EUROPEAN ASTRONOMICAL SOCIETY

NEWSLETTER

Issue 31. June 2006

Contents

EDITORIAL

Among the various topics of the present newsletter, the status of three infrared space missions, Spitzer, Akari, and Herschel, is presented by the corresponding Project Scientists. Twenty years ago the Infrared Astronomical Satellite (IRAS) opened a new window for the astronomical community resulting in major discoveries in a variety of research areas: from the properties of the zodiacal light, to the presence of debris disks around stars such as Vega, and the identification of hundreds of dust enshrouded ultraluminous infrared galaxies. Further advances were made possible ten years latter, when the Infrared Space Observatory (ISO), built by ESA, enabled for the first time infrared observations with high spectral resolution and good spatial resolution, at sensitivity levels 2 orders of magnitude fainter than IRAS. Since August 2003 the Spitzer Space Telescope has expanded the discovery space even more providing a leap of another factor of ~100 in terms of sensitivity compared to ISO. In addition to Spitzer, Akari, which was launched in February 2006, has been also successfully operating and over the next year it will produce an all sky map at a number of infrared wavelengths with substantially better resolution and to much greater depths than IRAS. Finally preparations for the upcoming launch of the Herschel Space Telescope, one of the cornerstones of the astrophysics science program of ESA, are well underway and the launch is expected in 2008. A large number of European institutes are involved in this project, which is expected to provide breakthroughs in the far-infrared in the both the Galactic and the Extragalactic front.

With only a fraction of the ISO data fully exploited so far, the high quality and volume of the Spitzer data, along with the ease of accessing them in their corresponding archives make this type of space missions an extremely valuable resource to the scientific community. The addition of the data from Akari and Herschel to the ones already available will clearly keep the astronomical community busy, at least in the infrared, for many years to come.

Vassilis Charmandaris
University of Crete, Greece

MESSAGE FROM THE PRESIDENT

We have no normal JENAM this year because the IAU General Assembly will be in Prague in August. I remind readers that the EAS will hold our own General Assembly on the morning of Monday, 21 August at the IAU venue. Meeting room 1.1 has been reserved for us. This will be my last meeting as your President and I hope to see you there.

EAS OFFICERS CHANGE

Other officers stepping down will be: Cesare Chiosi, Vice President; Joachim Krautter, secretary; Birgitta Nordstroem, Treasurer; and Michel Dennefeld and Oddbjorn Engvold, Councillors. On behalf of all our members, let me thank these colleagues for their efforts on our behalf.

Last autumn Council appointed a nominating committee, consisting of Françoise Combes, Boris Shustov, and chaired by

Lo Woltjer, to determine the slate of candidates for the Council positions that will become vacant this year. The committee proposed the following candidates, who have agreed to serve.

- President: Joachim Krautter, Landessternwarte Königstuhl, Heidelberg.
- Vice President: Thierry Courvoisier, Obs. de Genève, INTEGRAL Science Data Centre, Geneva.
- Secretary: Elias Brinks, Centre for Astrophysics Research, Univ. Hertfordshire, Hatfield, UK.
- Treasurer: Anne Dutrey, Lab. d'Astrodynamique, d'Astrophysique et d'Aeronomie, Bordeaux.
- Councillors: Ernesto Oliva, INAF/Telescopio Nazionale Galileo, IAC, La Palma; Alexander V. Stepanov, Central Astronomical Obs. Pulkovo, St. Petersburg.

The deadline for additional proposals has passed without new candidates coming forward, so these colleagues will formally take up their functions in Prague. Our thanks go out to Françoise, Boris and Lo for producing the slate.

Finally, I remind readers that the terms of Vice President Yaroslav Yatskiv, and Councillors Alvaro Giminez, Sabine Schindler and Milcho Tsvetkov are continuing so as to provide continuity.

Politics and planning

On the European stage interesting things are happening. While we wait for the budget and boundary conditions of the 7th Framework Programme to be sorted out, at least two other activities will be of importance to our members.

First, as noted last Newsletter, our national funding agencies have applied for an FP6 grant to network with each other, were successful and now have set up AstroNet to coordinate activities and plan for the future. A website that describes the plans is available at URL:
http://www.astronet-eu.org.

Of particular interest is a two phase consultation procedure. In the coming months, until roughly the end of the year, several ad hoc panels will develop a Science Vision document that tries to present a consensus of future scientific priorities across Europe. A draft will appear in the fall on the website, and comments from astronomers will be solicited, also via the website. I urge all our members to look for this document and to comment at length on its strengths and weaknesses. Then, from early next year a second phase discussion will start, aiming to present priorities for investment in both enhancements to existing telescopes and development of new large facilities. Contact persons for both discussions are Roger Davies, Oxford, and Tim de Zeeuw, Leiden.

Unclear at the moment is how these discussions will take account of parallel discussions in ESFRI (an inter-governmental forum), and in OPTICON, RadioNet, ILIAS etc, all of which also plan to produce priorities and infrastructure roadmaps in astronomy for use by governments. These bodies will likely produce their conclusions before those of the AstroNet panels. With luck, of course, everyone will agree and our future priorities really will clearly be consensual.

Second, governments are uncertain that all these independent discussions will lead to a clear outcome, but also whether that outcome will be politically acceptable. To maintain some semblance of control over the matter, several ministries are promoting discussion within the ESO Council concerning the role which that Council might play in deciding future European programs in astronomy. That is, the ESO Council is currently an inter-governmental forum that brings astronomers and ministry representatives together and in which multi-lateral decisions between governments can readily and efficiently be made. It could therefore be wise, is the thinking, to expand the Council's remit to allow consideration not just of the program for the ESO organization, but also for other activities in astronomy that might or might not involve ESO itself. Examples of such activities would include new telescopes for solar physics, radio astronomy, astroparticle physics, and so on.

It will be important for our members also to take note of these discussions and to contact their ESO Council members with their views. Because governments are involved the discussions will unavoidably be fairly secretive. But if any of our members feel strongly about whether and how ESO should evolve, now is the time to contact ESO Council members. A list of the latter may be found at URL:
http://www.eso.info/about-eso/organisation/committees/cou/.

