astronomy with an international public. Both programmes show the advantages and enjoyment that an audience can receive using modern technologies—the internet—as a means of on-line education for SAO and computer-generated stereoscopic movies in a Virtual Reality theatre for AstroTour. The Centre aims to continue developing these and other forms of astronomy education, such as involvement in the Faulkes Telescope project (http://www.faulkes-telescope.com/ & http://astronomy.swin.edu.au/faulkes/) in its ongoing mission to inspire a fascination in the Universe.

SEEING INFRARED

Visualizations Beyond the Visible

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ABSTRACT

The Spitzer Space Telescope represents the infrared segment of NASA's "Great Observatory" program. Working outside of the visible spectrum presents a set of challenges in clear communication of astronomical concepts, some of them unique to this powerful telescope. We present a number of case studies of challenges for press release visualization, including visual representation of infrared data, presenting spectra, producing meaningful artwork and illustrations, and approaching non-standard image problems.

CHALLENGES OF SPITZER

The Spitzer Space Telescope is the most powerful infrared observatory to date. Building on the extensive legacy of such instruments as the Infrared Astronomical Satellite (IRAS) and the Infrared Space Observatory (ISO), Spitzer has opened the door to a new era of infrared imaging and spectroscopy. The span of Spitzer's infrared reach is illustrated in Figure 1. The three instruments on Spitzer include two capable of imaging, the Infrared Array Camera (IRAC) and the Multiband Imaging Photometer (MIPS), as well as the Infrared Spectrograph (IRS). Since Spitzer has no filter wheel (or in fact no moving parts) there are a set number of bands observed by this telescope.

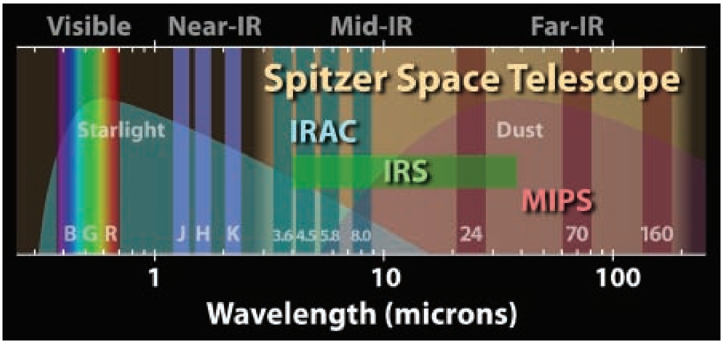


Figure 1. *Spitzer's Infrared Window. The wavelength coverage of the Spitzer Space Telescope is shown in comparison to visible light*

The scientific context of Spitzer is also indicated in the backdrop of Figure 1. The wavelength range spanned by Spitzer detectors is shown relative to visible light and near-infrared the J, H, and K bands (commonly observed from the ground). Behind this are two curves approximating the relative strength of starlight and dust emission. Spitzer picks up on the long wavelength side of stellar blackbody radiation and extends throughout the regime of complex molecules and dust emission.

Infrared observations can take an astronomically familiar object and reveal striking new views of it. Perhaps most apparent is the fact that dark, obscuring dust clouds become increasingly transparent, and ultimately luminescent, at longer wavelengths of light. Spitzer can thus peer deeply into visibly hidden regions and map the distribution of dust within the Milky Way and beyond. Infrared observations sample the more numerous base population of smaller, cooler stars better, tracing the underlying mass distribution in galaxies.

SPITZER IRAC IMAGING

The primary imaging instrument on Spitzer is IRAC. It consists of four 256x256 detectors with each one sampling a set wavelength (3.6, 4.5, 5.8, 8.0 microns). There is an offset between the area covered by the 3.6/5.8 and 4.5/8.0 micron detectors, so full spectral sampling of an area requires multiple observations at different pointings. IRAC images are easily expanded over large areas by mosaicing dozens, even thousands, of individual images.

At the shortest of the IRAC wavelengths, starlight is the primary contributor in most observations, or more generally the blackbody radiation from objects at temperatures of thousands of degrees Kelvin. This drops off quickly, and in the longer wavelength channels IRAC easily detects the emission from “polycyclic aromatic hydrocarbons” (PAHs), a common family of organic molecules that is ubiquitously associated with dust clouds. There are other emission features from hot gasses that show up in the various channels, and a particularly strong line from hot hydrogen gas is often seen in the 4.5 micron channel.

Images made from IRAC, or indeed any infrared detector, are by necessity “false” colour. The detector images must be mapped into colours that the human eye can perceive. IRAC images produced for media/outreach purposes generally use all four channels. Since the human eye only distinguishes the three colours red, green, and blue, at least one channel must be mapped to an intermediate colour. The colours are chromatically ordered, with the shortest wavelengths being represented by the bluest colours, and so forth. This provides the most natural-looking images and is better representative of what human vision would perceive if it were shifted into this infrared band.

A colour IRAC image of the starforming Tarantula Nebula is seen in Figure 2. This image uses a colour mapping of 3.6, 4.5, 5.8, and 8.0 microns mapped to blue, green, orange, and red respectively. This choice has proven to be well suited for virtually all IRAC images. Stars appear blue as they are brightest at the shortest wavelengths. The PAHs are strongest at 5.8 and 8.0 microns, so they are mapped to similar red/orange colours. In regions like this with hotly-ionized hydrogen gas, the 4.5 micron feature shows up very distinctly as green. Since the IRAC bands are fixed, we have chosen to use this colour map consistently for virtually all IRAC imagery. The greatest advantage is that the image colours correspond to the phenomena noted previously, and that the IRAC images on the Spitzer site can be meaningfully compared to one another.

Our workflow is now based on the FITS Liberator plug-in (developed in collaboration between ESA/ESO/NASA) and Adobe Photoshop. The raw astronomical data is taken either from either the Spitzer archives or directly from the principal investigator who may have performed advanced cleanup processing on it. Each channel is read into a separate Photoshop layer using the FITS Liberator. In the case of high dynamic range datasets, an appropriate stretch function is selected to enhance faint structure without burning in bright regions. The same stretch is used for all channels to maintain meaningfully consistent colour. Any final alignments between layers are made using Photoshop tools. Colours are assigned to each layer and they are combined using the “Screen” blending mode.

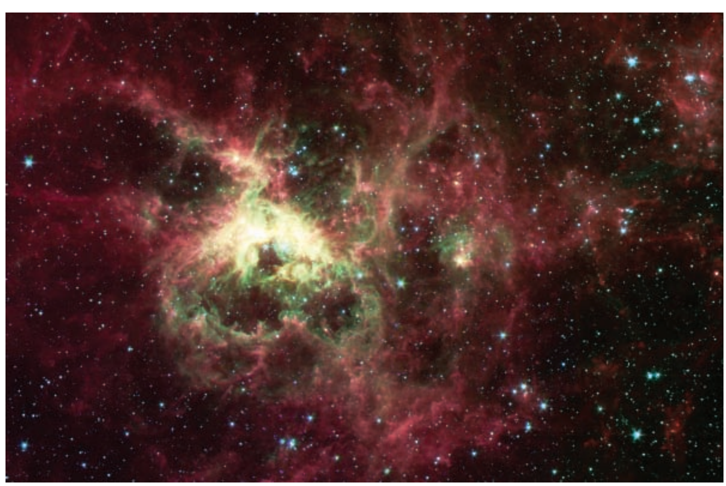


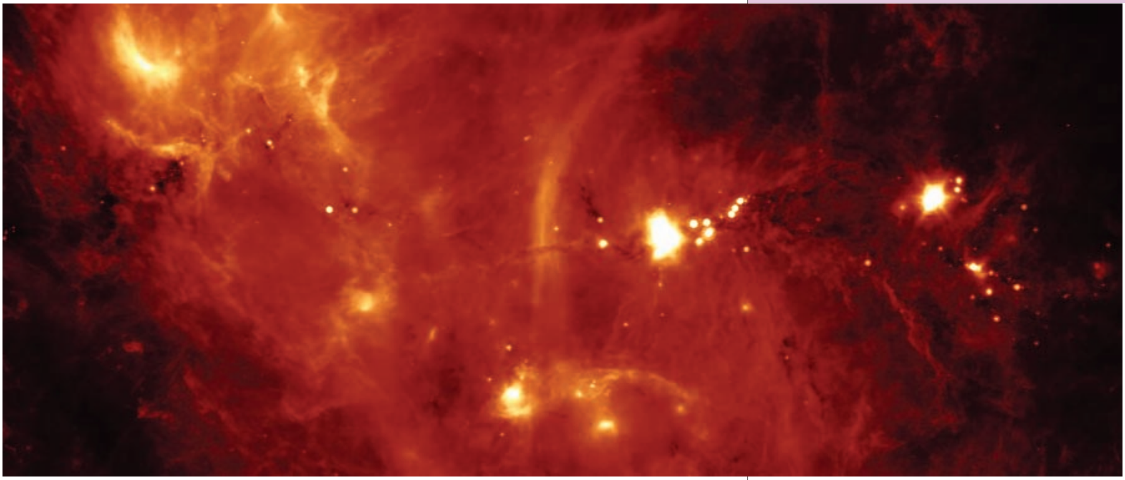
Figure 2. *Spitzer IRAC Image of the Tarantula Nebula. The 3.6, 4.5, 5.8, and 8.0 micron bands are mapped to blue, green, orange, and red respectively. Stars are seen as blue, ionized hydrogen gas as green, and fluorescence from organic PAH molecules as red.*

SPITZER MIPS IMAGING

The long-wavelength MIPS instrument extends Spitzer's imaging capabilities to wavelengths of 24, 70, and 160 microns. Thermal blackbody emission from dust dominates at these wavelengths. MIPS presents a set of unique challenges public imagery. Basic physics dictates that the resolving power of a telescope is determined by the ratio of the wavelength of light being observed and the diameter of the telescope mirror. For Spitzer this is a fixed diameter of 83 cm. Therefore, compared to a 24 micron image, a 70 micron image will be about 3 times blurrier, and at 160 microns that increases to a factor of 7. Because of the dramatic variations in resolution, multi-band colour composites are not practical for MIPS data. For the composite to be meaningful, all of the data would need to be convolved to match the lowest resolution. For public imagery we usually choose to present only the 24 micron image due to its relative clarity.

A MIPS image of the DR21 starforming region is shown in Figure 3. The image is in colour though we are only presenting a single channel of data. Because colour images are more visually appealing than greyscale ones, MIPS 24 micron pictures are generally produced using a pseudocolour gradient applied to the greyscale values. We have chosen a so-called "heat" gradient for MIPS images, mimicking the range of colours seen due to thermal emission from an object at increasing temperatures. Because this colour gradient has an intuitive connection with thermal processes, it seems well-suited to use with these images that are showing the thermal emission from clouds of dust almost exclusively.

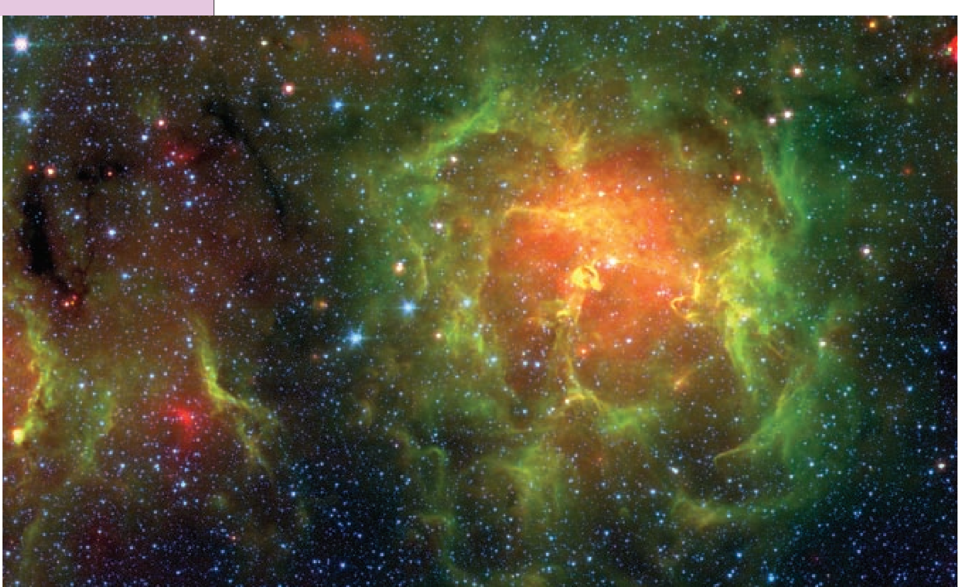
Figure 3. Spitzer MIPS Image of Starforming Region DR21. This 24 micron image has been rendered with a "heat" colour gradient to improve the visual impact of the grayscale information. The brightest areas highlight ongoing star formation, and the extended features trace dust spread throughout the disk of the Milky Way (running from upper left to lower middle of the image).



COMBINING IRAC AND MIPS IMAGES

In some cases when a region has been observed by both the IRAC and MIPS instruments, it is desirable to make a single image that combines both datasets. This can be particularly instructive in highlighting the differences between the PAH emission (primarily from organic molecules on the outsides of molecular clouds illuminated by nearby stars) and the thermal dust emission. The first can show the extent of a cloud surface, while the latter can probe the heat distribution through the cloud. The Spitzer IRAC/MIPS view of the Trifid Nebula is shown in Figure 4. In this image, the starlight at 3.6 and 4.5 microns is mapped to blue and cyan, the PAH emission at 8.0 microns is mapped to green, and the warm dust emission at 24 microns is mapped to red. The 4.5 micron channel was added in as cyan to help brighten up the starlight. Pure blue does not appear bright even on a good monitor, and prints very darkly, so bringing in more cyan greatly improves visibility of the stars. The 5.8 micron channel (which still has a somewhat strong contribution from stars) was dropped so that the PAHs would stand out as vividly green in the 8.0 micron channel (where the starlight is almost gone). Thermal dust emission is red, and regions with strong PAH and thermal dust blend to yellow. Note that the resolution limits discussed for MIPS affect this image. The 24 micron image is also 3 times blurrier than the 8.0 micron image. Even though resolutions are mismatched, visually the image is not degraded since the eye will readily focus on the bands of higher resolution. The lower 24 micron resolution can even help pick out a significant science result: very young stars are surrounded by envelopes of very warm gas that is especially bright at 24 microns. Since the longer wavelength image is blurrier, these protostars jump out due to their red haloes.

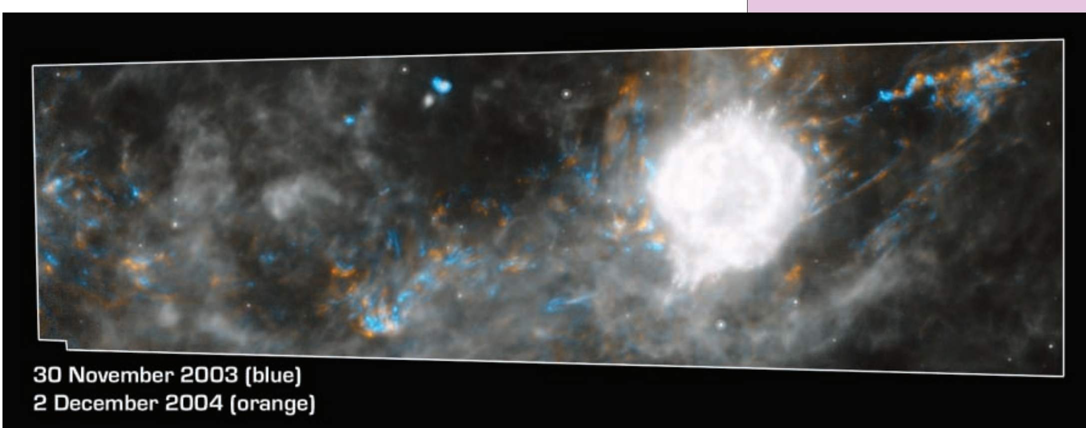
__Figure 4.__ Spitzer IRAC-MIPS Image of the Trifid Nebula. The combination of a wide range of infrared colours provides a striking view of the processes shaping this nebula. The wavelengths of 3.6, 4.5, 8.0, and 24 microns are mapped respectively onto blue, cyan, green, and red.



NON-STANDARD IMAGING

While consistent colour mapping has many advantages when creating a library of easily compared images, sometimes unusual situations do crop up. In these cases, different techniques can create useful images for print. In a recent press release, Spitzer detected a “light echo” in the dust clouds around a supernova remnant. The observations consisted of two MIPS images of the same part of sky taken a year apart. Flipping between the two images, it is easy to see a substantial shift in the illumination of the dust clouds around the remnant. This was easily captured in an animation accompanying the press release, but a good print representation was required as well. Unfortunately the motion is sufficiently subtle that it is hard to detect when the images are viewed side-by-side. A different approach is shown in Figure 5. Here the observations from the two epochs are combined as two complementary colours, cyan and orange. Anything that is identical in the two images comes out as greyscale (since adding two complementary colours yields white). However, the offset of the echo in the two source images splits into two colours in the combined image. At a glance, colour now provides the cue about what has changed between the two images. With proper colour choices, this technique can in principle be extended to cover 3 or more observing epochs.

__Figure 5.__ Spitzer MIPS Composite of Light Echo around Cas A. In this composite, two images taken a year apart have been assigned complementary colours and combined. Differences between the two observations show up clearly as either blue or orange, giving a sense of time evolution in a single still image.



SPITZER IRS SPECTRA

Some of the most fundamental science from Spitzer is the result of analysis of spectra from the IRS instrument. Unfortunately the general public cannot readily interpret a spectrum (or often graphs of any kind). Features indicating the presence of various compounds are difficult to recognize in the context of the basic graph, and are visually unappealing to all but the most devoted astronomy enthusiasts. When a fundamental Spitzer result is interesting enough to warrant publishing the original spectrum as part of the press release, the goal is to package it visually in a way that aids a non-technical viewer in its interpretation. This can involve a combination of three techniques: 1) colour code features in the spectrum, 2) add astronomical images of the object from which the spectrum was derived, and 3) include artist's visualizations of the inferred result.

Figure 6 presents an example utilizing all three techniques. In this IRS result, spectra from known protoplanetary disks around young stars were found to have ice-coated dust grains, potentially providing the building blocks for comets, atmospheres, and someday, life. Two similar spectra from similar objects are included, and the ice features are colour-coded and labelled. Behind each spectrum an inset shows the Hubble image of the corresponding disk. The backdrop is an artist's concept of an ice-coated dust grain, rendered with depth-of-field to imply small sizes. The goal is that, taken together, these visual elements will help the casual viewer understand the basic nature of the result, connecting it to the data (at least in an abstract sense).

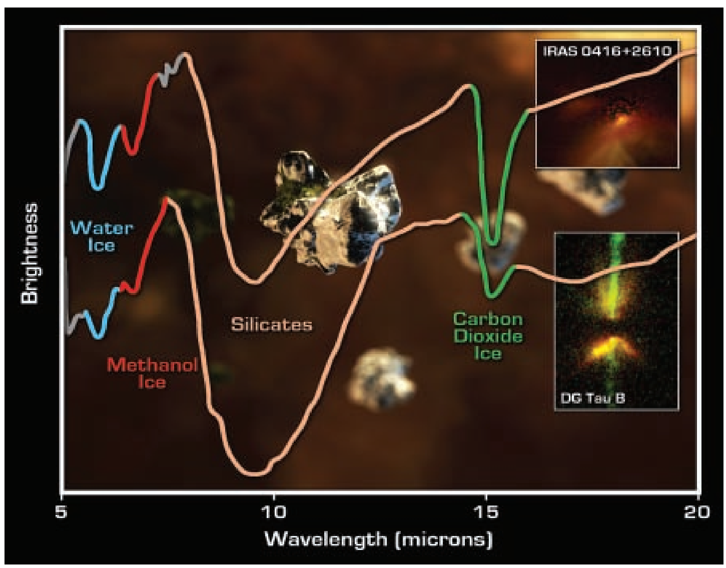


Figure 6. *Spitzer IRS Spectra of Ices in Protoplanetary Disks. The spectra are colour-coded and labelled to emphasise ice features. Hubble images of the objects are provided for context, and an artist's visualization of the result is used as a backdrop.*

ARTIST'S VISUALIZATIONS AND ANIMATIONS

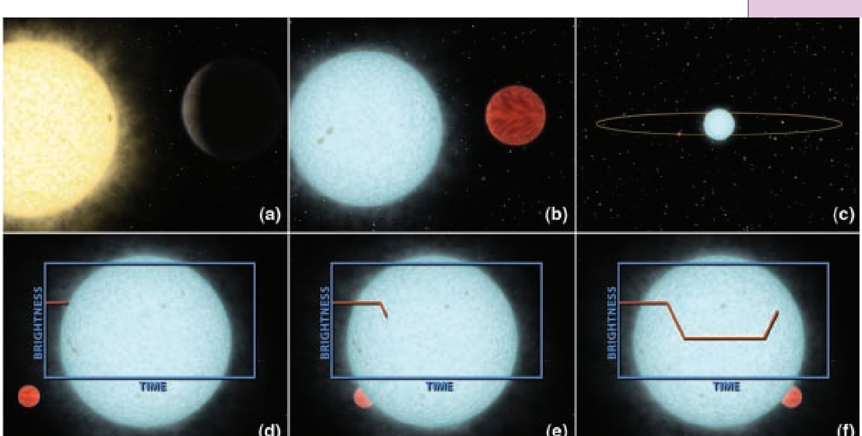
Many astronomical observations can imply a relatively spectacular result, but in a very indirect manner. In these cases it is often desirable to provide an artist's visualization, a still image and/or an animation, to communicate the result in a more exciting way. Moreover, such a visualization can often convey a variety of complex ideas that would be very difficult to put into words alone.

In a recent press release, two Spitzer researchers detected light from two known planets around other stars directly. The systems are very similar, with the planets orbiting their stars in around three days. The planets' orbits are aligned to our view so that they pass directly in front of and behind their stars. The dip in the stars' light (caused by the transit of the planet in front of the star) had already been established, but Spitzer detected the dip in the systems' total light when the planets passed behind their stars for the first time ever. In order to allow the audience to understand how the data plot is related to this result we would need clear visualization aids. The scientists presented these results in a live press conference, so we produced two animations to assist their explanations on a variety of science points.

In all such artist's visualizations, we first define a set of science/education goals that need to be evident in the final product. The visualizations are developed in such a way as to adhere to these goals, but also to be as aesthetically appealing as possible given these constraints.

The goals of the first animation (Figure 7 a-b) were to convey the following points: 1) In visible light the planet is seen only in reflected sunlight, 2) in infrared light the planet glows on its own, 3) the brightness of the planet relative to the sun is much higher in the infrared, 4) the planet is very large and very close to its star. To address these, we start with a visible light view of the system, and switch to an infrared view. The relative colours are chosen to reflect real changes in colour due to two objects at very different temperatures. Even the cloud patterns, which do not look like Jupiter, were artistically adapted from a research paper showing results of computer models of the atmospheres of so-called "hot Jupiters." For the second animation (Figure 7 c-f) the goals were to convey: 1) the eclipsing geometry of the system, and 2) show how the total observed light from the system drops as the planet moves behind the star. The 3D simulation of the system, shown from above and from the line of sight, helped establish our viewing angle. By overlaying an animated graph of the combined light of the system, the drop in light associated with the secondary eclipse of the planet helped clarify the data plot shown afterwards.

Figure 7. *Artist's Concept Illustrating a Transiting Extrasolar Planet. Frames (a) & (b) from the first animation show the contrast of viewing this system in visible light and infrared. The sequence from the second animation shows how the system would be seen if it could be resolved by a telescope, and helps explain the light curve by showing the events associated with the eclipse.*



SUMMARY

In these case studies for the Spitzer Space Telescope we have surveyed some of the logic applied to our scientific visualizations. These represent one set of solutions that we feel have worked well for specific problems faced in Spitzer press releases. The astronomical community must continue to push the boundaries of visualization in all areas, using its power to better educate and inform the public. As more powerful tools for image presentation, composition, and rendering become commonly available, the challenge is to develop new approaches to help people see and understand the Universe.


esa
Miquel Serra-Ricart

Credit: The Hubble Space Telescope, NASA, ESA, and M. Robberto (STScI)

PLENARY SESSION 12:
Virtual Repositories

"CATCH THE STARS IN THE NET!"

Eight Years of Experience in Communicating Astronomy via New Technologies

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INAF—Astronomical Observatory of Padua, Italy

ABSTRACT

The authors describe their work and experience gathered in the field of Public Outreach Education (POE) and Information in Astronomy over the last 8 years, mainly but not only, through the web. "Catch the stars in the Net!" is a long term project made up of many initiatives for nearly all types of possible users: young, students, amateurs, general public or the merely curious. All the initiatives are developed within a focus group on the framework for the particular field and then, after this experimental phase, are published and managed on the web. There are more than 33 astronomica independent websites in Italian on the project webserver; all of them are reachable from one "Web door" with the name *"Prendi le Stelle nella Rete!"* (Catch the Stars in the Net) at the url: www.lestelle.net. We have called it a "Web door" because it is neither a simple Home Page nor a Web Portal, but presents all the related websites in a well structured way to facilitate their use by the different types of user for different purposes. Half of the 33 websites are in English, and they are all reachable from the url: www.astro2000.org. The project was born from and has developed in parallel with emerging technologies: from the first website in 1997, to the weekly news bulletin in streaming audio/video in 2000, to the last project with wireless technology for an astrophysical mobile learning programme, supported by industry, undertaken this year at primary and middle schools.

INTRODUCTION

The authors work at the National Institute for Astrophysics, INAF, which was established in July 2000. INAF is the Central Administration Institute that promotes and coordinates research activities in astrophysics in Italy through its network of 12 Italian Astronomical Observatories and 3 research institutes of the Italian National Research Council that joined INAF in January 2004. INAF also manages two National Observing Facilities: the Telescopio Nazionale Galileo Galilei (TNG), La Palma (TF—Spain) and the Large Binocular Telescope (LBT), Mount Graham (Arizona-U.S.). INAF has more than 600 staff researchers and 500 technicians and administrative people on the permanent staff.

By law, INAF must contribute to basic and advanced education at all levels from schools to universities, in other words, function as Public Outreach of Astrophysics and Space Science. As an example we can quote two important acts of INAF in the field of POE: the coordination of a national initiative for the Venus Transit 2004 (www.

pd.astro.it/ thersites/venere/) for the general public, schools and also the press (in collaboration with the European Southern Observatory). The second initiative was related to the inauguration of Large Binocular Telescope for which several products, from a website (www.lbt.it) to a brochure were produced for the press.

INAF is a new research institute, but it is supported by the long-term experience in astrophysics education, information and outreach gained by the astronomical observatories and the other research institutes that constitute it. An INAF Press Office was established in 2003 and is working hard to set up the necessary communication links with the media and with the researchers themselves. Regarding communication with the public, we expect to have full operability before the end of this year.

Among several groups involved in the outreach, education and information activities at INAF, the Astronomical Observatory of Padova (Padua) has acquired a strong and successful track record over the past years. This group is composed of astronomers who have been working in science education, learning and outreach since 1997, both through webstreaming and conventional media (presence at schools, exhibits, newspapers and magazines). The team has a solid background in astrophysics outreach, information and teaching, and is supported by a wealth of technological skills.

THE "WEB DOOR" CATCH THE STARS IN THE NET!

The Web door is hosted on the Padova Observatory webserver where there are several other Public Outreach projects. The main bulk of these are made up of more than 33 independent astronomical websites in Italian; all of them are reachable from one "Web door" with the name *"Prendi le Stelle nella Rete!"* (Catch the Stars in the Net!) at the url: www.lestelle.net. We call it a "Web door" because it is neither a simple Home Page, nor a Web Portal, but it presents all the websites in a well structured way to facilitate their use by different kinds of users for different purposes. Half of these 33 websites are in English and they are all reachable from the webpage www.astro2000.org.

Our information activities have an important role and include a daily Astronews bulletin, www.astronews.it, .and a weekly audio and video astronomical bulletin, Urania, at the url: www.cieloblu.it. We also host the European Association for Astronomy Education Italian website.

Some statistics: we answer about 1,200 questions per year and there are nearly 5,000 subscribers to our weekly newsletter. We reach more than 100,000 users a year and register thousands of hits per day when a particular astronomical event occurs (such as an eclipse, Venus transit, etc.). Furthermore the group, thanks to both new and former connections, manages a very large network of Italian schools (1,014 at the time of writing). Suffice to say that the Web door only represents the "visible" part of a more complex project of didactics and popularisation of our science, astrophysics.

At the present, material for several different groups of people are available: for example, school children from primary to the secondary school level; people with disabilities and people who have a real interest in astrophysics or just want to "know more" about the sky.

COMMUNICATION IS A PROCESS OF NEGOTIATION

We will not catalogue all our projects here as they are all visible on web, but concentrate on just a few of the numerous experiences and projects realized and managed by "Catch the Stars in the Net!" that are strictly related to the key point we wish to stress here. That is: we (people who work for and in an astrophysical research institute) are privileged. We are privileged because we have time to test a variety of new approaches with the public, to test new media, to apply new technologies and, last, but not least, to test new content. Moreover, we share a common knowledge with the main actors of scientific research, and can use emerging technologies before they spread into the community. We also have time to reflect on what kind of content and languages are most appropriate to the presentation of astrophysics to the public.

But what do we mean when we say "to test"? We mean that all our initiatives are first planned and then developed within a focus group, which gives us the proper feedback and then, only after this test phase, are they published and managed on the web. In our opinion testing is fundamental for good communication because we live in rapidly changing times; in particular, as far as science and technology is concerned we have never presumed to know exactly what and how it should be communicated.

To express this idea we would like to use the words of Jane Gregory and Steve Miller:
"[…] key to the relationship between science and the public is trust, and that trust is established through the negotiation of a mutual understanding, rather than through statements of authority or of facts!
[…] Models of the public and their understanding have developed from the passive and empty "black box" to an active, discriminating body which should choose information within its own cultural framework. Models of communication too have become more complex as the transmitter-receiver descriptions have failed to account for the variety of interactions observed between communicator and audience.
[…] The recipient of the communication is a complex human being whose back-

ground, beliefs, and sensibilities play a large part in his reactions to scientific knowledge.

Communication is a process of negotiation: it is one of a mutual getting-to-know. Science communication is a process of generating new, mutually acceptable knowledge, attitudes and practices. It is a dynamic exchange, as disparate groups find a way of sharing a single message. Negotiation is a two way process: if the public needs are to be met, they must be put in the position to articulate what these needs are.'' ("A protocol for Science communication for the public understanding of Science" Sept. 2004, University College London)

NEW TECHNOLOGIES FOR EDUCATION

The group "Catch the Stars in the Net!" has been involved in education and e-learning activities, focussed on young people and schools since 1997. Our experience in education has grown steadily thanks to collaborations with teachers and learning experts. Keeping in mind what we have just said about the way we work on our projects, be they education or information activities, let us proceed with a first example of best practice: the Virtual Planetarium (www.pd.astro.it/education/PlanetV/planetarium/). This is an interactive online astronomy course. The Virtual Planetarium was designed to provide children with a new tool for learning the basics of astronomy. The course is amusing, but at the same time rigorous: it provides teachers with various images, animations and examples to reinforce children's knowledge. Furthermore it was the first interactive astronomical website in Italian!

