Report on the Workshop

Interstellar Medium and Star Formation with ALMA: Looking to the Future. A Workshop to Honour Tom Wilson

held at Consejo Superior de Investigaciones Científicas, Madrid, Spain, 16–17 June 2008

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In June 2008, a group of friends and colleagues of Tom Wilson gathered in Madrid to honour his scientific career in a workshop on ALMA organised by three of his PhD students. The workshop was devoted to reviewing recent progress in our understanding of the main topics of research that Tom has pursued during his career: the physics and chemistry of the interstellar medium and how stars form. Specific topics included H II regions, molecular clouds, clumps, cores, outflows and masers in Galactic and extragalactic environments, mainly from an observational perspective.

Introduction

Last December our colleague and friend Tom Wilson celebrated his 65th birthday. During his fruitful career he has made important contributions to the understanding of the physical and chemical properties of the interstellar medium and the processes leading to star formation. In the last five years, while at ESO, Tom has helped to realise the Atacama Large Millimeter/submillimeter Array (ALMA). To honour him, his former students Christian Henkel (Max-Planck-Institut für Radiostronomie, MPIfR), Jesus Martin-Pintado (Consejo Superior de Investigaciones Científicas, CSIC) and Rainer Mauersberger (ESO) organised a two day workshop entitled "Interstellar Medium and Star Formation with ALMA: Looking to the Future". The workshop was organised by the Departamento de Astrofisica Molecular (DAMIR) and held on 16–17 June on the campus of the CSIC in Madrid. Support for the workshop was provided by CSIC, ESO and RadioNet.

Scientific programme and attendance

Sixty people attended the workshop. Most of the attendees were Tom's friends, colleagues and former PhD students. Unfortunately, not all of those invited could come; many were prominently mentioned by Tom and others in their presentations. A significant number of those mentioned were PhD students and postdocs, who are Tom's scientific grandchildren.

Following Tom's suggestion, the emphasis was on the future of molecular astrophysics, rather than a review of his career. Thus most of the programme was devoted to future studies of interstellar matter and star formation in the Milky Way and in external galaxies. The organisers also decided that Tom's students would act as chairpersons of the sessions to give short introductions, recounting anecdotes and personal experiences from their professional or personal relationship with Tom. The presentations from the workshop, which are available online at *http://www.damir.iem.csic.es* included two kinds of talks. The first were given by Tom's old friends and colleagues, who looked back on Tom's life, relating anecdotes and also presenting their view of future areas of research to be done with ALMA. The second kind were given by the younger generation of students, many of them Tom's scientific grandchildren; these were mainly concerned with providing perspectives on ALMA's contribution to their research area.

The after-dinner speech on 16 June was given by Professor Robert Rood, who gave an extended talk about Tom Wilson's career.

Tom's scientific career

The workshop started with a summary of Tom's career by Professor Bernard F. Burke, Tom's thesis adviser. He described the first steps in Tom's career as a PhD student in MIT, when he had also just arrived at MIT. He mentioned three of Tom's main virtues: persistence, change and transition, all of which are fundamental to success in astronomy and astrophysics; he noted that Tom has shown the ability to handle all of them. Tom started his thesis by surveying a catalogue of H II regions in the northern sky in recombination lines with the Green Bank 140-foot telescope. Tom also joined Peter Mezger in an extension of this project to survey recombination lines from southern H II regions with the Parkes 210-foot radio telescope. Both surveys were great successes. The Parkes work constituted the main body of his thesis.

Tom then moved to MPIfR and started to work with the new 100 m radio telescope at Effelsberg in Germany. Using the 100 m telescope Tom made the transition from studying H II regions to observing molecular clouds, mainly in the centimetre wavelength lines of ammonia and formaldehyde. Most of Tom's students were basically trained on molecular line observations related to the field of star formation. Tom continued working on recombination lines from H II regions and one of the most innovative works in this field was the venture with Robert Rood (the dinner speaker, Tom Bania and later Dana Balser) to detect the hyperfine line of ionized ^{3}He.

Bernard Burke stressed that big radio telescopes became Tom's *métier* and he was involved in the commissioning of big radio telescopes operating from centimetre to short sub-millimetre wavelengths: the 100 m telescope at Effelsberg (Germany), the Institut de Radio Astronomie Millimetrique (IRAM) 30 m at Pico Veleta (Spain) and the 10 m Heinrich Hertz telescope at Mt. Graham (Arizona, USA). All of Tom's students will always remember him as ready to go at any time to observe or commission receivers and backends at the 100 m telescope. His typical response in these cases was, "We will take the telescope time, please sign up for the Dienstwagen to go to Effelsberg."