This is also my last Message as your President. My term in office has been most interesting, as our Society has been closely involved in several developments important for the future of our science. We were also able in recent years to increase our activities on several fronts – our publications series, our JENAM job market, our survey of national investment priorities, etc – and we continued to sponsor JENAMs and to finance a grants program to encourage young people to attend those meetings. Still, I feel we have been less than successful in adding value at the level one might ultimately desire. There is no magic here – the solution lies in the ability of our members to contribute financially. The promise of European expansion is that all our economies will improve and make this possible within a matter of years. I leave office, therefore, in the expectation that my successors will be able to make the EAS an increasingly important force in European astronomy.

Harvey Butcher
President of EAS

NEWS

Open Session of the European Astronomical Society in Prague

During the IAU General Assembly a special day has been reserved and will be devoted to European matters. This will include the EAS General Assembly as well Initiatives from the EU Commission, Actions from the EAS, reports from various EU Networks and I3's, and possibly a Job Market.

The date for this European event has been fixed for the afternoon of Monday, August 21st, 2006.

The current program of this EAS Open Session is the following:

- 14:00h: Status of Astronet and its Science Vision plan (T. de Zeeuw)
- 14:20h: OPTICON- The largest EU Astronomy network: progress and plans. (J.K. Davies)
- 14:40h: RADIONET- Advanced radioastronomy in Europe: look in the future (L. Gurvitz)
- 15:00h: The situation of the astronomical Job market in Europe
  - Presentation of specificities in some countries (Germany, Italy, etc...)
  - The Marie Curie program and perspectives in FP7 (T. Meziani, EU Commission)
  - Discussion
- 16:30h: EAS General Assembly (with election of new council members)

For more information and last minute updates on this program you may visit the web page of EAS at:
http://www2.iap.fr/eas/meetings.html

AAS International Affiliate Membership

The American Astronomical Society (AAS) invites astronomers from around the world to become an International Affiliate member.

The AAS Council established The International Affiliate membership type to provide economical access to benefits and services most likely used by astronomers residing outside the United States. Current full AAS members are not required to change membership type.

The International Affiliate membership dues are USD 55 and include a variety of benefits. For more information, and an application, see
http://www.aas.org/membership/classes.html

The 2006 Call for Mission Proposals by ESA

At the May SPC it was agreed that the ESA Executive might proceed in mid-June 2006 the release of a Call for Mission Proposals for the space missions to fly post-2015. However it was recognised that this would be subject to the opinion of the Science Programme Review Team (SPRT), which had not met at the time of the SPC meeting.

The SPRT had been set up by the ESA Council on the recommendation of the SPC in March. The team met first on 18 and 19 May 2006 and discussed the issuance of the call both with the Director of Science and the Chair of SPC, as well as in closed-session. The outcome was a strong suggestion being made to the Director-General to postpone the Call until the Autumn of 2006. The view-point of the Team is that an additional few months delay would give an opportunity for reviews by the Team to take place and the thoughts of the Team to be consolidated on those parts of the future Programme management impacted by the structure of the call. In their opinion, therefore, despite the virtue of releasing the call before summer, the greater long-term interest to space science in Europe is better served by a delay of a few months.

In the circumstances, the Director of Science has agreed that the call will be delayed until the Autumn, at the latest, in order that the SPRT will be able to review this aspect of the programme.

For more information and updates visit:
http://sci.esa.int/science-e/www/area/index.cfm?fareaid=72

IAU Symposia in 2007

The following meetings, sponsored by the International Astronomical Union, will take place in 2007.

IAU SYMPOSIUM No. 242
Astrophysical Masers and their Environments
12-16 March 2007, Alice Springs, Australia
Contact: Jessica M. Chapman <Jessica.Chapman@csiro.au>

IIAU SYMPOSIUM No. 243
Star-Disk Interaction in Young Stars
1-5 April 2007, Grenoble, France
Contact: Jérôme Bouvier <jbouvier@laog.obs.ujf-grenoble.fr>

IAU SYMPOSIUM No. 244
Dark Galaxies and Lost Baryons
25-29 June 2007, Cardiff, UK
Contact: Jonathan I. Davies <jid@astro.cf.ac.uk>

IAU SYMPOSIUM No. 245
Formation and Evolution of Galaxy Bulges
16-20 July 2007, Oxford, UK
Contact: Martin Bureau <bureau@astro.ox.ac.uk>

IAU SYMPOSIUM No. 246
Dynamical Evolution of Dense Stellar Systems
5-9 September 2007, Capri, Italy
Contact: Enrico Vesperini <vesperin@physics.drexel.edu>

IAU SYMPOSIUM No. 247
Waves and Oscillations in the Solar Atmosphere: Heating and Magneto-Seismology
17-21 September 2007, Porlamar, Isla de Margarita, Venezuela
Contact: César A. Mendoza-Briceño <cesar@ula.ve>

IAU SYMPOSIUM No. 248
A Giant Step: from Milli- to Micro-arcsecond Astrometry
15-19 October 2007, Shanghai, China
Contact: Imants Platais <imants@pha.jhu.edu>

IAU SYMPOSIUM No. 249
Exoplanets: Detection, Formation and Dynamics
22-26 October 2007, Suzhou, China
Contact: Ji-Lin Zhou <zhoujl@nju.edu.cn>

12th LATIN-AMERICAN REGIONAL IAU Meeting (LARIM-2007)
26-30 November 2007, Isla de Margarita, Venezuela
Contact: Gustavo A. Bruzual <bruzual@cida.ve>

IAU SYMPOSIUM No. 250
Massive Stars as Cosmic Engines
10-14 December 2007, Kauai, Hawaii, USA
Contact: Paul A. Crowther <Paul.Crowther@sheffield.ac.uk>

Call for Proposals for IAU Symposia in 2008

The International Astronomical Union (IAU) welcomes Letters of Intent (LoI) for Proposals for IAU Symposia to be held in 2008. The rules and guidelines give are available at http://solarphys.uio.no/IAU/

The deadline for the Letters of Intent (LoI) is September 15, 2006, while the final deadline for submitting the Proposals is December 15, 2006.

News From OPTICON

OPTICON continues to make excellent progress, both with its FP6 programme and with defining its plans for FP7.

Recent events have included a workshop on High Time Resolution Astrophysics organised by the HTRA network in June. Held at the National University of Ireland in Galway, this two day meeting reviewed the scientific results from existing instruments working in the high time resolution regime and looked forward to the developments needed to take this subject forward. A book summarising the meeting will be published in due course.