The Virtual Planetarium has been tested in several schools during the second part of the school year 1997/98 and during the whole of the school year 1998/99, with the goal of verifying the efficiency of the used methodology and language and to identify possible mistakes and deficiencies. Basic astronomical concepts are introduced progressively, each new level depends on the knowledge acquired in the previous level and the user can access it only after the successful completion of a test about the acquired concepts from the completed level.

The used methodology is the "Karplus cycle" (Atkin & Karplus, 1962; Karplus et al., 1976), which asserts that the correct acquisition of concepts is strictly related to the removal of misconceptions. A list of the most common misconceptions has been prepared, and it can be browsed. They have been used to set the basis for a series of preliminary tests. Responses to targeted questions identify pre-existing misconceptions. In order to remove these misconceptions, observations or lines of reasoning are proposed that lead to a contradiction with the remaining conceptual framework of the student, so that he or she has to revise it.

This multi-level structure is well suited to hypertext and the internet, which was seen as a very revolutionary tool in 1997. At that time the internet and its interactivity were very new both for students and teachers and we have worked very hard to gain their trust. It is well known that trust is hard won and easily lost, especially when dealing with schools. Education has always been a never ending experiment for us. We have continued to develop new educational projects over the past 8 years, always working in strict collaboration with teachers, testing our prototypes and requiring continuous feedback both from students and teachers. We have just described the first example of this.

"Heavens above!" is another example. It is an astronomy and physics course made up of seven modules designed for children aged 6-13. Each module is addressed to children of a given school year. The modules include teaching materials (instruction cards for hands-on activities, examples of discussions, other example sheets, etc.) and materials for students (evaluation cards, cards for instrument construction, etc.).

NEW APPROACHES FOR EDUCATION

A project that could be considered a milestone in our experience with schools is "Altrimondi—Life in the Universe". This project started in April 2001 as an Italian national programme addressed to schools with the aim of inviting young students to think and know more about the fascinating subject of the search for Life in the Universe. The initiative, addressed to all Italian students, was proposed as an educational project, promoted by EAAE (European Association Astronomy Education) and took advantage of a collaboration with many research institutions, educational associations, astronomical observatories and university departments. A competition called Altrimondi was announced as part of the project. This was open to young students aged between 13 and 18, with financial prizes for the first ten winners. The competition invited the students to investigate and analyse issues pertaining to Bioastronomy in depth.

"Life in the Universe" has been a good example of experimenting with new approaches for students. By using bioastronomy, a new science that investigates the possibility of life in other worlds, and using information and communication technologies as the sole vehicles for the project, we obtained many results as to how best to approach young students and to encourage them to study scientific disciplines.

The starting point and heart of the entire initiative was the website, Altrimondi.net (www.pd.astro.it/othersites/altrimondi/). Altrimondi.net provided the participants with all the tools required to take part in the project and in the competition. A weekly Newsletter gave information and updates. Moreover, the students and their teachers were put in contact with the experts, i.e. the researchers involved in bioastronomy. Within a short time, a virtual community of young people interested in the subject arose. The many entries submitted to the Altrimondi competition proved to be valid from an educational point of view and considerably enriched the contents of the site. The initiative was expected to be, and in the event, was, very successful, as is clearly shown by the following figures: 600 registrations to the weekly information Newsletter, 200 participant groups to the contest, 3000 young students at the event that marked the end of the competition.

After the success of "Life in the Universe" another project was launched in September 2002: *"Alla Scoperta del Cielo!"* (Discovering the Sky!) (www.scopriticielo.it). The success of this project has been so great that it was repeated for the next two school years 2003-2004 and 2004-2005 with even more impressive participation figures. We have now reached a network of more than 1,000 schools throughout Italy! This initiative develops learning in four stages: four "virtual nights" of observation of the sky in an ideal astronomical observatory during which the main topics of astrophysics are discussed.

As in Altrimondi, information is transferred solely through the net; once a week the students and their teachers receive age-appropriate contributions (four categories of age are provided: 6-8, 9-10, 11-12, 13-14) by email. At the end of every step, a test is administered to check the acquired knowledge. The most active and curious can connect to the dedicated website and find more details, suggestions, games. Participants can also ask astronomers questions directly, participate in guided chats and even contact other students joining the project through the site. Teachers receive separate advance messages containing a full description of every step, auxiliary material and suggestions for additional activities. This project also includes a competition, *"Scopri il Cielo nella tua Città'"* (Discover the Sky in your Town) where students are invited to look for any features related to the sky among the monuments, works of art, engineering works in their own town (buildings, paintings, sundials, etc).

"Altrimondi" and *"Alla Scoperta del Cielo!"* have been, and continue to be, special projects because they experiment with a new educational approach, that starts with the students themselves to reach out into schools. This has been made possible by the fascination of astrophysics itself, by the experience gathered over the past years of work in the field, by the language adopted and, not last, by the technologies employed. They have produced satisfaction, not only to the youngest participants, but also, and especially, to the teachers who have found a firm support to their fundamental and essential role as educators in these projects. (For further details see "A Successful Experimentation in Science Education: the Virtual Community Of Altrimondi.net", Proceedings Of The Iadis International Conference E-Society 2003, Lisbon, Portugal, pp. 19-26).

As we pointed out at the beginning of the present article, we are privileged also because we are able to experiment with an emerging technology before it spreads across the community. This has been the case of "Virtual Planetarium", but it is also the case of our latest 'mobile-learning' project "Learning from Starlight—*Progettare per comprendere''*.

Emerging technologies in the field of wireless communication used in conjunction with mobile devices are leading to the development of new opportunities for the educational environment to improve learning and teaching experience. The emerging mobile learning paradigm tries to implement the vision of ubiquitous and pervasive computing. Within this scenario, the "Learning from Starlight" project aims at mobilising these technologies to improve education and outreach in the field of astrophysics.

Three classrooms of students at three different stages in the Italian education system have been involved in the two phases of this educational project. In the two phases a classroom activity relating to the observation and analysis of astrophysical phenomena is followed by a full day at a research institute to improve knowledge about a particular topic and to allow students to interact directly with astronomers. The projects have benefited from a generous equipment grant by the Hewlett Packard Foundation, that gave us 26 Tablet PCs and 26 Pocket PCs along with other useful devices for the complete planning of an educational activity (for further details see the web-site of project: www.pd.astro.it/hp and the article "The "Learning from Starlight" project: experiencing mobile technologies to improve education and outreach of Astrophysics", Proceeding of m-ICTE2005, Cáceres, Extremadura, Spain, "Recent Research Developments in Learning Technologies (2005)" A.Méndez-Vilas Editino).

ASTROPHYSICS AND DISABILITIES

We created "The Sky at your Fingertips", the first astronomy website for blind people (www.pd.astro.it/othersites/stelle/ariveder/ English/) in 2000. "The Sky at your Fingertips" is dedicated to visually impaired users of all ages who wish to set off on a fascinating journey among planets, comets and galaxies and to discover the wonders of the Universe. There is an image that has been converted into a format that can be touched, followed by a piece of text on each page. A Braille printer is needed to print the image on special paper or plasticized paper, while the text can be listened to with a normal vocal synthesizer. In constructing the website we worked directly with a focus group of blind people, who gave us the necessary feedback for such a difficult task. A book written in Braille describing the website has now been produced.

After this experience we have continued with other projects, in particular for children with cognitive problems (see, for example “Universe for Dyslexia” – 2001 in www.pd.astro.it/othersites/english/handicap.html)

NEW CONTENT AND “NEW” MEDIA

In the last four years we have concentrated on a kind of communication that is separate from outreach and education: the dissemination of information. We have two main products supplying astrophysics information, Astronews (www.astronews.it) and Urania (www.cieloblu.it).

The first simply uses the web; it is very traditional but very effective. It represents a quick and simple way to inform users about the news from astronomical research, space technology and space missions daily. A webpage is updated every weekday with a short summary of the most relevant news from official Space Agencies (NASA, European Space Agency, Japan Aerospace Agency, etc.), press agencies and scientific magazines (Nature, Science, The New Scientist, etc.). Each news feature has a short appealing title and by clicking on it the user can reach the full article from the original source. So, with Astronews the user can be fully informed in just a few seconds. Furthermore the user is assured of the scientific correctness of the news and the reliability of the sources. Astronews is useful not only for professional astronomers but also for amateurs and journalists in search of further information or to verify the reliability of the news they have heard.

The second, Urania, is a weekly Astronomy and Astronautics news bulletin, with an audio version (mp3 for Podcasting), a flash version with images and browsing tools and an html version. There are now more than 30 radio networks broadcasting Urania! Radio is not a new medium but it could be considered a new medium for astrophysical information. Urania is new not only for the different media used, but also for its content and approach. In Urania, information for the general public is directly provided by experts (astronomers), not just by professional journalists. The news is selected for its scientific relevance and not only for “popularity”. Moreover, in Urania, we have chosen to give special emphasis to the consequences of aerospace research on everyday life (telecommunications, environmental monitoring, diagnosis instruments for Medicine, etc.), to the involvement of Europe in astronomical and space research and to the economic and technological aspects of this kind of research.

Urania is a simple, modern and flexible way to keep up to date about astronomy and space; the language is direct, simple and at the same time correct, the style is quick to fit in with new communication media, with a strong interaction between text, audio and video. The aim is to inform, entertain and to stimulate people's interest in science that is a common part of everyday life. In particular, both radio and web are well suited for bringing young people closer to science, stimulating interest, discussions and investigations at home or at school. All in all, Urania is a good tool that can be used as a format for information, education and outreach in other sciences and contexts.

CONCLUSION

We conclude by stressing once again the importance of testing education, information and outreach projects and to make clear a very important lesson learned in this process of negotiation, as communication was called at the beginning of the article. The principal lesson learned in these 8 past years is that the public needs correct scientific information. Outreach and education are also important, but they are capable of reaching fewer people than the total number of people interested in information in general.

But be careful! Information must be presented while respecting the audience. Let us end this article with the words used by H.G. Wells with Julian Huxley while they were writing The Science of Life (as referred to by J. Miller in "A protocol for Science communication for the public understanding of Science" – Sept. 2004, University College London):
"The reader for whom you write is just as intelligent as you are but does not possess your store of knowledge, he is not to be offended by a recital in Technical language of things known to him (e.g. telling him the position of the heart and lungs and backbone).

He is not a student preparing for an examination and he does not want to be encumbered with technical terms, his sense of literary form and his sense of humour is probably greater than yours.

Shakespeare, Milton, Plato, Dickens, Meredith, T.H. Huxley, Darwin wrote for him. None of them are known to have talked of putting in "popular stuff" and "treating them to pretty bits" or alluded to matters as being "too complicated to discuss here". If they were, they didn't discuss them there and that was the end of it"

LIFE AFTER PRESS:

The Role of the Picture Library in Communicating Astronomy to the Public

Gary S. Evans

Science Photo Library, London, United Kingdom

ABSTRACT

Science communication is increasingly led by the image, providing opportunities for 'visual' disciplines such as astronomy to receive greater public exposure. In consequence, there is a huge demand for good and exciting images within the publishing media. The picture library is a conduit linking image makers of all kinds to image buyers of all kinds. The image maker benefits from the exposure of their pictures to the people who want to use them, with minimal time investment, and with the safeguards of effective rights management. The image buyer benefits from a wide choice of images available from a single point of contact, stored in a database that offers a choice between subject-based and conceptual searches. By forming this link between astronomer, professional or amateur, and the publishing media, the picture library helps to make the wonders of astronomy visible to a wider public audience.

COMMUNICATING THROUGH IMAGES

Mass communication is dominated by images. Wherever one looks, from advertising hoardings around town to television and the internet, carefully chosen imagery looks back to tell a story or sell a product. Although a cliché, the idea that a picture is worth a thousand words is a truism in the modern media. However, of more importance is that these virtual words are expressed and comprehended with astonishing rapidity, certainly compared with reading and comprehending a thousand words of newspaper text. This speed of appreciation is, perhaps, the vital characteristic of the supremacy of the picture.

Science can take advantage of this to communicate with the public, to help make the public aware of what is being done with their taxes. However, a distinction needs to be drawn between communication and education.

Education may be regarded as the 'coalition of the willing', in that it requires both parties—educator and student—to want to be involved in the process. However, the majority of the audience for mass communication does not wish to be educated during its leisure hours, it wishes to be entertained. Television viewing figures are dominated by continuing drama ('soap opera') or 'reality' shows such as *"Big Brother",* which suggests that there is little willingness on the greater part of the public to study.

The situation has not changed much in a century or more. At the end of the working week, most people a hundred years ago were more likely to visit a circus to gawp at the freak show than to attend a discourse on natural philosophy by one of the great scientists of the day. Science in general and astronomy in particular, needs to feed those of the 'coalition of the willing' who wish to learn, but not at the expense of the loose confederation of the bored that craves entertainment. In short, astronomy needs to be today's freak show.

People want to look in wonder, to be amused and astounded, but don't need to understand what they are seeing at any deep level, any more than our ancestors needed to understand developmental biology and genetic mutation when gazing at the bearded woman or the conjoined twins. The way to bring science into the public eye is to communicate through images. The science community needs to provide images to a diversity of media so that they may be seen by the widest possible audience. These images need to inspire the same 'wow' factor as the freak show.

Among all science disciplines, it is the 'visual' sciences that are in the best position to achieve this. A 'visual' science is one in which the primary science data are gathered by some imaging modality. Examples include Earth observation, medical diagnostics and, of course, astronomy. Images of the Universe have a fascination of their own, something quite literally 'other worldly'—freakish, even. This is reinforced by public awareness of space as something 'other'. Science fiction in books, film and television reinforces this perception. The astronomical community can take advantage of this fascination to let the public know that what it does is not science fiction, that what is being observed is not the imagination of some effects artist, but is real. This conversion from imagination to reality is a powerful creator of true wonder. What is needed is a comprehensive set of channels for feeding images into the view of the whole public.

THE ROUTE TO THE PUBLIC EYE

Pictures need to make a journey from the source, through one or more mediators, to the public eye. For the purposes of this discussion, the term astronomer is used to include the professional working at an observatory and the amateur 'backyard' observer. The latter may not do much 'hard' science, although many comets and NEOs are discovered by amateurs, but an increasing volume of excellent and inspiring imagery is coming from privately owned telescopes fitted with superb CCD detectors, high-quality filters and processed using modern desktop computers and software.

Outside of the existing outreach and education programmes set up by observatories and planetaria, the route by which images reach the public is dominated by the publishing and broadcast media. Connection to the media is generally through an intermediary, referred to in the stock photo industry as the picture buyer. This is a person employed to find images to fulfil a publishing brief. This may be a magazine article, a textbook, a corporate awareness brochure, or any of a hundred other uses. The important point is that, broadly speaking, picture buyers are rarely employed solely on science-based projects. In fact, they are not particularly likely to be any more science literate than the demographic of the population as a whole.

The result of this is that, for the majority of media, there is little awareness of where to find good images of astronomical subjects. Of course, there are already a number of picture buyers who are conversant with astronomy sources, but most of these are working for specialist titles or publishers already. A link needs to be forged between the astronomer and the non-scientist picture buyer, and that link is the picture library.

BENEFITS OF THE PICTURE LIBRARY ROUTE

For a picture library to be a viable entity, it must meet the needs of its client picture buyers, but also in some way benefit its contributors.

For the picture buyer, the most important benefit is that the picture library is a 'one-stop shop'. Picture buyers rarely have either the time or the knowledge to trawl through lots of different web sites in search of the perfect image for their project. The project may involve a very large number of images; a single book project may require hundreds of images to be obtained, sometimes over a wide range of subjects. Even within the subject of astronomy, the client may want images of facilities and portraits of astronomers, not just images of sky objects. Often the search is conceptual rather than subject-based—for example, something spiral is wanted for the cover of a novel and the picture buyer might not have heard of spiral galaxies. Images in a picture library usually have some metadata attached, such as a caption and keywords, and a substantial investment in time is made to make these as comprehensive as possible.

Picture libraries also invest considerable resources into making the images accessible in digital form, the preferred medium for picture buyers. Many archive collections are in hard copy—print, film or even glass plate—and normally the picture library will provide scanning services to get these digitised.

A further commercial imperative for the picture buyer is being able to obtain rights clearance. Because the images in the library are either copyright-free or are subject to specific representation agreements, the buyer knows that they are able to obtain the required permissions to reproduce the image without the need to contact many image authors. There may be instances where specific rights clearances are needed.

Inclusion of an image in an advertisement might imply endorsement by the astronomer's institution of a product. Because the picture library maintains good contact with its contributors, it is best placed to facilitate and mediate the discussion.

Finally, something that is vital for the non-scientist picture buyer is that a specialist picture library provides a knowledge and advice centre. Some concepts can be difficult for non-scientists, such as the distinction between types of nebulae and thus their place in the stellar cycle.

For the astronomer, the first major benefit of working with a picture library is the huge increase in reach. Most astronomers publish through the internet, through specialist magazines and, in the observatories, through education and outreach programmes, CD-ROMs and so forth. However, the reach through a library is extended to all types of media across the world, some with which the astronomer may be less than familiar.

The picture library is also able to take some pressure from the understaffed outreach office, or from the shoulders of the individual astronomer, especially with fairly routine book requests for archived images. This can be, to a greater or lesser extent, as the astronomer wishes. Some prefer not to refer image requests, some are happy to offload as much as possible in order to free up staff resources for other projects.

As with the picture buyer, the astronomer benefits from effective rights management when collaborating with a picture library. The picture library takes on part of the role of rights policing, as it is in the interest of all parties to pursue possible unauthorised use of rights protected material.

Finally, there is an income stream available. This is of interest mainly to the individual astronomer, although some observatories are able to accept a commercial arrangement of this kind. No matter what the source, the picture library will make a charge for the supply of any image. Typically the reproduction fee charged by the library is split 50%-50% with the contributor.

CAVEAT DONATOR – LET THE GIVER BEWARE

Before entering into an agreement with a picture library, there are some issues that need to be resolved.

Copyright: This is by far the most important issue, and one that has to be clearly understood by all parties. The picture library must know for certain that one of the following is true:

- the contributor is the copyright owner, or
- has the right to act on behalf of the copyright owner, or
- that there is no copyright asserted in the images.

Without this information, no picture library will proceed with an agreement. Knowledge of the copyright status is central to the operation of any picture library, and these rights are strongly protected in domestic and international laws. Special care has to be taken by observatories, in that the data may have rights associated with them but that rights in an image derived from the data (with the data owner's permission) may reside with the image maker, not the original data owner. Likewise, it must be made clear whether derived images are covered by any agreements on the proprietary data embargo. These issues need to be clearly understood from the outset.

Commercial and ethical policies: Most institutional contributors will not allow their images to be used in any way that implies their endorsement of any product, service or activity. Other institutions may have more explicit ethical policies. Individual astronomers may not want their images used in conjunction with religion or astrology, for example. In any such case, it is important that concerns are raised with the picture library at the outset, so that timely action may be taken to prevent inappropriate use of the images. Generally, a notice to this effect will be displayed with the image on the picture library web site, and staff will be trained to look out for any possible commercial or ethical policy statements when negotiating rights clearances with a client.

Exclusivity: Many picture libraries will ask that you do not give the same or similar imagery as you supply to them to any other stock picture library. This is to prevent confusion or embarrassment should a client receive the same picture from two different sources, where conditions and fees may differ depending on various deals being offered. This doesn't reflect well on anyone. Some contributors, especially those working on Federal funding, may not be able to enter into such an agreement, in which case the clause will usually be dropped. This doesn't mean that you would be unable to enter into distribution agreements with any other company—several of our contributors have deals running with print and poster manufacturers, calendar companies and so forth.

Presentation: It is important that any picture library with which you choose to work presents your imagery in an attractive and accessible way, accompanied by clear, concise and accurate information. The contributor is automatically associated with the library in the mind of the client, and it is crucial that your work is presented to its best advantage.

CONCLUSION

The route to public awareness of astronomy doesn't have to include a public understanding of astronomy. While there are many opportunities for improving communication through education, there are many more potential outlets for communication through simple exposure to images produced by astronomers of all kinds. The picture library provides the scientist with a single point of contact through which images can reach the public, and provides the picture buyer with a single point of contact for accessing the images.

By making images of astronomy more widely available and published through more media, the aim is to increase familiarity with the images of astronomy and to encourage curiosity among the lay public, and eventually to increase the number of people willing to devote time to understanding astronomy through education and outreach programmes.

MOVING THE PRETTY PICTURES INTO THE 21ST CENTURY

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ABSTRACT

One of the first steps towards an Astro-Google or even a Virtual Repository (see Christensen, 2006, this volume) is the proper meta-tagging of outreach products such as images and videos. Meta-tags will allow information such as ID, object name, image coordinates and more to 'travel' with the products and thereby facilitate proper searching of the products. The ESA/ESO/NASA Photoshop FITS Liberator v.2 will support meta-tags, but a global consensus on these meta-tags must be reached. We report on the latest progress in this area.

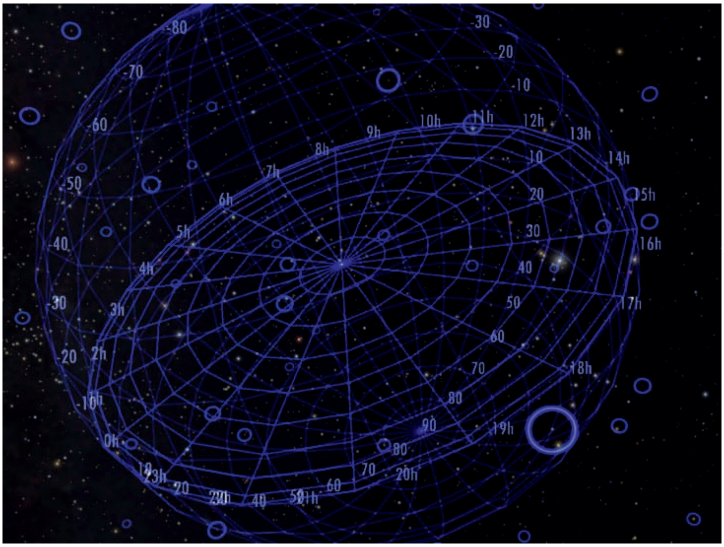

__Figure 1:__ Attaching metadata to EPO data is the first step to place them in a context as it is here done in an impressive way by the company Sciss AB in collaboration with the American Museum of Natural History. Credit: Image from the Uniview application, property of Sciss AB Sweden, and the Digital Universe database, property of the American Museum of Natural History

Imagine if the wonderful collections of press release materials from ground- and space-based telescopes could include common information, known as metadata, such as their positions on the sky, object names etc. An elaborate and standardised system could be envisaged whereby the world's archives of more refined outreach and education products such as 'pretty pictures' and videos could be tied together and made accessible.

This would make it possible for outreach offices as well as third party companies to build automated tools that could interface with image databases on the Internet and allow this treasure to be explored. Anything from simple searches using existing, and very powerful, internet search engines up to interfaces to fully three-dimensional 'digital universe' settings is conceivable as an outcome of such a framework. One could imagine using outreach images in live planetarium shows, in comparative multi-wavelength views, as a teaching aid and in many other places. Finally, and most important of all - so long as future PR images are compatible with some yet to be agreed upon standard, the treasury of 'mouse-click accessible' images will grow from day-to-day.

This is a challenging, but manageable, task. It demands consensus and collaboration among the entire outreach and education community - from the people creating the 'pretty pictures' (image processing specialists), via the data Holdings (the outreach archives) to the different end-users such as educators and 'visualisers', who use the resources to visualise 'Digital Universes'. The International Astronomical Union (IAU) Virtual Repository Programme Group was set up during 2004 to nurture the growth of such a collaboration known as the Virtual Repository (see Christensen, 2006, this volume)

On the technical, or implementation, side, the Virtual Repository is, in essence, a framework consisting of four components, namely:

1. Resource metadata tags attached to images, videos, news etc.
2. A centralised organiser / controller (for instance the IAU Working Group Communicating Astronomy with the Public)
3. A list containing the data archives, i.e. a "telephone book" or a registry that contains metadata about data resources and information services, and
4. A definition of a protocol for communication between the physical repositories and the users. For instance through the Registry with the help of a VO-style Data Access Layer, such as the Simple Image Access Protocol (SIAP)

The second component should be a well-defined list of metadata descriptors that would always accompany products such as images and videos. A draft for such a list is given below. It is currently under final discussion before hopefully being endorsed by the International Virtual Observatory Alliance (IVOA) and the IAU.

The Virtual Repository system content envisages that the metadata are transported within the multimedia files, i.e. embedded within the actual image and video files etc. in a so-called XMP format, which is Photoshop's XML format.

THE IAU VIRTUAL REPOSITORY PROGRAMME GROUP

The metadata topics are being discussed by a metadata subgroup of the International Astronomical Union (IAU) Virtual Repository Programme Group, see: http://www.communicatingastronomy.org/repository/virtual_repository.html. A more in-depth description of the suggested Metadata tags can be found here.

***Table 1:** Metadata tags example. Courtesy of the Metadata sub-group of the IAU Virtual Repository Programme Group.*

Identity Metadata		
1.	VR MetadataVersion	1.0
2.	Identifier	ivo://nasa.opo/opo0511a ivo://esa.heic/heic0503b
3.	Title	Hubble Detects Faint Galaxies
4.	DatasetIDs	ivo://ESO.HST/U2JZ0607B ivo://ESO.HST/U2JZ0603B ivo://ESO.HST/U2JZ0605B
Curation Metadata		
5.	Publisher (string)	NASA/AURA/STScI/Office of Public Outreach
6.	PublisherURL	http://hubblesite.org
7.	PublisherID	ivo://nasa.opo
8.	Date	2005-07-29
9.	Contact.Name	Cheryl Gundy
10.	Contact.Email	gundy@stsci.edu
11.	Copyright	CopyLeft
12.	Credit	NASA, ESA & Bent Smölph
General Content Metadata		
13.	ObjectType	SolarSystem.Mars
14.	ObjectName	NGC 256, Andromeda Galaxy, M 51
15.	Description	This spectacular color panorama of the center the Orion nebula is one of the largest pictures ever assembled from individual images taken with the Hubble Space Telescope. The picture, seamlessly composited from a mosaic of 15 separate fields, covers an area of sky about five percent the area covered by the full Moon.
16.	ReferenceURL	http://hubblesite.org/newscenter/newsdesk/archive/releases/1995/45/image/a
17.	Type	Photographic
Observation Metadata		
18.	Facility	Hubble Space Telescope Hubble Space Telescope Hubble Space Telescope
19.	Instrument	Advanced Camera for Surveys Advanced Camera for Surveys Advanced Camera for Surveys
20.	Coverage.Spatial.ReferenceValue	123.50,-59.56 [degrees]
21.	Coverage.Spatial.ReferencePixel	250.5, 250.5

22.	Coverage.Spatial.CoordinateFrame	FK5
23.	Coverage.Spatial.Equinox	J2000
24.	Coverage.Spatial.Scale	1.55e-5 [arcsec/pixel]
25.	Coverage.Spatial.Rotation	23.56 [degrees East of North]
26.	Coverage.Spatial.CoordsystemProjection	TAN
27.	Coverage.Spatial.Dimensions	2048, 2048 [pixels]
28.	Coverage.Spatial.Quality	A
29.	Coverage.Spectral	Optical Optical Infrared
30.	Coverage.Spectral.Bandpass	B [SII] I
31.	Coverage.Spectral.CentralWavelength	552.4 [nm] 659.1 [nm] 820.3 [nm]
32.	Coverage.Temporal.StartTime	2000-12-23-1205 [UT] 2001-11-29-1707 [UT] 2002-07-02-0005 [UT]
33.	Coverage.Temporal.IntegrationTime	200 [seconds] 400 [seconds] 800 [seconds]
34.	DataQuality	A
Image Processing Metadata		
35.	StretchFunction	Logarithmic Logarithmic Logarithmic
36.	BackgroundLevel	103.75 95.54 17.32
37.	PeakLevel	37506.52 17346.45 34523.34
38.	ScaledBackgroundLevel	0 0 0
39.	ScaledPeakLevel	10 10 10
40.	BlackLevel	0.754 0.293 0.191
41.	WhiteLevel	9.7 8.5 8.7
42.	ColorAssignment	Blue Green Red
43.	CreationNotes	This image was created with FITS Liberator. Total workload 38.5 hours. Cleaning was very difficult. Had problems with the CMYK gamut.

MAKING PRESS RELEASE ASTRONOMICAL IMAGES COMPLIANT WITH THE NATIONAL VIRTUAL OBSERVATORY

Lisa M. Frattare[1], Zolt G. Levay[1], and Frank J. Summers[1] and Kaushala Bandara[2]

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ABSTRACT

The beauty and splendour of astronomical images has made an enormously positive impact with the media and public alike. As a leading provider of astronomical imagery and a major contributor of Hubble Space Telescope press release images, the outreach division of the Space Telescope Science Institute (STScI) recognizes the importance of making press release images compliant with Virtual Observatory standards for inclusion in databases and repositories. A small working group has been formed to define and evaluate the procedures for making outreach images accessible by Virtual Observatory applications, and more specifically, to establish a World Coordinate System (WCS) for these images, which so far have none. We report on the status of various software techniques that can be used to transform coordinates on images easily and accurately, using reference images and astronomical star catalogues when available.

INTRODUCTION

Several virtual image repositories and observatories (the International Virtual Observatory Alliance, the Astrophysical Virtual Observatory, the Global Virtual Observatory, to name a few) have been gathering the momentum in the last few years to include pointers to digital astronomical data from all major observatories. The National Science Foundation's National Virtual Observatory (NVO) is no exception. The NVO is a U.S. effort to organize and make astronomical data, images, and other content available systematically so that it can be retrieved and used by many users. Preliminary work has begun to include raw and processed astronomical data into the NVO. To this end, it is well understood that the educational, inspirational and aesthetic impact of press release quality astronomical images should also have their place in such virtual databases.

Modern imaging techniques and the combination of multiple datasets calls for a change of format from the telescope's inherent data format of Flexible Image Transport System (FITS) files. The advent of astronomical data processing software such as IRAF, IDL, AIPS, and their combination with the latest image processing software, such as Adobe Photoshop (and Photoshop Elements) and The Gimp (GNU Image Manipulation Program), has improved the composition of the images, but at the cost of removing coordinate information from the file.

