HIPPARCHOS

The Hellenic Astronomical Society Newsletter

Volume 2, Issue 5

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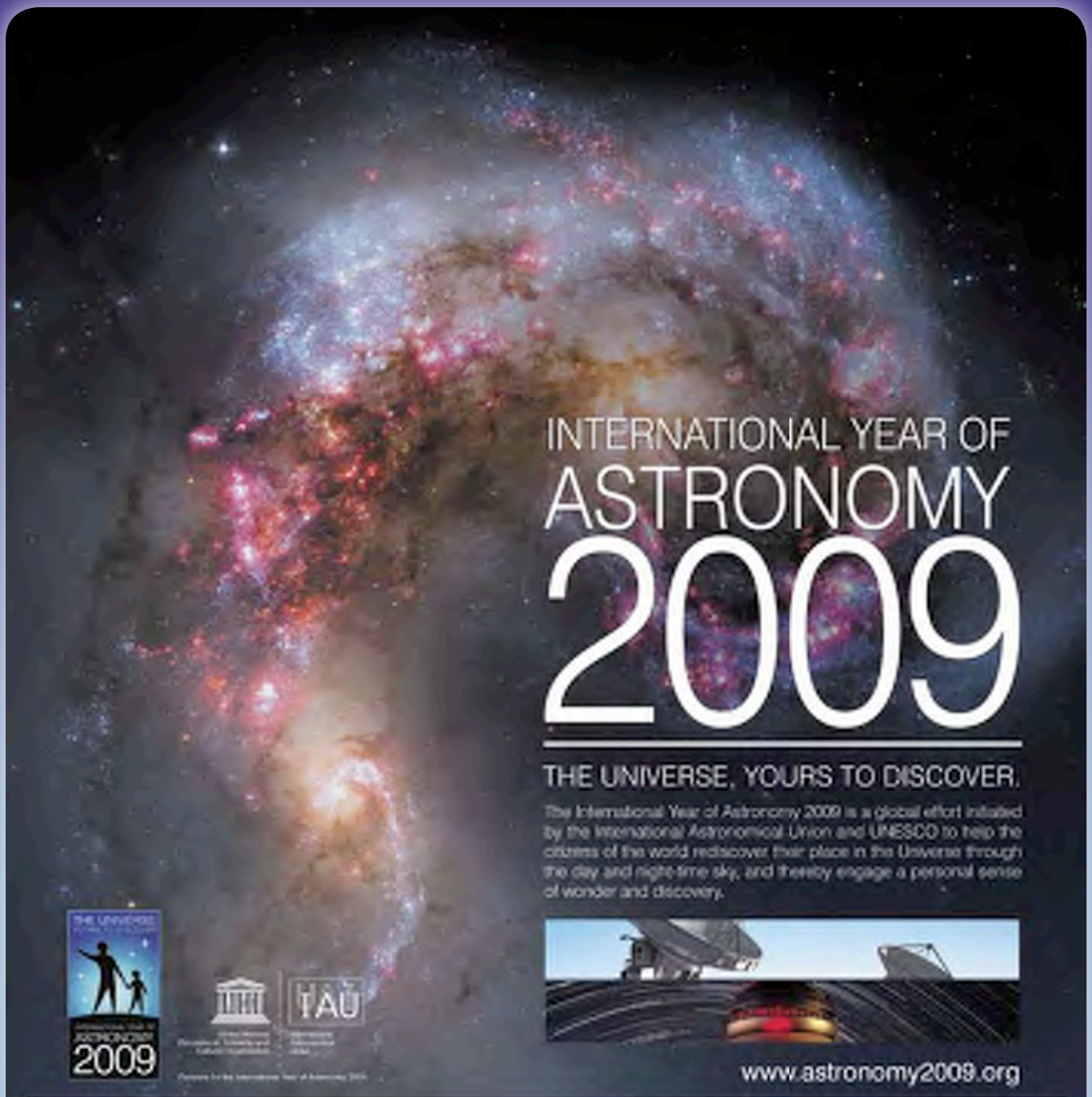

INTERNATIONAL YEAR OF ASTRONOMY 2009

THE UNIVERSE, YOURS TO DISCOVER.

The International Year of Astronomy 2009 is a global effort initiated by the International Astronomical Union and UNESCO to help the citizens of the world rediscover their place in the Universe through the day and night-time sky, and thereby engage a personal sense of wonder and discovery.

www.astronomy2009.org

Vision

The International Year of Astronomy 2009 aims to help everyone realise the impact that astronomy and other fundamental sciences have on our daily lives, and understand how scientific knowledge can contribute to a more equitable and peaceful society.