The NUVA Ultra Violet astronomy network are well in the way to a major milestone with their review of the state of the art in UV astronomy and the needs for the next generation of UV instruments being in press at Kluwer-Springer. They also plan a joint discussion at the IAU General Assembly in Prague and a major conference in 2007.

JRA-5, our smart focal planes project, has completed the production of the prototype star-picker, a device to pick and place small pick-off mirrors anywhere on a curved focal plane surface of a future multi-object instrument for a large telescope. The was device displayed at the SPIE conference in Orlando, Florida where it attracted much interest. At the seem meeting the Key Technologies Network presented one of its instrumentation roadmaps, setting out the technologies likely to be needed for astronomy in the next two decades

The ELT working group continues to work hard in collaboration with ESO to define plans for a European ELT and a joint ESO-OPTICON meeting entitled "Towards the European ELT" is scheduled for Marseilles in France from 27th Nov to 1st Dec 2006 The meeting is organized in 3 main sessions: Science (1.5 day), Presentation by ESO of the E-ELT status and discussion (1.5 day), Instrumentation (1 day). Contributed talks and posters are invited for the Science and Instrumentation sessions. For details please see http://www.elt2006.org.

The process of planning for FP7 has begun in earnest with OPTICON sponsored meetings on a variety of subjects being held to start people thinking about what they hope to do in the next EU framework programme. A highly sucessfull brainstorming on Adaptive Optics was held in Paris under the guidance of JRA-1 PI Norbert Hubin and the European Interferometry Initiative also met and confirmed that their plans were to continue to develop interferometry within the OPTICON community. European solar astronomers also expressed a desire to work for their future with an expanded Framework 7 OPTICON project. June 22-23 saw the first culmination of these efforts as the existing OPTICON contractors had a 2 day meeting to describe their aspirations for FP7. A huge package of potential projects, networks and access was put on the table in a day and half of almost non-stop presentations. The OPTICON board will now start the process of opening up our plans to as wide a community as possible ahead of the EU deadline, currently foreseen in about 15 months time.

OPTICON will be represented at the forthcoming IAU General Assembly in Prague where we will have a small booth in the exhibition hall, do drop by and see us if you are going to the IAU. A paper will presented in the European Astronomy session on Monday 21st. The next board meeting will be held in Heidleberg in October. As always more information can be obtained from www.astro-opticon.org or by contacting the project scientist, John Davies (jkd@roe.ac.uk) or the chairman Gerry Gilmore (gil@ast.cam.ac.uk)

John Davies
OPTICON Project Scientist,
UKATC, Royal Observatory, Edinburgh

The Spitzer Space Telescope

Introduction. The launch of the National Aeronautics and Space Administration's (NASA's) Spitzer Space Telescope (Spitzer) in 2003 provided the scientific community the most powerful tool yet available for astronomical explorations between 3.6 and 160μm. Spitzer combines the intrinsic sensitivity of a cryogenic telescope in space with the tremendous imaging and spectroscopic capabilities of the new generation of infrared detector arrays. As the infrared member of NASA's family of Great Observatories, Spitzer has been used very successfully in multi-spectral studies with its companion observatories, the Chandra X-Ray Observatory (CXO) and the Hubble Space Telescope (HST). Spitzer has also observed objects currently accessible only in the infrared. Detailed technical descriptions of Spitzer and its three focal plane instruments are available in the September, 2004, special issue of the Astrophysical Journal Supplement and also in v.5487 of the SPIE Proceedings.

Orbit. Spitzer utilizes an Earth-trailing heliocentric, or solar, orbit. As seen from Earth, Spitzer recedes at about 0.1 au per year and will reach a distance of 0.62 au in five years. For Spitzer, the Earth-trailing orbit has several major advantages over near-Earth orbits. The principal advantage is the distance from Earth and its heat; this facilitates the extensive use of radiative cooling, which makes Spitzer's cryo-thermal design extremely efficient. The orbit also permits excellent sky viewing and observing efficiency. Spitzer is constrained to point no closer than 80 degrees toward and no further than 120 degrees from the Sun, but even with these constraints 35% of the sky is visible at any time, and the entire sky is visible every six months. Even points in the ecliptic plane are visible for at least 80 days per year, broken into two 40-day continuous viewing periods. Finally, in a solar orbit the observatory is not affected by the charged particles in the Van Allen radiation belts. The orbit has one major disadvantage: as Spitzer moves away from the Earth, the power margins for downlink and uplink communication decrease, forcing changes in communication strategy and eventually reducing efficiency as more time is spent downlinking. The data is downlinked through the dishes of the Deep Space Network (DSN) by orienting Spitzer with its fixed X-band antenna pointed at the Earth. Our current downlink strategy of one or two ~45 minute passes per day and a downlink data rate of 2.2 Mb/s is robust for the projected cryogenic lifetime of at least five years, although the 70-m DSN dishes will have to be used for the final three years. The technical advantages of this solar orbit are shared by the L2 orbit in use for the Wilkinson Microwave Anisotropy Probe (WMAP) and planned for the Herschel Space Observatory, the Planck spacecraft, and the James Webb Space Telescope (JWST). The solar orbit has an additional advantage in that no station-keeping or propulsion is required following launch, while the L2 missions have a more favorable communications geometry.

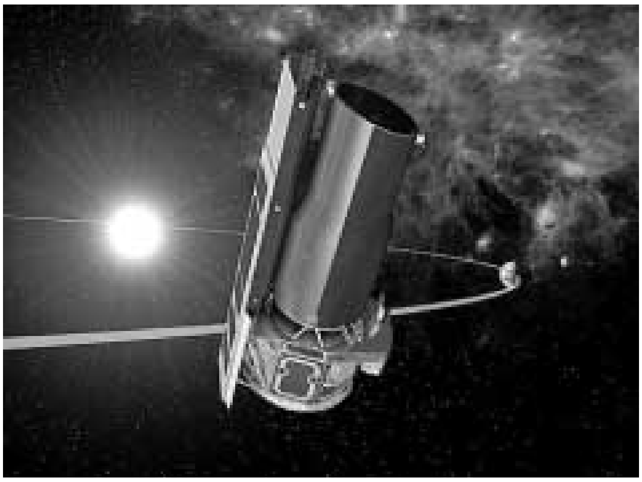

Fig.1 Artist rendition of Spitzer in its heliocentric orbit

Observatory Architecture. Spitzer divides naturally into elements which are either warm or cold on orbit. The warm components - the spacecraft and solar panel were provided by Lockheed Martin. The spacecraft has proven to be very robust and provides subarcsecond pointing accuracy and stability. The telescope, cryostat, and associated shields and shells make up the Cryogenic Telescope Assembly (CTA), built by Ball Aerospace. The CTA also contains the three instruments, two of which were built by Ball and one by NASA-Goddard Space Flight Center.