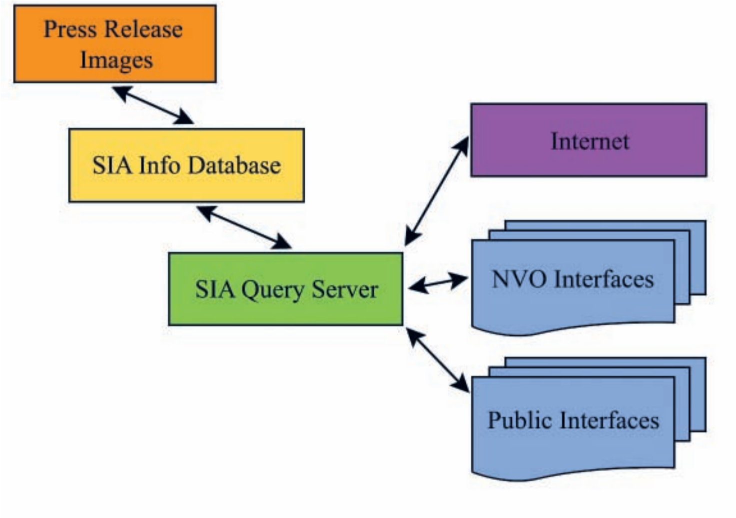

Figure 1: *Diagram showing how press release (PreSS) images can be included into a virtal database, which can then be accessed via a query from multiple users.*

One major step in making press release astronomical images compliant with those of the virtual observatories is to measure and record spatial information about the final presentation image that was lost due to processing. More specifically, measuring and recording the World Coordinate System (WCS) or the image's position on the sky is an absolute necessity in being able to catalogue these images into any sort of database.

The NVO has designed a list of guidelines known as the Simple Image Access (SIA) Protocol. This contains standards that are necessary to have images meet the compliance requirements. The specified format of the image and the metadata associated with the image will allow numerous query databases to search for and access the press release image. The SIA Protocol, available from the NVO Website (http://www.us-vo.org), is an important resource for those who manufacture astronomical images from digital instruments or observatory data and wish to have their press release quality images included and recognized in the NVO image database. This list of users may include professional and amateur astronomers, image processors, and personnel involved with observatory- and mission-based press release efforts.

PREPPING PRESS RELEASE QUALITY IMAGES FOR WCS MEASUREMENT

We have created a python-based software script that can, with human interaction, identify like objects (usually stars) in both a coordinate-based FITS file from the raw telescope data and a press release TIFF image. Ideally the instrument used to create the input FITS file should be a similar to that which was used to create the press release image. Once an appropriate FITS file is identified and made available, it is recommended that a cosmic ray rejection be performed on the reference image(s). Combining like-filter images to remove cosmic rays and improve signal is also a popular method of image preparation.

No preparation is necessary for the input target TIFF image, although for problem images where pattern recognition may be difficult, it may be advisable to split channels into a single colour component and to use the strongest filter for the image comparison. Note that desaturating, or splitting channels, will not impact the spatial resolution, size, or rotation of the image, and thus measurements of the WCS on a desaturated image can be automatically assigned to the full-colour image.

Due to the equatorial coordinate nature of the WCS, there are several press release images for which it is not possible to deduce a WCS. These image types include: Solar System objects (Sun, Moon, planets, asteroids, comets, etc.) or other moving targets; press release images contained within a composite layout such that more than one celestial object or multiple images of the same celestial object are included in the layout; those images that have a complex page or print layout attached; and artwork or artificially created images.

SOFTWARE TO MEASURE WCS

WCS.PY is an astronomy comparison routine that helps to determine a target's WCS based on manual comparison with like objects in a reference image. It consists of a python-based Graphics User Interface (GUI) that is compatible on all platforms. *Python Imaging Library (PIL)* and *matplotlib* are required in order to use the program. To compute WCS parameters, both the reference FITS image (with valid coordinate parameters in the header) and the target press release TIFF image are displayed. Rotation and resizing changes are allowed within the software so that more common features in both images can be recognised more easily. Four or more points should be selected in both images, noting that the residual fit may improve with more points. The software allows for the non-inclusion of points that have a large deviation from the computed fit.

As with other astrometry routines, extended objects, saturated stars, stars too close to the edge or stars very close to another object should not be used to create the fit. A linear transformation is computed from the set of marked points, and this transformation is then applied to the coordinate parameters in the reference image to obtain the parameters for the public-release image. The WCS transformation coefficients are then written to an output file. Work on attaching these values as metadata directly to the TIFF image header is still under examination.

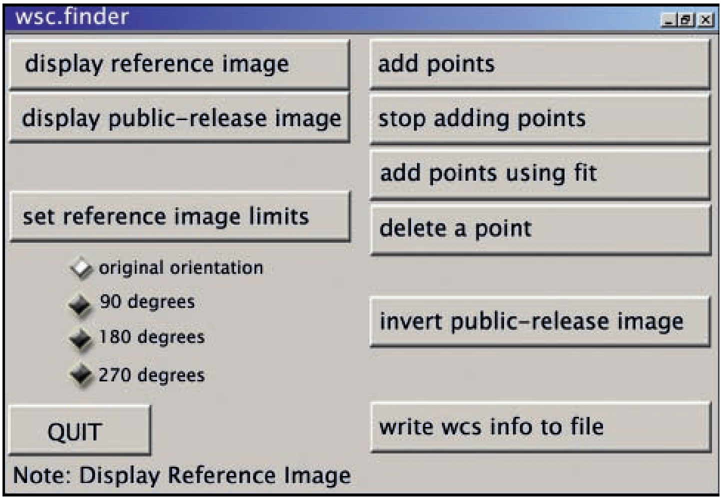

Figure 2. *GUI interface for WCS.PY*

The WSF.PY script and its GUI interface were created during the spring and summer of 2005 and have since been tested extensively. WCS transformation coefficients have been generated for several hundred images from the STScI Office of Public Outreach (OPO) Newscenter database (available at: http://www.hubblesite.org/news).

CURRENT WORK AND IMMEDIATE FUTURE GOALS

In the near future, we anticipate refining the WCS-finding software and GUI interface as needed, testing the software for systematic errors, and measuring WCS values for the remainder of press release images in the STScI OPO Newscenter database. Further work will also be done on creating an SIA Image database, and SIA Query Server, as well as a possible Public Image Access Interface. We also plan to make the WCS-finder software and accompanying documentation available to other observatories that are in need of such a function.

TEAM MEMBERS AND ACKNOWLEDGMENTS

The NVO/SIA working team includes Frank Summers (STScI—summers@stsci.edu; project manager, database and web service development), Zolt Levay (STScI—levay@stsci.edu; HST press release procedure development), Lisa Frattare (STScI—frattare@stsci.edu; software research and outline), and Kaushala Bandara (U. Toronto/STScI 2005 summer intern: processing of HST press release archive images). We also wish to thank Phil Hodge (STScI; programming), and Carol Christian (STScI; NVO/EPO coordinator). Funding for this work comes from the Virtual Cosmos Project (Berkeley/STScI). Future status reports, software releases and discussions will be available at: http://terpsichore.stsci.edu/~summers/projects/hst_pr_sia/

THE VENUS TRANSIT 2004 (VT-2004) PROGRAMME

The Exceptional Impact of a Unique Public Science Discovery Project

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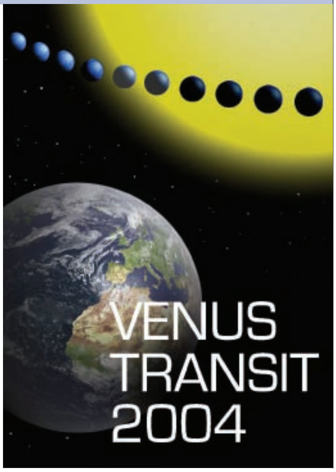
ABSTRACT

We report on a major pan-European educational activity: the Venus Transit 2004 Public Science Discovery Programme. The key objectives were to use the 2004 Transit as a vehicle for disseminating knowledge about the Solar System, for raising awareness of exoplanet research, to enable the public to re-enact the historical measurement of the Sun-Earth distance, to raise public appreciation of the scientific method and to collectively obtain a basic scientific result based on geographically distributed observations. This very successful pilot project encompassed the development of an extensive set of teaching materials for schools, an effective web-based information and reporting system, observational activities as well as a video contest and a thorough post-event evaluation during a final meeting.

INTRODUCTION

On June 8, 2004, a large part of the world shared a unique sight, never seen before by any person now living. During a little more than six hours, the Earth's 'sister' planet Venus crossed the face of the Sun, offering a wonderful celestial show for everybody. Such an event—a transit in astronomical terminology—is extremely rare; the last one occurred in 1882, i.e., 122 years ago. Easily observable in Europe, Asia, Africa and Australia, it attracted the attention of millions of people on these continents and, indeed, all over the world. Fortunately, the observing conditions were quite favourable in most areas.

Figure 1: *The VT-2004 Programme logo*



The associated **Venus Transit 2004 (VT-2004)** programme was established through a major organisational effort by the European Southern Observatory (ESO), in collaboration with the European Association for Astronomy Education (EAAE), the Institut de Mécanique Céleste et de Calcul des Éphémérides (IMCCE) and the Observatoire de Paris in France, as well as the Astronomical Institute of the Academy of Sciences of the Czech Republic. It profited from substantial support from the European Commission within the framework of the European Science and Technology Week. The main idea of this highly innovative, educational programme was to take advantage of this extraordinary and rare celestial event to expose the general public—in a well-considered, interactive and exciting way—to a number of fundamental issues at the crucial interface between society and basic science.

MAIN OBJECTIVES OF THE VT-2004 PROGRAMME

A key intention was to introduce (and hence, to 'sensitise') the public to various issues of wide general interest, with the Venus Transit and related issues as a natural starting point:

1. As the basis for the measurement scale of the Solar System and beyond: for many centuries it was impossible for humankind to gauge the distance to the planets, the Sun and the stars from the Earth: all celestial bodies appeared to be located on the same 'celestial sphere'. The complete ignorance of these distances or, later, the large uncertainty in the qualified guesses made by leading natural philosophers in antiquity, led to wrong appraisals of distances in the Universe and hence to wrong world models that persisted for centuries. However, following the revolutionary work by Copernicus, Tycho Brahe, Galileo and Kepler in the 16th and 17th century, it became possible to deduce the correct, *relative* distances in the Solar System. To learn the true size, only one distance must then be known in *absolute terms*, e.g., the distance from the Earth to another planet. Astronomers soon realised that the rare transits of Venus in front of the Sun provided unique opportunities for such a measurement—the exact distance from the Earth to Venus may be deduced by near-simultaneous observations of the transit from several different sites across the world. If the Earth-Venus distance in kilometres is known, all other distances in the Solar System can then be calculated and, next, the distances to the stars by straightforward trigonometry. These measurements were made mainly during the 18th century in the course of numerous scientific expeditions to remote locations and often under dramatic conditions. They were the forerunners of European scientific collaboration, and they were brilliant and instructive examples of fundamental scientific projects. It was the stated goal of the VT-2004 programme to have such measurements remade by today's students, high schools pupils, amateur astronomers and interested laypeople, helping them to understand how the scale of the Universe was first established by means of thorough and educational, but exciting, preparations for the event.
2. The uncertainty of scientific measurements: The accuracy of a scientific measurement of a natural phenomenon is of paramount importance for the interpretation of the data. However, it has proven notoriously difficult to convey to the public that almost all research is based on more or less uncertain measurements and that there is no such thing as 'absolute scientific truth'. On the basis of information about the historical aspects of Venus transit observations, the public was invited to appreciate the uncertainty of the earlier measurements as these were performed at different epochs. Furthermore, the actions of each participant in the VT-2004 Observing Campaign forced

the uncertainty of his or her measurements to be considered. Each participant was able to compare his/her own values of the timings of the different phases of the Venus transit with those of other contributors and additionally with the predicted values by connecting over the internet to a powerful resource centre, and thus to obtain an appreciation of the personal accuracy achieved and the associated implications for the accuracy of the historical determination of the distance to Venus.

3. Extra-solar planet research: Nowadays, the simple observation of the transit of a planet in front of the Sun will not entail novel and useful scientific observations. Radars have effectively replaced such distance measurements, achieving much higher precision, now at the level of one metre over hundreds of millions of kilometres! However, transits of exoplanets in front of stars other than the Sun constitute similar events. While they are difficult to observe—being barely within reach of current amateur equipment—they do present the best current opportunity to detect the presence of small exoplanets in orbit around other stars. In fact, the transit method is probably—for the next decade at least—the only method that will allow Earth-sized planets near stars other than the Sun to be detected reliably. And as such, the transit method may ultimately lead to the discovery of other habitable worlds. The VT-2004 programme introduced this highly exciting topic by means of examples, also from ongoing research programmes.
4. Scientific methods and international collaboration: Simultaneous measurements of a planetary transit—this time by Venus—performed by observers at different geographic locations are required to measure the solar 'parallax' (the angle at which the Earth radius is seen from the distance of the Sun). It is inversely proportional to the Earth-Sun distance, the 'Astronomical Unit (AU)', and therefore allows the true value of this fundamental cosmic distance to be deduced. In the wake of the early scientific campaigns to observe such events that provided the first measures of this distance (albeit, with some lack of accuracy), the world-wide VT-2004 Observing Campaign was now co-ordinated, but with contemporary tools, once more demonstrating how coordination and international collaboration are a powerful lever in science. A modern approach was taken, e.g., by using GPS devices for measuring the exact geographical coordinates of the observation sites and, not least, by intense communication via the internet. All of this illustrated the enormous value of such a wide collaboration in a very direct and powerful way, notably by displaying the progress towards the determination of a fundamental value (the AU) in real time, based on successive reporting from numerous local observations to the central data pool. Each participant thus became intensely aware of being part of an extensive international network

and of contributing to the common goal

5. The stellar nature of the Sun: Participants were invited to rehearse their observations before the Venus transit and thus to observe the Sun in some detail. VT-2004 went to great lengths to explain the associated, crucial safety issues—fortunately, no reports were received about accidents. Participants became aware of the very active nature of our central star, with sunspots, flares and prominences appearing and disappearing. This was supported by comprehensive educational material and generated interest in the physical nature of the Sun. Another aspect of this issue concerns the way solar activity affects our daily lives, for example, natural phenomena such as auroras and the associated impact on satellites and communications. This was also a fine opportunity to introduce and further develop the theme that the Sun is our nearest star and as such helps us to understand other stars in the Universe.

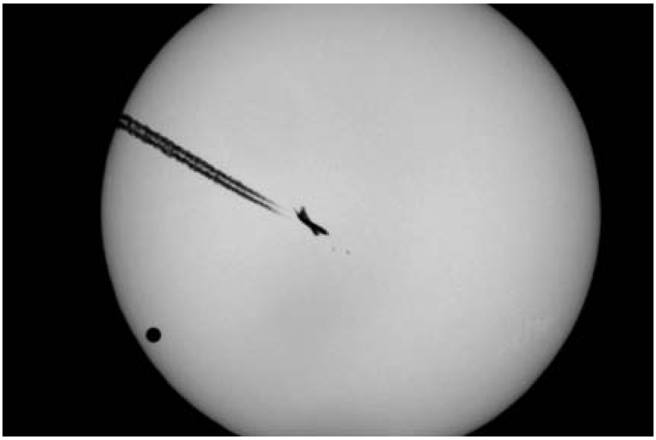


Figure 2: *The Transit of Venus on June 8, 2004. An example of the numerous images taken on that day.*

6. Invite the public to approach the history of science: Venus Transits may be rare events, but the related historical background is extremely rich and interesting. Only five Venus transits had been observed since the 17th century when the knowledge of the planetary motions became sufficiently good to permit such events to be forecasted. Johannes Kepler first predicted planetary transits in front of the Sun in the 1620s, and Pierre Gassendi was the first to observe a Mercury transit from Paris in 1631. During the 18th and 19th centuries, Venus transits provided unique opportunities to obtain an improved estimate of the fundamental Astronomical Unit and led to an extensive international collaboration among European scientists. Several French and British astronomers, in particular, tried to establish the best methods to predict and observe the first and last contacts of Venus with the solar limb

and to get the most accurate value of the Astronomical Unit. Expeditions were sent to remote parts of the world—the one led by Captain James Cook to Tahiti in 1769 being perhaps the best known. Dramatic accounts highlighted the ordeals of the brave participants and brought the general public closer to the workings of science. The history of Solar System research and astronomical progress in general is closely related to these historical events, and the admixture of human fate and idealistic exploration of the unknown continues to provoke a deep and immediate interest to a broad section of the public, even today.

7. Dissemination of information about the structure of and movements in the Solar System: Venus transits are very rare—on average, only four events can be observed every 243 years. A Venus transit was first observed in 1639, then in 1761 and 1769, in 1874 and 1882, and now in 2004. The next one will occur in 2012, but will only be partially visible from Europe. The Moon and planet Mercury also transit the Sun; Moon transits cause the well-known solar eclipses. Mercury transits are much more frequent than Venus transits; during the 20th century, fourteen Mercury transits occurred, but as the apparent diameter of Mercury is only about 1/200th of that of Sun, they are difficult to observe. In contrast, Venus transits are very rare, but are easily observed since the apparent diameter of Venus' disc is about 1/30th of that of the Sun. The understanding of how and when these events occur implies detailed and accurate knowledge of Solar System orbital dynamics. In fact, these celestial events only occur when the orbital nodes of the Venus orbit are located near the Sun-Earth axis.

PUBLIC PARTICIPATION

The general public could participate actively or passively in the VT-2004 programme in various ways. The programme established broad international networks of individuals, including school teachers and their students, amateur astronomers and interested laypeople, as well as educational institutions such as astronomical observatories, planetaria, science centres, etc. As outlined above, it went to great lengths to encourage real-time measurements from which one of the most fundamental astronomical parameters could be determined, the distance from the Earth to the Sun. In order to promote the Venus transit and provide information about the opportunities for participation in the various countries and geographical regions, VT-2004 'National Nodes' were established in many places. These 'National Nodes' collaborated closely with the organisers of the programme represented by the International Steering Committee and the Executive Manager and as such constituted the main contact points for the media in the corresponding countries and regions.

In addition VT-2004 promoted web-encounters and international collaboration throughout Europe and in Africa and Asia, stimulating visual and photographic observations of this rare celestial event, with related debates via the internet. It provided everybody with the opportunity to add their observations to a large, common database. The VT-2004 programme was based on the active and intense involvement of the media, of students and teachers as well as amateur astronomers in order to spread this information as widely as possible and to ensure the best possible return and common benefit. During the preparatory phase, highly useful meetings were held between the organisers and school teachers (Luxembourg, January 2004), media representatives (Germany, March 2004), and amateur astronomers (Czech Republic, May 2004), respectively, which greatly contributed to the shaping of the various activities so that they could best respond to the expectations and needs of different communities. This comprehensive strategy proved very rewarding and the 'penetration', in societal and geographic terms, was excellent, as will be documented below.

THE VT-DAY

Any public astronomical observing programme, however well planned, will suffer if the weather is bad. However, on June 8, 2004, the day of the transit, the sky was fortunately clear in many regions of the world, allowing millions of people to witness this spectacular celestial display with their own eyes. A vast number of public events took place on all continents, including those organized by the VT-2004 National Nodes and other VT-2004 Network Members. There were, of course, some geographical areas that were clouded out. Nevertheless, modern technology saved them from the sinister fate of French astronomer Le Gentil in 1769, who, having traversed a large portion of the globe, enduring all the perils of a long sea-voyage, and waiting 8 years for the transit to occur, was finally unable to observe it because of a vexatious, black cloud that covered the Sun at the critical moment. For the unlucky people in such places, or more generally, for those who could not observe the event directly for one reason or another, there were ample opportunities to witness it in real-time from several websites, in particular from the extremely comprehensive 'VT-2004 Central Display' page.

This page was powered by Akamai and mirrored on many hundreds of sites all over the world, offering selected images from the event that were acquired by professional astronomers at large solar telescopes across the world from the Canary Islands to China, as well as by numerous amateurs with impressive instrumentation. Dedicated links to the foremost observatories and from numerous websites were set up by observers in many different countries, and the best images available were selected and displayed at the 'VT-2004 Central Display' page with live comments by a team of professional astronomers in the 'VT-2004 Control Room' at ESO headquarters in Garching. All of the Central Display page versions were duly archived, providing a complete record of the event and now allowing everybody to relive the transit and once more to share the unique experience and strong emotion of witnessing this event.

Judging from the number of registered hits, there is no doubt that the VT-2004 website may be described as resoundingly successful. Following the record impact of the Mercury transit on May 7, 2003, which served as a very useful testing ground for the present project, the hit count was now over ten times higher. There were no less than 55 million hits on the VT-2004 website and 1.75 terabytes of data were delivered in an 8-hour interval spanning the transit period. This would have brought most servers to their knees, but thanks to foresight and good preparation, the VT-2004 website with its hundreds of Akamai mirrors did not suffer the fate of several other sites—including some of other major organisations—which collapsed under the load, as was reported in the news. In fact, at the moment of the transit, the VT-2004 website received almost exactly as many hits as the official website of the Athens Olympic Games and it was one of the 6000 most visited websites worldwide.

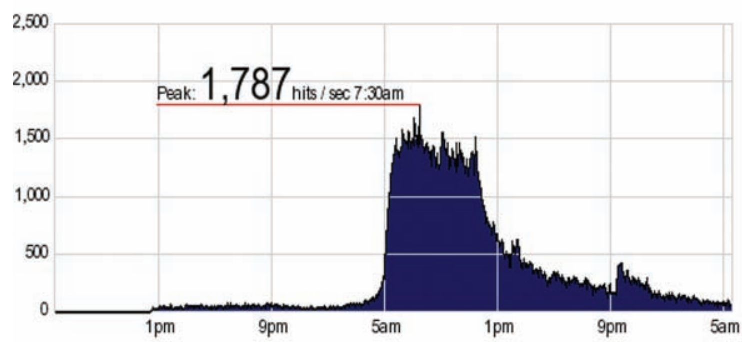


Figure 3: *During the 8-hour interval around the transit, the VT-2004 website recorded no less than 55 million hits with peaks of 100,000 per minute!*

Another way to measure the outstanding success of this event is the great number of images that appeared at many websites, including those of the members of the VT-2004 Network, the listed webcast sites, as well as the many websites linked directly from those of the VT-2004 National Nodes, etc. Many excellent images are now displayed at the ‘Photos’ section of the VT-2004 website.

It is worth mentioning that a very useful ‘by-product’ of the VT-2004 programme was a basic Image Processing site, now available to everybody! Most digital images contain more information than is obvious at first glance. In order to make it possible for observers to get the most out of their digital camera images, including those of the Venus transit, an easy-to-use facility was set up at the Ondrejov Observatory in the Czech Republic within the framework of the VT-2004 programme. Using this welcome facility, observers were able to submit their images to a variety of well-documented operations, to improve the appearance of the images by cleaning and contrast manipulation, and thus enabling exact measurements. Many amateur astronomers used the pipeline to analyse their images of the transit and so obtained more accurate timing measurements. This contributed to the quality of the present determination of the AU. This on-line facility is still available for other applications; it can be reached via the VT-2004 website (www.vt-2004.org).

Especially welcome were a large number of drawings made by children who witnessed the Venus transit. A unique collection of these pieces of art—many of an amazing quality and testifying to great inspiration—is now deposited at the VT-2004 Gallery. They come from many different places, in ESO countries and elsewhere. The authors of drawings that were entered into the Gallery before June 30, 2004, had a chance to win a unique VT-2004 T-shirt.

Figure 4: *Two examples of drawings made by children in the framework of the Venus Transit Programme. Left: Yuki (8 years); right: Helen-Elise (9 years)*

In order to extend the attraction of the Venus Transit 2004 programme to the arts and thus to add another dimension to the project, it was decided to establish an associated video contest early on. In this, members of the public—either as individuals or in teams—were invited to present a video with a maximum of 8 minutes duration (in any European language but with an English transcript of the manuscript) in connection with the transit. It was suggested that the video could either present the astronomical event itself, a local event that was witnessed by the participants, including preparations for the observations, reactions of participants and on-lookers, ... or it could try to demonstrate sociological or historical aspects, or wider scientific or philosophical issues, etc.

REAL-TIME AU MEASUREMENT

The ‘VT-2004 Observing Campaign’ was launched with the goal of a making a real-time measurement of the Astronomical Unit and was a unique aspect of the VT-2004 programme and of a kind that had never been attempted on this scale before. This sub-programme was carefully organized to re-enact the historical determination of the AU by means of accurate timings of the four moments of contact between Venus’ black circle and the border of the solar disc. The preparations paid off and this complex project generally went very well. A large number of groups of observers registered in the months and days before the transit; in the end, there were no less than 2,763 from all over the world and among these were almost 1,000 school classes. As might be expected, not all groups delivered timing observations of the transit. In some places, the weather did not cooperate, some observers may have had instrumental problems, e.g., with the time signals, and others may not have felt confident enough to send in their measurements. Still, the resulting database is impressive: by the stipulated deadline on July 10, 2004, no less than 4,509 contact timings had been received from 1,549 registered observing teams. While most of these were located in Europe where the observing conditions were particularly good, there were also data from teams on all other continents except Antarctica.

Following extensive analysis of this large body of material by staff members of the Institut de Mécanique Céleste et de Calcul des Ephémérides, the final result of the VT-2004 Observing Campaign to determine the distance from the Earth to the Sun was published in late 2004: 1 Astronomical Unit = 149 608 708 km ± 11 835 km,
i.e., only 10 838 km larger than the “true” value!

This excellent outcome of the VT-2004 Observing Campaign indicates that most observers took great care to achieve the best possible accuracy with their equipment. A comparison with the results obtained by transit observations in the past shows that the present determination of the distance to the Sun (in 2004) is the ‘best’ in terms of accuracy, despite the relative lack of experience of most of the (lay) observers and notwithstanding the random distribution of observing sites, caused by the absence of any of the specific planning in 2004 that was usual in earlier centuries. This success is undoubtedly due, above all, to more accurate timings and better known geographical locations, better optics in the telescopes, digital image recording and advanced image processing software.

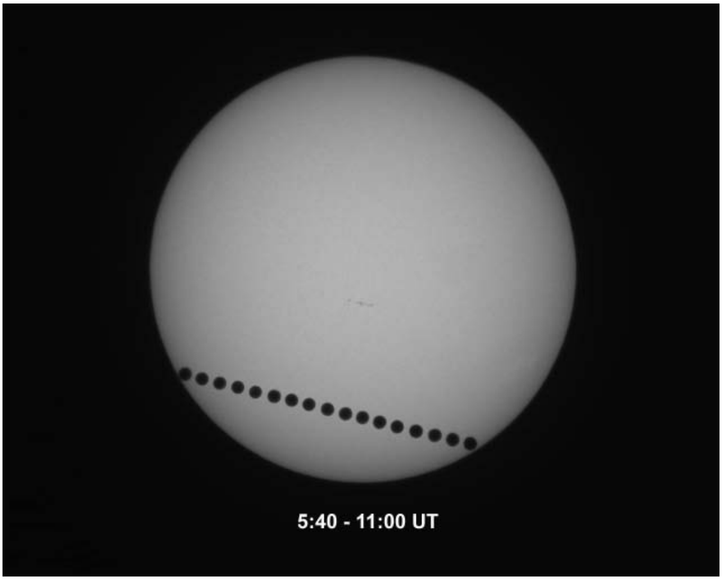


Figure 5: Venus' path across the solar disc on June 8, 2004. This sequence of images was taken by the Slovak Union of Amateur Astronomers at the Rimavska Subota Observatory. Numerous other examples are available in the Photos section of the VT-2004 website

In a nutshell, even if we had not known the distance to the Sun before the Venus Transit 2004, we would have been able to measure it with an accuracy of one hundredth of a percent by means of the observations made by the many participants all over the world on this occasion!

THE 'VENUS TRANSIT EXPERIENCE'

In addition to the many activities surrounding the Venus Transit itself, the organisers also aimed at evaluating the sociological impact of such a very rare astronomical event in gross terms and the way it was perceived in different countries. This programme provided a rare field test for the execution of large-scale public activities relating to a particular, scientific event with strong operational constraints (including the requirement to act in real-time as the scientific event progresses). The organisers were keen to gather valuable experience for possible future continent-wide activities involving the same mechanisms and carried out under similar conditions. A thorough post-event evaluation was incorporated as an important element of the VT-2004 programme.

Thus, on November 5-7, 2004, a follow-up conference took place at the French Ministry of Research in Paris. Entitled the 'Venus Transit Experience', this unusual meeting was organised by the VT-2004 International Steering Committee (ISC) and the local arrangements were ably taken care of by the staff of the IMCCE and the Observatoire de Paris. It brought together more than 150 persons closely connected to the VT-2004 programme in various functions, as organisers, specialists, educators, students, observers, participants, etc. The major goal was to sum up the vast experience gained through this exceptional public science discovery programme and to evaluate its many components and overall public impact. On the first day, a large number of students from the Paris area who had participated actively in this programme were also present.

The meeting was opened by the Directrice de la Recherche, Mrs. Elisabeth Giacobino, on behalf of the French Minister of Research, as well as Mr. Bernard Leroy, from the CNRS, on behalf of the Director General of the National Institute of the Sciences of the Universe (INSU, CNRS). Following an overview of the VT-2004 programme by members of the ISC and the presentation of some of the highlights, an exciting lecture by the famous astrophysicist and populariser Hubert Reeves on 'Humanity and Astronomy' placed the associated themes into a larger cultural perspective.

This was followed by the showing of ten Laureate Videos selected by a professional jury from the many entries to the 'VT-2004 Video Contest'. The participants at the meeting accorded a special 'Prix du Public' to an entry from Belgium, recording the observations of the transit by a team of school students and their teachers in the presence of curious onlookers in a lively and entertaining way. The three top prizes went to British, Czech and Polish teams who presented their personal impressions of the transit in very distinct and remarkable, but also quite different, ways. The jury, in agreement with ESO, and in recognition of the excellent quality of the winning entries decided to award all three teams a trip to Paranal, home of ESO's Very Large Telescope Array, a gesture that was received with much emotion by all.

__Figure 6:__ Astronomical events can awake the interest of children for science. Here, 6-7 years old children explain the Venus Transit to even younger children, using drawings they made (Luxembourg – Photo: Martine Haustgen-Wagner).

On the second day of the conference, detailed reports about the circumstances and impact of the Venus transit were given by experts operating in different surroundings, e.g. in primary and secondary schools, at the media and among amateur astronomers. National Committees from about 25 countries, either orally or by posters, documented the individual approaches taken in different regions and cultural environments comprehensively and reported many useful 'lessons learned' within the unique VT-2004 pilot project. These presentations clearly demonstrated the eminent success of the entire effort but also served to identify some technical and organisational shortcomings—as was to be expected in a complex and ambitious pilot project like this. However, the overall impression was thoroughly positive and much experience has been gained that will become extremely useful for any future projects of this kind. Most of the presentations given at this conference are now available on the web at: www.vt-2004.org/FinalEvent/.