IYA2009 activities will take place locally and globally. Nodes have been formed in over 120 nations to plan activities and establish collaborations between science centres, astronomers, educators, enthusiasts, artists and many others.

To help coordinate the huge global programme and to provide an important point of contact for the participating countries, the International Astronomical Union has established a central Secretariat and website (www.astronomy2009.org) as the principal IYA2009 resource for the public, professionals and media.

Goals

1. Increase scientific awareness.
2. Promote widespread access to new knowledge and observing experiences.
3. Empower astronomical communities in developing countries.
4. Support and improve formal and informal science education.
5. Provide a modern image of science and scientists.
6. Facilitate new networks and strengthen existing ones.
7. Improve the gender-balanced representation of scientists at all levels and promote greater involvement by underrepresented minorities in scientific and engineering careers.
8. Facilitate the preservation and protection of the world's cultural and natural heritage of dark skies in places such as urban oases, national parks and astronomical sites.

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HIPPARCHOS

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Hipparchos is the official newsletter of the Hellenic Astronomical Society. It publishes review papers, news and comments on topics of interest to astronomers, including matters concerning members of the Hellenic Astronomical Society.

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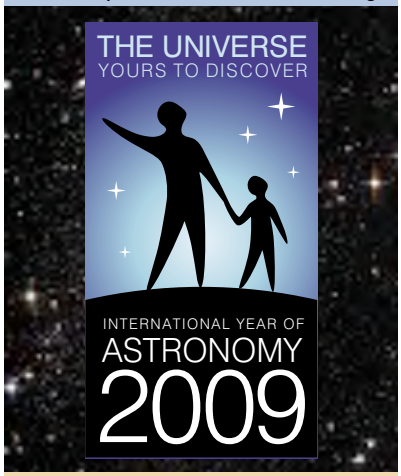


Cover photo:
Logo of the International Year of Astronomy

Editorial assistance is needed!

To improve the contents of Hipparchos please provide us with information related to your Institute or with exciting news from your field of research.

Editorial

Dear members and friends of HelAS,

I have been appointed by the recently elected governing council of HelAS as the new editor of Hipparchos, substituting Professor K. Kokkotas, who successfully completed two terms as a member of the council of HelAS. It will be a great challenge for me to contribute, at any significant level, to the already up-grated and wonderfully edited Hipparchos newsletter by Professor Kokkotas. He managed to truly bring our newsletter to an international standard. Being an editorial advisor, together with V. Charmandaris, D. Hatzidimitriou, J.H. Seiradakis, N. K. Stergioulas, K. Tsinganos, I hope that he will continue assisting our effort to provide the Hellenic astronomical community with a professional and interesting newsletter.

Manolis Plionis

Message from the President

Dear Hel.A.S. members,

We have just started the 2009th orbit of the Earth around the Sun since the birth of Christ. This particular revolution of the Earth happens to be the 400th since Galileo pointed to the Heavens for the first time the newly discovered telescope and observational astronomy started to revolutionize our understanding of the Universe. To commemorate this cornerstone event in the history of science, the United Nations Educational, Scientific and Cultural Organization (UNESCO) with its resolution of 20/12/2007 adopted a proposal by the International Astronomical Union (IAU) to name the year 2009 as the *International Year of Astronomy* (in short IYA09). The IYA09 is a global effort aiming to help the citizens of the world rediscover their place in the Universe through the observation of the night and daytime sky, and thereby engage in a personal sense of wonder and discovery. In this way, everyone may realize the universal laws of nature that scientists, over the course of centuries have enabled us to better understand and which are also a great incentive to contemplate and appreciate the Psalmist's beautiful words, «the heavens are telling the glory of God» (Ps 19[18]: 1).