In recent years, Tom has been heavily involved in the realisation of the ALMA through key positions at ESO (European ALMA Project Scientist and Deputy Director). The workshop continued with technical and scientific presentations on the potential of ALMA.

Status of ALMA and the synergy with Herschel

The anticipated performance of ALMA and the current status of the project were described by Richard Hills, the ALMA Project Scientist. At the time of the workshop eight antennas were already at the Operations Support Facility; these will be delivered to ALMA after a series of tests. As one can imagine, the activity is frantic, with equipment being delivered

and tested. In addition to the antennas, the two antenna transporters were also undergoing testing. Pere Planesas presented a visual tour of ALMA and the site. He showed a number of beautiful pictures of the landscape and the current status of construction. The synergies between the Herschel Observatory and ALMA were discussed by José Cernicharo.

The molecular interstellar medium

Studies of the chemical complexity and the structure of the molecular interstellar medium (ISM) will play a central role in ALMA. John Bieging described the role of large-scale mapping of the structure of the molecular clouds to understand the impact of massive stars and their evolution. The large-scale, very high angular resolution images of dust and line emission will allow scientists to study the origin and the role of turbulence in the fragmentation of molecular clouds.

Alain Baudry showed the great potential of the ALMA correlator in searching for new molecules in the ISM. Molecular abundances vary with evolutionary state, as different species appear and disappear, for example by depletion onto dust grains. A plethora of molecular species can be used as tracers of the complex physics and chemistry and the ability to model these processes with high spatial resolution was identified as an essential complement to ALMA observations. Eric Herbst reviewed chemical models, showing how molecular abundances vary with the evolutionary state of star formation in molecular clouds. Aina Palau discussed the intriguing behaviour of nitrogen-bearing molecules in molecular clouds with intermediate mass star formation. Finally Javier Rodriguez-Goicoechea presented the chemical effects observed in photodissociation regions generated by UV radiation from massive stars.

Low mass star and planet formation

Turning to low mass star formation it was noted that the processes leading from molecular clouds to stars cannot be followed in detail at present. Progress depends on new instrumentation, especially ALMA. Stars form in the central cores of molecular clouds by accreting material onto protostellar cores. However, we do not understand in detail the kinematics and dynamics of this process; neither the formation and collimation of outflows nor the eventual evolution of circumstellar discs to form planetary systems, asteroids and comets. Presumably magnetic fields play an important role, but this is not understood at present.

Frédéric Gueth presented recent results of molecular outflow observations with high angular resolution obtained with the IRAM interferometer and argued that ALMA will be able to see central regions in young stellar objects, providing images of the complex structure and kinematics of the outflowing and accreting material. Stephane Guilloteau presented the potential of ALMA for understanding the formation and evolution of circumstellar discs. ALMA will provide a complete view of the physical conditions, the kinematics and the chemical evolution of circumstellar discs by imaging with very high angular resolution several lines of a large number of molecules. The gaps predicted to occur in circumstellar discs as a result of planet formation can be imaged directly by ALMA. Josep Miquel Girart discussed the expected role of magnetic fields in star formation. He presented images of dust polarisation obtained with the Sub-mm Array (SMA) and compared the results of low mass versus high mass star formation. The expected hourglass shape of the magnetic field is found in both cases.


Credit: Sergio Martin (CfA)

Figure 1. Workshop participants collected around Tom Wilson (jacket and tie in the front row, 6th from the right).

Massive star formation: masers, star clusters and H II regions

Massive star formation has been one of the central themes in Tom's career and ALMA will provide images with the required angular resolution and sensitivity to study the formation of stellar clusters and also the individual stars in clusters. There were a number of talks covering topics from molecular excitation in massive star-forming regions to the properties of hot cores associated with intermediate mass protostars in clusters. Karl Menten summarised the results obtained from imaging maser emission from different molecular species in massive star-forming regions. Al Wootten also reported the results of high angular resolution imaging of water masers and thermal emission from other molecules. Both stressed the importance of the longest baselines in ALMA to use maser emission to trace the smallest scale structures in these regions.