Cryo-thermal Design. Spitzer employs a novel architecture in which the greater part of the CTA was launched while at room temperature; only the science instrument cold assemblies and the superfluid helium vessel were cold within the vacuum cryostat shell. This allowed a much smaller vacuum pressure vessel and a smaller observatory mass than achieved by the cold launch architecture used in the IRAS and ISO missions. A combination of passive radiative cooling and helium boil-off vapor cools the components of the CTA after launch, using a concept developed by F. Low. Radiative cooling works for Spitzer because the solar orbit allows the spacecraft always to be oriented with the solar array pointed toward the Sun, while the Earth is so distant that its heat input is negligible. The system of reflective and emitting shells and shields, which is always shadowed by the solar array, rejects almost all the heat that leaks inward while radiating the small amount not rejected into the cold of deep space. The outermost CTA shield—the outer shell—achieved an operating temperature of 34 to 34.5 K solely by radiative cooling. This establishes a very cold boundary within which a small amount of cold helium vapor is able to keep the telescope at operating temperature. With this added cooling, the telescope achieved its operating temperature of 5.5 K some 41 days after launch. The performance of the cryo-thermal system on orbit has exceeded expectation. Measurements of the system's helium volume suggest that Spitzer's cryogenic lifetime will exceed five years, extending well into

CY2009. Following the depletion of the cryogens, the telescope will warm up, but it will still be colder than the outer shell; current estimates suggest that the temperature will be <30 K. At this temperature, both the instrumental background and the detector dark current should be low enough for Spitzer to continue natural background-limited operations in the shortest wavelength IRAC bands at 3.6 and 4.5μm.

Fig.2 Spitzer after the CTA at Lockheed Martin

Optics. Spitzer has an f/1.6 primary mirror with a diameter of 85 cm and a Ritchey-Chretien Cassegrain optical design with system f-ratio f/12. The telescope optics and metering structure are constructed entirely of Beryllium so that changes in both the telescope prescription and its alignment with the focal plane are minimized as the telescope cools on-orbit. A focus mechanism was installed on the secondary mirror to compensate for any changes in focus due to gravity release and uncertainties in the ground testing of the telescope. In response to on-orbit measurements of the image quality as the telescope reached its equilibrium temperature, this mechanism was used to adjust the position of the secondary mirror by ~10μm, producing an axial motion of the position of best focus by ~1mm. The resulting imaging quality is excellent, and the Spitzer telescope provides diffraction-limited performance at all wavelengths greater than 5.5 μm. Measurements taken after the completion of the focus campaign revealed that the three instruments are confocal to within their depths of focus.

Instruments. Spitzer's three instruments are situated in the multiple instrument chamber behind the primary mirror. Together, the three instruments provide imaging and photometry in eight spectral bands between 3.6 and 160 μm and spectroscopy and spectrophotometry between 5 and 95 μm. They share a common focal plane, with their fields of view defined by pickoff mirrors. The instruments the use of state-of-the-art infrared detector arrays in formats as large as 256_256 pixels, with typical imaging fields of view of 5x5 arcminutes. Spitzer's telescope is not much larger than that used in ISO; it is worth reiterating that the dramatic scientific advances which Spitzer is achieving are largely due to the size and quality of these arrays. For broadband imaging and low spectral resolution spectroscopy, Spitzer has achieved sensitivities close to or at the levels established by the natural astrophysical backgrounds—principally the zodiacal light—encountered in Earth orbit. The only moving part in use in the entire science instrument payload is a scan mirror in the Multiband Imaging Photometer for Spitzer (MIPS).

Operations. The Spitzer Science Center at Caltech (SSC: www.ssc.spitzer.caltech.edu) maintains the user operational interface for Spitzer. It is responsible for science program selection and scheduling, data calibration and pipeline processing, and data distribution and archiving. As is done for the other Great Observatories, the SSC annually issues calls for General Observer proposals. The Astronomical Observational Template (AOT) is the underlying principle of Spitzer's science operations. The AOT is a web-based form that the user completes to define a particular observation. A completed AOT becomes an Astronomical Observational Request (AOR), which expands directly into a series of spacecraft commands. The executed command sequence consists of a series of AORs, each individually lasting between ten minutes and six hours, interspersed with spacecraft activities such as pointing system calibrations and data downlink. These command sequences are prepared in one week blocks starting several weeks before they are uploaded and executed. For a high-priority target of opportunity, a new sequence can be generated and executed on board within about 48 hours of the decision to carry it out. This flexibility was used to observe both a gamma ray burst afterglow and a microlensing event in the SMC during the first two years of the mission. The campaign scheduling and the excellent sky visibility from solar orbit allow Spitzer to operate with very high efficiency. In a typical week, only 10% of the wall clock time goes to downlinking, target-to-target slews, and spacecraft engineering activities. Spitzer spends 90% of the time carrying out either observations or necessary campaign-level calibration activities.

Science. Even at this early stage there are many more results in hand from Spitzer than can be discussed in a short paper such as this. The initial results from the mission appear in a dedicated special issue of the Astrophysical Journal Supplement, September 1, 2004, and additional results appear almost daily. Spitzer has measured the composition of the ejecta from the Deep Impact encounter with Comet Tempel I, made the first direct detection of light from extra-solar planets, characterized the sources responsible for the diffuse far infrared background, and identified surprisingly massive and mature galaxies at redshifts as high as 6. Werner et al have prepared a review of the first two years of Spitzer galactic and solar system science which appears in Vol. 44 of Annual Reviews of Astronomy and Physics, dated 2007. Additional early mission Spitzer science results appear in the proceedings of the first two Spitzer science conferences “New Views of the Cosmos” and “Infrared Diagnostics of Galaxy Evolution”, to appear in the Astronomical Society of the Pacific Conference Series. The SSC maintains an archive of particularly newsworthy Spitzer images, data, and scientific results which have been released for public affairs purposes.