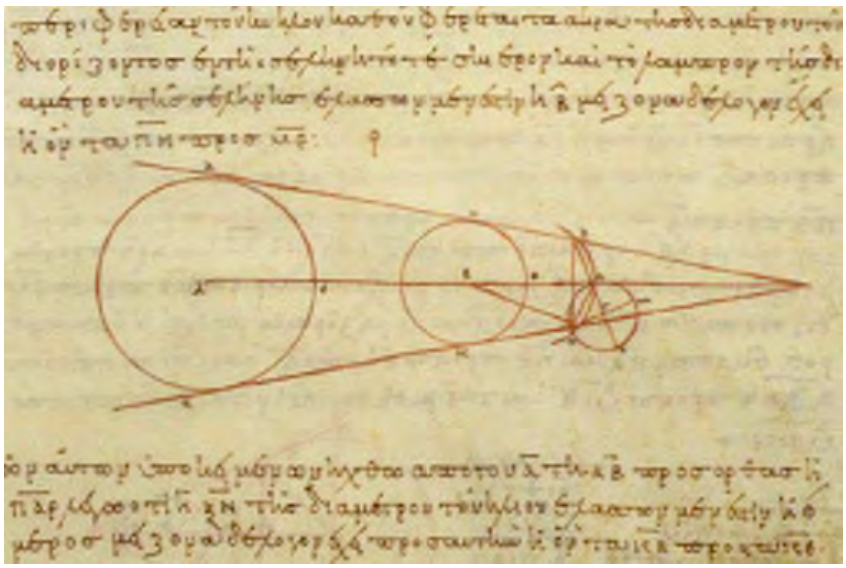
The message of the IYA09 is "The Universe, Yours to Discover" in order to emphasize that everyone should realise the impact of astronomy and other fundamental sciences on our daily lives, and understand how scientific knowledge can contribute to a more equitable and peaceful society. With 2009 just over the horizon, a staggering 135 nations are collaborating to "bring" the Universe closer to Earth. The IYA09 activities will take place internationally, nationally, and locally over the coming 365 days and beyond, in a spectacle of cosmic proportions. Catherine Cesarsky, IAU President, says: «135 countries have committed themselves to the Year, all pulling together toward the common aim of making astronomy accessible to the public. IYA2009 will reinforce the links between science education and science careers, stimulating a long-term increase in student enrolment in the fields of science and technology and an appreciation for lifelong learning.» With such a range of activities planned, now is the ideal time to learn more about the cosmos and our place within it. The International Year of Astronomy 2009 promises to make the Universe ours to discover.

For what concerns us Greek astronomers, we should always recall the contributions of Hellenic Astronomy throughout the last millennia of world-wide civilization. The great astronomers of antiquity and founding fathers of Αστρονομία, Αρίσταρχος, Πυθαγόρας, Ίππαρχος, Ερατοσθένης, Πτολεμαίος, etc laid the basis of all what we understand today.

Accordingly, the international astronomical community, as expressed by the IAU, has agreed to decorate the skies by the 88 officially named constellations whose names are inspired by Hellenic mythology and similarly is the case with the names of planets, satellites, galaxies, galaxy clusters, nebulae, etc. Today, the Hellenic astronomical community continues the old and long tradition, by playing an important role in modern astrophysics and space physics, with several prominent astronomers and space physicists contributing to the advancement of the field, organizing international conferences and advanced schools in Greece, etc. Thus, it is natural that this festive and landmark year, the Hellenic Astronomical Society, the professional society of Greek astronomers, should undertake the initiative to coordinate a number of events for the IYA09 in the following broad areas:

- ✓ New developments in modern Astronomy
- ✓ The role of Astronomy in our society
- ✓ The role of Astronomy in education.

Credit: NASA, ESA, HEIC and The Hubble Heritage Team



In particular, the following 10 action items, are recommended by the Hellenic Astronomical Society and are coordinated by members of Hel.A.S.:

1. A dedicated *TV programme* launching the IYA09. Preparation of a leaflet with the programm of the various activities. *(Coordinator: I. Daglis)*

2. Participation to the worldwide event taking place from 2-5 April 2009, «*100 hours of Astronomy*» (http://www.100hoursofastronomy.org/) with a wide range of public outreach activities including observing events and more. One of the key goals of *100 hours of Astronomy* is to have as many people as possible look through a telescope, just as Galileo did for the first time 400 years ago. Such activities will take place at the National Observatory of Athens and the Observatories of the Universities of Athens, Thessaloniki, Heraklion, etc, including public outreach talks and observation of the night sky, weather permitting. (*Coordinators: P. Niarchos, M. Plionis, N. Stergioulas, V. Charmandaris*)

3. Organizing several *lectures popularizing recent results of modern astronomy to the general public* and covering the main areas of contemporary astrophysics and space physics. In the Athens area, the Hel.A.S. Governing Council (GC) in collaboration with the Univ. of Athens and the National Observatory of Athens, is planning the following set of lectures, which will take place at the central University (Propylaia) between the 15th and 17th of May 2009 (*Coordinator K. Tsinganos*):