On the last day of the meeting, representatives of the many National Nodes met with the ISC members to consider how to build on the enormous momentum gained throughout the VT-2004 project. An extremely constructive and enthusiastic discussion resulted which also provided a rare opportunity to gain interesting insights into the varied approaches of public education dictated by different national and cultural traditions. Riding on a powerful wave of success and expressing a strong desire to 'keep up steam', it was unanimously decided to work towards the creation of a continent-wide 'European Astronomy Day' in autumn 2006, aimed at the general public, and at schools in particular. The intention is to manage the day in a broad collaboration between European astronomy-oriented organizations and institutes, science communication institutions (planetaria, science centres) and amateur organizations, all bound together by a network with national/regional nodes, based and modelled on the current VT-2004 National Nodes, but suitably modified and amended to reflect the change of emphasis.

LOOKING TOWARDS THE FUTURE

While the Venus transit is now over, the VT-2004 programme is still very much alive on the web. From the outset of the project, and given its all-European dimension, it was decided that the internet would be the main vector of interaction, with a central website at http://www.vt-2004.org. It includes an extensive collection of background information and offers a profound insight into the many interesting facets of this particular celestial phenomenon and also detailed advice on the active participation by individuals and groups which is equally useful for other observational projects. There is also a VT-2004 Web-Forum, as well as numerous links to organisations (observatories, planetaria, science centres, amateur clubs and associations, etc.) which registered as members of the extensive VT-2004 Network.

Moreover, with a treasure trove of photos, videos, drawings, and writings, the VT-2004 website serves as a wonderful 'memory' bank about the Venus Transit. Specific Information and Educational Sheets, a Teachers' Cookbook and Guidelines for Observers are but a few examples of the rich material available here. Altogether, there are about 20,000 web pages and over 2.6 GB of material —not counting the numerous comprehensive National Node websites in many languages—that offer insights into the many interesting facets of this celestial phenomenon and which will remain a rich source of information and stimulation for years to come.

Faithful to its high goals, the trailblazing VT-2004 programme successfully developed into a true encounter between science and society. It leaves a rich legacy and we have no doubt that this unique public education project will serve as a most effective and useful guide for future projects of this kind, whenever an opportunity again arises. The next Venus Transit will happen in 2012, but there may be other events before!

CONFERENCE SUMMARY

Paul Murdin

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I have summarised the talks that we have heard in tabular form (Table 1), using Ian Robson's model for astronomy communication:

Astronomy > Mediators > Media > Audience.

Table 1 also includes features of some of the processes in the chain of communication—the arrows in the above chain. Between the Scientists and the Mediators, of whom there are many representatives at this conference, there are issues of culture, ethics and credibility. Together we have explored some of these in open debate. Between the Mediators and the Media are the Gatekeepers, of whom there are very few here this week. They have their own ideas about what science they can let through to the audiences. And of course between the Media and the Audiences there are issues of language (I mean not only whether the language is English, Spanish, French etc, but also the clarity, and the inclusion of difficult concepts and technicalities.) I have inserted these issues between the appropriate columns.

I have added into Table 1 estimates of the size of the potential audience and the cost of reaching them (in universal monetary units—US$ or euros, it makes no difference to the accuracy given), including the unit cost. Sometimes I have taken these numbers from the talks and sometimes I have made estimates myself, so they are guesses perhaps uncertain by factors of ten. The resultant numbers should not be taken too seriously. Table 1 is ranked by audience numbers, more or less.

My first impression is that we are doing well. Of course we can always do better, but I am very struck by the variety of the modes of communication in Table 1—a dozen main classes. The number could be expanded to twice that many by treating my subclasses separately; and maybe I (or the conference organisers) forgot some altogether. We are lucky that astronomy is so universal a topic, sought by audiences and thus by the media, and of almost universal interest. I will not mention by name other sciences that find it difficult to access any of these channels of communication, even one. But I think we are getting more practised and more successful at communicating our science.

Another striking feature is that the unit cost varies a lot, usually in a way that is anti-correlated with audience size and correlated with the 'quality of the experience'. In general, but not always, the bigger the audience the lower the unit cost. Obviously it is a matter of judgement how these two factors are played into an evaluation of what to set out to achieve.

I have added a subjective assessment of the degree to which a member of the audience has to engage with the communication—this may be a measure of the impact on the individual of the communication. In general the mass media are lower on engagement than the media to which an individual has to make a commitment of time, effort or money. I expect that the less the engagement, the less transformational of the experience to the individual. On the other hand, lower impact mass communication may be highly desirable for those wanting to publicise a current facility in order to generate support to obtain resources for the next, certainly if this is partly a matter of popular vote.

Table 1. Communicating Astronomy 2005

					Communication			
	Astronomy	**>**	**Mediator**	**>**	**Media**	**>**	**Audience**	**No. per year**
1	**A space event**	Culture Ethics Credibility	Astronomer Space scientist	The Gatekeepers	All	Language and Difficulty	Global	1 billion
2	**Pictures**		Archive/VO/NVO Picture Library		All visual media		Global	Very large
3	**Wow! Science**		Astronomers > PIOs		TV Newspapers		Viewers Readers	100 million
4	**Facts & Enchantment**		Planetarian		Planetaria		Visitors	100 million
5	**Astronomy for amateurs & novices**		Writer		Magazines		Readers	 100,000 several 100,000
6	**Experience the sky**		Demonstrator		Telescope		Novice to amateur	1 million
7	**Experience the observatory**		Guide Writer & programmer		Real place Virtual reality		Visitors Home viewers	100,000 10,000
8	**Taught science**		Teachers		Activity Centre Mobile planetarium Class room College/Uni		Students	huge
9	**Elementary science**		Presenters		Radio Podcast Rap music		Listeners	Millions
10	**Elementary to advanced science**		Writers		Books Distance learning		Readers Students at home	1000s to millions tens of 1000s?
11	**First hand account ('Ask-an-astronomer')**		Astronomer		Lecture Q&A		Audience	100s
12	**Science investigation**		Astronomer Engineer		Robotic telescope Lab		Students	10-100s

	Cost		Unit Costs	Audience engagement
	Capital	Recurrent		
	High	High	cents	Low
	High	High	cents	Medium
	Small	1 million	cents	Low
				Medium
	High	1 million	1 to 10	High
	Moderate	millions	10 to 100	High
	100 - 10,000 ea	Nil	Dollars	Very High
	Nil	10,000 up	10	High
	Small	100,000	1	Medium
	High	High	10 to 100	Medium
				High
			Lower than we would like	
				Medium
	Moderate	Low	cents	Medium
				Medium
				Very low
	Low	Low	10 to 100	High
				High to medium
	Low	Low	10	Medium to high
	Moderate to high	High	100 to 1000	Very high
				Very high

Cost is an impediment to carrying out communication. Communication modes vary in their capital cost and their recurrent cost. Buying a telescope for your own use, for example, has a high (but affordable) entry cost and virtually no running cost thereafter. Experiencing an observatory through visits may be essentially zero capital cost if you show people just what is there, but higher if you have to build a visitors' centre, possibly very high. The running costs may be significant in either case if you have to hire people to show visitors around. Virtual observatories may be cheaper in both respects but the audience experience is probably of lower impact, in general.

I found it difficult in the time I had to think about this summary to make any clear diagram of how to interpret Table 1—the correlations are not clear to me. In any case, there is no one best method of communication because the aims of the communicators vary so much. What does seem clear is that there are unquantifiable factors involved —particularly the quality of experience, the talent of the communicators, their enthusiasm and skill. The individuals concerned are very important to the success of the communication process. We are lucky as astronomers to have such individuals on our side.

There was less discussion here than I remember in Tenerife about the role of the Gatekeepers. Does this mean that they are no longer so important, or that they have less fixed ideas about what they will let through? I did get the impression sometimes during the talks that some of us are Gatekeepers—we have our own prejudices about what we can communicate and what we cannot. It is a kind of self-censorship. However, the number of modes of communication and the number of channels within each of the dozen modes of Table 1 are so large that we may be getting better at wriggling through some open gates, even if others are firmly shut against us.

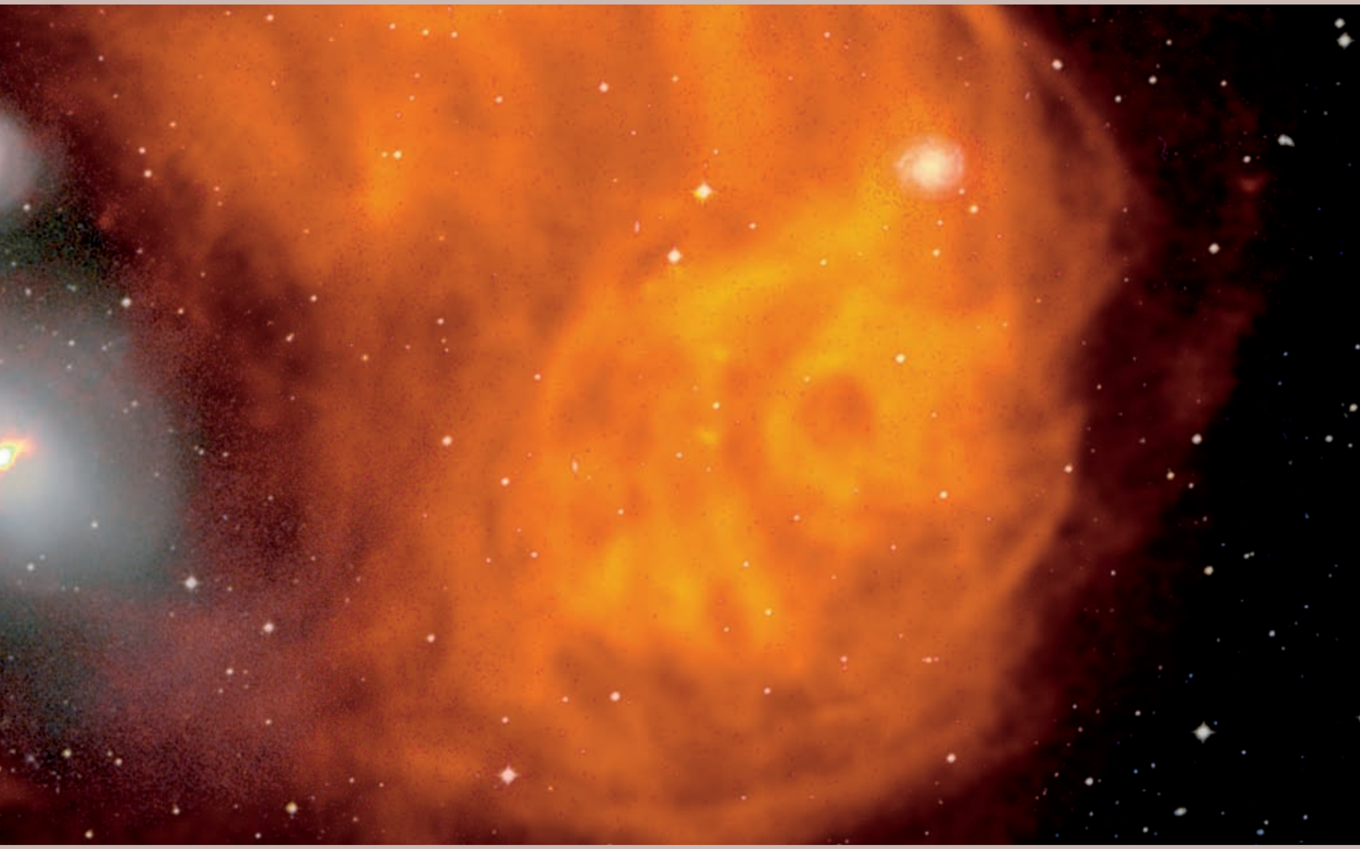
During the conference we identified other impediments or modalities to communication, including language and ethical issues. I get the impression that we are better than we used to be at moderating our own language and explaining ourselves more clearly—certainly we should be better now after the workshops at this conference. Europeans have more of a problem in communicating than our North American colleagues, given the large number of languages spoken in Europe. Catherine Cesarsky mentioned the proposed European Union Science Translation Centre. This is an idea worth looking at to see if we can facilitate science communication in this large and well-educated subfraction of the global population. One manifest failure by us is to communicate astronomy through non-European languages. I think there is no one present at this conference from Asia or Africa (apart from one English-speaking South African). We may be reaching four out of the six inhabited continents but we may be underachieving our reach to the world's population—1.6 billion out of 6.4 billion. Except for pictures.

So far as the ethical issues are concerned—we explored the concepts, but I felt we did not crystallise our discussion. Perhaps this could be a topic pursued at the next conference in the series—suggesting standards of ethical communication without impedance.

What is communicated of astronomy covers a broad spectrum of science. But I felt concern before I came here that we are not being ambitious enough, and I retain this concern at the end of the conference. Wow! is not enough. I saw encouraging evidence in some of the presentations, for example from the HST, Spitzer, and the robotic telescopes that we are pushing the envelope of science communication, testing to see how far we can go.

Perhaps the theme of the next conference should develop this further—'Communicating astronomy behind and beyond the image.'

Credit: Very Large Array and Digitzied Sky Survey, NRAO/AUI and J. M. Uson



PLANETARIUMS, THE GREAT MESSENGERS OF THE ASTRONOMICAL RESEARCH

Acker Agnes

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ABSTRACT

A close partnership between planetariums and astronomers allows the public better access to the results of the astronomical research through high quality audiovisual tools. The French-speaking planetariums have shared their areas of expertise, their different approaches and techniques and their resources since 1984. They created the *Association of French Language Planetariums* (APLF) in 1989, with a head office located at the Observatory/University of Strasbourg in collaboration with teachers and astronomers. The French Planetariums welcome ~1,300,000 visitors per year, 65 % of which come from schools. APLF comprises about thirty fixed structures, 70 small and portable planetariums, and ten French-speaking Planetariums: Brussels and Genk (Belgium), Brescia (Italy), Lafayette (the USA), Lucerne (Swiss), Montreal (Canada), Tunis.
APLF wish to develop planetariums in France and beyond in order to diffuse scientific knowledge towards a large audience and especially towards young people.

APLF ACTIVITIES ARE FOCUSED ON FOUR POINTS

Annual meetings, taking place around 8th May since 1986:

- Annual Journal "*Planetariums*" published since 1995 and web-site since 2003: www.aplf-planetariums.org
- Training activities in 1990-91, 1994, 1999, 2005: about 100 people involved so far.
- Documents for education: 2000-01: booklets *Earth, planet to be protected* and The astronomical *Universe*. 2002: booklet The Earth and its Universe in 7 models. 2004-2005: CDrom *Universe Explorer.*

On the web:
You are invited for a real-life astronomical adventure in an observatory. Choose a mission, collect relevant images, and analyse them on the computer by using a toolbox. http://www.2exvia.fr/HOU/trilingue/#

PLANETARIUM SHOWS ARE PRODUCED AT A EUROPEAN LEVEL: A UNIQUE EXPERIENCE

APLF creates specific shows in conjunction with institutions that conduct astronomical research and wish to communicate their results to a large public. The shows stand out from the usual productions thanks to the exceptional quality and brightness achieved through the collaboration with professional producers, the cost being supported by grants of the scientific organizations and by those involved. The shows transmit (i) discoveries in "natural science" of the Earth and Universe, (ii) the process of research, and are:

- based on a story-board created by a "science communicator" under the supervision of a scientific committee and in interaction with all the planetariums involved
- illustrated with images, videos and animations developed at international institutes
- enriched continuously with music (including classical music) and special effects
- audiovisual elements are adapted by a professional society for three different technical levels of planetarium configurations
- proposed in six language synchronized versions (French, German, English, Italian, Spanish, Dutch)
- duplicated and distributed by APLF to 40 planetariums in Europe and beyond.

2001-02 *"The planet with a thousand eyes"* about the Earth as seen from space:

- natural phenomena coming from inside the Earth (seismic effects, volcanic effects,..)
- natural climate interplay (greenhouse effect, El Niño,…)
- human interaction by natural resource management (agriculture, forests..)
- human influence on long term climate evolution (ice thaw, desertification, increase in sea level ,..)

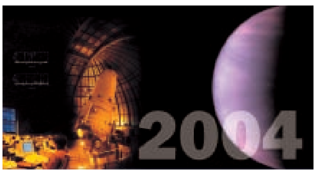
The scientists provide the original information, and each of us plays a role in the preservation of our planet. A version has also been produced for deaf people with the support of the CNES—(French Space Agency). Overall, 37 planetariums were involved and 10 of them still present the show to date (June 2005).

2002-03 *"The Mysteries of the Southern Sky"*—the VLT and new Astronomy at ESO:

- A journey from Europe to the Atacama Desert and the VLT
- Discovery of the southern sky
- New technology !
- Nebulae, dust, and formation of stars and planets
- Death of the stars

- From the Milky Way and out beyond the galaxies
- mysteries of the expanding Universe.

With the support of ESO within the framework of its 40th birthday. 45 planetariums were involved and most of them still present the show to date.



2004 *"Venus and the planet hunters"* - transits of Venus (historic and 2004), the description of Venus and of the Solar System, the discovery of extrasolar planets. With the support of the Ministere de l'Education Nationale et le la Recherche, through a specific "Opération Vénus" for 16 European planetariums.

CONCLUSIONS

Astronomical research provides a lot of exciting results and wonderful visuals. But both the high technology used in making the observations and the methods of analysis are very difficult to understand, and some concepts remain very difficult to explain (especially the "Big Bang" — it is a cosmological model and should not be described wrongly as a time-zero explosive event). Planetariums are very attractive sites with increasing technological resources, have very large audiences and play an important role in science communication, being the "voice" of the research. Planetariums need the collaboration of the astronomers, and the astronomical research organizations need the help of planetariums to communicate their work.

IN VIAGGIO FRA LE STELLE:

The making of the GSC II

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ABSTRACT

We present here “IN VIAGGIO FRA LE STELLE” (Journey amongst the Stars), a project to develop an educational application for Microsoft Windows based on multimedia and interactive tools that will be distributed as a CD-ROM. The uniqueness of this project consists in using the making of an astrometric catalogue (GSC II) as its guiding theme in the explanation of many different branches of astronomy from the Solar System to Cosmology. The choice of such a specialized subject, apparently so ill-suited for popularisation at first sight, as the guiding theme, will highlight the process of research instead of focusing only on the final achievements, giving a clear idea of how science evolves in practice. Its modular structure will permit its use as a classical tool for the popularization of the many fields of astronomy and astrophysics.

THE PROJECT

The general approach to the popularization of science, and of astronomy in particular, focuses on the final results of the research, or on the historical point of view. This technique induces the user to forget the practical work and the methodology that is behind the “final product”, and hides the rich world of interconnections among apparently distant subjects. This project will be an attempt to shed light on these aspects of scientific research by describing the genesis and development of a real astronomical project and the influence that it has had (and will have) on the various areas of astronomy.

This will be done by producing an educational application that will be distributed via CD-ROM and entitled “IN VIAGGIO FRA LE STELLE”. It will use multimedia and interactive tools developed under Microsoft Windows and the making of GSC II (the Second Guide Star Catalogue) as its guiding theme. GSC II is the largest collection of celestial objects in existence, whose realization is the product of a ten-year collaboration between the Astronomical Observatory of Turin and the STScI, Baltimore, with the support of several other international astronomical institutions. The idea is to take a project such as the construction of an astrometric catalogue, a highly technical and specialized subject that would seem ill-suited for popularisation at first sight, and make it accessible to an audience with little if any expertise in the field.

This material will be made appealing and easy to follow by combining the flexibility of multimedia applications with an original approach to the subject, i.e. by favouring a narrative rather than a didactic style. Examples of the approaches used and some of the technical material that will be used can be found on the CD-ROM "The Making of GSC-II" that was distributed at this conference. The general structure of the CD-ROM will be a tour of the different branches of astronomy, from the Solar System to cosmology shown schematically in the flow chart below. The CD-ROM will be distributed through several channels, involving both public and private institutions, scientific exhibitions, special astronomical events, and Italian popular science magazines. In addition, the executable file will be available for download via the web.

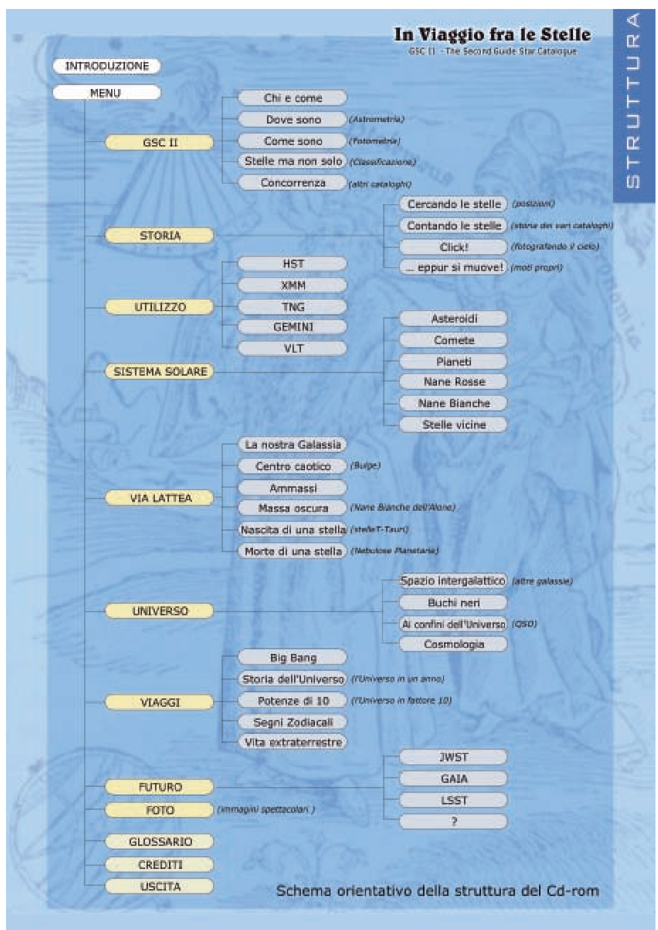
THE STRUCTURE OF THE CD-ROM

The CD-ROM will be organized in several sections (Fig. 1). Each section can stand alone, but they will follow a logical path that will introduce the user to both a general view of astronomy and how the GSCII fits into this picture. The sections are reported below, along with a brief explanation.

- **Introduzione (Introduction):** the GSCII will be described briefly using images, videoclips, animations, audio and text. The history of the GSCII will be presented as an example of the genesis and development of a scientific idea.
- **GSCII:**composed of several subsections that will explain why the GSCII was compiled, its contents, how it was implemented and who contributed to its making.
- **Storia (History):**the birth of astronomy as a science, referring in particular to the reasons that brought mankind to the observation of the sky and describing its evolution from the early days of astrology to modern astronomy. In some specific sections the effort made by ancient astronomers (from Hipparcos to the Renaissance) to catalogue the objects in the sky will be highlighted. A final section will emphasise the evolution of modern astronomy thanks to the techniques of astronomical photography.
- **Utilizzo (Use):** how the GSCII is used by several space telescopes and also by the largest ground-based ones.
- **Sistema Solare (The Solar System):** the first step of the virtual journey through the Universe where the GSCII will be used as road map dealing with the planets, asteroids and comets of our system before crossing its boundaries to the nearest stars.
- **Via Lattea (The Milky Way):** will show all the different types of objects of our Galaxy (e.g. stars, halo objects, star clusters) and will explain the structure of the Galaxy.

- **Universo (The Universe):** This section will show the different types of galaxies. It will also talk about the birth and fate of the Universe according to the most recent cosmological theories, and will introduce the user to different types of exotic objects such as black holes and QSOs.
- **Viaggi (Voyages):** This is an educational section with games, short films, tests, etc., mainly devoted to the clarification of some concepts not in every day use. Two examples are astronomical distances, which will be explained using the famous documentary “Powers of 10” as a model, or the description of the history of the Universe in a year.
- **Futuro (The Future):** This section will be about the astronomy that will be possible in the future from new space telescopes (NGST, GAIA, etc.) to the most advanced ground-based telescopes (LSST and others).

Figure 1: Structure of the CD-ROM.



BRINGING FORTH THE SPIRIT OF ASTRONOMY BY USING CONCEPTUAL MAPS

Mirel Birlan[1,2], Gheorghe Vass[1], Constantin Teleanu[3]

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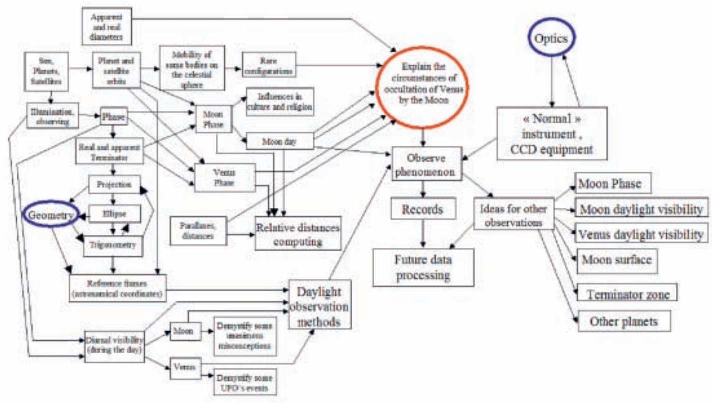
CONCEPTUAL MAP

The epistemological statute of astronomy, which is defined below, is related to the place of this science among the other exact sciences. Astronomy is the frontier science between mathematics and all other exact sciences. For example, mathematical modeling, one of the fundamental methods of exact sciences, was developed by astronomers. Usually, these strong links are so evident so as not to be worth mentioning. Sometimes, however, these links are not evident even to the astronomer, even as a background to his work. This is a pedagogical lack, linked to weaknesses in the methodology of training astronomers.

Such a fundamental lack in the presentation of a concept (phenomenon, event, etc.) could be eliminated if one begins with the conceptual diagram (map) of the astronomical subject. The conceptual map is the graphical representation of links between the concept itself, and the concepts used in its definition. These basic underlying concepts could be the result of reasoning made during another experiment and could extend beyond the formal framework of any one science (the conceptual map can contain also concepts from other sciences). The conceptual map can obviously contain various sentences (theorems, axioms, etc.) which will sustain the conceptual structure. Using images of the first and last contact for the occultation of Venus by the Moon([3]) a Conceptual Map of the event with the primary concepts and links to them can be developed. The number of primary concepts required to explain an astronomical event and the high number of links between them is readily seen.

THE EPISTEMOLOGICAL STATUS OF ASTRONOMY

Such an analysis usually reeals the necessity to elucidate various problems concerning the fundamentals of scientific knowledge. This family of problems can be named “the epistemological statute of astronomy”([1]). Every science is focused on a specific domain (or **universe**) of objects and facts; the first phase of conceiving that science is to **define specific concepts**. But any **conceptualization** supposes an **“abstraction”**, meaning that it eliminates a part of the initial information that defines “the nature” of facts, maintaining only those that are involved in the equiva-



lency relationship which determines the conceptualization. It is very difficult to find those points of view that lead to a visible structuring of facts, while keeping a substantial reference to their nature at the same time. The "***structure or nature***" dilemma explains many of the long hesitations frequently noticed in the historical process of concept crystallization. Too much richness of information often represents, apparently in a paradoxical way, an obstacle in the path of this process.

In this regard, the field of primary astronomical facts is singular, because humans are not equipped to sense extraterrestrial conditions directly. As a consequence, among all the incipient sciences, astronomy began with the poorest baggage of "facts" coming from the observation of the nature; furthermore the information about these facts was presented "unilaterally", so there was much less diversity in comparison with other fields.

Inevitably, the primary concepts of astronomy have excluded references to the individual nature of the celestial bodies, being, *ab initio*, concepts primarily structural, quasi-mathematical, themselves generated from a basic collection of astronomical facts. At this stage, a "star" is a mathematical ***point***, an illuminated one, true, but this only at a second glance.

Since human vision is incapable of distinguishing distances among the stars early models proposed that they were all at the same distance from the observer. Here is an (false!) ***equivalency relationship*** arising directly and immediately from our limited senses. The equalization of all distances to the celestial bodies led to the essentially mathematical concept of the ***celestial sphere***, underpinning much astronomical and mathematical knowledge.

Astronomy provides a ***description***, but not one concerning the object of its study. Astronomy replaces the object with ***a mathematical model***, in which the real objects are ***substituted*** perforce by mathematical concepts.
In this manner, astronomy created ***mathematical modeling*** ([2]), the *methodological* instrument that became fundamental for an entire family of sciences, known as the *exact sciences*.

In time, it was considered a natural requirement that the mathematical model ***should include* all** the observed facts. This *desideratum* required a greater attentiveness to the accuracy of the observations. Increasing precision presented new problems requiring the mathematical model to be refined, and so a ***mechanism*** for the continuous development of astronomy emerged.

We must make a special mention of the geocentric system of the Universe, synthesized in Ptolemy's "Almagesta", ***the first widely known mathematical model in the history of science.***

CONCLUSIONS

We underline several elements that have not been emphasized on any occasion: (a) **astronomy** has created "**mathematical modeling**", a fundamental scientific method that is important to all exact sciences; (b) a great part of the **fundamental mathematical concepts have been created by astronomy** for its own needs; (c) it is **astronomy** that **has created the fundamental concepts of physics**, opening the way for its modern development, through Galileo, Kepler, etc (more generally, we can say that astronomy, the first science of nature, created the *Spirit of Science*; in fact, the spirit of astronomy is the spirit of the science*);* (d) and so this is why, we believe that it is better to pass from the "***education in astronomy***" to the "***education through astronomy***"; in the context of CAPs, we consider that it is better to think about "**communicating (science) through astronomy**" instead of, simply, "**communicating astronomy**".

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USING ASTRONOMY AND SPACE FOR NATIONAL SKILLS AGENDAS

Robin Clegg

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ABSTRACT

PPARC is the funding agency for high energy particle physics, astronomy and space science in the UK. The three main aims of our science and society programme are to stimulate public interest in current research, to support researchers to communicate with public audiences, and to engage young people. The main drivers are the need to account to the public for the work funded by taxpayers and the UK need for a skilled workforce in science and technology. There are shortages of graduates in physics, maths and engineering, and a shortage of school teachers with good physics knowledge. We are capitalising on the excitement value of astronomy and space for young people to encourage more to study science and engineering subjects, especially beyond 16.

PUBLIC INTEREST

Our vigorous media programme includes press releases and media briefings. In a recent example of the Cassini-Huygens space mission and the Huygens landing on Titan, there were 380 articles and broadcasts in the UK media, 252 of which included quotes from British scientists; and a special TV ‘Stardate’ programme drew 1.7M viewers to the original and the repeat broadcasts. We are linking more with the UK science museums/centres sector, which has grown substantially with around 13M visits per year to centres. There are currently three touring exhibitions across Britain: ‘Space Detectives’, ‘UK Goes to the Planets’, and ‘Move Over Einstein’—the latter aimed at 11-14 year olds and part of the Einstein Year (World Year of Physics) celebrations. A publishing programme produces posters, brochures, education packs and catalogues of educational resources in astronomy and space.