Scientific Utilization. Perhaps of greatest interest to the readers of this newsletter is the fact that observing time on Spitzer is available competitively to the international scientific community. With the heritage of IRAS and ISO and an active group of astronomers, the European community has been active and visible in the Spitzer science programs. Over 100 of the 600+ General Observer proposals submitted in the recently concluded GO cycle 3 were from European institutions, and a casual glance at the selected proposals listed on the SSC web site shows that many of these were successful. There will be two more General Observer cycles during the helium-cooled phase of the mission. The call for Cycle 4 General Observer proposals will be distributed by the Spitzer Science Center around November 2006, with proposals due around February 2007. If the pattern followed in the previous three cycles persists, Cycle 4 will award around 6000 hours of Spitzer observing time, and individual programs requiring as much as 500 hours will be accepted. Interested scientists should monitor the Spitzer Science Center at www.ssc.spitzer.caltech.edu for updates on the performance of Spitzer and the schedule for the proposal process.

Summary. The technical and scientific triumphs of Spitzer set the stage for follow-on infrared missions being developed or planned by NASA, ESA, and the Japanese Space Agency. The most ambitious of these, the Japanese SPICA mission and the NASA/ESA/CSA James Webb Space Telescope, will launch in the next decade. Together, these missions promise to provide the astronomical community with continuous access to the infrared spectral band to extend the remarkable exploration begun by Spitzer, just as Spitzer itself builds on the predecessor IRAS and ISO missions.

Michael Werner
Spitzer Space Telescope Project Scientist
Jet Propulsion Laboratory / California
Institute of Technology

Portions of the research described here were carried out at the Jet Propulsion Laboratory, operated by the California Institute of Technology under contract with the National Aeronautics and Space Administration.

AKARI - A NEW ALL-SKY INFRARED SURVEY MISSION

AKARI (formerly known as ASTRO-F), is the second space mission for infrared astronomy from the Institute of Space and Astronautical Science (ISAS) of the Japanese Aerospace Exploration Agency (JAXA). Its main objective is to perform an all-sky survey with better sensitivity, spatial resolution and wider wavelength coverage than IRAS, mapping the entire sky in six infrared bands from 9 to 180 µm.

Figure 1- The Launch of AKARI on 21 February 2006.

AKARI will also perform pointed observations over the wavelength range 2-180 μm in 13 bands, providing comprehensive multi-wavelength photometric and spectroscopic coverage of a wide variety of astronomical sources: nearby solar system objects, zodiacal light, brown dwarfs, young stars, debris disks and evolved stars in our Galaxy and in other galaxies of the Local Group. It will also probe galaxy evolution and the large scale structure in the Universe out to great distances. In addition, an extensive coverage of two high-visibility regions, the Large Magellanic Cloud and the North Ecliptic Polar region will be performed.

ESA is collaborating with JAXA/ISAS in order to increase the scientific output of the mission by capturing all of the possible data (providing tracking support from the ESA ground station in Kiruna) and to accelerate the production of the sky catalogues, which will be extremely valuable in the exploitation of the Herschel and Planck missions, in return for 10% of the observing opportunities in the non-survey part of the mission, distributed to European scientists, via Calls for Proposals, followed by peer-review.

The ISO Data Centre team at ESAC provides attitude reconstruction for the survey data and support to European users for the pointed observations. A consortium including Imperial College University of London, Open University, University of Kent, Sussex University, and SRON-Groningen with University of Groningen participates on the data reduction of the All-Sky Survey. Seoul National University representing the Korean community also joins the data reduction activity.

AKARI has a 68.5 cm-diameter telescope cooled down to 6K and observes in the wavelength range 2-180 μm from a sun-synchronous polar orbit at 700 km altitude. It was successfully launched on 21 February 2006 (UT) by an M-V rocket from the Uchinoura Space Center (USC), Japan. On 13 April, during the second month of the system checkout and verification of the overall satellite performance, the AKARI telescope's aperture lid was opened and the on-board two instruments commenced their operation. These instruments - the Far Infrared Surveyor (FIS) and the near-mid-infrared camera (IRC) - make possible an all-sky survey in six infrared wavebands. First images from the mission have confirmed the excellent performance of the scientific equipment.

AKARI's two instruments were pointed toward the reflection nebula IC4954, a region situated about 6000 light years away, and extending more than 10 light years across space. Reflection nebulae are clouds of dust which reflect the light of nearby stars. In these infrared images of IC4954 _ a region of intense star formation active for several million years – it is possible to pick out individual stars that have only recently been born. They are embedded in gas and dust and could not be seen in visible light. It is also possible to see the gas clouds from which these stars were actually created. These beautiful views already show how, thanks to the better sensitivity and improved spatial resolution of AKARI, it will be possible to discover and study fainter sources and more distant objects which escaped detection by the previous infrared sky-surveyor, IRAS, twenty years ago.. With the help of the new infrared maps of the whole sky provided by AKARI it will be possible to resolve for the first time heavily obscured sources in crowded stellar fields like the centre of our Galaxy.

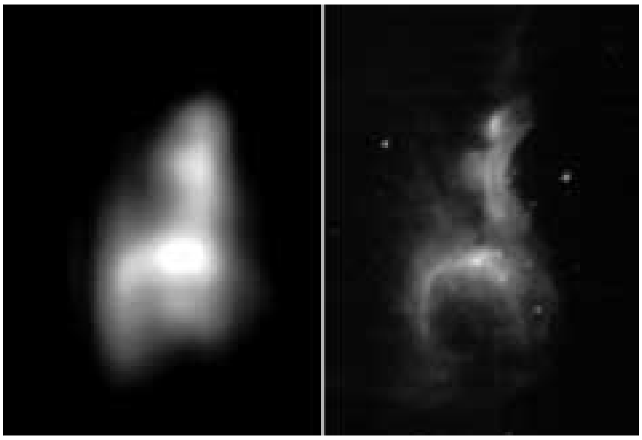

Figure 2 - IC4954 reflection nebula (90μm and 9μm)

