The ESA-ESO Topical Science Working Groups

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Starting in September 2003, ESO and ESA have now held two science planning coordination meetings in order to ensure that there remains a joint awareness of potential future synergies or missed opportunities on the ground or in space. The meetings were attended by the chairs (or representatives) of the scientific advisory committees and by the executives of both organisations. The initiative was taken with the realisation that the two organisations are serving essentially the same scientific communities and share common scientific goals.

At the first meeting, it was decided to set up a small number of working groups that would examine scientific topics or specific instrumental synergies that would be important over the next decade or so. The first of these was on the topic of the search for and the subsequent characterisation of extra-solar planets – the report of this group, chaired by Michael Perryman (ESA/ESTEC) and co-chaired by Olivier Hainaut (ESO, Chile) is summarised in the accompanying article by Kerber and Hainaut. The second was to look at the joint opportunities offered by Herschel and ALMA in the infrared and sub-mm wavebands. Chaired by Tom Wilson (ESO Garching) and co-chaired by David Elbaz (CEA/Saclay), it is nearing completion and will become available towards the end of 2005.

During the second meeting in February 2005, a new working group was proposed with the intention of reviewing cosmology with particular emphasis on the investigations of the nature of dark energy and dark matter from an astrophysical perspective. This new working group on Fundamental Cosmology was established in June 2005, with John Peacock (Edinburgh) as Chairman and Peter Schneider (Bonn) as Co-Chairman. It will consider projects in the areas of dark matter, dark energy, and other aspects of the early universe, with the aim of reporting in February 2006.

The full membership of these groups and access to their reports as they become available can be obtained from: *http://stecf.org/eso-esa/*

ESA-ESO Working Group on Extra-Solar Planets

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The ESA-ESO working group on extra-solar planets was the first of a number of such groups to make a careful analysis of scientific fields that are of interest to both ESA and ESO. The groups also make recommendations for the development of the fields facilitating coordinated planning between the two leading European organisations advancing astronomy from the ground and from space.

The extra-solar planet working group, chaired by Michael Perryman (ESA), consisted of: Olivier Hainaut (Co-chair ESO), Dainis Dravins (Lund), Alain Léger (IAS), Andreas Quirrenbach (Leiden) and Heike Rauer (DLR). Florian Kerber and Robert Fosbury from the ECF were the support scientists. A group of experts contributed on specific subjects[1]: François Bouchy (COROT), Fabio Favata (Eddington), Malcom Fridlund (Darwin), Anne-Marie Lagrange (Planetfinder), Tsevi Mazeh (Transits), Daniel Rouan (Genie), Stéphane Udry (Radial velocity), and Joachim Wambsganss (Microlensing). The group operated between June and December 2004 and documented their findings and recommendations to both agencies in a report which is available in printed form from the ST-ECF and on both ESO and ESA websites (*http://www.eso.org/gen-fac/pubs/esaesowg/* and *http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=36935*). This article gives a very brief summary of the report and encourages feedback from the community.

[1] The working group membership was established by the chair and co-chair: the report is not a result of consultation with the community as a whole. The experts contributed considerable information to the report, but the conclusions and recommendations are the responsibility of the members.

The terms of reference provided by ESA and ESO called on the working group to the following:
1. Survey of the Field: this will comprise: (a) review of the methods used or envisaged for extra-solar planet detection and study; (b) survey of the associated instrumentation worldwide (operational, planned, or proposed, on ground and in space); (c) for each, a summary of the potential targets, accuracy and sensitivity limits, and scientific capabilities and limitations.
2. Role of ESO and ESA Facilities: this will: (a) identify areas in which current and planned ESA and ESO facilities will contribute; (b) analyse the expected scientific returns and risks of each; (c) identify areas of potential scientific overlap, and thus assess the extent to which the facilities complement or compete; (d) identify open areas which merit attention by one or both organisations (for example, follow-up observations by ESO to maximise the return from other major facilities); (e) con-

clude on the scientific case for the very large facilities planned or proposed.

As a final step the members of the working group came up with a number of recommendations that will help the further development of the field. These are directed at both agencies separately but a subset specifically calls for joint or coordinated efforts of the two agencies. Note that the recommendations of a similar ESO working group in 1997 (appendix C in the present report) directly led to the development of HARPS, the leading spectrograph for radial-velocity work today.