SUPPORTING RESEARCHERS

We are helping astronomers and space scientists through:

- funding for public engagement work—directly from their research grant money
- special funding schemes for communications projects
- specialist advisers (media, schools) and project outreach co-ordinators
- free communications training
- free popular publications and resources to support their communications work

The report to the UK Government's Treasury Department by Sir Gareth Roberts 'SET for Success' outlined the need for a skilled workforce in an increasingly knowledge-based economy. It identified shortage areas and problems in the 'supply chain' of recruiting young people into science and technical subjects through school and university.

ENGAGING YOUNG PEOPLE

Much of PPARC science and society funding goes to projects addressing teachers of 11-16 year olds or involving young people directly. Supported by our awards schemes, a very wide range of organisations have included astronomy and space in their work with young people including Science Centres, Youth Hostels Association, Summer Camps, Hospital for Sick Children, National Academy for Gifted & Talented Youth, local education authorities, Girl Guides/Scouts, etc. Both the formal and informal education sectors are represented in the approximately 350 awards given over the past 10 years. Priority is given to projects addressing previously unengaged audiences (see below) or addressing 11-16 year-olds.

Examples of particular interest include those where young people get involved in 'real' science or engineering. We have invested nearly £1M in the Faulkes Telescope Project (see also, article by Dr Paul Roche) in which school groups use professional standard 2m telescopes over the internet. 'Classroom Space' (www.star.le.ac/classroomspace) provides space contexts to deliver points in the UK's national curricula for students aged 11-16. Lastly, schools' radio astronomy projects encourage young people in hands-on engineering and electronics projects which are inspired by a wider and exciting application of the kit they have helped to build: awards to a network of schools in the SouthWest of England at Bristol and Taunton have supported this.

A current development is that of linking 'space' better with school education (see also, article by Ian Jones). The recently built National Space Centre at Leicester has made a good impact and hosts the only Challenger Learning Centre outside North America. PPARC is a member of the British National Space Centre, a partnership recently joined by the UK's Education Ministry, and a coming consultancy report will advise us on how national agencies can best add value to the UK space education community. Likely outcomes include a space education office (for the UK but also ESA's office in the UK), a national forum, a one-stop-shop website for the best resources, programmes of visits and teacher training, and continuing provision of resources linking missions and their new science with schools' curriculum—recent and current examples being Mars Express and Beagle2, Cassini-Huygens, Cryosat and Venus Express.

Much of the UK science communications effort does not connect well with audiences not traditionally engaged with science and technology—such as some ethnic minority groups. A national framework has been set up, and a PPARC contribution to this in 2005 is 'Cosmic Africa', a project in which a black African astronomer is visiting schools and community groups in three cities with significant African-Caribbean representation. This pilot should help us see how to use astronomy as a good subject and activity to engage under-represented audiences including young people.

Paramount in a funding agency's communications work are the partnerships we have—with research groups, journalists, science centres, teacher associations, learned societies, etc. Amongst the sciences, astronomy is relatively accessible in a non-threatening way to all groups and all ages and provides a good subject for inclusion in hands-on activities and lifelong learning. Evaluating communications work is generally hard, so I end with a call for further and detailed national and international exchange of best practice—and evaluation of impacts—in this area.


FOUR DECADES OF PUBLIC
AT KITT

THE IAC AND SCIENTIFIC OUTREACH

Luis Cuesta Crespo on behalf of the Director's Support Team of the IAC

Instituto de Astrofísica de Canarias (IAC), La Laguna, Spain

ABSTRACT

The Instituto de Astrofísica de Canarias (IAC) is a Spanish research centre. It comprises the Instituto de Astrofísica, the main headquarters in La Laguna (Tenerife), the Teide Observatory in Izaña (Tenerife) and the Roque de los Muchachos Observatory, in Garafía on La Palma. Whilst maintaining a level of excellence, not only for the facilities of the observatories under its administration, which constitute the European Northern Observatory, but also in its research and its technological projects, which include a telescope with a diameter of 10.4 metres, and its involvement with universities, the IAC has not neglected its cultural outreach. On the contrary, as one of its goals, the IAC is constantly making an effort in the popularization of science. The Director's Support Team carries out the cultural outreach of the IAC. Activities include visits to the observatories, exhibits, outreach courses and conferences, educational projects, attention to the media, publications and many other activities related to astronomical events.

INTRODUCTION

The IAC considers scientific outreach to be one of its most important aims. As proof of its success in this work the Institute received a prestigious award—the Special Award of the Jury—at the "XVI Convocatoria de los Premios Prismas «Casa de las Ciencias» a la Divulgación Científica 2003". This body awards people and institutes that have stood out in the popularization of science and technology. The jury pointed out that the award was given to the IAC "for being a model of how science can be carried out without losing sight of the interests of the people, for their concern for outreach, and their interest in communicating with society by means of exhibits, digital magazines, radio programmes and many other activities".

ACTIVITIES

The Director's Office is in charge of outreach activities carried out at the IAC. In addition, in 1993, the Government of Tenerife and the IAC created the Museum of Science and the Cosmos of Tenerife. It is the only museum in Spain promoted by a research centre.

The most common outreach activities are:

- Visits to the observatories
- Open house days
- Exhibits
- Outreach lectures and conferences
- Educational projects: "Cosmoeduca"
- Interaction with the media
- Scientific advice to the media
- Publications: IAC Noticias
- Gran Telescopio Canarias supplement
- Winter School of Astrophysics supplement
- Other publications, including posters, videos and CD-ROMs
- Digital publications: Caosyciencia (www.caosyciencia.com) and GTCdigital (www.gtcdigital.net)
- Communication and external outreach for the Gran Telescopio Canarias (GTC)
- Training of scientific journalists
- Institutional reports
- "Canarias innova" radio programme
- Space-time Odyssey: a series of 10 lectures offered to teacher training programmes, astronomy professors, science teachers interested in astrophysics, to amateur astronomy groups and to people doing outreach in general
- Information: www.iac.es

Director's Support Team:

Head: Luis Martínez Sáez
Secretariat: Ana M. Quevedo González, Eva Untiedt Lomo
Press Office: Carmen del Puerto Varela
Scientific Referee: Luis Cuesta Crespo
GTC Communication: Natalia Ruiz Zelmanovitch
COSMOEDUCA: Itziar Anguita
Grant Holders: Laura Ventura, Karin Ranero, Elvira Lozano
Design: Gotzon Cañana, Inés Bonet

ASTRONOMIA.PL

Polish Astronomy Portal

Krzysztof Czart

Astronomia.pl, Milanowek, Poland

ABSTRACT

Astronomia.pl is an educational internet service for students, teachers and all astronomy amateurs. It is the biggest and the most popular astronomical portal in Poland. Our main address is www.astronomia.pl, but we created additional services: Copernicus - biographies of famous astronomers (www.kopernik.pl), AstroWWW - a collection of interesting webpages created by amateur astronomers (www.astrowww.pl), AstroSHOP - an on-line shop (www.astronomia.com.pl), Planetarium - website about Polish planetaria (www.planetarium.pl). An English version of the portal is available at www.astronomia.pl/english. In this article we give a short introduction to many of the portal's projects.

A SHORT HISTORY OF THE PORTAL

Astronomia.pl is an educational internet service for students, teachers and all astronomy amateurs. It is the biggest and the most popular astronomical portal in Poland. The portal opened on October 17th, 2001 and it is a private non-profit project. It is made both by professional astronomers as well as amateurs. The age of the people preparing the portal ranges from 15 to 32. The website was rewarded for its high quality in November 2003 by receiving the patronage of the Polish Society of Astronomy Amateurs, the biggest and the oldest astronomical organization in Poland.

THE PORTAL'S SERVICES

The main portal website is www.astronomia.pl, but the portal obtained more well-named internet domains and created additional services. Copernicus—www.kopernik. pl—is a website presenting the biographies of famous astronomers. On AstroWWW—www.astrowww.pl—one can find a collection of the most interesting webpages created by amateur astonomers. The two latest projects are: www.astronomia.com.pl—an on-line shop and Planetarium—www.planetarium.pl—WWW site about Polish planetaria.

PARTS OF THE PORTAL

The portal Astronomia.pl contains over 20 sections, some of them standarized and shared by all portals, such as: forum, chat, news, catalogue, gallery. But Astronomia.pl also presents unique ideas, and one of them is a virtual library of master's theses written in the field of astronomy. The main part of the service consists of a knowledge base of articles divided into several thematic categories and separated into different levels of difficulty. We also invite professional astronomers, students of

astronomy and advanced astronomy amateurs to our chatroom. 'News' has updates on astronomical research, any phenomena visible in the sky, the time and place of future events that will be interesting for an astronomical society.

There are also several databases. One of them is an astronomical dictionary English-Polish and Polish-English that contains over 1000 words. This dictionary is used by several big internet dictionaries, including the greatest general portal in Poland (Onet.pl) and the Polish Astronomical Society website. We have also a database of astronomical books edited in Poland in the last 50 years. Our records include editorial data about books and scans of covers. A list of popular lectures delivered in several cities is very useful. Moreover, we used questionnaires asking people about different astronomical issues in our portal from the very beginning. So far, there have been about 110 questionnaires, receiving 70,000 answers in total. Some questionnaires are repeated more than once to check the reliability of the results.

SOME STATISTICS

The portal hosts 50,000 sessions and 250,000 displays monthly. The newsletter is sent to 2200 people. For comparison, the circulation of popular astronomy magazines in Poland is following: Urania—1500, Vademecum—1350 copies.

ACTIVITY

After 3 years of operation, Astronomia.pl is a big media power in the astronomical community. The portal supports various astronomical initiatives. The service participated in the Venus Transit 2004 program, together with the Polish national node of the VT-2004 network—the Astronomical Observatory of Wroclaw University. The portal, in cooperation with several astronomical outposts, organized an internet

transmission from 4 cities (Torun, Wroclaw, Lodz, Krakow). The transmissions were watched by 21,000 visitors. The portal cooperated with the British Council in their promotion of science (SpaceUK) and also supports the so-called «Eclipse Hunters», who observe solar eclipses all over the world.

Astronomia.pl hosts many astronomical websites, among them: Polish Society of Astronomy Amateurs, magazine Vademecum Milosnika Astronomii, OZMA—General Polish Camp for Astronomy Amateurs, TOS—Society of Sun Observers.
The website organizes quizzes and competitions a couple of times every year with rewards ranging from astronomical postcards to 20 cm telescopes.

CONTACT

The fastest way to contact Astronomia.pl is to email redakcja@astronomia.pl. The English version of the portal: www.astronomia.pl/english. Full poster download: http://www.astronomia.pl/wspolpraca/astronomia_pl_plakat.pdf.

HUMAN LINKS TO THE UNIVERSE:

A cultural shift

Francisco Diego

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ABSTRACT

Our modern view of the Universe has potential implications in all aspects of human culture. In this contribution I outline fundamental concepts and facts and propose simple ways to deal with them at elementary levels of education. These include the basic structure of the Universe and its origin and evolution; the amazing link between stars and humans and the majestic scales in time and space that make us feel humble and insignificant and at the same time, proud of the emotions and intelligence that drive us on to explore and discover. The content of this paper is a summary of a series of publications in process.

Traditional (conventional?) teaching of astronomy has been limited to the movements of the earth, phases of the moon and the seasons. The astronomy of the 19th century. Proper understanding of these topics implies a complicated transformation of our spatial frame of reference from the surface of the Earth to a distant position above the solar system. This is usually enough to drive people away from anything to do with the subject. Away from this approach, the excitement of modern astronomy (shall we say astrophysics and cosmology?) and its close connection to almost every single aspect of human intellect, has not yet reached the elementary classroom, nor the general public. Let me give a few examples on fundamental topics and how they could be dealt with in a very simple way, accessible to anybody.

THE STRUCTURE OF MATTER

Big things are made of smaller things and smaller things are made of even smaller things. Smaller things came first, then joined together to make bigger things. The Universe we see, stars, moon, trees, clouds, dogs and people are all made of the same three kinds of very tiny little bricks. In the end, the Universe is the same everywhere.

ORIGIN AND EVOLUTION

The three kinds of tiny little bricks were all formed at the origin of the Universe. They are called protons, neutrons and electrons and they can be put together to assemble atoms, but only at temperatures of millions of degrees. Only 92 different kinds of atoms can be found in the Universe. The difference between them is their number of protons. Hydrogen atoms have only one proton, carbon ones have eight, gold 79 and uranium 92. The only places in the Universe hot enough to assemble atoms are deep inside the stars. When stars die, they spread out as clouds that carry the atoms they have put together and from these clouds, new stars and planets are formed. This is how our solar system was formed millions of years ago and this is why we have only these 92 atoms on Earth. No stars, no atoms. No atoms, no planets. No planets, no life. No stars, no people. Knowing this, what would people of any age feel next time they look at the clear night sky?

A SENSE OF SCALE: THE VERY SMALL

Atoms are really tiny. They join together to form molecules. For example, every molecule of water has one oxygen atom and two hydrogen atoms. There are more molecules of water in a glass than glasses of water in all the oceans.

A SENSE OF SCALE: THE VERY LARGE

A broad view. Our planet is a ball about 12,500km in diameter. If we fly nonstop in a jet airliner, it would take more than 40 hours to go around the Earth. Make a linear (and I emphasise LINEAR) scale model: the Sun is 100 times larger than the Earth. Say the Sun was a football, the Earth would be a pepper corn and the Moon a pin head. The Moon would be 7cm away from the Earth and they both would be 30 metres away from the Sun. Jupiter would be an apricot 170 metres away and Pluto, a pin head more than one kilometre away. The nearest star would be another football in another continent, 8,000km away and with nothing in between. The Universe is mainly empty space.

A SENSE OF SCALE: TIME

Stretch a 14m long rope across the classroom. Every millimetre will represent one million years. Use clothes pegs to hang the following pictures from the rope: an exploding firework to emulate the origin of the Universe at the left end of the rope; a galaxy 50cm down the line; the Earth another 9 metres away; a bacteria at one more metre; a flower 50cm now from the righthand end; a dinosaur 25cm from the right end; a sheet of paper around 0.1mm thick placed edge on at the right end would be equivalent to the last 100,000 years, time that has seen the development of the human race (to make it clearer I normally print a picture of a pre-human skull on one side and a picture of Einstein on the other).

Leave all pictures on the rope and look at the vast empty space between the galaxy and the Earth, when stars were forming and dying, producing the material to make planets and people. Look at the empty space between the bacteria and the flower, when life was struggling to get somewhere. Look at the small gap (in this context!) between the dinosaur and the end of the line. Think about all what we have done since we became humans, in terms of the thickness of that sheet of paper. Once again, the scale needs to be linear.

THE SECRETS IN THE RAINBOW

Modern astronomers make rainbows with the light from the stars. Rainbows from the stars tell us about their lives, about their ages and sizes, about their chemical composition, about their movements. Rainbows from stars led us to discover more than 150 solar systems. Life is part of the Universe and it may exist in millions of planets. Knowing this, what would people of any age feel next time they see their next rainbow?

CONCLUSION

The Universe challenges our minds. It makes us aware of our place in time and space, of the origin of everything, including ourselves. It links the very small with the very big. All this could and should reach every single aspect of human culture, from science to art, to philosophy and religion. Hopefully, it will not be long before this modern view plays a prominent role in elementary levels of education to become part of every day life.


D-FWIM

NEEDS OF A SCIENCE EDITOR

Oliver Dreissigacker

ASTRONOMIE HEUTE, Spektrum der Wissenschaft Verlagsges. m.b.H, Heidelberg, Germany

ABSTRACT

None of the classic media sources report in greater depth about this science discipline than monthly astronomy magazines. They may not reach the widest audience, but their readers are 100% interested in astronomy, astrophysics and spaceflight, so the targeting is perfect! This article provides some insight into the production and selection process using examples from ASTRONOMIE HEUTE (AH), the German edition of *Sky & Telescope (S&T)*.

TIME FRAME

As the name says, monthly magazines appear once a month (although there might be double issues, for example, AH currently has two, 1/2 and 7/8 making a total of 10 per year). But that doesn't mean that once you have sent in a press release or pitched a story for a feature article, that you will see it in the issue on the stand the next month.

The production process, including distribution, of a four colour, glossy magazine such as Astronomie Heute is quite complex, taking more than two weeks from the time the publishing company sends the data to the printer.

And if your contribution is more than "just" a news snippet: Feature articles or stand-alone contributions are usually scheduled more than three months in advance to allow enough time for (a) good writing, (b) intensive editing, (c) pleasing layout /artwork /instructive and aesthetic imagery.

"Hot" topics (like the Deep Impact results) can make it to the reader in less than 6 weeks, but then they are usually written by one of the editors.

MINIMUM REQUIREMENTS

Particularly important for releases destined for the News Section:

a) make sure that there is not only a media contact given, but also a science contact and that they are available to respond to e-mail inquiries within 12 hours during—at least—the ten days following submission. If any of the scientists are of particular interest for a foreign language publication, flag it!

b) Have high-resolution imagery and illustrations available, both captioned and non-captioned. Typical printing resolution is 300 dpi, so the dimensions

Fig. 1: *Needs of a science editor.*

of the files should exceed 3 Megapixels. If you want the image used in a feature article, a calendar or a poster, create a version with a minimum of 15 Megapixels!

c) In the press release, provide a working link to the science publication—reprint or preprint. Editors of specialist magazines may be experts in the field and might have questions way beyond your release. Or simply find additional information or aspects more interesting than those focussed on in your summary.

Without these three prerequisites, the story won't make through to the:

MINIMUM REQUIREMENTS

The actual news section typically has 6 to 8 pages, allowing a total of between 12 and 15 pieces (S&T has more pages but longer stories, so their number is roughly the same if not less). In cases of high-impact events, such as: Huygens landing on Titan, Deep Impact hitting Tempel-1, Discovery Return-to-Flight, that number is reduced even further.

The mix of topics is then chosen so as to give a broad spectrum of sub-disciplines: spaceflight (civil/commercial), major space missions update, optical astronomy, non-optical astronomy, astrophysics, high-energy/particle physics, cosmology, planetary science. So it may be that given two high-impact stories that cover the same subject, one will be rejected.

Magazine editors are always interested in stories that they know their readers like. To increase the chances of your story being covered, be aware of the editors' needs and facilitate their work.


HUBBLE
European Space Agency Information Centre
esa
How far can we in the name of science communication keep pushing, or
promoting, our respective results or projects without damaging our individual,
and thus also our collective credibility? The pressure is larger than ever, and
the temptation for hype huge. Are comparisons between different projects of
the sort "my scope is better than your scope" necessary? Do we really need
scientific results to be peer-reviewed in advance of their public dissemination?
Do we need internal political and scientific 'editorial boards', or is it just a kind
of double-refereeing? How do we handle the really BIG discoveries (e.g. exo-
Simpsons)? How do we treat the NEO threat? Why do press releases that are
later proven wrong rarely get withdrawn? Is the time ripe to make a Code of
Conduct for press releases that outlines recommended ethics and procedures
for conflict resolution, analysis and retraction?

THE XMM-NEWTON IMAGE GALLERY

M. Ehle, N. Loiseau, & R. Bailey

XMM-Newton Science Operations Centre, European Space Astronomy Centre (ESAC), ESA, Madrid, Spain

ABSTRACT

The XMM-Newton Image Gallery has been designed by the xmm.esac.esa.in XMM-Newton Science Operations Centre to provide a web-based repository for XMM-Newton related images, submitted by members of the users' community. The images are intended for educational and informational purposes. Some images have already been used to highlight talks on X-ray astronomy and book editors have asked for permission to extract images for their publications.

PROJECT

Scientists who have remarkable and/or high quality images and results related to XMM-Newton are invited to submit their pictures via an on-line web form together with a short description, figure caption, technical details and references. The user interface of the XMM-Newton Image Gallery has been based on the NRAO image gallery (http://www.nrao.edu/imagegallery/php/). The existing PHP/MySQL engine was re-written to allow for easy maintenance and adaptation to X-ray astronomy. The first images were extracted from published papers and submitted to the gallery by scientists from the XMM-Newton User Support Group (USG) to demonstrate the gallery's functionality and to make some first examples available for download.

In December 2003 the XMM-Newton image gallery was opened and announced in an XMM-Newton Newsletter (http://xmm.esac.esa.int/external/xmm_news/news_list/). In the meantime, astronomers from the users' community of XMM-Newton have contributed their own highlight pictures: currently there are 88 images available for download, a significant number of them submitted by external community members. The web page portal of the XMM-Newton Image Gallery is available, also offering further information, at:
http://xmm.esac.esa.int/external/xmm_science/gallery/public/

IMAGE SUBMISSION FORM

The community is invited to submit their XMM-Newton related images via a dedicated web form. The users (i.e. the experts) themselves fill in all relevant details (see Fig. 1, left panel for an example). After the submission of the image form, the users receive an (automatically generated) acknowledgement email with all the details of their submission for confirmation. Entries are validated by scientists from the XMM-Newton USG and can be modified, revised or updated online at any time (for example by adding a link to a refereed paper that was not yet published at the time of the image submission). The entries are converted by the PHP/MySQL-software of the gallery into a proper HTML page. Images automatically get a 'watermark' bottom line attached to the data file showing at least "European Space Agency" and the ESA logo as copyright statement. Users receive another automatic email notification when their image goes public in the XMM-Newton Image Gallery.

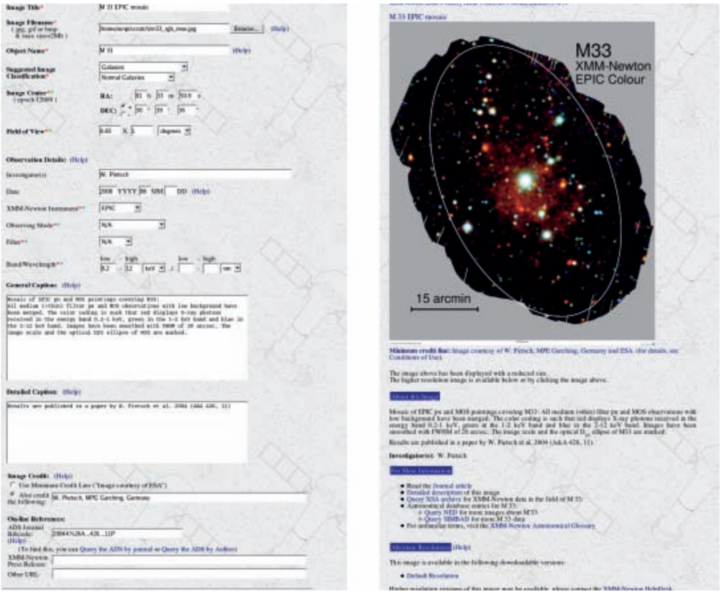

Figure 1. *Part of the web form for online submissions to the XMM-Newton Image Gallery (left panel) and an example of an individual database entry and corresponding web page (right panel).*

GALLERY ENTRIES

Images in the gallery are sorted by the astronomical object category of the X-ray source that is presented in the picture: from small to large scales, i.e. from sources in the Solar System, through stars, supernovae, binaries, galaxies, clusters of galaxies, to Cosmology (each with sub-categories). In addition there are three categories called 'Miscellaneous' (including Gamma-ray bursts), 'The underlying Physics' and 'XMM-Newton spacecraft images'. Fig. 1, right panel gives an example of a gallery entry for an image of the XMM-Newton EPIC mosaic of the spiral galaxy M33 (kindly submitted by W. Pietsch, MPE Garching). The displayed image itself provides a hyperlink to a popup window with the highest resolution version of the graphics file that is probably suited best for downloading and further usage., Hyperlinks under the section 'For more information' point to the following external and XMM-Newton internal web information pages:

- NASA Astrophysics Data System Abstract Service (ADS)
- NASA/IPAC Extragalactic Database (NED)
- SIMBAD Astronomical Database
- XMM-Newton Science Archive (XSA)

Links to a related journal article (or press release) and to a more detailed description of the image are automatically generated if the user provides such details. The links to NED or SIMBAD are based on the object name and can be switched on or off during the image validation step. The link to the XSA queries the XMM-Newton data archive and is provided if object coordinates are available.

ACKNOWLEDGEMENT

Patrick P. Murphy and the National Radio Astronomy Observatory (NRAO) are acknowledged for providing access to the original software of their image gallery.

FOUR DECADES OF PUBLIC OUTREACH AT KITT PEAK

Richard Fedele

NOAO/Kitt Peak, Arizona, USA

ABSTRACT

Since its inception in 1958, Kitt Peak has served as the U.S. national center for nighttime astronomy and daytime studies of the Sun. The Kitt Peak Visitor Center, constructed in 1964, serves as the hub for the thousands of visitors each year who come to explore "their" national observatory. For over 40 years, the visitor center has functioned as part-museum, part-interpretive center, and part-comfort station, along with transitory functions as an auditorium, classroom and media center. More than 2 million people have come to learn about the science, history, and mission of Kitt Peak National Observatory, NOAO, AURA, and the National Science Foundation http://www.noao.edu/outreach/kpoutreach.html.

Considered to be one of the major tourist attractions in Southern Arizona and a unique experience for even seasoned world travelers, the Kitt Peak Visitor Center (KPVC) receives an estimated 60,000+ guests annually. Visitor response is routinely positive, with many inspirational and encouraging verbal and written comments received weekly. The KPVC is nearly self-supporting, with about 80% of its annual budget of approximately $800,000 generated by revenue from public programs and gift shops sales. About 7 FTEs are required to operate the KPVC and its current suite of programs, including many part-time employees, plus a cadre of about three dozen volunteer docents. While daytime admissions and self-guided walking tours of the mountain and its major telescopes are free, NOAO recently received approval from the NSF to implement a small fee ($2 per adult, $1 per child) for our three daily docent-led tours. In addition, we are about to begin a new paid membership program offering gift shop discounts, special events, and a newsletter.

PUBLIC PROGRAMS

Nightly Observing Program (NOP): Over 7,000 visitors each year attend the nightly stargazing program—the "crown jewel" of public programs. This hands-on, fee-based program provides a leisurely introduction to the night sky for three dozen people per night, with plenty of time for questions and interaction with our paid guide staff. The 3.5-hour NOP incorporates sunset viewing, an orientation lecture, a box dinner, basic instruction on the effective use of binoculars and star charts, and direct observation through one of the two visitor center public telescope domes, which house a 20-inch RC Optical telescope and a 16-inch Meade.

Advanced Observing Program (AOP): This program addresses the desire of the public to experience telescope observing in the style of a visiting professional astronomer, albeit on a small scale. Participants in the Kitt Peak AOP spend the night on the mountain, eat in the cafeteria and stay in the observer dorm rooms. This all-night program, which begins after the end of the NOP, includes a staff guide in the role of "observing assistant." The two public participants can chose whether to do a purely visual program, take images using their own film or digital camera, or capture and process images with a CCD camera that can rival those from much larger research telescopes. These images are then posted on the public outreach AOP website (www.noao.edu/outreach/aop/observers/bestof.html); images from the AOP have appeared many times on popular web sites as the "Astronomy Picture of Day."

SCHOOL PROGRAMS

The Public Outreach staff is in the process of revamping its school program. Schools have the option of either coming to Kitt Peak or doing an in-house outreach program at their school. The Kitt Peak program will include a series of astronomy activities that can be chosen by the teachers and that meet necessary state science standards. Schools choosing a site visit can choose from a variety of activities, from star parties to solar viewing to booking a portable planetarium.

SPECIAL PUBLIC NIGHTS

The KPVC Public Outreach staff conduct a variety of fee-based workshops for the public and telescope enthusiasts, ranging from asteroid hunting and CCD image processing workshops to telescope basics for new hobbyists and family-oriented "Fun with Sun" programs. Each workshop is tailored to reach a target group of various ages, interests, and expertise; some are hosted at the NOAO building near downtown Tucson rather than on the mountain. The more advanced workshops have proven to be the most consistently popular. KPVC Public Outreach staff also support special nights on the mountain to coincide with timely astronomical events, such as meteor showers and eclipses, and daytime events like Astronomy Day and special guest lecturers. These events usually sell out before much advertising is even required.

VISITOR CENTER OPERATIONS

Most of the visitors who make the scenic 90-minute drive from Tucson to Kitt Peak National Observatory experience the observatory during the daytime, even though the observatory comes most "alive" at night. To meet this demand, the KPVC offers both guided and unguided tours. Visitors can purchase a guided-tour ticket for $2. This ticket lets them participate in one of the three scheduled telescope tours offered to the public on a daily basis by trained docents. They also have the option of taking the free self-guided tour if they choose. These tours lead them into the observatory galleries of the Mayall 4-meter, 2.1-meter or McMath-Pierce solar telescopes. One of the biggest complaints we have received is that visitors are unable to look through one of the telescopes while they are here. We have addressed this desire with the installation of a solar-filtered telescope in an unused dome on the mountain, which enables visitors to get a live look at the Sun. The revenue from the well-stocked gift shop helps to offset the operating expenses of the Visitor Center directly, as required by NSF policy. The 3,000-square foot Visitor Center also houses a number of exhibits on a variety of subjects.

DOCENT PROGRAM

The Public Outreach department trains and supervises 40 volunteer docents who interpret the operations and scientific work of the telescopes, and verbally pass on the Kitt Peak "story" to the hundreds of guests who visit daily throughout the year. The docents are the true backbone of Visitor Center operations. Their personal commitment to the program enables us to offer much more to the public than we could through paid staff alone. Each docent goes through a comprehensive eight-week training session which covers topics dealing with astronomy to zoology. Within that eight-week course, they are given a three-week immersion on interpretative techniques. In exchange, the docents are treated to a monthly knowledge enrichment meeting, which includes a free dinner and a speaker related to the science currently being conducted on Kitt Peak. Further rewards include special star parties, a year-end awards ceremony, free lunch during their shifts, and free uniforms and name badges. Docent duties have recently been expanded to include the conduct of hands-on science demonstrations in the Visitor Center.

SUMMARY

The long history and vibrant programs of the Kitt Peak Visitor Center demonstrate the importance of offering a wide-range of activities for the public, both free of charge and paid, from self-paced exploration to guided tours to special events to extended, in-depth observing experiences. U.S. visitors in particular seem to greatly appreciate this vivid "return on their investment" in federally funded astronomy, which surely must translate into increased appreciation and support for basic scientific research, and greater shared knowledge about the wonders of the Universe.

STARS ON STAGE:

The new Planetarium of Rome as an Astronomical Theatre

S. Giovanardi, G. Gandolfi, G. Catanzaro, V. Vomero

Planetarium of Rome, Roma, Italy

ABSTRACT

We present the new planetarium of Rome as an astronomical theatre: a facility to combine the research of new formats for the communication of astronomy with an attention to the cultural significance of astronomy for the public. This approach has resulted in the production of more than 50 shows and is an independent presenter of science.

The new Planetarium and Astronomical Museum of Rome opened in May 2004, filling a 20 year old void in the city after the old planetarium was closed. It is a remarkably flexible resource for the communication of astronomy to help visitors bridge the gap towards understanding the sky. As recent results confirm, this gap is widening, due to the fast progress of astrophysics as a big science versus the lack of references in the public perception of the Universe beyond the solar system.