- *Astrophysical jets: cosmic fireworks signalling the birth and death of stars and galaxies*, (*K. Tsinganos, Hel.A.S. president*)
- *The Sun and planets: their relation and importance to us (I. Daglis, Hel.A.S. GC member*)
- *The search for extraterrestrial planets (P. Niarchos, Director of AAM section at the Univ. of Athens*)
- *Searching for the truth through light in the Universe* (*V. Charmandaris, Hel.A.S. Secretary*)
- *X- and and γ-ray Astronomy* (*A. Mastichiadis, Hel.A.S. Treasurer*)
- *Modern developments in Cosmology: dark matter and energy* (*M. Plionis, Hel.A.S. vice-president*)
- *Cosmic accelerators: acceleration of charged particles in the Universe* (*L. Vlahos, Hel.A.S. GC member*)
- *Optical observational astronomy* (*D. Hatzidimitriou, Univ. of Athens)*
- *Black holes and gravitational waves: was Einstein right?* (*K. Kokkotas, N. Stergioulas, Univ. of Thessaloniki*)
- *The role of Astronomy in worldwide culture* (*E. Theodossiou, Univ. of Athens).*

This event is under the auspices of the President of the Hellenic Republic.

4. Special edition of the Hel.A.S. journal Hipparchos for the IYA09, including the above talks. *(Coordinator: M. Plionis)*

5. *The astronomical question of the week:* a short (5 minutes) weakly radio broadcast with a specific question and its answer on modern and/or interesting astronomical issues, posed by Hel.A.S. members. Volunteers are requested to send their questions and answers to the President. A special link will be held in the Hel.A.S. webpage hosting such questions and answers by our members. *(Coordinator: K. Tsinganos)*

6. *Public outreach talks in selected High Schools* and the organisation of an astronomy, astrophysics and space physics competition. *(Coordinator: D. Hatzidimitriou, M. Metaxa)*

7. *Astronomy evenings in selected capitals of peripheral counties* organized in collaboration with the local government, high school teachers and local astronomical associations. During these 2-3 hours meetings, members of Hel.A.S. will present a public outreach talk popularizing recent results of modern astronomy to the general public, followed by observation of the night sky with a Celestron telescope whether permitting and also a presentation of astronomical posters. *(Coordinators: P. Niarchos, N. Stergioulas, V. Charmandaris)*

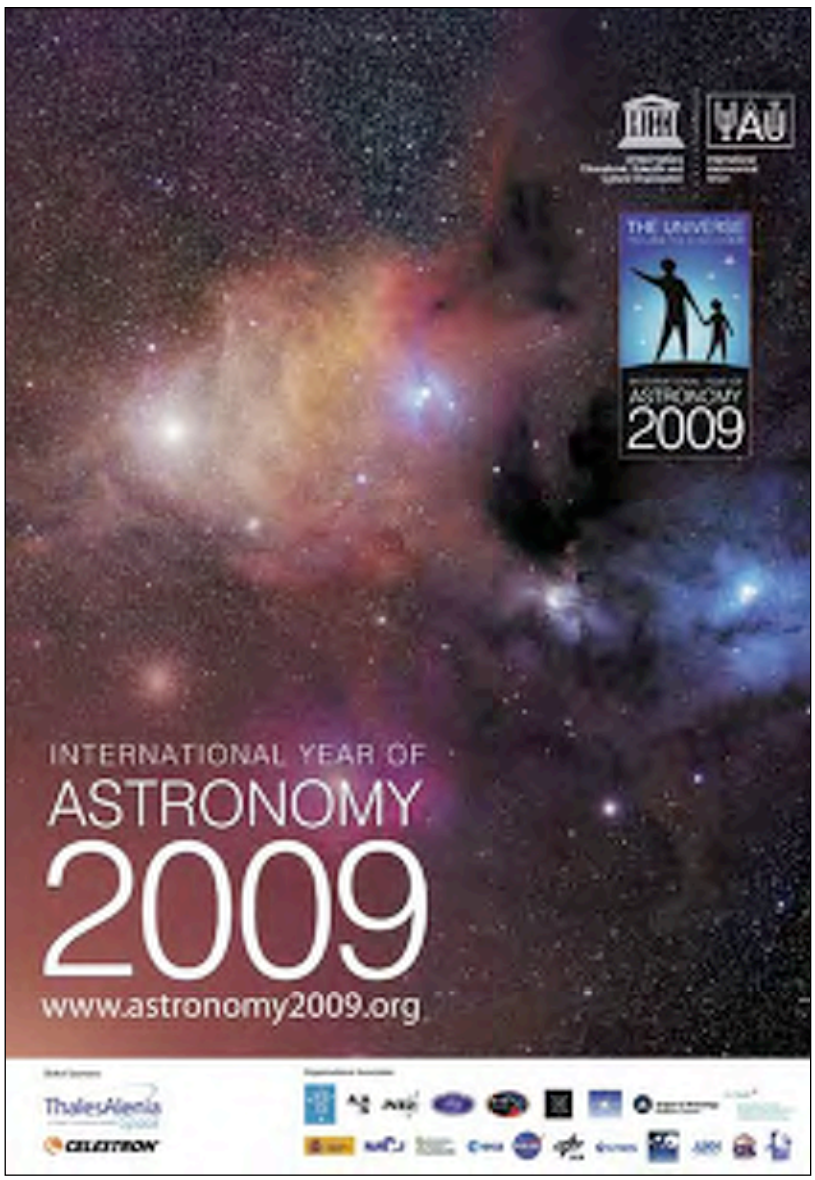
8. Creation of a *detailed programme at the Hel.A.S. home page* (http://www.helas.gr/iya2009.php) with all IYA09 related activities that will be linked to all appropriate webpages (at NOA, UoA, AUTH, UoC, etc. In this web page, which will be updated through out the year, we will include information about astronomy activities and events for the general public, which are being organized all over Greece under the auspices of the Hellenic Astronomical Society. *(Coordinator: V. Charmandaris)*