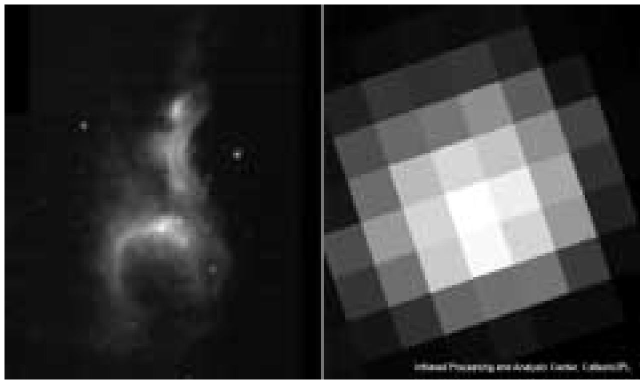

Figure 3 – IC4954 at 9μm (AKARI) compared with an IRAS 12μm image

With its near-mid-infrared camera, AKARI also imaged the galaxy M81 at six different wavelengths. M81 is a spiral galaxy located about 12 million light years away. The images taken at 3 and 4 microns show the distribution of stars in the inner part of the galaxy, without any obscuration from the intervening dust clouds. At 7 and 11 microns the images show the radiation from organic materials (carbon-bearing molecules) in the interstellar gas of the galaxy. The distribution of the dust heated by young hot stars is shown in the images at 15 and 24 microns, showing that the star forming regions sit along the spiral arms of the galaxy.

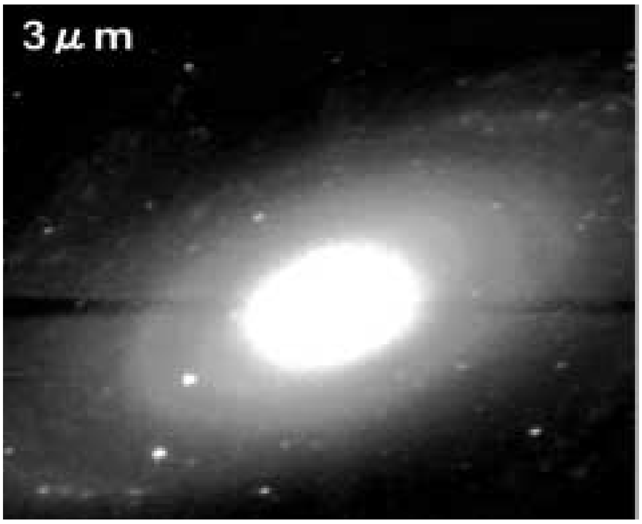

Figure 4 - M81 galaxy (3μm)

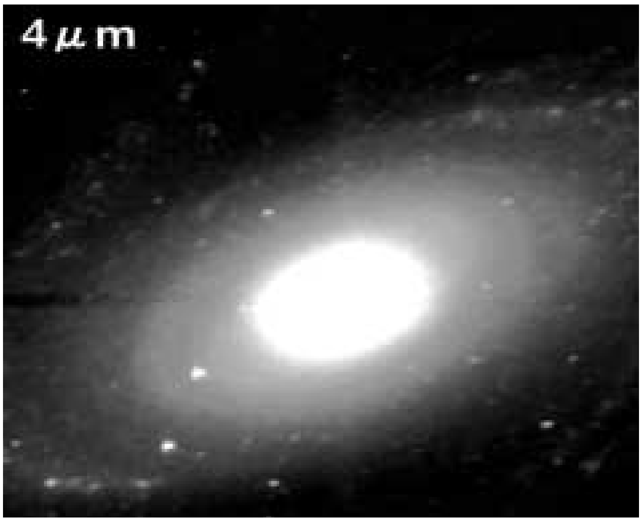

Figure 5 - M81 galaxy (4μm)

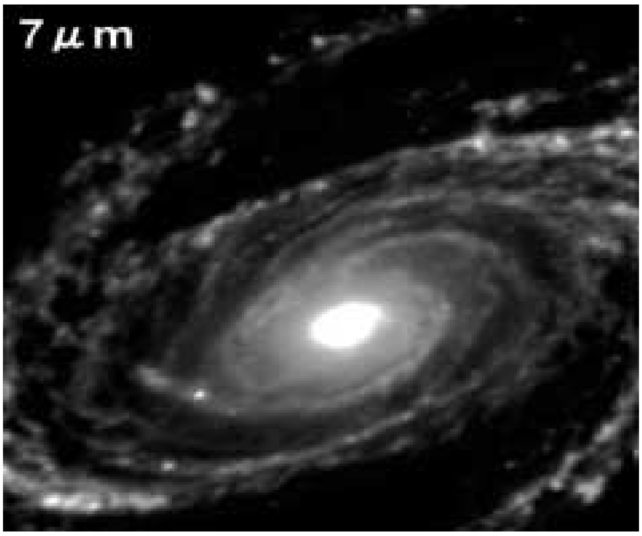

Figure 6 - M81 galaxy (7μm)

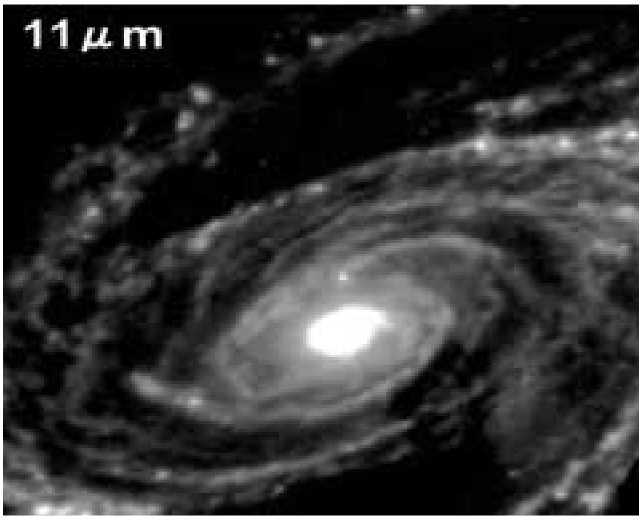

Figure 7 - M81 galaxy (11μm)