The planetarium can be defined as an “astronomical theatre” open to all:

a) like a theatre, the mission of the planetarium is to share a cultural identity with a community;

b) people are invited to enjoy a show, i.e. a representation that conveys a cultural message via an emotional link;

c) the emotional value is triggered by careful musical, visual, linguistic choices, that involve the role of a director;

d) there are different shows for a variety of audiences.

In order to achieve its mission, the Planetarium of Rome is conceived as a communication laboratory where it is possible to experiment with new linguistic combinations and the definition of new communication formats, such as our live astronomical shows. The programs developed within this conceptual framework include over 50 shows and events, shaped around the symbiotic connection between the planetarium and the nearby Astronomical Museum.

However, giving full shape to the metaphor of the planetarium as an astronomical theatre means going beyond research into new forms of language and communication styles. It implies looking at the astronomical content from a new perspective that aims neither at pure education nor at plain entertainment. Rather than acting as a passive amplifier of scientific research, the role of the planetarium is to question the meaning of old and new astronomical knowledge and to dig out its cultural relevance. It focuses on rethinking astronomical information to turn it into culture, to return the sky to its fundamental position as the mirror of the cultural identity of a society.

According to our view, the planetarium is meant to offer a cultural playground where imagination and knowledge cooperate in building new views of the world, and in weaving a network of references through which astronomical information becomes meaningful to the public.

In the absence of institutional subjects able to produce a critical reading of modern science—a peculiarity with respect to the arts, literature and the human sciences, and certainly a missing link for a successful acceptance of science into popular culture—it is possible to use the planetarium as an observatory for science. It offers an excellent vantage point to read a projection of the current relationship between scientific research and society in the sky. Thus, the planetarium may become the ideal theatre for a science critique, independent of any propaganda and in close contact with the public.

Figure 1. *The hall of the new planetarium of Rome*

Table 1*: Essential facts about the new planetarium of Rome.*

THE NEW PLANETARIUM OF ROME	
Opening	May 26, 2004, http://www.comune.roma.it/planetario
Dome	Diameter 14 metre, 98 seats
Equipment	Optical projector SN95 RSA Cosmos, 4500 stars; 3 digital video projectors; 12 all sky slide projectors
Visitors	57,000 as of May 2005
Mailing List	1608 subscriptions as of May 31, 2005
Production	50 astronomical shows
Special Events	The Full Moon lectures, Rome's Notte Bianca, Mtv Music Pollination Week, 6th National Astronomy week, 19th Meeting of Italian Planetaria

APRITICIELO

Interactive Museum of Space and Astronomy, Torino Planetarium

M. Giovalli, A. Ferrari, G. Bernardi, P. Rossi

Osservatorio Astronomico di Torino, Università di Torino, Italy

ABSTRACT

ApritiCielo (www.planetarioditorino.it/)is an interactive museum with a planetarium that is under construction in the compound of the Astronomical Observatory of Torino, Italy, following an educational project developed in collaboration with the University of Torino and the township of Pino Torinese. It was conceived as a centre to communicate the most recent and advanced theories about the Universe and its components using modern media techniques. Its location next to the building of the Astronomical Observatory is intended to promote a connection between scientific researchers and the general public.

ApritiCielo is divided into two sections—the interactive museum and the planetarium dome—that are ideally connected in an educational voyage through the conquests of astronomy. The interactive museum introduces visitors to the two main subjects of astronomy and astrophysics, and is composed of exhibits of different levels to excite the interest of a young and adult public alike.

The exhibition is distributed on four floors, entered from the top, and presents the following themes.

THE NAKED-EYE SKY

The journey starts from video walls showing images of the sky as seen by early astronomers and the first primordial models of the Universe.

ASTRONOMICAL OBSERVATIONS

Exhibits and panels illustrate the astronomical instruments used in ground and orbiting observatories to explore the sky over the entire electromagnetic spectrum.

THE FORCES THAT FORM AND MOVE THE UNIVERSE

Joseph Louis Lagrange, the great mathematician and scientist born in Torino, welcomes visitors at the entrance of this section. Hands-on exhibits will allow visitors of all ages to experiment with the deeper nature of gravity and rotation and to understand the mechanisms of the formation of galaxies, stars, planets.

THE EVOLUTION OF THE UNIVERSE

“The runaway Universe” is an original way to present the charm of modern cosmology and its constant state of development. Beginning with Edwin Hubble’s discovery of the recession of the galaxies, the expansion of the Universe and the Big-Bang, visitors are introduced to Einstein's theories of space-time and general relativity, the possible futures of the Universe, the mysterious cosmic microwave background, and ideas of dark matter and dark energy.

The visit culminates in the planetarium dome, which is equipped with the advanced technology digital projection system DIGISTAR 3, produced by Evans&Sutherland. The shows leads visitors on a voyage through the wonders of the sky, the distribution of far away galaxies, the depth of galactic nebulae, the movement of the planets, the sky of the ancient and future generations, using the real data collected by space missions and the most powerful telescopes.

The architectural project has been developed by Giancarlo Gonnet and Loredana Dionigio and has been funded by the Assessorato alla Cultura of the Regione Piemonte, Compagnia di San Paolo and Fondazione CRT. The construction is supervised by the staff of the Osservatorio Astronomico di Torino. The educational content has been developed by a Scientific Committee, where all sponsoring institutions are represented, in collaboration with the SISSA Telematica.

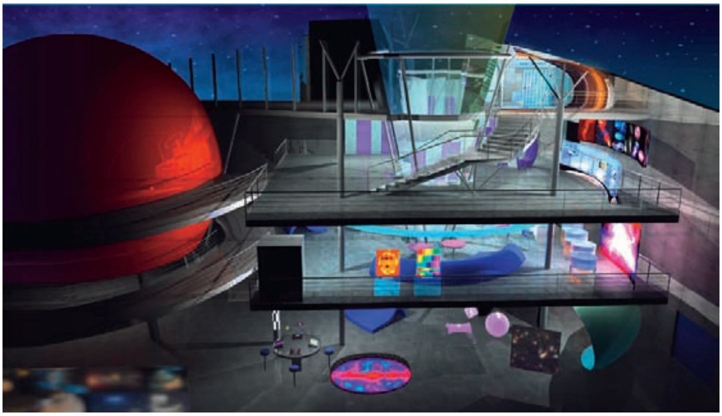

Figure 1. *Architectural concept*

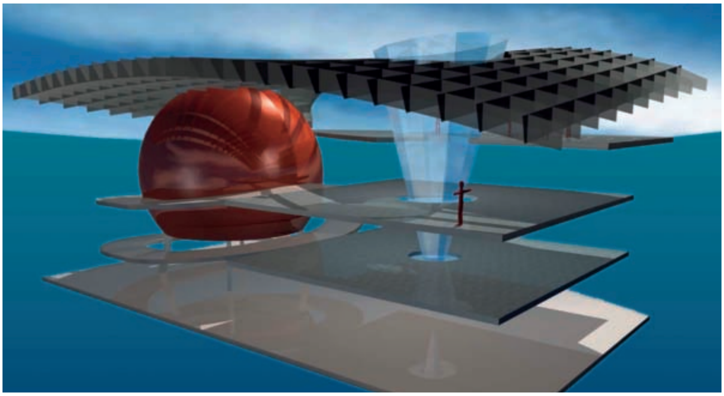

Figure 2. *Internal view*

JOURNEY THROUGH THE UNIVERSE

Janice Harvey

Gemini Observatory, La Serena, Chile

ABSTRACT

Journey through the Universe held its first Journey Week January 21-28, 2005 in Hilo, Hawaii. This ambitious program uses the fields of space, earth science and exploration to engage communities with long-term connections to science, mathematics and technology. All content is aligned to state and national education standards. Last year, the Hawaii-based program trained 135 teachers, visited more than 120 classrooms, talked to more than 5,000 students and hosted three family science events for more than 2,500 people. In 2006 the program seeks to reach an additional 8,000 students in public, private and charter schools in North Hawaii. Below we show a series of images of the various events.

Figure 1. *Visiting journey astronomer.*

Figure 2. Teacher Training.

Figure 3. Journey Familiy Science Day at the local mall.

Figure 4. Journey module training.

A SCOTTISH SCIENCE TRAINING PROGRAMME FOR TEACHERS

Dan Hillier

Royal Observatory Edinburgh, UK

ABSTRACT

The Royal Observatory Edinburgh Visitor Centre has led a national project to provide Continuing Professional Development for teachers of science in Scotland. We have trained over 400 teachers, of whom we trained 50 to train their colleagues.

The project has two valuable lessons for astronomy outreach:

1. In promoting pupils' interest in and learning in relation to astronomy, how you teach astronomy is as important as what you teach or even the materials you use.
2. High quality training is a powerful way of disseminating ideas and materials widely among the teaching profession.

Since 2001, the Scottish Science Strategy has invested over £10 million to improve science education in schools. We received a grant to second four teachers over two years to develop workshops that demonstrate ways of teaching three parts of the Earth & Space curriculum:

- Sun, Moon and stars (for 5-7 year olds)
- The Earth and its resources(for 8-10 year olds)
- The model of matter (for 11-14 year olds)

The team then ran five residential training programmes based around the workshops:

- An Easter and a Summer School. These lasted three days and were the first residential science schools for primary teachers in Scotland.
- Three "Train the Trainer" programmes. Again, these were residential and based on the core workshops. They had additional sessions on how to plan, organise and deliver CPD workshops for teachers.

PUBLIC PROGRAMS

All the events were based at informal science education centres—the Observatory's Visitor Centre and outdoor education centres—which were stimulating venues for the teachers.

Figure 1. *Talking, and therefore thinking, is at the heart of many effective and teaching and training activities..*

SPECIAL PUBLIC NIGHTS

The workshops demonstrate teaching activities that incorporate key approaches to promoting learning, including:

- Setting the right environment and establishing pupils' readiness to learn.
- Helping pupils to articulate their prior conceptions about the topic at the start of the lesson.
- Giving pupils the chance to use a range of media in their learning eg group work, graphics, music, movement. This allows them to use different skills and intelligences in their learning.
- Using questions effectively during a lesson—for example—the average wait-time after a question is less than one second, whereas waiting ten seconds encourages all pupils to think about the question.

These and other techniques in the workshops are not unique to astronomy education, nor even science education. But they can radically influence the way pupils engage with and learn about astronomical concepts. They are being widely adopted in science education throughout the United Kingdom, especially by primary teachers.

EFFECTIVE TRAINING

There are many astronomy materials for teachers but teachers are short of time to find and appraise them. A good CPD workshop will help them with this process and will embed ideas about how the materials can be used effectively.

However, many teacher workshops are poorly run—teachers find the transition from teaching children to training their peers difficult. We worked with a professional training adviser to ensure our programme was high quality.

The project partners are:

- The Royal Observatory Edinburgh
- Moray House (teacher training college)
- Scottish Earth Science Education Forum
- Our Dynamic Earth (visitor attraction)
- Five local authorities

Figure 2. *Practical training can influence teaching practice. Spot the ESA education pack!*


HUBBLE
esa
How far can we in the name of science communication
promoting, our respective results or projects without
and thus also our collective credibility?

NATIONWIDE ASTRONOMY EVENTS IN AUSTRIA: Summary and experiences

J. Hron[1,2], F. Kerschbaum[1,2], A. Pikhard[1,3], H. Raab[1,4]

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[3] Wiener Arbeitsgemeinschaft für Astronomie, Austria
[4] Linzer Astronomische Gemeinschaft, Austria

ASTRONOMY IN AUSTRIA AND ITS SCIENCE COMMUNICATION ACTIVITIES

The scientific astronomical community in Austria comprises about 70 people and is distributed between three universities (Vienna, Innsbruck and Graz). Furthermore there are three major planetaria, several public observatories and about 50 amateur associations. In 2002 a platform for professionals and amateurs was established, the *Österreichische Gesellschaft für Astronomie und Astrophysik* (ÖGA², *www.oe-gaa.at*). This organization has the primary aim of promotion and propagation of astronomy and astrophysics in science, teaching and among the general public. ÖGA² represents Austrian astronomy in the European context through its affiliation with the EAS and the Astronomische Gesellschaft. The main current scientific activity is the coordination of Austrian efforts to join ESO. Other initiatives relate to the organisation of meetings and outreach events, the support of young astronomers, the stimulation of astronomy teaching at high schools, efforts to increase public awareness about light pollution and the collection and dissemination of information on pseudoscientific matters related to astronomy. The astronomy communication activities in Austria are manifold, and some examples are given below.

AUSTRIAN SCIENCE WEEKS

Between 2000 and 2004, a nationwide science festival was organised (partly sponsored by ministries) each year with the participation of research institutions, schools, companies etc. The events mostly took place at public places like parks or shopping centres but also at the institutions themselves. There was some financial support from the organisers for staff and material. Austrian astronomy strongly participated in these science weeks and also organised the “flagship” nationwide event “How many stars do we still see” in 2001. The aim of this activity was to measure light pollution through a simple comparison of the visible stellar pattern in Ursa Minor with a set of charts. More than 2000 observations from all over Austria were collected during one week, allowing a scientific estimate of light pollution to be made (see ApSS Lib. 284 and *www.kuffner-sternwarte.at* for further details). The event in itself was very successful, but at the limit of the available resources.

The competition with other fields of science during the Science Weeks was an interesting challenge but confirmed that, in spite of the somewhat lower visibility, astronomy still has a flagship role! The externally set date of the events was problematic because it generally didn't coincide with good times for observing attractive astronomical objects like the moon or planets. While the observatories proved to be attractive sites for visitors, the organisation of events at public places was important for achieving wider attention and a closer contact with the public. Shopping centres were found to be less effective than open spaces, partly because looking through a telescope is still the most successful eye-catcher. Also the need for experiments/attractions not dependent on the weather became more evident and the financial and organisational effort turned out to be considerable.

THE AUSTRIAN ASTRONOMY DAY

Astronomy Day originates from similar events in other countries and is one of the major initiatives of ÖGA[2]. It has been held annually since 2003 and is now a widely accepted event by the public and among both professional and amateur astronomers. It takes place on a Saturday near the moon's first quarter in spring. Any organisation interested in astronomy can contribute (in the sense of a "grassroots" concept). The organisation and promotion in the national media is carried out by ÖGA[2], the individual events and the promotion in local media is organised by local groups of professional or amateur astronomers. The table gives some statistics about this event. All readers and consumers of related articles and reports in newspapers as well as radio- or TV-broadcasts (e.g. of the order of more than 50 related media stories each year) have to be added to the few thousand visitors to the events themselves.

Date	Participating Organisations	Events	Visitors	Known articles or reports in media
2003 May 10	29	98	2,000	53
2004 Apr. 24	27	103	3,000	51
2005 Apr. 16	32	129	3,800	57

Table 1: *some statistical information about Austrian Astronomy Day*

Astronomy Day is another good example of the successful cooperation between professionals and amateurs. The financial and human resources required are small but critical, practical observation is the most common activity offered and the local events are mostly carried out by research institutions and well-established groups at their home base. In future it would be fine to have more weather independent activities as well as more events at public spaces and involving smaller groups.

INTERNATIONAL ACTIVITIES

Austrian astronomy also participated very successfully in the ESO-coordinated Venus Transit campaign with the Austrian node located at the Kanzelhöhe Solar Observatory. Eleven events attracting some 11,000 visitors were organized all over Austria with very good media coverage, solar images were transmitted via webcasts and there were almost half a million hits on the main Transit websites. Another important event was the "Lange Nacht der Sterne" in September 2004 with about 3000 visitors. The cooperation with Stern magazine was very efficient and useful.

CONCLUSIONS

In spite of its small size, the Austrian astronomical community is very active and also quite successful with regard to astronomy communication. The foundation of the ÖGA[2] has been very helpful in increasing the effectiveness of communication and raising public awareness about astronomy in Austria. It also has stimulated closer cooperation between professionals and amateurs. This cooperation is of special importance in a small country and has worked very smoothly. Nevertheless, all the activities still depend on only a few individuals and the amount of support from public and private institutions outside of astronomy is very limited. This work is upported by the Bundesministerium für Bildung, Wissenschaft und Kultur.

SUBARU TELESCOPE SUMMIT FACILITY TOURS

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ABSTRACT

The Subaru Telescope is now offering public tours within its telescope enclosure. Positive feedback from tours for VIPs led to both internal and external pressure to give the Japanese public an opportunity to see the telescope they fund through their taxes. Despite difficulties of access, approximately 40 people from around the world make it to the summit of Maunakea each month to participate. Although this number is smaller than we had anticipated, the intangible benefits have been substantial, as measured by an increase in positive local press, while tangible drawbacks have been minimal. Providing tours may not be innovative, but it represents a radical change in our attitude towards the public.

BACKGROUND: UNIQUE CHALLENGES

Success and Access: The Subaru telescope enjoys wide name recognition and support from the Japanese public. The success of tours for VIPs in generating enthusiasm for the telescope and greater expectations of openness in all national institutions led to a demand, both inside and outside NAOJ, to provide an opportunity for all to see the telescope.

Culture Clash: Without substantial architectural modifications, visitors must enter work areas of the enclosure to see the telescope. Those who felt that allowing the public to see the telescope was a moral obligation and/or a political necessity had to convince those who felt that the public would be better served if observatory staff could concentrate on operating the telescope without distraction.

Mauna Kea: Difficulty of access and environmental and cultural concerns about the use of the summit area of Mauna Kea create several operational hurdles. The cost and permission process for building new structures in the summit area are prohibitive. Despite the remoteness of the summit area of Mauna Kea, observatories are not allowed to provide transportation. The high altitude poses potentially severe health risks to visitors.

CURRENT STATUS: THE PROGRAM

Despite the challenges Subaru Telescope began offering tours on October 1, 2004. During the first half year of the program, we welcomed approximately 350 guests.

A potential visitor reserves a place on a tour by submitting a web form a month in advance, and confirms the reservation by signing and mailing a liability waiver form. The tour schedule is released two months in advance. The visitor is responsible for transportation, and for taking the necessary precautions to ensure their own comfort on the summit.

We try to offer tours at least twice a week. On each day that we offer tours, there are two tours in English and one in Japanese. Each tour can have up to eight visitors - the number of people a single staff member can safely usher through the enclosure. If a group of visitors arrives with an experienced tour guide who works for one of the nine tour operators licensed to operate on Mauna Kea, we increase the number limit to fourteen.

Two part-time staff guides conduct the thirty minute tour. The tour begins at the bottom of the telescope enclosure where we house mirror re-coating facilities, and leads to a balcony with a view of the telescope at the level of the tertiary mirror. The guide carries oxygen tanks throughout the tour, and there are wheelchairs available if necessary.

VISITOR STATISTICS

After an initial peak, the number of actual visitors is now settling at around 40 per month. This represents approximately 15% of the total number of “places” that we have been offering each month. Only two thirds to half of the people who begin the reservation process actually go on a tour. Although over half of the people making requests for tours are Japanese, only one third of the actual visitors are Japanese.

Several other numbers are important in interpreting these statistics: Approximately 100 thousand people visit Mauna Kea each year (8500/month). Up to 90% of visitors come on tour packages offered by one of nine tour companies licensed to operate on Mauna Kea. A third of these visitors are estimated to be Japanese. In addition to the public tours, Subaru Telescope continues to accept over 800 visitors each year in the VIP category. These include people with links to NAOJ and its staff, including any educational organization.

DISCUSSION

The number of people visiting the telescope through our public tour program has been smaller than our initial expectations. We had not anticipated the full consequence of the intersection of our own operational limitations and those of visitors, tour companies, and the authorities responsible for the stewardship of Mauna Kea. Fortunately, the quality of the visitor experience appears to correlate positively with the difficulty of visiting. Unfortunately, these are difficult to quantify. Nonetheless, visitor response and media coverage has been uniformly positive. We are enjoying the goodwill generated by the symbolic significance of allowing the public to enter into the research facility, even though in practice few have the desire and persistence to do so.

WHAT ARE THE GOALS OF POPULARISING ASTRONOMY FOR SCIENTISTS AND SOCIETY?

V. Luridiana

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ABSTRACT

This project addresses the reasons that may motivate efforts to popularize astronomy. Data relevant to this research question were collected by means of focus groups involving professional astronomers at a large Spanish research institute, followed by a questionnaire to the same group of people. The data showed that the main driver for astronomy popularisation is personal satisfaction. Motivations related to the public responsibility of scientists are also important, but less important than the personal ones. These results are discussed in the context of the Spanish Public Understanding of Science (PUS) policy.

INTRODUCTION

Astronomy is a rather unusual scientific discipline because it has virtually no impact on daily life. Its discoveries have, at most, just a distant echo in the lives of most people, and even the link between investment in basic astronomical research and technological return is controversial. In this sense, astronomy is perhaps more like an art than a science.

If astronomy is of no practical use, the classical motives for communicating science are not relevant to its case. Nonetheless, astronomy popularisation is a very active field. This project set out to understand why this is so and if there are any utilitarian reasons to promote popularisation of astronomy. To answer this question I have adopted a straightforward approach consisting of focus group discussions and a questionnaire, in which professional astronomers were invited to express their points of view on the topic.

CONCLUSIONS

The reasons expressed by astronomers for doing outreach can be grouped into three categories, according to whether they are beneficial to:
a) society at large, b) individuals in the public or c) the astronomers themselves.

The main reasons why the popularisation of astronomy is deemed to be beneficial to society are the increase in critical thinking and in the overall level of culture. However, the practical consequences of this are not specified.

To individuals, popularisation of astronomy is beneficial to the extent to which it satisfies a basic curiosity, although no practical consequences have been identified either. Astronomy is intrinsically interesting to people because of its cultural value, linked to religion, mythology and cosmogonies, hence its power to *"influence the way we think about ourselves"* (Bodmer, 1985). In this aspect, this study confirmed previous suggestions of interest as a driver for scientific literacy (Turney, 1996; Bodmer and Wilkins, 1992).

For astronomers, the reasons for which outreach activities are beneficial are numerous. The personal reports of most astronomers support Gustaffson's (1989, cited by Pringle, S., 1997) claim that popularisation activities may improve the quality of research. Popularisation is an intrinsically satisfactory activity; it is a means to enhance your reputation and to make your work better known, thus increasing the probability of getting future funding. This last point is mentioned in the face of the lack of specific support from the institutions, so that outreach appears as an activity fundamentally based on the good will of individual astronomers, sometimes conflicting with the constraints imposed by career progression, and almost invariably done in response to a personal sense of responsibility and a taste for teaching. This circumstance may be peculiar to Spain, where the dominant academic culture does not favour outreach activities. In the UK for example, the scientists' reports probably would be different thanks to a greater institutional awareness of the importance of PUS there.

There is a frequent complaint that the general public is scientifically illiterate (e.g., Miller 1983) and uninterested in science. At the same time, there is also a recurrent remark that astronomy scores high in the preferences of the general public. On average, the public is seen as moderately ignorant.

Private motivations (personal taste and, to a lesser degree, promotion of personal research) appear to be the main drivers for outreach activity. A sense of responsibility towards the public is also a driver, but it appears to be subordinate to personal taste. This is to be expected, given the widespread complaint that institutions do not properly support and acknowledge PUS activities.

Summing up, this project found that astronomy communication is primarily done as a vocational activity and that it is carried out in spite of (as opposed to thanks to) institutional policy. If this study is taken as a representative sample of Spanish reality, it also highlights the lack of institutional awareness of the importance of PUS. Scientists are not trained to communicate with the public, nor are they encouraged to do so. Given this situation, and given on the other hand the lack of time and resources that any astronomer presumably has as a consequence of normal work pressure, it is natural that whatever outreach is done is tailored to individual tastes.

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THE VISITOR CENTRE "MARCELLO CECCARELLI"

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ABSTRACT

The "Big Ears" of the Medicina Radio Observatory are a great attraction for visitors. The Observatory is located near the town of Medicina, at about 35 km from Bologna, Italy, and it is operated by the Istituto di Radioastronomia, a part of the National Institute for Astrophysics (INAF). Weekly guided tours have been organized for high school students and the general public since 1983. A typical tour starts with an introduction to radio astronomy, followed by a visit to the observing facilities, the 32-m dish and the 30,000 m2 "Northern Cross". There are about 5,000 visitors per year.

Figure 1. *Aerial view of the Medicina Radio Observatory.*

VISITOR-STATISTICS

Most of the visitors are high school students. About 52% of them are students from Scientific Lycées, 10% from Classical Lycées, 20% from Technical Institutes. The remaining groups are from Secondary Schools (7%) and from cultural associations (10%) and amateur astronomy associations. The school classes and associations that visit the Medicina Radio Observatory are mainly (64%) from the Emilia-Romagna Region. The remaining 36% come from all over Italy, although mainly from the north.

THE NEW VISITOR CENTRE "MARCELLO CECCARELLI"

A 100 year old building, a former rice store, has been renovated and adapted to house a 500 m2 Visitor Centre and a restaurant. The Visitor Centre, named "Marcello Ceccarelli" to honour the father of Italian radio astronomy, hosts a permanent exhibition, including historical equipment, a multi-media theatre with a 100-seat capacity, and a small radio interferometer. The installation of a scaled version of the Solar System is planned, located between the telescopes and the Visitor Centre. We expect to receive about 50,000 visitors per year. For more information consult the web site http://www.ira.cnr.it/visitorc

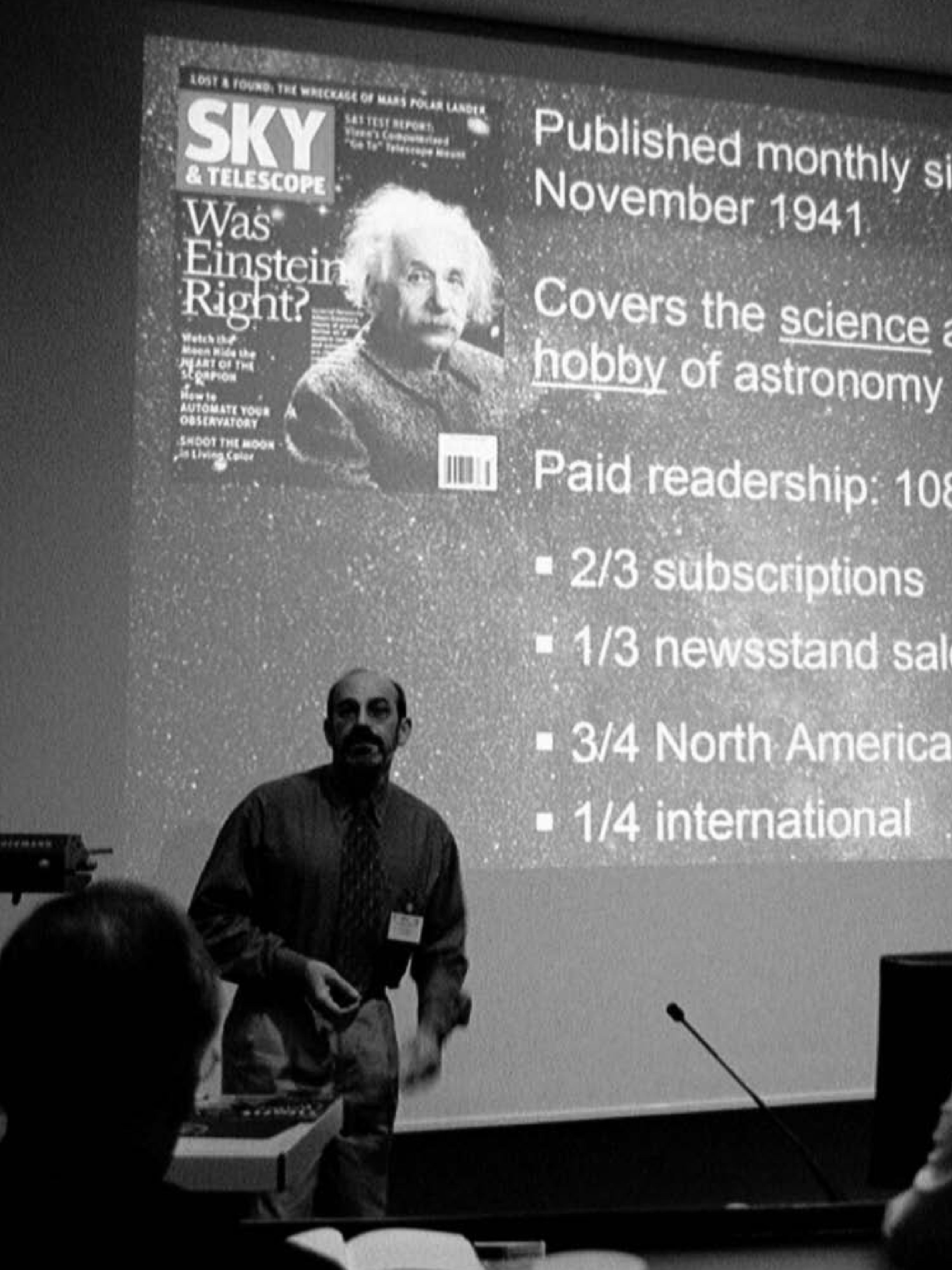
Figure 2. *The historical rice store renovated to host the Visitor Centre. The Visitor Centre is located on the first floor. A country style restaurant is located on the ground floor. The building is about 1 km away from the Medicina Radio Observatory.*

Figure 3. *Image of the inside: View of the permanent exhibition*

Figure 4. An interactive station.

Figure 4. *An interactive station.*

Figure 5. *The big screen of the conference room, able to host up to 100 persons.*


LOST & FOUND: THE WRECKAGE OF MARS POLAR LANDER
SKY & TELESCOPE
Was Einstein Right?
How to AUTOMATE YOUR OBSERVATORY
SHOOT THE MOON
Published monthly si
November 1941
Covers the science a
hobby of astronomy
Paid readership: 108
2/3 subscriptions
1/3 newsstand sal
3/4 North America
1/4 international

THE ESO-MIM STAR TREK:

A broadbased public oriented short interactive exhibition for an introduction to contemporary astrophysics

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[1] ESO, [2] École des Hautes Études en Sciences Sociales (EHESS) Paris, France

ABSTRACT

In the course of the European Southern Observatory (ESO) Public Relations work in Chile, we have created a permanent exhibition of astronomy for a broad section of the public in the Museo Interactivo Mirador—MIM (Interactive Museum of science, Chile), a collaboration between ESO and MIM. This Museum is mostly directed towards schoolchildren (7-14 years old), with adult visits at weekends. It is funded by public money and is unique in Chile. We decided to present the most recent questions relative to astronomy, based on pictures taken mostly at ESO observatories, and to skip the basics of astronomy that are taught at school.

In the first part of the tour the public can watch a series of four 3 minute videos: including an introduction on the history of astronomy; a time-line showing the evolution in discoveries and principles and from ancient civilizations to modern concepts of astrophysics.