9. Broadcasting of *several independent TV programs* on recent results of modern astronomy addressed to the general public and covering the main areas of contemporary astrophysics and space physics. *(Coordinators: M. Plionis)*

10. The IYA09 activities will be culminated with the organisation of the 9th Conference of Hel.A.S. in Athens, from the 21st till the 24th of September 2009, which will include a special session for high school teachers. *(Coordination: Local organizing committee of the* 9th Conference of Hel.A.S.*)*

The Hel.A.S. recommends to all its members to participate in the IYA09 events and to organize such activities in their own geographical area after consulting the Society for advice and assistance. Let us make the IYA09 one of our projects throughout this year!
I wish to all of you health, happiness and success to your projects during the IYA09.

Kanaris Tsinganos



Greek Astronomer photographs directly and for the first time an extra-solar planet

The first directly observed extra-solar planet (*Fomalhaut b*), orbiting the bright southern star Fomalhaut which is at a distance of 25 light-years in the constellation Piscis Australis, was recently announced by NASA. The discovery was led by the Greek astronomer Paul Kalas, of the University of California at Berkeley, who together with his team had already proposed in 2005 that the dust ring, discovered around the parent star by the old-timer Infrared Astronomy Satellite, was being gravitationally modified by a planet orbiting between the star and the ring's inner edge.

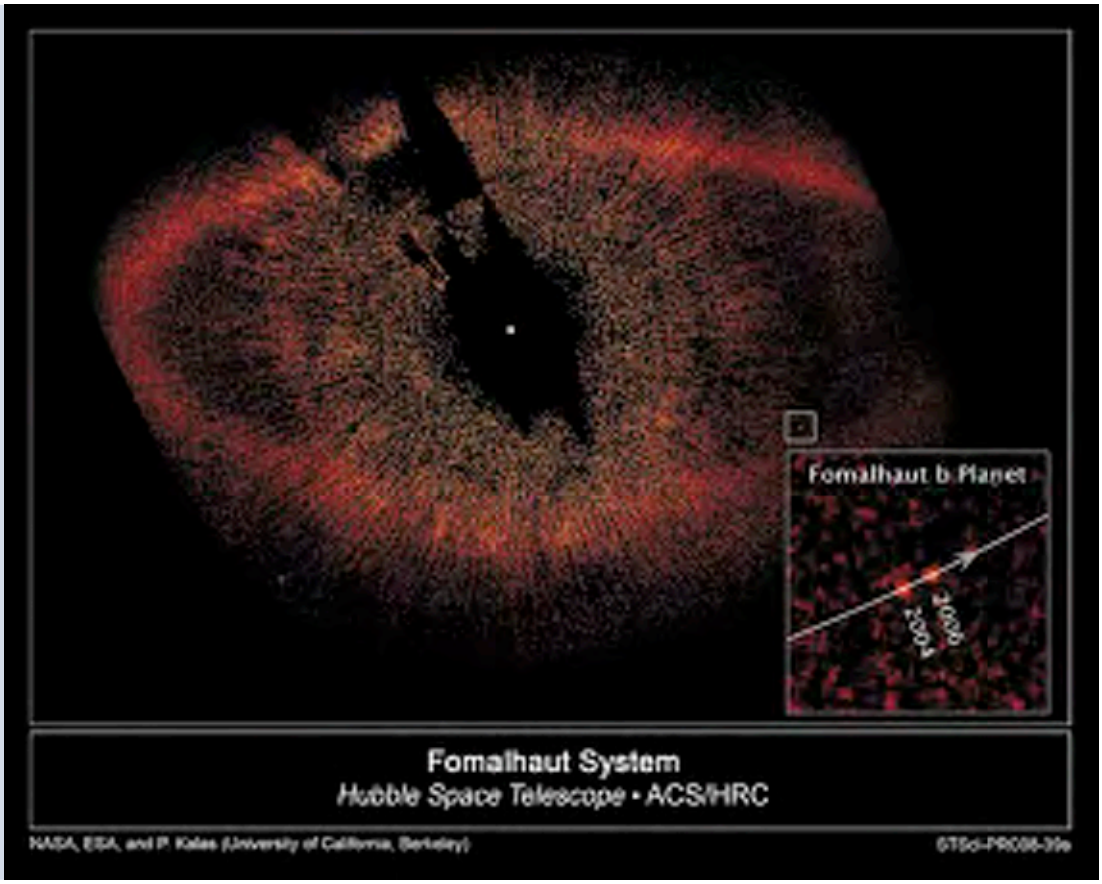
The High Resolution Camera on Hubble's Advanced Camera for Surveys (ACS) produced in 2004 the first visible-light image of the region, which showed a ring of proto-planetary debris, similar to the Kuiper Belt, approximately 21.5 billion miles across and having a sharp inner edge. Subsequently, many researches reached the conclusion that the ring is offset from the centre of the star.