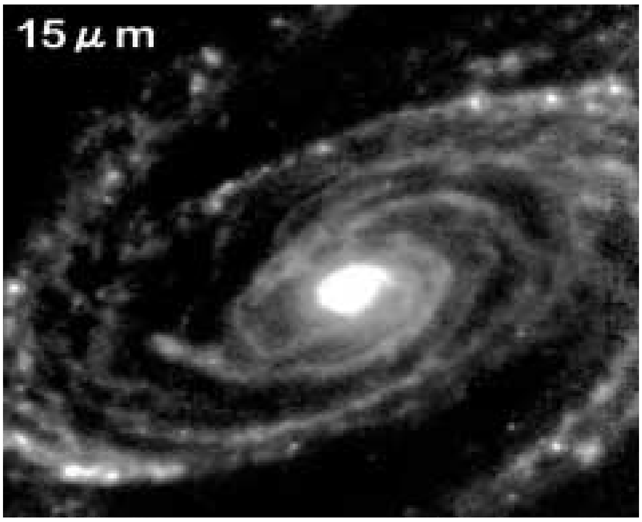

Figure 8 - M81 galaxy (15μm)

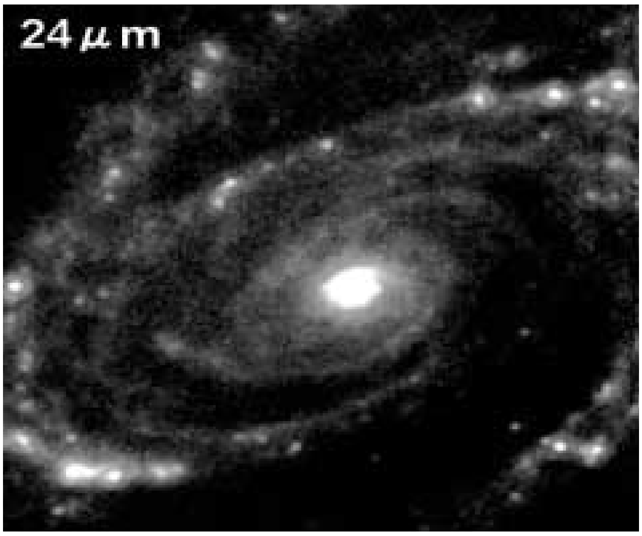

Figure 9 - M81 galaxy (24μm)

Having concluded all in-orbit checks, AKARI is currently in the first mission phase. This will last about six months and is aimed at performing a complete survey of the entire infrared sky. This part of the mission will then be followed by a phase during which thousands of selected astronomical targets will be observed in detail. European astronomers will have access to ten percent of the overall pointed observation opportunities. A Call for Observing Proposals, issued in September 2005, resulted in 50 proposals from 42 Principal Investigators in 9 European Countries. These have been peer-reviewed by an ESA appointed Time Allocation Committee and then merged with the proposals from the parallel Japanese Call. Successful proposals will be executed in the period starting in Autumn 2006. A subsequent Call will be issued to cover the third and last phase of the mission, where the near infrared camera will continue operation further to cryogen consumption. More information on AKARI and its operations can be obtained from

http://astro-f.esac.esa.int/

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Herschel - the next infrared space observatory

Introduction

The Herschel Space Observatory (normally referred to as Herschel) is the next next ESA 'flagship' mission. It is an observatory mission that will provide unrivalled observing opportunities in the relatively poorly explored 57-670 μm part of the far infrared and submillimetre spectral range. Herschel will provide 3 years of routine science operations starting in 2008, two thirds of this time is open time available to the entire astronomical community through a normal competitive time allocation procedure.

Scientific objectives

Herschel will bridge the wavelength gap between earlier infrared missions like IRAS and ISO, and the currently operating Spitzer and Akari, which all are limited to wavelengths shortward of ~200 μm with much smaller apertures, and what with great difficulty has been achieved by groundbased observatories around and beyond its long wavelength end.

Herschel is the only space facility dedicated to this part of the spectral range. Its vantage point in space provides several decisive advantages. The large telescope will be passively cooled and thermally stable, its low emissivity and the total absence of atmospheric emission offers a low and stable background enabling very sensitive photometric observations. The absence of even residual atmospheric absorption gives full access to the entire range of this part of the spectrum, which offers the capability to perform completely uninterrupted spectral surveys. Herschel will address questions related to how galaxies formed and how they evolved to give rise to the present day galaxies, as well as how solar systems like our own are forming – in the past and today.

Herschel is specifically designed to observe the 'cool universe'; it has the potential of discovering the earliest epoch proto-galaxies, revealing the cosmologically evolving AGN-starburst symbiosis, and unravelling the mechanisms involved in the formation of stars and planetary system bodies. Redshifted ultraluminous infrared dominated galaxies, with spectral energy density functions (SEDs) that peak in the 50-100 μm range in their rest frames, as well as class 0 proto-stars and pre-stellar objects in our own and nearby galaxies have SEDs that peak in the Herschel 'prime band'. Herschel is also well equipped to perform spectroscopic follow-up observations to further characterise particularly interesting individual objects.

Targets for Herschel will include the lowest emission regions of the sky as well as clouds of gas and dust where new stars are being born, disks out of which planets may form, and cometary atmospheres packed with complex organic molecules.

From past experience, it is also clear that the 'discovery potential' is always significant when a new capability is being imple-mented for the first time. Observations have never been performed in space in the 'prime band' of Herschel. As a space facility is essential in this wavelength range and Herschel will be providing unrivalled new observing capabilities it can be expected to be breaking new ground!

Spacecraft and payload

The Herschel spacecraft configuration (Fig. 1) is based on the well proven ISO cryostat technology. It is modular, consisting of the 'extended payload module' (EPLM) comprising the superfluid helium cryostat - housing the optical bench with the instrument FPUs (Fig. 2) - which supports the telescope, the sunshield/shade, and payload associated equipment; and the 'service module' (SVM), which provides the necessary 'infrastruc-ture' and houses the 'warm' payload electronics. It measures approximately 7.5 m in height, 4 m in width, and has launch mass of order 3000 kg.

Figure 1: The Herschel satellite during the mechanical qualification campaign in the ESTEC Test Centre. The picture was taken on 1 February 2006 during a Herschel Science Team meeting.

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Herschel will be equipped with a 3.5 m diametre low background telescope, and a complement of three scientific instruments. The telescope will be passively cooled - by placing it outside the cryostat it is possible to maximise its size - while the instrument focal plane units will be mounted on a common optical bench housed inside a cryostat containing superfluid helium at a temperature below 1.7 K. The bolometer arrays in PACS and SPIRE (see below) will be cooled to approximately 300 mK using dedicated instrument provided sorption coolers.