Survey of the field

A mere 10 years after the first detection of exoplanets around normal stars, this field has become one of the most active and exciting branches of astrophysics. Detection methods for extra-solar planets can be broadly classified into those based on:

(i) dynamical effects (radial velocity, astrometry, or timing in the case of the pulsar planets);
(ii) microlensing (astrometric or photometric);
(iii) photometric signals (transits and reflected light);
(iv) direct imaging from ground or space in the optical or infrared; and
(v) miscellaneous effects (such as magnetic superflares, or radio emission).

Each method has its strengths, and advances in each field will bring specific and often complementary discovery and diagnostic capabilities. Detections are a prerequisite for the subsequent steps of detailed physical-chemical characterisation demanded by the emerging discipline of exoplanetology.

As of December 2004, 135 extra-solar planets had been discovered from their radial velocity signature, comprising 119 systems of which 12 are double and 2 are triple. One of these planets has also been observed to transit the parent star. Four additional confirmed planets have been discovered through transit detections using data from OGLE (and confirmed through radial-velocity measurements), and one, TrES-1, using a small 10-cm ground-based telescope. One further, seemingly reliable, planet candidate has been detected through its microlensing signature. A much more detailed assessment of the current status, which is illustrated in Figure 1, can be found in the working group's report.

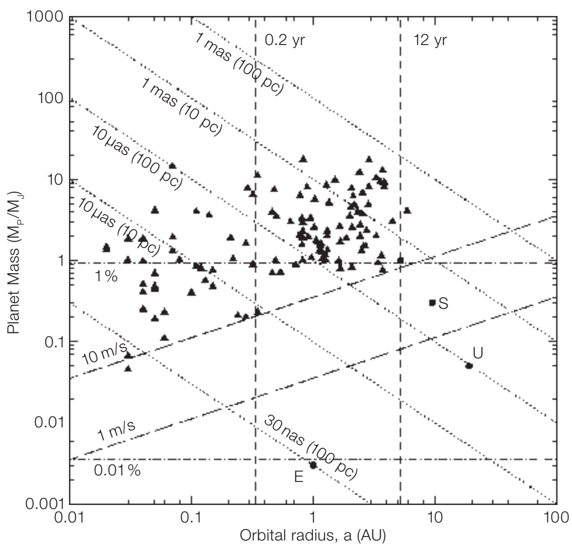

Figure 1: Detection domains for methods exploiting planet orbital motion, as a function of planet mass and orbital radius, assuming $M_* = M_\odot$. Lines from top left to bottom right show the locus of astrometric signatures of 1 milli-arcsec and 10 micro-arcsec at distances of 10 and 100 pc; Vertical lines show limits corresponding to orbital periods of 0.2 and 12 years. Lines from top right to bottom left show radial velocities corresponding to K = 10 and K = 1 m s^{-1}. Horizontal lines indicate photometric detection thresholds for planetary transits, of 1 % and 0.01 %, corresponding roughly to Jupiter and Earth radius planets respectively (neglecting the effects of orbital inclination). The positions of Earth (E), Jupiter (J), Saturn (S) and Uranus (U) are shown, as are the lower limits on the masses of known planetary systems as of December 2004 (triangles).

The working group surveyed the experiments that are planned or in prospect, and estimated their output qualitatively and quantitatively. Table 1 (see next page), expanded from a similar table in the report, summarises the situation for the next 15 years.

The projects can roughly be classified in "pathfinders", which find new populations, projects characterising populations as a whole, and finally projects aiming at detailed physical studies. It is crucial to have a good balance between these three categories of projects in order to ensure at the same time a consolidation of the current knowledge and a long-term development of the field.

The pathfinders typically expand the explored region of parameter space, and will lead to the discovery of a small number of objects, but these define new classes of planets. NACO on the VLT is a typical example: the instrument was originally not designed for planet search, but by opening a new window to high-resolution and high-contrast imaging, it led to the discovery of 2M1207b, the first planet detected by direct imaging, and the first planet around a brown dwarf. (The Messenger 120, 2005, page 25). HARPS has demonstrated its capability to explore the very-low mass end of the exoplanet mass distribution (Pepe et al. 2005, The Messenger 120, 22). The VLT Planet Finder is expected to make an important contribution to the study of bright, well separated planets for which it is built (therefore belonging to the "population study" projects), but its new capabilities will also put it in the pathfinder category, and one can expect new discoveries in regions that cannot be explored today.