The success of Kalas however, published in the November 14, 2008 issue of Science magazine, was that he managed to photograph a point source lying 1.8 billion miles inside the ring's inner edge at a location suggested by the analysis of the dust ring's shape. This point source, *Fomalhaut b*, is 1 billion times fainter than the parent star while the observations show that it is orbiting the star, a fact which proves that it is gravitationally bound to it. The distance between the planet and its parent star is 10.7 billion miles, corresponding to about 10 times the distance of the planet Saturn from our sun.

The Greek astronomer Paul Kalas.

Many interesting scientific issues have been generated by these observations, as for example the fact that the planet appears to be brighter than expected for a planet having three times the mass of Jupiter, which points to the possibility that it has a Saturn-like ring of ice and dust reflecting starlight.

Manolis Plionis



This Hubble ACS image shows the discovered planet, *Fomalhaut b*, orbiting its parent star. The small white box at lower right indicates the planet's location while the inset is a composite image showing the planet's position during the ACS observations taken in 2004 and 2006. Astronomers have calculated that *Fomalhaut b* completes one orbit every 872 earth years.

21775 Tsiganis: An asteroid named after a young Greek Astronomer

Last summer the *Committee for Small Body Nomenclature* of IAU named an asteroid after the young Greek astronomer *Kleomenis Tsiganis*. The newly named asteroid, *21775 Tsiganis*, was discovered on September 5, 1999 by the *Lowell Observatory Near-Earth Object Search* at the *Anderson Mesa Station*. The year of the discovery and the observation site were coded in the preliminary name, by which this asteroid was previously known, *1999 RC 221*. In a short text justifying the selection of the new name, published in the *Minor Planet Center Circular*, we read that:

> "Kleomenis Tsiganis (b. 1974), of the University of Thessaloniki, works on the chaotic diffusion of minor planets and the effect of the late heavy bombardment on the structure of the Trojan clouds and the main belt."

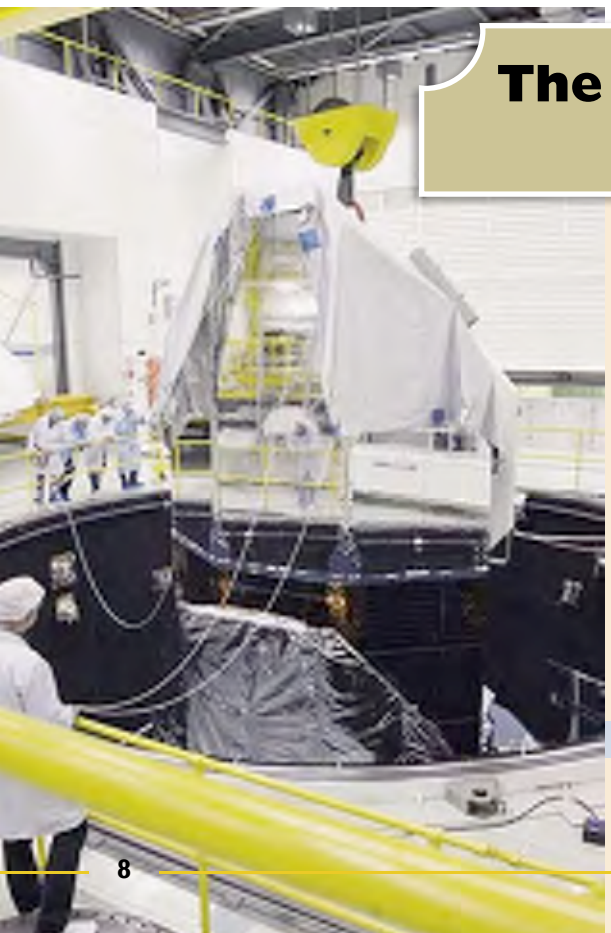
Menios, as Dr. Tsiganis is known to his friends, obtained his Bachelor degree in 1996 and his PhD in 2002, both from the University of Thessaloniki. In his PhD thesis he advanced a statistical description of the motion of asteroids following chaotic orbits. He applied the statistical methods he developed to the interpretation of the *Kirkwood gaps* of the main asteroid belt and the phenomenon known as *stable chaos*. We recall that Kirkwood gaps are intervals in semi-major space that are void of asteroids and that stable chaos is an oxymoron, describing the situation where an asteroid follows a strongly chaotic trajectory but does not diffuse away from its present position for time intervals of the order of the age of the Solar System.