The second part of the exhibition is based on a walk among the stars, an innovative way to keep the program interactive without modern technology. We have designed a star trek, which lasts about 15 minutes in a dark room, requiring a special helmet to look at pictures placed on the roof. While visitors look at the images, an audio commentary is played, so that they can enjoy images and stories of galaxies, nebulae, planets and finally humans in space.

First, the Hubble Deep Field of galaxies welcomes the visitors, introducing the Big Bang concept, the age of the Universe and what galaxies are. At the second station, a group of interacting galaxies is shown, followed by the Sombrero image. The types of galaxies (spiral, irregular, etc) are introduced, as well as their contents of gas and dust. Then closer to us we see the Magellanic Clouds, and the concept of time of travel for light is introduced. In the third station we are back to our Galaxy: a similar galaxy is shown, the rotation of the spiral arms, the location of our Solar System and how many stars exist within one galaxy are explained. Then we get closer into our Galaxy, with an image of the Eagle nebula. Distances to the closest stars are given, and the colours of stars are discussed. At the fourth station, the Orion, Crab and Dumbbell nebula, together with an image of the Sun support the story of a star's life: from star formation to supernovae and extrasolar planets. At station five, the Solar System and its main planets are presented. Finally, the last station is an invitation to space exploration, with astronauts, the space shuttle, the HST, and images of the Earth and the Moon. This exhibition is a great success, the astronomy room being the most visited part of the museum since its inauguration last year.

CALENDARS, CRESCENTS AND CALCULATION

The ROG's Islamic Astronomy project

Robert Massey

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ABSTRACT

The Royal Observatory Greenwich (ROG) has acted as a resource centre for mosques in the UK, providing data on the visibility of the new crescent Moon that is essential for determining the beginning of each Islamic month. A series of projects have sought to take advantage of this link, strengthening the connection between the ROG and the British Islamic community and seeking to engage a traditionally 'hard to reach' audience with modern astrophysics. I will describe these activities and offer a brief analysis of their impact.

INTRODUCTION

Since 1998 the ROG has acted as a first point of contact for press and public enquiries related to modern astronomy in the UK, running a number of educational and outreach projects around this theme. London offers a unique setting for an astronomical observatory. As a city, it encompasses extremes of wealth and poverty and one of the world's most ethnically diverse populations. For example, some 8.5% of citizens (around 600,000 people) describe themselves as Muslims compared with just 3.5% in the rest of the UK. There are also large Jewish, Hindu and Chinese communities as well as recent arrivals from all over the world (2001 census data). ROG staff have sought to ensure that our visitors and participants in events reflect this diversity, but with limited success.

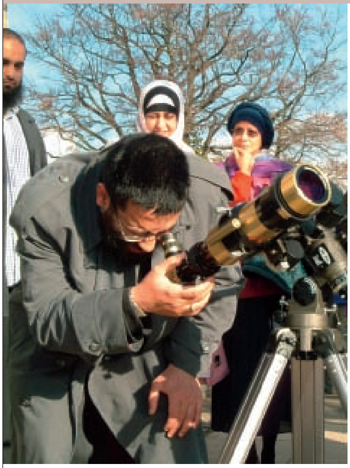
CALENDARS, CRESCENTS AND CALCULATIONS: ISLAMIC ASTRONOMY OUTREACH PROJECTS

Exceptionally, the Muslim calendar is set through direct observation of the new crescent Moon, the visibility of which remains difficult to predict with high accuracy. This factor has led to a long association between classical astronomy and Islam (e.g. Hoskin M., Cambridge Illustrated History of Astronomy, CUP 1996; Schaeffer, B.E., QJRAS, vol. 37, pp. 759-768 1996; Yallop, B., NAO Technical Note No. 69, 1998). Along with other astronomical institutions the ROG supplies predictions generated by HM Nautical Almanac Office to the UK Islamic community. This, and its substantial collection of Islamic artefacts, makes the ROG an ideal setting for workshops and lectures targeting the UK Muslim population.

Firstly, an initial meeting at Greenwich in October 2004 ran in partnership with the Muslim Council of Britain (MCB) and brought in key figures from UK mosques and universities. It concentrated on the technical issues of sighting the new crescent Moon, the changing appearance of the sky at sunset and the calculation of prayer times. The Spitz opto-mechanical planetarium then in use illustrated many of these concepts. Delegates were also introduced to the observatory collections, used our 70-cm refractor to observe Venus and a small hydrogen alpha telescope to view prominences around the Sun. 48 people participated, with a cap set by the size of our then planetarium.

Extensive consultation with different communities followed and informed a 'family learning day' at the National Maritime Museum in March 2005. This broadened the theme of astronomy and calendars from different cultures and offered activities such as Chinese calendar making and traditional Jewish storytelling alongside more conventional work in our planetarium and lecture theatre. The larger range of activities engaged over 300 members of the public of all ages. In June 2005 two further higher level days took place at the National Space Centre in Leicester and the Glasgow Science Centre. Both of these venues are sited in cities with high Islamic populations (11% and 6% respectively—2001 UK census). The events attracted a high turnout with 165 delegates in Leicester and 79 in Glasgow. Finally a web resource on calendar systems will be live by the end of 2005. This makes a direct connection between astronomy and timekeeping and is intended to support the raw data provided by the observatory.

Figure 1. Islamic astronomy delegates viewing the Sun through a hydrogen-alpha telescope (courtesy of Dr Jamil Sherif, MCB)



INITIAL EVALUATION

Surveys indicate that the Greenwich events were well received with 96% of delegates rating them as good or excellent. Virtually all participants were interested in taking part in future events with a focus on modern astronomy, including courses and telescope viewing evenings. In Glasgow and Leicester the feedback was also very positive with the vast majority of attendees interested in further events associated with modern astronomy. Future activity will capitalise on the strong partnership between the ROG and the MCB with the goal of changing the demographic profile of participants in astronomy events.

CONCLUSION

This project offers a model for science centres and observatories in cosmopolitan urban settings. At least in the Anglo-Saxon countries, there is much interest in broadening the ethnic diversity of scientists and events of this kind may help to move that process forward.

I would like to thank Steve Bell, Alan Longstaff, John Griffiths, Emma Clarke and Usama Hasan for their invaluable support throughout this project. This work was partly funded through COPUS Small Award SM030645.

PUBLIC OUTREACH FROM THE JODRELL BANK OBSERVATORY

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ABSTRACT

The observatory undertakes a multi-faceted Public Outreach programme ranging from the provision of a Visitor Centre with ~ 65,000 visitors per year, educational opportunities for primary, junior and senior school children, distance learning courses at undergraduate level for the general public, teacher training activities, external lectures, support for the media and the provision of an comprehensive website.

VISITOR CENTRE

The original extensive Visitor Centre buildings, some dating from the 1960s, were demolished at the end of the 2003 season. Whilst plans are put in place for its replacement, a temporary centre has been opened with a cafe, shop and small display area. Two new developments are a 3D theatre showing astronomical films and a walkway around the Lovell Telescope. Beside the walkway is a small amphitheatre where, each day during the school holidays, the visitors can "Meet an Astronomer" who describes the work being undertaken by the telescopes and answers questions from the adults and (particularly) children. Not surprisingly, this has proven to be a very popular attraction.

OUTREACH TO SCHOOLS

As we can no longer host many groups of primary school children at JBO we are, instead, going out to them. Staff and postgraduate students take a portable planetarium out to schools and supplement its use with astronomy talks and "question and answer" sessions. In the last nine months over 7000 children from 70 schools have attended one of 243 planetarium shows. Senior school physics students still visit the Observatory and are given a guided tour of the JBO site and a talk about the research work being carried out by the Lovell Telescope and MERLIN array.

WORK WITH TALENTED AND GIFTED CHILDREN

For a number of years, University staff members, sometimes assisted by postgraduate students, have run astronomy workshops for pupils that have been put forward as especially gifted by their county education departments. There have been half-day events in Cheshire and Lancashire and, in 2004 and 2005, week-long programmes for Cheshire students which included a visit to Jodrell Bank. The aim is, of course, to try to encourage young students to take up science at university and then as a career.

THE JODRELL BANK WEBSITE: WWW.JB.MAN.AC.UK

In this internet age our website is now providing a major route by which the public can learn about the work of the Observatory. Areas of the site give details about the history of the Observatory, a guided tour behind the scenes and sections about each of the research topics that are studied by our astronomers. A news area gives access to our press releases describing exciting discoveries such as that of the "Double Pulsar" in 2004 which is providing the best current test of Einstein's Theory of Gravitation.

There is a "Jodrell Bank Live" page giving details of the operation of all the telescopes on site along with webcams showing images of the Lovell and two other telescopes, together with time lapse movies showing their motion as they track radio sources across the sky.

As part of our efforts in encouraging amateur astronomers an extensive "Monthly Sky Guide" is provided. Receiving over 7000 viewings each month it is our most visited page. In addition, full observing details are given of 50 of the best objects to observe in the heavens using one's eyes, binoculars or a small telescope. We also provide a web-based question service and one of a team of astronomers will reply soon after they are received.

DISTANCE LEARNING AND TEACHER TRAINING

JBO offers a range of part time undergraduate level courses in astronomy, two of which give students the chance to make their own observations using a dedicated 7-m telescope. Over 700 students have taken part in the last five years. In 2005, over 50 schools used the telescope to map the spiral structure of the Milky Way in an event sponsored by the Rotarians called the "Excitement of Science", which culminated in a one-day event at the Royal Institution in June.

We are a regional centre for the training of teachers in the use of the Faulkes Telescopes, and provide "INSET" training days to help keep science teachers abreast of the latest advances in astronomy.

TALKS, VISITS AND THE MEDIA

Staff members give talks to astronomy societies, community groups and professional bodies all over the UK and provide behind the scenes tours of the Observatory. They also run Day Schools, Evening Classes and Weekend Courses in astronomy across the Northwest of England. Our local astronomical society meets at the Observatory and we provide support for our largest national amateur society.

We are turned to by the local and national media for background and comment when astronomical and space topics are in the news and give guidance for members of the public to safely observe astronomical events such as the Transit of Venus.

L'AULA DEL CEL

Communicating Astronomy at School Level

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Observatori Astronòmic de la Universitat de València, Spain

ABSTRACT

L'Aula del Cel (The "Sky Classroom") is an effort to bring astronomy closer to school children. It is a project led by the Astronomical Observatory of the University of Valencia in collaboration with the regional education authorities. It has been running for two years and it has been a big success, with nearly three thousand students visiting the Aula during the school term.

INTRODUCTION

Astronomy teaching in the Valencian school curriculum

The role of astronomy in the school curriculum of Valencia (Spain) is very limited. It often appears only as a sub-subtopic included in larger science areas, such as physics or the natural sciences. At high school it is an optional subject, but it is offered only in very few schools (many teachers do not feel prepared to teach it) and it is on its way to extinction. It is more often just an extracurricular activity, through visits to science museums, astronomical centres or planetaria.

The reasons behind this situation are:

- Lack of didactic material available at the schools
- Scarcity of resources elsewhere
- Teachers who can only work with didactic material written in Spanish or Catalan
- Lack of information about the already existing resources

The "Aula del Cel'" (The "Sky Classrooom")— http://www.uv.es/obsast/in/divul/auladelcel.html was created partially to mitigate this situation, as a place where both teachers and students encounter astronomy. The project was started as an agreement between the Astronomical Observatory of the University of Valencia and the Generalitat Valenciana (the regional government), but it soon attracted more sponsors, some from other areas of the same university (like the Vicerrectorat de Cultura), the national government, and even some private companies (Caja de Ahorros del Mediterráneo, Telefónica).

OUTLINE OF THE ACTIVITIES

We are located in a modern building at one of the three campus sites of the University, where we have a small laboratory for about 20 students, with plenty of didactic material (seven Pentium IV computers, activity books, celestial globes, planetary systems, planets, simple telescopes, spectrographs...). There is also a seminar room where the audiovisual presentations are held. A typical visit follows this scheme:

1. The teacher talks to the Aula´s didactics team to agree on the educational content of the visit so that the program matches the students' current area of study better.
2. The group comes to the "physical" Aula at the Astronomical Observatory´s building. The maximum group size is 30 students, and it is split into two in order to make it easier for everybody to communicate and share ideas, thoughts, questions...
3. We start with an interactive multimedia presentation at the seminar room. The students can ask any question they have at any moment, to enable easy communication among everybody.
4. After the talk, we look at the Sun with a small solar telescope to check the number of sunspots on that particular day. Our pool sundial (which is included on The Planetary Society's Earth Dial project—http://www.planetary.org/ mars/earthdial,) tells us about the relation between the solar and official times and the current season of the year. It also reminds us of the two NASA rovers that are exploring Mars and are provided with similar sundials.
5. After the "astronomical'" break the students go into the laboratory, where they build a simple paper or cardboard sundial, starcharts, constellations with phosphorescent stickers, homemade telescopes, etc. Computer activities are also carried out using a variety of local and internet resources.

Figure 1 *(top) Observing the Sun through a small solar telescope &* ***Figure 2*** *(below) The EarthDial project's sundial at the University of Valencia*

REMOTE OBSERVATIONS AND HANDS-ON HISTORIC INSTRUMENTS

In the near future we will perform remote observations by using the 60 cm robotic telescope TROBAR, a fully automated telescope at our observing site at Aras de los Olmos (Valencia, Spain), the darkest spot of the region, which makes it a very good astronomical site. Because it can be controlled through the internet, the students will be able to perform the observations themselves from school, moving and pointing the telescope to the celestial object of their choice.

In the same vein, agreements with institutions that have robotic telescopes in South America are being set up, so we can perform night observations during daylight, that is, during local school hours.

The Observatory owns a valuable collection of old astronomical instruments (sextants, astrolabes, theodolites...) and they constitute the "historic side" of our outreach program. We are currently in the process of building replicas of these instruments for them to be used, manipulated and explored by the students, complemented with a visit to the Observatory's museum.

THINK INSIDE THE SPHERE

Stephanie L. Parello

Hayden Planetarium/American Museum of Natural History, New York City, USA

ABSTRACT

Bringing the Universe down to Earth—isn't that what it's all about? The Hayden Planetarium in New York City offers frequent occasions to experience the night sky, interact with researchers, and even fly to the edge of the Universe. We invite the public into our hemispherical 'living room' on Tuesday nights. Our well-established audience enjoys opportunities to explore our growing sets of cosmic data, discuss the latest news and images, and reflect on the simple enjoyment of just looking up at the stars. Through these regular offerings, we endeavour to convey our love of the cosmos—to reveal the inner workings of the heavens.

Figure 1. *Hayden Sphere inside the Rose Center for Earth & Space at night photo © AMNH – Dennis Finnan*

THINK INSIDE THE SPHERE: TUESDAY EVENINGS IN THE DOME

Virtual Universe

On the first Tuesday of each month, join us in exploring the Hayden Planetarium's three-dimensional atlas of our Universe. Piloting the Space Theatre, we immerse you in our Digital Universe, taking you on a guided tour through charted space—an experience that will redefine your sense of "home." Step into the Sphere for a mind-expanding trip through the cosmos. To explore on your own, download some of the Hayden Planetarium's Digital Universe data and software at www.haydenplanetarium.org

OTHER HAYDEN PROGRAMS

This just in... the latest news from the Universe

On the third Tuesday of each month, join us in a discussion of the science behind the headlines. This January, the Hayden Planetarium launches a new program — an up-to-the-minute review of the latest news in astronomy and astrophysics. Our astrophysicists will give you the low-down on the cutting edge. We'll tell you what it is, what it all means, and how it fits (or not) with prevailing theories.

Celestial Highlights

On the last Tuesday of each month, join us under the brilliant stars of the Zeiss Mark IX Star Projector in touring the ever-changing night sky as viewed from Earth. Hear about the current positions of the Moon, planets, and stars, as well as visual spectacles such as meteor showers, eclipses, and conjunctions.

Lecture Series

- **Frontiers in Astrophysics**
  The Hayden Planetarium is pleased to bring the latest advances in our knowledge of the Universe to our audience, presented by the scientists working at the cutting edge of the field.
- **Distinguished Authors in Astronomy**
  The Distinguished Authors program introduces our audience to authors who have published popular level books in astronomy. After each of these lectures, books are on sale and the author is available to sign copies of his or her book.

Special Courses

- Stars, Constellations & Legends
- Introduction to Astronomy
- How to Choose & Use a Telescope
- Scientific Revolution
- ...and more...

Asimov Debate

The Hayden Planetarium hosts the annual Isaac Asimov Memorial Debate—a panel series, generously endowed by relatives, friends and admirers of Isaac Asimov and his work—bringing the finest minds in the world to the Museum each year to debate pressing questions on the frontier of scientific discovery.

www.haydenplanetarium.org
www.amnh.org/hayden

OUTREACH FROM MCDONALD OBSERVATORY

Sandra Preston

Macdonald Observatory, Texas, USA

ABSTRACT

The University of Texas McDonald Observatory communicates astronomy in a variety of different ways to a vast audience in the U.S. and internationally. Its widest reaching programs are the daily two minute astronomy radio programs

Figure 1. *StarDate & Universo Announcers Sandy Wood & Teresa Fendi de la Cruz*

StarDate and Universo (Spanish-language version) which, together, reach over 2.2 million people each day. A German version, called Sternzeit, airs daily throughout Germany and is produced by DeutschlandRadio. All three programs are also sold on CD to individual subscribers. *StarDate* magazine, a 24-page colour publication, is produced six times a year. Subscriptions are $24 a year, available at www.stardate.org/magazine/subscribe.html.

StarDate Online (stardate.org) and Universo Online (radiouniverso.org) offer rich resources to a large audience of over 100,000 visitors weekly via the internet. The "What Are Astronomers Doing?" website (mcdonaldobservatory.org/research) provides online visitors with an interview with the astronomers using the telescopes at McDonald each week, information on their research projects, and background on the telescope and instruments being used.

McDonald Observatory's Visitors' Center in Fort Davis, Texas, welcomes 100,000 visitors a year and conducts K-12 professional development workshops for 700 teachers annually and field experiences both onsite and by distance learning to 3,000 students annually. See mcdonaldobservatory.org. Visitors can learn how astronomers use spectroscopy to uncover the mysteries of the Universe in a bilingual (English/Spanish) exhibit called "Decoding Starlight." A new outdoor exhibit called "Parallax Park" is being designed. When built, this bilingual (English/Spanish), interactive family exhibit will help visitors explore how astronomers measure the distance to stars and how they find extrasolar planets.

Figure 2. *Aerial view of McDonald Observatory Visitors Center*

Funding for a portion of this work was made possible by the National Science Foundation and NASA

Links:

- mcdonaldobservatory.org
- stardate.org
- radiouniverso.org
- www.dradio.de/dlf/sendungen/sternzeit/

THE LORD OF RINGS & THE OLMI-COMICS

Two cases of non-traditional approach to astronomy

S. Romaniello, F. Cavallotti, S.Sandrelli

INAF—Osservatorio Astronomico di Brera, Milano, Italy

ABSTRACT

Besides its traditional activities, the Public Outreach & Education office (POE) of INAF-Osservatorio Astronomico di Brera (Milan, Italy) is carrying out two experiments in informal education for children aged 10 to 13: “The Lord of Rings – the mysterious case of the stolen rings” and “The Olmi-comics”. The former is an astronomical role-playing game. Pupils are requested to discover the burglars of the rings of Saturn by hunting for them in an area where they meet actors playing their parts at distances scaled to the ones of the Solar System. The latter is a writing/ drawing workshop. Pupils try to write stories or draw comics about science. While the two projects are rather different both in content and in format, they have a common goal: making pupils live science, mainly astronomy, both with the mind and the body.

THE LORD OF THE RINGS: THE MYSTERIOUS CASE OF THE STOLEN RINGS.

“The Lord of Rings–the mysterious case of the stolen rings” is an astronomical role-playing game. Its goal is to introduce participating children to some of the main topics of our Solar System: a) the role of gravity; b) the distribution of mass and light; c) the effects of rotation; d) the distribution of water. The game was first held during the second Perugia Science Festival (3-12 September 2004). The following description makes reference to that experience.

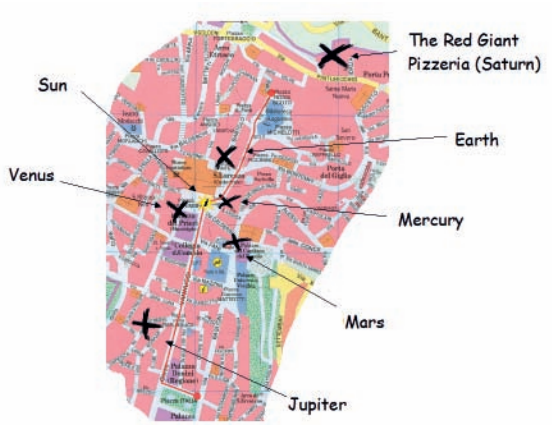

Figure 1. *The Solar System was scaled so as to fit Perugia’s historical centre.*

The pupils were divided into 6 groups of 8 members. They were given a newspaper report that the rings of Saturn were stolen by a mysterious Centaur while Saturn was sleeping. They were appointed astro-detectives in charge and asked to find the rings by cruising around the Solar System, which was scaled so as to fit Perugia's historical centre. Each group started playing the game from a different area of the city, following the hints they found by reading the news. By talking with the shepherd moons, the astro-detectives discovered that the rings were destroyed by accident. From that point on, their task was to gather the physical ingredients to remake the rings. They were requested to collect the right amounts of gravity, light, rotation, inclination, dust and water, represented by simple objects like apples, spinning tops, bottles of water, and so on. They could find the ingredients in different parts of the town, representing different planets (Fig.1). On each planet they found the ingredients in quantities that are proportionate with the real physical properties of that celestial object (Table 1). In the end, they had to gather the right ingredients, write down a recipe and take the ingredients and the recipe to the "The Red Giant" pizzeria. The winning group was the one which prepared the best recipe to re-make the rings in the smallest amount of time. The game has been selected for the Genoa Science Festival 2005.

Table 1. *Ingredients are expressed in points, according to the real scaled quantities at each celestial object.*

	Gravity (apple)	Light (flour)	Rotation (spinning tops)	Inclination (pie-dish)	Water (bottles)	Centaur (water-melon)
Mercury	1.4	60	2	-	-	Only reached by taking the Comet Express, which goes beyond Neptune
Venus	4	18	½	-8	-	
Earth	4	9	100	8	2	
Mars	1.4	4	95	92	½	
Jupiter	9	1/3	250	8	nc	
Saturn	4	1/10	220	100	nc	
Rings	1	1/10	220	100	2	

THE OLMI-COMICS

The Olmi-comics is a workshop to stimulate children to use scientific suggestions as a starting point for creative processes in writing and drawing. It is carried out in collaboration with Maria Giaele Infantino, who is a teacher at the ISC intermediate school "Munari", in Milan's Olmi neighbourhood . The name of the project itself contains traces of its origin: comics from the Olmi neighbourhood.

During the school year 2004-05 we had a series of informal meeting with pupils (aged 10 to 13) and teachers, both in their school and in our Osservatorio, and we discussed some aspects of modern astronomy so that pupils could get an overview of contemporary astronomical discoveries and visions: the 3D dimension of our Solar Systems, the features of black holes, light as a cosmic messenger and so on. Afterwards, the pupils read some tales from Italo Calvino's "Cosmicomics", a famous experimental literary work: in Calvino's tales scientific descriptions of the Universe (for example the Big Bang) act as the stage on which the characters play.

Finally, they wrote stories and comics about the subject they preferred, trying to use scientific ideas as narrative structures or simply suggestions. Tales and comics written by pupils can be roughly subdivided into three categories:

1. Science says so and so, but I know why this is so! (anti-scientific approach).
2. Science says that once upon a time things were so and so. And I am now telling you how they (whoever they are) lived (cosmicomics).
3. Science says so and so, I like it and I play with it with no limits (science fiction approach).

The results were presented at Science Under 18, Milan (3-12 May 2005) and are collected on the web site http://poebrera.mi.astro.it/Lab_Olmicomiche/.
The Olmicomics are now an established writing and drawing workshop which will involve an increasing number of schools in the following years.

Acknowledgments: A. Sandrelli for revising the English text.

NAVEGAR FOUNDATION

5 Years of Communicating Astronomy

Pedro Russo and António Pedrosa

Navegar Foundation, Portugal

ABSTRACT

The Navegar Foundation was created to manage Centro Multimeios de Espinho—Portugal. From the beginning, one of the foundation's main areas was, by default, astronomy education: its main equipment was a planetarium. Regular planetarium shows attracted a large number of schools (we now have an average of 20,000 students per year in a city of 30,000 inhabitants, so our public is now national and not regional). With the introduction of new ideas and equipment new activities came to life: the astronomy public library; observatory; student and teacher training; content development; astronomy laboratories; production of planetarium shows; public talks, among others.

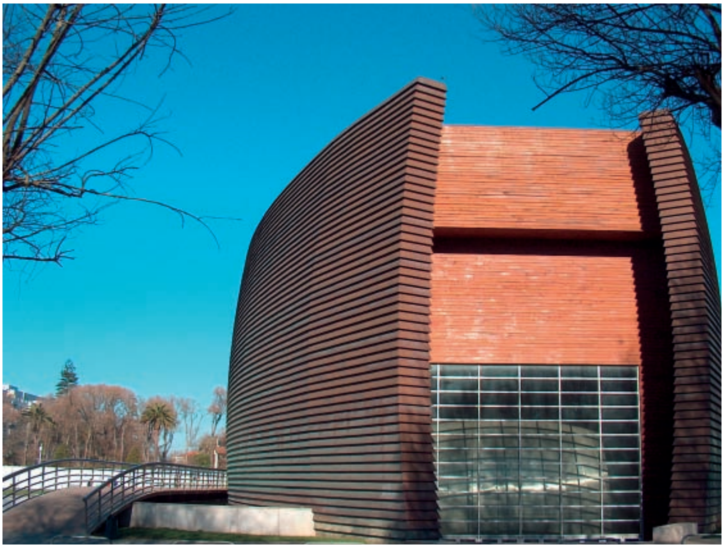

Figure.1 *– Centro Multimeios de Espinho*

MISSION

Created in the year 2000, the Navegar Foundation works to increase the awareness of Art, Science, and Cultural Science. Among other things, the Foundation is responsible for the management of the Centro Multimeios de Espinho (fig.1), a building with several separate facilities, such as a planetarium, a large format film theatre, an astronomical observatory, an astronomical library, and an exhibition gallery. The creation of educational material, mainly in astronomy, is one of the major tasks of those working at Navegar Foundation. It includes planetarium shows, DVDs, books and other educational material.

PLANETARIUM

The Konica-Minolta Cosmoleap 10 star projector is at the centre of our dome. This machine enables our audience to see more than 6000 stars, the Sun and its planets from any point in the Solar System using the most accurate calculations. Under the stars, people can appreciate a variety of shows covering different subjects in astronomy, science in general and even history. But the planetarium is not only made of stars and planets. A great number of projectors surround the audience with images and videos. A digital sound system with six independent channels and three subwoofers creates an even more splendid ambiance. The Planetarium is not only a scientific tool, it's a place where science, culture and art can meet to celebrate the conquests of human mind.

OBSERVATORY

The Astronomical Observatory is located in Centro Multimeios de Espinho, at the top of the building. It has an automated roof that can be opened in order to make astronomical observations. The observatory is equipped with a modern 16 inch reflector telescope, digital CCD cameras, filters, autoguider and several eyepieces. Everything is automated and controlled by a computer, using astronomical software thus making its operation very simple, whether in loco, or remotely. The observatory is used for public shows, workshops for students, and science purposes.

COSMOTECA: SKY AND SPACE LIBRARY

Cosmoteca is a public library dedicated to astronomy. It works as a complement to the planetarium and the astronomical observatory that also can be visited at Centro Multimeios de Espinho. It is a place for study, training and science education, where it is possible to find educational and didactic material, including books, magazines, videos, CD-Roms, DVDS and computers. Cosmoteca, Sky and Space Library, is available for everyone who has an interest in astronomy. It was created with the rising importance of astronomy in modern school programs in mind. Here, teachers can find support in their class preparation, and the students in their homework and group projects.

CONTENT DEVELOPMENT, RESEARCH AND PRODUCTION: PLANETARIUM SHOWS

The Navegar Foundation already has several years of experience in the production of new content for planetarium shows. The shows are completely original, and targeted at specific audiences, according to their ages. The production involves a team with different areas of expertise, such as astronomers, planetarium technicians, movie directors, animators, music composers, sound technicians, among and others. The shows are intended to reach an international audience, and special care is taken that they are both entertaining and educative. The shows are first exhibited in our Planetarium, as this gives us the opportunity to test them before release, and to evaluate several different aspects of the shows, such the story, astronomical content, music, sound effects, etc.

The Moon is Angry: The challenge was to produce a session for a very young audience between 3 and 10, where the basic concepts of astronomy and space sciences are introduced in 25 minutes. The premise for the story is a never ending solar eclipse. The Moon is fixed in the sky, obscuring the home town of the story heroes, who go on a fantastic trip around the Solar System to solve the mystery. The creation and production of this session involved experts from more than 10 different areas, from scriptwriters to astronomers.

Camping With the Stars: This is the fourth show produced by the Navegar Foundation, and its main target audience are students in the 8th grade, although it can be seen and enjoyed by all the family. The producers decided to use comics as the foundation for the entire show to illustrate the scientific themes that are being introduced, making this a very colourful and dynamic show. The story: a school class goes on a camping trip with some teachers. At night everyone goes to sleep, except one of the teachers, who takes the opportunity to watch the sky. Two of the students, Pedro and Luis, hear a noise and decide to see what is happening. They find the teacher admiring the sky and decide to stay with him. Their curiosity is aroused and they question the teacher about the galaxies, the stars, and the movement of the sky and so on—you can see how it unfolds.

SKYWATCH

Introducing European Youth to the World of Scientific Research through Interactive Utilisation of a Global Network of Robotic Telescopes

Sotiriou, M., Vrazopoulos, H., Ioannou, P., Q-Plan S.A., Sotiriou, S., Vagenas E, Ellinogermaniki Agogi, Athens, Greece

ABSTRACT

The SkyWatch project is co-financed by the European Community, within the FP6 framework of Science and Society, The SkyWatch consortium is composed by the following partners: Q-PLAN (GR), EDEN—Open Classroom (UK), Astrophysics Research Institute—Liverpool John Moores University (UK), European Physical Society (FR), Ellinogermaniki Agogi (GR), Stockholm University (SE), SCIENCE PROJECTS (UK) and University of Duisburg—Essen (DE). The aim of the SkyWatch project is to build up the number of youngsters involved in a series of science projects to create a virtual community of prospective young researchers promoting scientific culture. The project will allow young people to access and use robotic telescopes remotely in real-time, perform observations, analyze data and results and finally to develop and suggest solutions to selected research/scientific topics, all achieved through an innovative web-based learning environment. The dissemination of the project's activities is also served by a European Science Contest on science topics and projects, a series of popular science distance learning courses (Science Days) for European youth, promotion of concepts and ideas of science of a multidisciplinary nature: astronomy, physics, mathematics, chemistry, etc. The young participants are prompted to organize teams (school classes, groups of students, etc.) and to design, develop and implement projects and activities with the use of robotic telescopes under the guidance and the continuous support of a team of experts.