Large, dedicated projects or missions are ideal to characterise a whole population: for instance, Kepler is expected to find tens of thousands of planets of a given type (transiting giants), therefore permitting a detailed study of the global properties of this population. A major programme using FLAMES for follow-up studies of transit candidates from OGLE has provided physical properties for seven planets and has demonstrated that small stellar companions are about as frequent as hot Jupiters, emphasising the need for spectroscopic confirmation and study of candidates (Pont et al. 2005, The Messenger 120, 19).

Finally, some experiments are best at performing detailed analysis of specific objects. For instance, while the number of planets that it will be able to reach is modest, the VLTI is expected to produce spectra of planets, which will be of extraordinary value for exoplanetology.

Method	Ground/Space	Time	Project	Pathfinder	Population $> 0.1\ M_{Jup}$ / $< 0.1\ M_{Jup}$	Spectroscopic studies
Radial Velocity	Ground	< 2004		First detection		
Radial Velocity	Ground	2004	Harps and others		120/0	
Adaptive Optics	Ground	2005	NACO	First direct detection	Few	Few
Interferometry	Ground	2005	VLTI	All nearby stars	Few	Some
Adaptive Optics	Ground	2010	VLT Planet finder	New parameter space	20/0	Some
Radial Velocity	Ground	2010	many		450/20	
Transit	Space	2008	COROT		200/50	
Transit	Ground	2010	many		1000/0	
Transit	Space	2010	Kepler		30000/1500	
Astrometry	Space	2015	SIM		250/25	
Astrometry	Space	2016	GAIA		20000/0	
Transit	Space	2016	GAIA		4000/0	
Photometry	Space	2016	GAIA	Protoplanetary collisions	3000/0	
Interferometry	Ground	2015	OWL partially filled		125000/60	
Photo-/Spectrometry	Ground	2018	OWL complete			60 “Jupiter” 5 “Earths”

Table 1: Prospects for the coming years. The first column lists the method used, the second identifies whether it is a ground-based or space-borne method. The third column gives an approximate time scale. Project identifies the name or class of the project. The next three columns summarise the main emphasis of the project, either as pathfinder (few, but significant discoveries), or in terms of the number of planets discovered for the projects aiming at defining the populations (detailed for planets more massive and less massive than 0.1 $M_{Jupiter}$), or finally in terms of detailed physical studies of the objects. This table is an expanded version of Table 5 in the report.

Beyond 2015 the current plans call for a detailed characterisation of individual planets and systems. In that framework, OWL could play an important role by searching for targets during its assembly phase (while the mirror is still partially filled), and then studying them in detail once the mirror is completed. Other projects, possibly by interferometry from Antarctica and by interferometers and coronographs in space, are also starting to be conceived.

ESA-ESO facilities

The working group then carefully analysed the future needs of research and what role current and planned facilities of ESA and ESO can be expected to play. Specifically they tried to give some answers to the following questions: What follow-up observations and facilities are required to characterise these systems more completely? What does the resulting (statistical) knowledge of exoplanet distributions imply for the targeted observations of Darwin and OWL? What information will be available, or should be anticipated, for a deeper astrophysical characterisation of the host stars of planetary systems? The working group also looked into the potential overlap amongst the major facilities currently planned or studied by ESO and ESA. They tried to identify specific long-lead time space or ground facilities which should be considered to fill observational gaps anticipated over the next 10–20 years? And, finally, they looked at other considerations that ESO/ESA should investigate for proper interpretation of the data which will be generated by these two European organisations, or others, and which might limit the development of the field unless suitably coordinated. From the above facts and considerations the working group then came up with recommendations to the agencies. The first goal is to establish an offensive policy to optimise the scientific return of instruments already built or foreseen in the near future. The second goal is to prepare new initiatives. Suggested directions are detailed in the report.

First steps towards implementation

ESO has established a high-level working group supervising the implementation of the report’s recommendations. A number of steps have already been initiated. For example ESO will study the feasibility of a high-resolution spectrograph on the VLT for radial-velocity work and for high-cadence transit spectroscopy. Coordinators have been appointed by both ESA and ESO to develop a plan for supporting observations from the ground for the COROT satellite mission. We are also carefully looking into the options for an amateur involvement in extra-planet research. Finally, ESO is undertaking a number of concept studies for OWL instrumentation at this point that will also address issues related to e.g. the search for earth-mass planets and the study of exoplanet atmospheres. ESO and ESA are committed to making sure that the findings and recommendations of the ESA-ESO working group are fully appreciated, and are studying how to best implement them.