A recent photograph of Kleomenis Tsiganis.

After obtaining his PhD, Dr. Tsiganis was awarded a Marie Curie postdoctoral fellowship and moved to the Nice Observatory in France, where he worked as a post-doc. During his stay in Nice he was one of the key authors of a series of papers, published in the journal *Nature*, where a concise theory for the creation of the outer solar system was presented. This theory is nowadays generally accepted as describing accurately the early solar system and is known as *the Nice model*.

Since his return from Nice, Dr. Tsiganis is working in the University of Thessaloniki, where he now holds a Lecturer position in the Department of Physics.

Harry Varvoglis



The Herschel Space Observatory is now ready for launch

"Successful end of the satellite and observatory level tests - we are really heading for launch now!". This was the message sent on December 19th 2008 by the PI of HIFI, one of the instruments onboard the Herschel Space Observatory.

Since early November 2008 the second system operation verification tests (SOVT-2) took place inside the LSS (the Large Space Simulator – Figure 1) at ESTEC. During this phase a series of Thermal Vacuum/Thermal Balance (TV/TB) tests that mimic the challenging environmental conditions that Herschel is going to meet in space took place and the performance of the observatory was verified.

Herschel being lowered into the LSS. *Credit: ESA*

The Herschel and Planck observatories are now ready to be packed and transferred to Guiana Space Centre, Kourou in French Guiana. Three Antonov-225 will be used for the transportation of the two satellites and the auxiliary equipment to Kourou and the launch is expected to take place in April 2009 by an Ariane-5 launcher.

The Herschel Space Observatory promises to take our knowledge of the far reaches of space to a new level. It will have the largest mirror of any space telescope launched to date and

The "European Astronomy Infrastructure Roadmap" has been released

On the 25th of November 2008 the ASTRONET, an ERA-net (European Research Area network) consortium of European funding agencies, supported by the European Union to establish a long-term planning for the European Astronomy, released the "*European Astronomy Infrastructure Roadmap*" during a press-conference in the Academy of Science in Paris. The Hellenic astronomy participates in the ASTRONET consortium through the associate membership to the ASTRONET board of the Greek National Committee for Astronomy.

The comprehensive *Infrastructure Roadmap* was established through a 3 year process that included:

- The identification and prioritization of the main scientific questions that the European astronomy should address in the medium term (epitomized in the *Science Vision for European Astronomy - www.eso.org/public/outreach/press-rel/pr-2007/Astronet_ScienceVision.pdf*).

The original proposal of the nominated experts (forming the *Science Vision Working Group*) was discussed by the European astronomical community through a web-based forum and in the open *Science Vision Symposium* that took place near Poitiers/France in January 2007.

- The identification and prioritization of the astronomical large-scale ground or space-based infrastructures (existing or at the phase of planning), from gamma-rays to gravitational waves, which are necessary to realize the goals of the *Science Vision* within the next 20 years. These included human resources as well as education and outreach. Again the ASTRONET seeked the collaboration of the European astronomical community in its broadest sense (including observers, theorists, instrumentalists and educators) and opened a relevant web-based discussion forum. The draft Roadmap was discussed during the symposium that took place in Liverpool/UK last June and the outcome of the meeting was incorporated in the final roadmap.

(the presentations can be found in: http://www.astro.ljmuac.uk/~airs2008/Programme.html)

It is unfortunate that the Hellenic astronomy did not participate significantly in this European endeavour.