Mayra Osorio presented model predictions for dust and molecular emission from high mass protostars and Carlos Carrasco Gonzalez showed recent inteferometric (VLA and Combined Array for Research in Millimeter-wave Astronomy, CARMA) images of the molecular outflows and discs in the stellar cluster of NGC 2071. Izaskun Jimenez-Serra presented high angular resolution images of the

Cep A HW2 region and showed that a cluster of intermediate mass stars is being formed.

Studies of H II regions were presented by Dan Jaffe and James Moran. Dan presented observations of the kinematics in compact and ultracompact H II regions using the [Ne II] emission line at 12.8 μm. The kinematics are inconsistent with the predictions that the exciting stars are moving with high velocities; a disc geometry explains the evolution of very young H II regions better. Jim Moran presented the results of SMA observations of the recombination line maser in MWC 349. The kinetics of the disc around this young massive star is not fully consistent with Keplerian rotation. Although MWC 349 is far in the north, ALMA can provide images with enough resolution to discriminate between kinematical disturbances produced by gas spiralling toward the star from gas ejected from the disc of this source.

Extragalactic molecular astrophysics

ALMA will enable a series of advances in the field of galaxy formation and evolution, particularly at early epochs. Galaxy number counts will be extended to the faintest sources in every ALMA band. The spatial and redshift distribution of these sources, as well as their luminosity functions, will become measurable, as ALMA will not be confusion-limited in any of its bands. It will excel as a follow-up instrument for large-area surveys with bolometer arrays, both in resolving continuum emission and in measuring redshifts from molecular lines. In this context, Pierre Cox presented the new results of the molecular emission at high redshift and Paola Andreani discussed the star formation at high redshifts in obscured sources detected by the Spitzer satellite, stressing the potential of ALMA for understanding the nature of the power sources. Dennis Downes presented recent high angular resolution imaging of the continuum of the ultraluminous galaxy Arp 220 and concluded that active galactic nuclei (AGN) activity dominates the output, in contrast with previous models that favoured star formation as the dominant mechanism.

Sergio Martin and Daniel Espada argued that detailed chemistry of star formation in nearby galaxies and in the Galactic Centre will be a major topic for ALMA, as will be the relationship between the chemical complexity and the dominating activity in galactic nuclei (AGN or starbursts). Based on a model of molecular emission, Sergio proposed that the power source in Arp 220 could be due to a burst of massive star formation (now in the protostar phase), similar to the hot core phase in Galactic star-forming regions.

Links

Workshop contributions:
http://www.damir.iem.csis.es/alma2008/
http://www.astro.virginia.edu/~rtr/photos/tlwfest/

Award of the Ioannes Marcus Marci Medal to Tom Wilson, Associate Director for ALMA

Tom Wilson, who has been at ESO since 2004, first as ALMA Project Scientist and, after 2006, as ESO Deputy Director, was awarded the renowned Ioannes Marcus Marci Medal of the Czechoslovak Spectroscopic Society at a ceremony in Prague. Previous medallists include T. W. Hänsch, the 2005 Nobel Laureate in Physics.

Ioannes Marcus Marci was born in 1595 in Lanškroun, on the border of the former provinces of Bohemia and Moravia, currently in the Czech Republic. In 1627 he was appointed Professor of Medicine at Charles University, Prague, later Dean of the Faculty of Medicine and Rector of Charles University. He was also a private physician to the Emperor Ferdinand III. The results of his research activity have been collected in 16 scientific books. His most important contributions in the field of physics were his studies of the refraction of sunlight by a prism and the explanation of the origin of the rainbow, collected in his work, *Thaumantias. Liber de arcu coelesti deque collorum apparentium natura ortu et causis*. I. M. Marci died in Prague in 1667.

Since 1977, the I. M. Marci Medal for out - standing achievements in the field of spectroscopy has been awarded annually by the Spectroscopic Society of Ioannes Marcus Marci. This is a non-profit organi - sation for scientific, educational and tech - nical workers with the aims of promoting and fostering advancement in the field of spectroscopy.

The ceremony took place on 3 Septem - ber 2008 in the Prague City Hall Audito - rium, a historic lecture hall in central Prague. Tom presented a lecture on the "Current Status and Scientific Potential of the Atacama Large Millimeter/submillimeter Array" and he and Terry A. Miller (Ohio State University) were awarded the Ioannes Marcus Marci Medal for their contributions to different areas of spectroscopy.