The Herschel telescope (Fig. 3) is a classical Cassegrain with a 3.5 m diameter primary and an 'undersized' secondary, and a total wavefront error of less than 6 µm. It must also have a very low emissivity to minimize the background signal, and the whole optical chain must be optimised for high straylight rejection. Manufactured of silicon carbide (SiC) and protected by a fixed sunshade, in space the telescope will radiatively cool to an operational temperature in the vicinity of 80 K, with very low thermal gradients and variations.

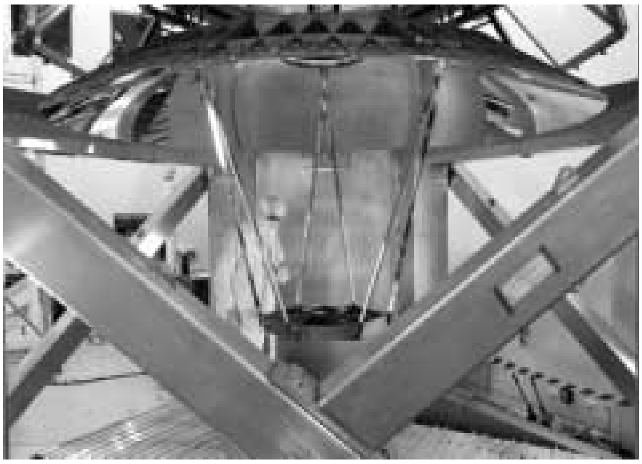

Figure 3: The Herschel telescope, shown during warm alignment activities in Astrium (Toulouse) in late summer 2005.

The 'Photodetector Array Camera and Spectrometer' (PACS, PI: Albrecht Poglitsch, MPE) instrument is Herschel's short wavelength camera and low to medium resolution spectrometer, it covers wavelengths up to approximately 205 µm. PACS employs in total four detector arrays, two bolometer arrays for photometry, and two 'bulk' Ge:Ga photo-conductor arrays for spectroscopy. It can be operated as a photometer, fully sampling a field of view of 1.75 x 3.5 arcmin on the sky simultaneously in two broadband colours (either of the 60-85 or 85-130 µm bands plus the 130-210 µm band). Alternatively, it performs imaging integral field line spectroscopy covering just under 1 arcmin square on the sky with spectral resolution in the range 1500-4000 depending on wavelength (higher for the shorter wavelengths) with 16 spectral elements for exery pixel on the sky.

The 'Spectral and Photometric Imaging REceiver' (SPIRE, PI: Matt Griffin, Univ. Cardiff) instrument is Herschel's long wavelength camera and low to medium resolution spectrometer, it covers wavelengths longer than approximately 200 µm. Although PACS and SPIRE functionally complement each other, together covering the entire Herschel spectal range, they utilise very different design solutions. SPIRE comprises an imaging photometer and a Fourier Transform Spectrometer (FTS), both of which use 'spider web' bolometer detector arrays with individual feedhorns for each detector. There are a total of five arrays, three dedicated for photometry and two for spectroscopy and spectrophotometry. As a photometer, SPIRE covers a large 4x8 arcmin field on the sky which is imaged in three colours (centred on 250, 360, and 520 µm simultaneously, and in spectroscopy a field approximately 2.6 arcmin across with spectral resolution in the range tens to hundreds.

The 'Heterodyne Instrument for the Far Infrared' (HIFI, PI: Thijs de Graauw, SRON) instrument is a heterodyne spectrometer, providing a very high velocity resolution spectroscopy. HIFI offers high sensitivity by employing low noise detection using superconductor-insulator-superconductor (SIS) and hot electron bolometer (HEB) mixers. Five dual polarisation SIS mixer bands cover the frequency range 490-1250 GHz, and the two HEB bands cover 1410-1910 GHz. The observed signal is mixed with a stable monochromatic local oscillator signal to provide an intermediate frequency signal which is amplified and fed to the acousto-optical and autocorrelation spectrometrer backends. HIFI covers just a single pixel on the sky, but with thousands of spectral channels, and builds up spectral images ('data cubes') either by raster mapping or by employing 'on-the-fly' scanning.

Mission and science operations

Herschel will share an Ariane 5 ECA launcher with the Planck CMB mission. Both spacecraft will be injected into a transfer trajectory towards the second Lagrangian point (L2) in the Sun-Earth system. They will then separate from the launcher, and subsequently operate independently, proceding to orbits of different sizes around L2 point that offer stable thermal environment with good sky visibility. Commissioning and performance verification will take place enroute towards L2, followed by a science demonstration phase. Once these crucial mission phases have been successfully accomplished Herschel will go into routine science operations, nominally 6 months after the launch.

Herschel will be an observatory open to the general astronomical community. It will perform routine science operations for a minimum duration of 3 years (until depletion of the helium). The available observation time will be shared between guaranteed time (one third) 'owned' by contributors to the Herschel mission (mainly by the PI instrument consortia), and open time which will be allocated to the general community (including the guaranteed time holders) on the basis of calls for observing time. The initial call for observing proposals is planned to be issued in winter 2006/07, the exact date is still subject to optimisation.

The Herschel Science Centre (HSC) will act as the interface to the science community providing information and user support related to the entire life-cycle of an observation, from calls for observing time, the proposing procedure, proposal tracking, data access and data processing, as well as general and specific information about using Herschel and its instru-ments. All scientific data will be archived and made available to the data owners, after the proprietary time has ex-pired the data will be available to the entire astronomical community.

Status and further information

The first actual spacecraft hardware to show up for testing in the ESTEC Test Centre was the SVM structural thermal model (STM) arriving in spring 2005. It was followed by the proto-flight model cryostat in early autumn, both were tested in the Large Space Simulator (LSS). The entire spacececraft in STM configuration underwent mechanical qualification in early 2006. The flight telescope is under cryotesting since late autumn 2005.

The current planning envisages a series of milestones, including instrument and telescope flight model deliveries to ESA in the course of 2006, to be followed by spacecraft integration and extensive testing and verification activities in 2007, leading to the launch in 2008. Once launched routine science operations are planned to commence about 6 months later.

Additional information – and eventually the AO for observing proposals – can be found on the ESA Herschel Science Centre 'Herschel astronomers website' at http://www.rssd.esa.int/herschel/ which also provides links to additional ESA and external Herschel related websites.

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