THE SKYWATCH PROJECT

SkyWatch has an innovative approach to promoting increased public awareness of scientific and research culture. This approach is designed to cut across the boundaries between schools, research centres and science thematic parks and involve users in extended episodes of playful experience and scientific research. The project uses its advanced science and technology to create a 'feel and interact' user experience, promoting the development of an increased scientific culture open to societal changes and at the same time adequately modulated to the needs and capabilities of each user (Fig. 1 below).

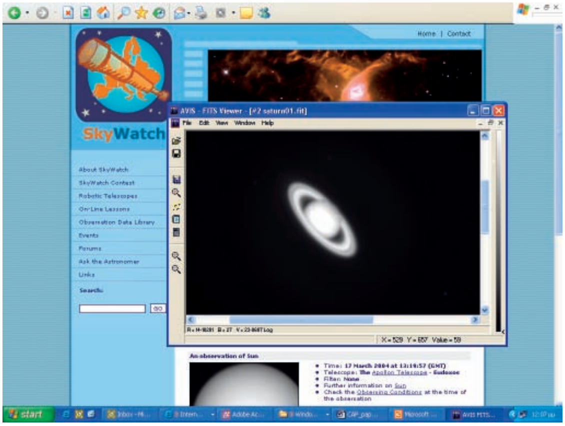

***Figure 1.** SKYWATCH.*

The SkyWatch approach is engaging groups of young people all over Europe in a scientific quest by implementing a set of multidisciplinary scientific scenarios related to astronomy and astrophysics. Young people are given an opportunity to perform and experiment with scientific research and evaluate its impact on society and everyday life. SkyWatch is not simply acting as a science demonstrator but primarily as an interactive and vivid initiative where users are equipped with powerful real-scale research tools to become the researchers, the seekers and finally the leaders of the scientific quest.

SCIENTIFIC CONTEST

The SkyWatch project's objectives focus on raising public awareness for scientific and technological developments by motivating the general public to actively participate in the process of realizing the beneficial impact of science and technology on our day-to-day lives. One successful method, especially among young people, is to present science and scientific research through challenging activities that combine intelligence, existing knowledge and innovation. A scientific contest is to be held in the general field of astronomy and astronomical observations within this framework.

PARTICIPATION

The SkyWatch contest addresses three age groups. The contest topics, evaluation criteria and presentation format will be common for each age group, but eventually there will be nine (9) final winners, three (3) from each group. The three age groups are students $<$ 15 years old, between 15 and 18 years old, and adults. All participants are allowed to enter the contest either individually or in pairs.

CONTEST FIRST PHASE (7 MONTHS)

During the first phase, the young participants will use a database of astronomical observations conducted by the telescopes of the SkyWatch network of observatories. Participants can select from a pool of 5 suggested contest topics, and are expected to design, develop and implement projects and activities with the use of the database in the telescope provided and under the guidance and the continuous support of a team of experts in the field. The contest participants will be asked to create scenarios and well-defined small projects to express these ideas and to seek for answers to scientific issues. All projects will be presented and assessed following specific criteria that will be applied by the project's scientific committee. An initial selection procedure will be established that will lead to the creation of a pool of 30 projects. This evaluation / selection procedure will be followed independently for each of the three groups. The 10 best projects from each group will qualify for the 2nd phase of the contest, which lasts 1 month. These participants will be granted access to a network of the robotic telescopes in order to be provided with new research material comprising observations on demand. Based on these "ordered" observations, the participants will develop their submitted projects further or even create a new project on the same topic. These 30 integrated projects will be evaluated by the project's scientific committee who will finally come up with the three best projects from each age defined category. All the projects will be presented in the closing event in Athens on November 2005.

SCIENCE DAYS

Several interactive sessions on popular science will be organized based on (a) science topics and educational material related to the contest topics and (b) the results of the scientific – research scenarios that will be developed by the contest participants before and during the European Science Week 2005. The programme will include **Contest Science Days** and **Public Science Days** (e.g. Astronomy Days, Physics Days, Mathematics Day) during which the youngsters and the general public get additional information about the latest achievements in the relevant field and the contest results and the opportunity to ask questions. Young people will have the opportunity to become familiar with the process of scientific research and to find out more about the work of scientists and technologists.

ASTRONOMY AS SCIENCE, ART AND INDUSTRY

H.Teimoorinia[1] *& A.Moosavi*[2]

[1] Azad University of Zanjan, Young Research Club, Iran

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ABSTRACT

This project aims to introduce astronomy to the public. We argue that one of the most effective ways is to follow an unconventional approach in which the young people get engaged in a subject and then act as mediators to general audiences. We try to communicate using very simple language and not with complicated formulas! To make it more tangible we try to convince others that one can look at astronomy as an art, industrial scheme or scientific phenomenon.

INTRODUCTION

For people who are not professionally involved with sciences, the applied sciences and research laboratories, like medical laboratories for example, are the bridges that connect them to scientific world. The reason is quite simple: they can see the actual results in their daily life!

The outcomes of the applied sciences are tangible so they appear significant; therefore it is extremely important to familiarize the public with the results of basic sciences such as astronomy. It is helpful to pave the way by introducing the "night sky" as the research lab for astronomers and physicists.

Like any other basic science, astronomy demands time and patience, in which one cannot expect immediate results and much of excitement. However by implementing the "learning by doing" structure people learn how to wait, be patient and look forward to long-term results with many connections to other exciting fields.

Take building a "telescope" as an example. This could be seen as architectural design by designers or artists and at the same time as an industrial project by industry and as a software and computational project for scientists.

And last but least, astronomers and physicists have to choose the "right" language for non-physicists and people who are not professionally engaged in these fields. Keep in mind that if they cannot understand what we say, they will not pay attention to what we do!

Young people with no significant background and interest in science, who are not necessarily physics students, are an "echo voice" for their parents and friends.

When they become engaged in astronomy as a hobby or interest, they will echo the excitements of astronomy and encourage others to get involved. Because their friends, relatives and parents pay attention to what these young people are doing and saying, this will create a “domino effect” and spread the beauty and excitement of astronomy to the public.

Channel 4 of IRIB broadcasts a live documentary, hosted by young students, named “forgotten sky” which is very successful in attracting general audiences towards astronomy.

CONCLUSION

An unconventional approach to engage the public with astronomy has been developed. People with very diverse interests become involved and young people act like connecting devices between astronomy and general public.

Further works are needed to continue and improve this approach; this cannot be done without the help of the same people who were excited with the astronomy at the first place, i.e. the young people!

A WEBSITE ON BLACK HOLES

Gijs Verdoes Kleijn

ESO, Munich, Germany

ABSTRACT

We are building an educational website on the nature of black holes in the Universe. The aim of the website is to convey the properties of black holes, the basic principles of gravitation and its relation to the physics of black holes in an interactive way. We developed the website to reach a wide target audience. The planned launch of the web site on the Hubble Site is late 2005. It will be possible for science centres and planetaria to add the website to their own including their own logo.

INTRODUCTION

The central theme is that there are places in space where gravity has gone insane, and we can find them and study them. The website contains various interactive modules. The visitor finds and collects black holes on the night sky. The visitor then travels to them and explores them by performing experiments with them. In addition there is a Black Hole Encyclopaedia that offers information on black holes in a factual format. The website includes the following facts:

- Black holes are real, they exist and are not just hypothetical.
- Black holes are a gravitational phenomenon: a place where gravitation has won above all other forces in the Universe.
- Black holes are very far away and are not an imminent threat.
- That the Universe is really big.

Although black holes are invisible, we can detect them with clever instruments.
We aim to get the point that black holes are awesome examples of the natural world across and that the visitor is capable of understanding such complex objects as black holes.

The site was developed in a very a close collaboration between scientists from several institutes, science communicators and educational web designers.

Support for this website was provided by NASA through grant EO-08261.02-97A from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555.

Principal Investigator: Roeland van der Marel, STScI
Web design: Educational Web Adventures
Text, Image Selection & Storyline: Roeland van der Marel, STScI
Gijs Verdoes Kleijn, ESO
Dave Schaller, Educ. Web Adventures

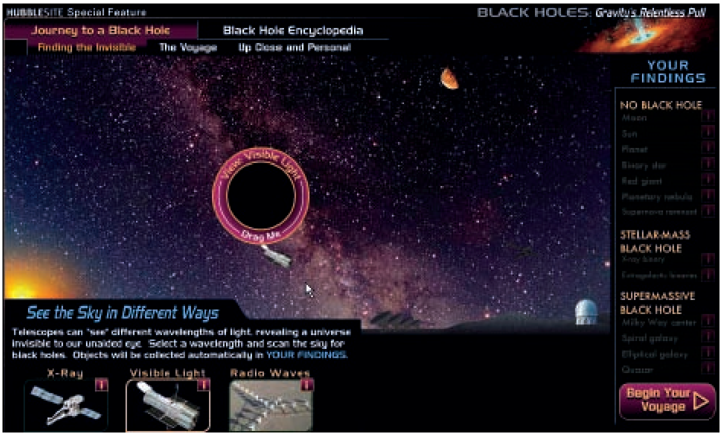

Figure 1. *Screenshot of the mutli-wavelength sky on which the user can search for black holes in the Universe and get information about them*

EUDOXOS OBSERVATORY:

Communicating Astronomy using Robotic Telescopes

M. Zoulias & N. Solomos

N.O.E. Eudoxos Observatory, Kefallonia, Greece

INTRODUCTION

The Greek National Observatory for Education *"Eudoxos"* (http://eudoxos.snd.edu.gr) and its educational projects have the primary mission to "deepen the understanding of physics through astrophysics and provide education through research". In such a context, they provide hands-on astronomy research experiences to students of all levels. The internet revolution has made it possible to access an observatory remotely and request observations from a wide variety of instruments. Remote control of the observatory's instrumentation and monitoring equipment was a challenge in itself! The next milestone was the development of educational curricula, tailored to the equipment of the observatory in the form of lab exercises using real data. All the exercises are designed to guide the students to understand the Universe using the scientific method of hypothesis, observation (experimentation) and analysis.

PURPOSE AND GOALS

Astronomy studies nature on the grandest scale and answers some of the primeval questions of humanity. Space-based observatories and modern ground-based telescopes provide stunning images and unprecedented views of the cosmos. As such, astronomy strongly attracts the public interest, apparently more than any other scientific discipline, and thus, becomes particularly suitable for the purpose of developing fundamental scientific skills. The key agent here is the excitement generated by people's own curiosity. Astronomy provides an excellent carrier for an introduction to science and to scientific methodology per se.

But how could the public or students best perceive this exciting information? The *Eudoxos* approach offered a 'behind the scenes' view of what the astronomical pictures and numbers mean. Hands-on access to raw observational data, appropriately explained by accompanying educational material provides the non-expert audience with a unique experience-based method that communicates enquiry-based studies of the size, age and nature of celestial bodies and the Universe as a whole. The project's educational goals can be summarized as follows:

- Development of a pedagogical framework that incorporates research methodologies into science teaching. Make the students learn how to acquire new knowledge by re-discovering what is known to scientists but unknown to them.
- Introduction of motivating interactive learning methods by implementing ac-

tive participation and involvement in modern astronomical observations, their careful planning, data reduction, conclusion. Use the real numbers from real data.
- Advancement of critical thinking and understanding the interplay among underlying physical laws and associated scientific concepts.
- Focusing on the connection between physical science and experimental investigation.
- Development of new and innovative educational tools and approaches.

During the last few years a few educational projects have been carried out by *NOE-Eudoxos*, some of which in collaboration with external partners. Two major projects of such type were *Eudoxos I* and *II* (http://eudoxos.snd.edu.gr):
- *Eudoxos-I* (1999-2001) was funded by the Greek Ministry of Education. This project emphasised discovery (i.e. supernovae, microlensing event patrols) and hands-on experimentation. More than 10 self-contained exercises were developed, covering modern astrophysics. For their content, we have adopted the intuitive and pedagogical "near" to "far" approach, starting from the Solar System and moving towards cosmological scales. The exercises and corresponding teaching guides of this phase were written in Greek and have been tested in 5 high schools spread over throughout Greece.
- *Eudoxos II* (2002-2004) was funded by the European Commission. In this second project, emphasis was given to communication technology, to visual and functional improvements of the user interface as well as to the elaboration of a more comprehensive but less demanding curriculum. Teaching and studying materials in this phase were developed in English, targeting younger audiences in schools throughout Europe. Translations of this material are to appear in other European languages, including Greek.

FUTURE PLANS

From the experience gained from the application of *Eudoxos-I* (Advanced) and *II* (Normal), two additional curricula are being prepared: *Eudoxos-Radio* and *Eudoxos-Interdisciplinary*. They will extend the measurement content to the radio spectral domain and, most importantly, will focus on the synergies of the various scientific disciplines (mathematics, physics, computer science, technologies etc) associated with the modern scientific endeavour.

CONCLUSIONS

Modern science teaching requires novel approaches to learning and especially astronomy, for which the distant sky that is outside of any everyday experience is the ultimate learning laboratory. Building an observatory at every school, for example, would require extensive funding and educators with specific technical skills to operate and maintain it. In most cases funding would be impossible, while in most cities this would just be a waste, taking into consideration the light pollution involved.

NOE-Eudoxos, a dedicated robotic observatory, overcomes these limitations. It offers remotely based observational services and through its curricula introduces secondary education students and the public to research methodologies. It is breaking the traditional barriers of lecture-based teaching and brings the real sky within the classroom, in a cost-efficient way. Globally available through the internet, *NOE-Eudoxos* and similar projects can be easily characterized as the ultimate public (most easily accessed) observatories.

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THE FAULKES TELESCOPE PROJECT

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ABSTRACT

The Faulkes Telescope Project (FTP) www.faulkes-telescope.com offers access to research grade, 2-metre telescopes in Hawaii and Australia. Users carry out live observations from anywhere over an internet connection, or submit targets to the offline queue. Each telescope is equipped with a scientific-grade CCD and a filter set consisting of u'BVRi' plus Hydrogen Alpha and Oxygen III. Spectrographs will become available in future, opening up exciting new possibilities to all FT users.

THE FAULKES TELESCOPE PROJECT

Apart from rapid acquisition of extremely high quality images, the FTP offers access to the southern sky from Australia, and the opportunity to collaborate in a range of research projects. Research projects already running involve objects as distant as Gamma-Ray Bursts and galaxy clusters or as close as NEOs—in the latter case, we can track these fast-moving targets to greater distances than almost any other regular observer, contributing vital data.

Figure 1. Spiral galaxy NGC1232 in Eridanus, the so-called "Turbine Galaxy". A beautiful face on spiral that fits nicely in the Faulkes Telescope's 4.6 x 4.6 arcminute field of view. Image by Nik Szymanek.

The telescope is available to any subscriber, but in most cases it will be used by UK schools and universities. Interested amateur astronomers or societies can use it for their own projects, as can overseas users, although priority will usually be given to UK users if demand is high. The project aims to involve users in "real research" projects, with schools gathering data on behalf of professional astronomers. The recent NASA Deep Impact mission demonstrated the power of this approach, with the first ground-based images of the Tempel-1 impact being obtained by Hawaiian and UK school students using FT North on Maui. The FTN images were widely featured in the UK press and media, and the schools involvement was highlighted as a key feature of the science programme.

OBSERVING WITH THE FAULKES TELESCOPES

Once allocated a user name and password, you can browse the FT Project Web site, which is very user-friendly and accessible. There is plenty of good information here regarding the use of the telescope, including hints on how to plan your observing session, altitude pointing limits, Moon avoidance during imaging and telescope and CCD characteristics. There are ideas for research projects and getting the best out of your data. A very realistic telescope simulator can be used to plan an observing session and it's definitely worth doing this to be sure that all the targets will be visible and to account for telescope slewing time.

Time is allocated on the FT in blocks of 30 minutes. Due to the phenomenal sensitivity of the system, typically it's possible to get 6-8 great colour images during this period. Registered subscribers can view the current or latest images taken with the telescope which is useful for gauging the quality and steadiness of the sky prior to

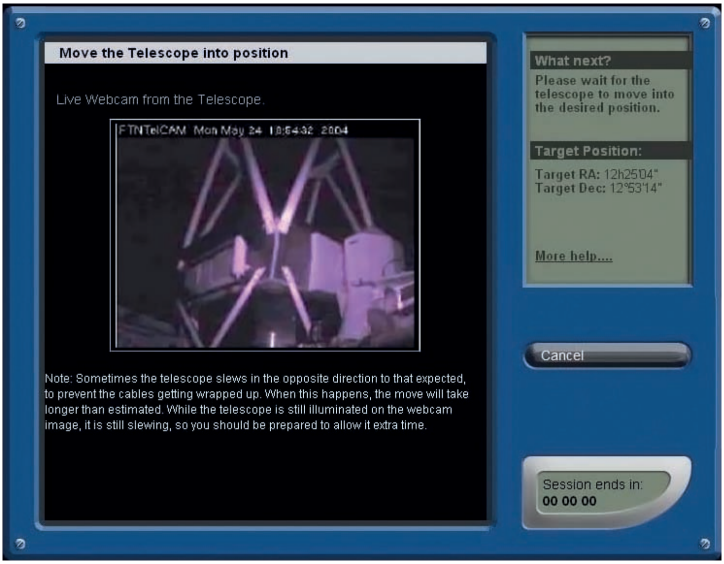

Figure 2. *This screenshot shows the Faulkes telescope operating software. The telescope has been instructed to slew to a target and the left hand picture shows the telescope in mid slew as viewed by an infrared Webcam. Images from Faulkes Telescope Project.*

Figure 3. Spiral galaxy NGC 1097 in the southern constellation of Fornax. On the left is the pipeline-processed JPEG file that is sent immediately after the image set is acquired by the telescope, and consists of just three 45-second exposures. On the right is a processed version for which the digital development algorithm has been used to extract detail from the galaxy's core – this image consists of 5 one-minute exposures with the BVR filters. Images by Nik Szymanek.

starting a session. Weather information is displayed on the website with an up-to-date readout on temperature and humidity. If the weather is cloudy during an observing run then the time lost is re-allocated (unlike professional observers who go to the back of the queue if their time is lost to bad weather!).

JPEG images are returned in real time by the telescope control software, and the raw FITS data can typically be downloaded within an hour of the observation. Once processed, the quality of the FT images is apparent, and image processing can produce some spectacular results. A variety of images produced with FT North by Nik Szymanek accompanies this article, showing the results that can be obtained using FT data and suitable image processing software.

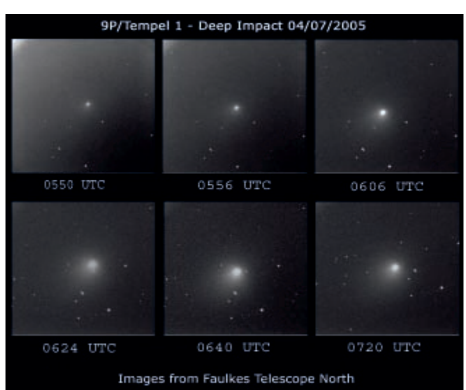

Figure 4. A selection of images from FT North for the Deep Impact mission, taken over 90 minutes that covered the impact of the probe with comet Tempel 1. Images were obtained by a team of professional astronomers and school students working on Maui and in London. Images from Faulkes Telescope Project.

THE ESA/ESO/NASA PHOTOSHOP FITS LIBERATOR VERSION 2

Lars Lindberg Christensen, Lars Holm Nielsen, Kaspar K. Nielsen & Teis Johansen

ESA/Hubble, Munich, Germany

ABSTRACT

Since the first version of the FITS Liberator software was released on the 8th July 2004 more than 50,000 people worldwide have looked over the scientists' shoulders and worked with digital images from telescopes in space and on the ground themselves. In this way the Liberator has become the 'industry standard' for the production of astronomical colour images. The new version 2 of the software has recently been released and opens up a significant number of new possibilities.

INTRODUCTION

The coming of the digital age in the 1980s changed the workflow patterns in astronomy for ever. The transition from photographic glass plates and films inside the instruments to electronic CCDs (Charge Coupled Devices) meant that astronomical images changed from analogue to digital in the space of a few years.

The access to digital observations from the many different telescopes around the world partly improved the quality of the measurements themselves and partly simplified the astronomers' workflow when analysing the information from remote stars and galaxies. Digital images exist as numbers that can be handled directly by a computer whereas the now historic photographic films had to go through a laborious digitisation process before they could be worked on. The ready availability of digital images had huge benefits and provided great flexibility in the work of analysing light and accessing quantitative measurables.

It is not well known that astronomical observations, for instance from the Spitzer Space Telescope and the Hubble Space Telescope, are freely available in large archives. In principle everyone has access to these enormous amounts of data, but for many years only astronomers have made use of this opportunity.

HE FITS LIBERATOR

We all know the impressive—almost artistically beautiful—images from Hubble, Spitzer and Chandra and other professional telescopes. For many years it has taken a considerable amount of expert knowledge to retrieve the raw exposures, reduce them to remove artefacts etc., not to mention process them to turn them into beautiful representative colour images. With the freely available ESA/ESO/NASA Photoshop FITS Liberator software - now just out in version 2.1 -all this has changed. All inter-

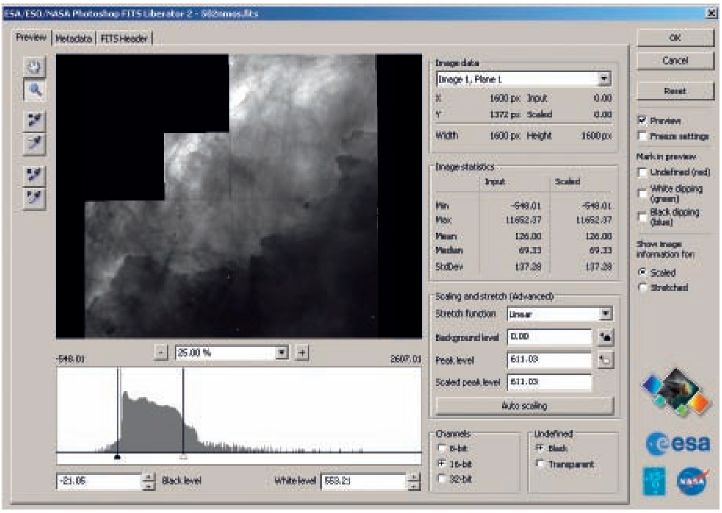

Figure 1: *A screenshot of the FITS Liberator user interface.*

ested amateur astronomers and lay people, now have easier access to, and can exploit, huge databases filled with images that are not only packed with information, but beautiful too. The software is not meant to run as a stand-alone but is a supplement to the commercial image processing software Adobe Photoshop® (as a so-called plug-in).

The somewhat curious name, FITS Liberator, arose from the FITS (Flexible Image Transport System) file format that has been a standard for most astronomical observations since 1982, and is indeed very flexible, but also rather technically advanced and so inaccessible to 'normal people'. FITS files come in numerous different shapes and sizes and to 'free' them and make them accessible to non-astronomers requires a piece of specialised software like the Liberator that can take a huge number of special cases into consideration. Before the Liberator only professional astronomical image processing software could open and process FITS files, which made them more or less unusable for lay people.

The FITS format is, as already mentioned, not the easiest to work with and it has taken the team much work to crack the many nuts along the way to make the extensive programme with 20,000 lines of code functional.

Somewhat surprisingly the software turned out to be a huge success right from the first version released in July 2004 and within the first year more than 50,000 people have started using it. Many different kinds of people use the FITS Liberator. There are naturally many amateur astronomers who either have a telescope in their backyard or who would like to roam the professional data archives themselves. Some educators also use the software and quite a lot of curious youngsters have become 'FITS Liberators'. In the coming years some attention will be focused on making the enormous data archives from, for instance, the Spitzer and Hubble Space Telescopes, as well as ground-based archives such as the European Southern Observatory's Very Large Telescope (VLT), more accessible under the auspices of the international Virtual Observatory collaborations. Already many astronomical archives today deliver so-called 'science-ready" products, i.e. relatively clean images where the artificial 'fingerprints' from telescope, optics, and detectors have been removed. The stage then is already set to combine them and turn them into spectacular colour images.

PIONEERING SPIRIT

As the Liberator developed we have had to define new workflows and principles for producing attractive astronomical images from start to finish. It has been a great adventure to pioneer the future of pretty astronomical pictures. Most of us have grown up with posters of beautiful nebulae and galaxies on our walls. These images were created using photographic methods in the darkrooms of the 'real' pioneers, such as the legendary David Malin in Australia. There is no doubt that the darkroom and the enlarger are far slower and more demanding tools and that these early results should command a great deal of respect. The new digital workflow makes it a lot easier to achieve beautiful results and opens the doors to everyone. As always new technology creates new horizons for the old as the revival of the old Schmidt glass plates seen here illustrates.

FITS Liberator can be downloaded for free from: http://www.spacetelescope.org/projects/fits_liberator/

Acknowledgements

The project is a collaboration between ESA (the European Space Agency), ESO (European Southern Observatory) and NASA. ESA has financed the development and NASA has delivered manpower to support with scientific and technical issues. The team that produced the ESA/ESO/NASA Photoshop FITS Liberator consists of:

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- **Engine and GUI**: Teis Johansen
- **Scientific support**: Robert Hurt
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Figure 1. *It is now possible to compose beautiful colour images in a simple way from all telescopes, both on the ground and in space. What could be more "old school" than creating images from data from scanned glass plates from the period between the fifties and the nineties? This is what amateur astronomer Davide de Martin has done with extraordinary results. Credit: Davide De Martin (http://www.skyfactory.org/) & Digitized Sky Survey 2*

THE ESA HUBBLE 15TH ANNIVERSARY CAMPAIGN

Lars Lindberg Christensen & Martin Kornmesser

ESA/Hubble, Munich, Germany

ABSTRACT

The 15th anniversary of the launch of the NASA/ESA Hubble Space Telescope occurred on 24th April 2005. As Hubble is one of the most successful scientific projects in the world, ESA decided to celebrate this anniversary, among other things, with the production of a Hubble 15th Anniversary movie and a book, both called "Hubble, 15 years of discovery". The movie covers all aspects of the Hubble Space Telescope project—a journey through the history, the problems and the scientific successes of Hubble. With more than 700,000 multi-lingual DVDs distributed to the public, media, educators, decision-makers and scientists, the Hubble 15th anniversary campaign has been one of the largest such projects in Europe.

Hubble has exploited its unique scientific capabilities in regions where no other instruments can compete. The telescope consistently delivers super-sharp images and clean, uncontaminated spectra over the entire near-infrared to ultraviolet regions of the electromagnetic spectrum. This has opened up new scientific territory and has resulted in many paradigm-breaking discoveries.

__Figure 1.__ The cover of one of the nearly 30 different versions of DVD covers that were produced in different languages and qualities. Here it is ESA's own "VIP" version with a 32 page booklet inside.

INTRODUCTION

Exquisite quality images have enabled astronomers to gain entirely new insights into the workings of a huge range of different astronomical objects. Hubble has provided a visual overview of the underlying astrophysical processes taking place in these objects, ranging from planets in our Solar System to galaxies in the young Universe.

The renowned British astronomer Malcolm Longair writes in the preface to ESA's anniversary book: *"The Hubble Space Telescope has undoubtedly had a greater public impact than any other space astronomy mission ever. The images included in this beautiful volume are quite staggering in the detail they reveal about the Universe we live in and have already become part of our common scientific and cultural heritage."*

THE PROJECT

Many people agree that the long-term well-being and cultural development of European citizens depends on research and technological development. Information about science and scientists is a vital component of the scientific process, but the competition for attention in today's mass-media market is fierce. Attracting the attention of the younger generation with scientific information is especially difficult. Furthermore, the cultural and linguistic diversity of the member states within Europe demands the development of multi-lingual products.

The 15th anniversary of Hubble's launch presented the ideal opportunity for a dramatic and dynamic ESA project to grab the attention of the public, with a special emphasis on the younger generation, and to further the knowledge of science in general and astronomy in particular. In this project, Hubble was presented as a "science superstar" to make the largest possible impact and reach the maximum different target groups, including that section of the general population whose interest does not usually include science.

The project consisted of a number of activities, or vehicles to transport these messages: The full-length documentary movie "Hubble—15 Years of Discovery" issued on DVD and for broadcast TV; Events, planetarium shows and press meetings; Educational Material; Full-colour 120 page anniversary coffee-table book translated to several languages; Movie Poster; Movie soundtrack; Planetarium Show Package for planetarium show production. Read more about the individual activities on the Anniversary web page: http://www.spacetelescope.org/projects/anniversary/

THE MOVIE

The movie covers all aspects of the Hubble Space Telescope project—a journey through the history, the troubled early life and the ultimate scientific successes of Hubble. More than 700,000 copies of the DVD have been distributed, making it possibly the most widely available science documentary ever.

Bob Fosbury, a scientist from the European Space Agency, who has frequently used Hubble for his own research, presents the movie. Through the movie Bob explains various astronomical phenomena and describes the workings of a major telescope like Hubble. As an active, but approachable scientist himself, he brings an added depth and insight to the material while simultaneously helping to demystify the image of scientists. Bob can perhaps serve as a role model for the younger generation.

THE BUSINESS MODEL

For science communication the project used a highly untraditional business model. By relying on the value of the DVD movie a snowball effect was created by making the project a multiple win-win situation for everyone involved, all the way from the participants in the production to the partners and the end-users. Collaborators and partners from more than 20 EU member states and third countries joined in the collaboration. For example, some of the partners took out advertisements in large national newspapers and magazines for the DVD, thereby promoting Hubble and ESA in a way not otherwise possible, and so reaching target groups that we would normally not reach.

HUBBLE DAY EVENTS

At more than 60 events in more than 20 countries all over Europe, Hubble's 15th anniversary was celebrated and the excitement of space shared: "Hubble Day", talks, the unveiling of two large, 3-metre anniversary images, exhibitions and more. Thousands of people heard talks by scientists and saw planetarium shows, images and movies of spectacular beauty.

CONCLUSION

The outcomes of the project are manifold. More than 700,000 copies of the DVD movie were distributed through more than 80 delivery points all over Europe (magazines, newspapers, science centres etc.). This makes it probably the most widely distributed science documentary ever. Nearly 30 different DVD 'packages' were made in different languages and quality to cater to the different needs of the partners. An estimated 10-20 million viewers or more have watched the movie through various TV channels. The movie has been shown at numerous venues such as planetaria, science centres, public observatories etc. Searching on the title of the DVD movie on Google gives an impressive 14,000 hits!

In many ways, the European Hubble anniversary project can be seen as a role model for trans-national science communication, and the informal network created here will be exploited for many years to come.

Acknowledgments

We would like again to thank all the individuals and organisations involved in this massive project! The list is unfortunately too large, but most are listed in the end-titles of the DVD. This project would never have happened without you!

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