Details regarding the ASTRONET program and its activities can be found in the following link:

http://www.astronet-eu.org/

while the actual infrastructure roadmap can be downloaded from:

http://www.astronet-eu.org/IMG/pdf/Astronet-Book.pdf.

Manolis Plionis

will detect the "glow" of cosmic dust at a temperature around –250°C.

Cosmic dust plays an important role in helping hot gas to cool and collapse to form galaxies and stars, and is the raw building material for planets like our own. The Earth is actually a giant ball of cosmic dust! Discovering how dust is created, how long it survives and how much of it is out there, are important pieces of the puzzle of cosmic structure formation and of how the Universe came to appear the way it does.

Manolis Xilouris

The Herschel spacecraft in a clean room at ESTEC prior to being lifted into the LSS. *Credit: ESA*

Probing the Obscured Universe

by Dimitra Rigopoulou
Oxford University & Rutherford Appleton Laboratory, UK

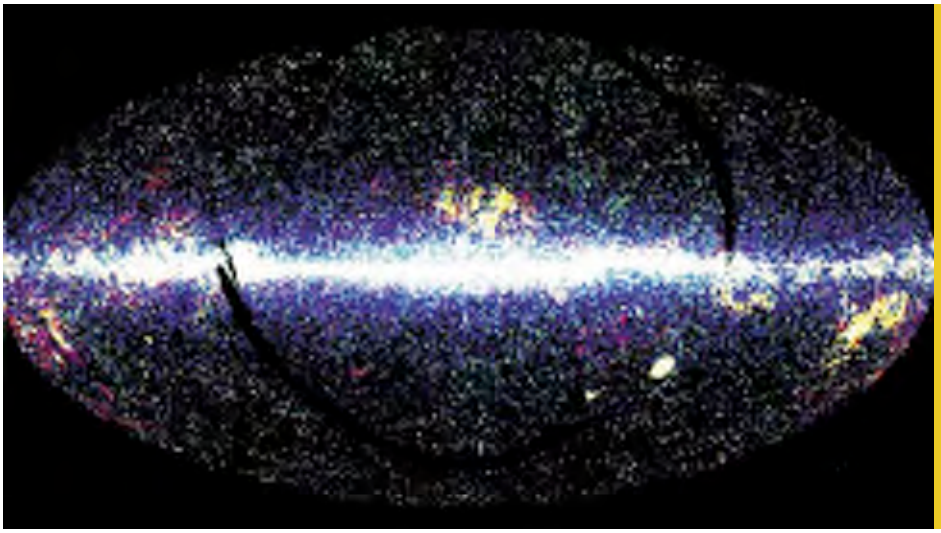


Figure 1. An image of infrared point sources in the entire sky as seen by the Infrared Astronomical Satellite (IRAS). The plane of our Galaxy runs horizontally across the image. Sources are colour coded by their infrared colours. Blue sources are cool stars within our Galaxy, which show an obvious concentration to the galactic plane and center. Yellow-green sources are galaxies that are basically uniformly distributed across the sky, but show an enhancement along a great circle above the galactic plane. This enhancement is caused by galaxies in the Local Supercluster. Reddish sources, the infrared cirrus, are extremely cold material close to us in our own Galaxy. Black areas were not surveyed by IRAS.

Abstract

The Cosmic Background Explorer revealed for the first time that, the extragalactic light at infrared wavelengths is comparable to that at optical wavelengths indicating that a large fraction of the activity in the Universe takes place in dust obscured areas. In this article I attempt a review of the cornerstone infrared missions that have revolutionised our view of the dusty cosmos. The focus is on advances in extragalactic astronomy and in particular the discoveries of galaxies whose bolometric luminosity is dominated by emission in the mid- and far-infrared wavelength regime. Alongside discoveries in the infrared domain I discuss advances in the sub-millimetre regime and stress the synergy between the two. The imminent launch of ESA's next infrared mission, the Herschel Space Observatory, offers many opportunities and I highlight some of the unique strengths of this mission. Finally, the availability of the ATACAMA Large Millimetre Array will push the frontiers of exploring the dusty Universe even further. These are certainly exciting times for infrared astronomy.

The past: A historic review

Infrared Astronomy is perhaps the youngest branch of modern Astrophysics owing partly to its inherent difficulty of the radiation being undetected by human eye but also to late technological advances in this domain. The InfraRed Astronomical Satellite (IRAS) launched in 1983 set the first inroads into the exploration of the then unknown territory, ***the infrared Universe***. The IRAS mission lasted less than a year but was enough to provide a first glimpse through the dusty regions of the Universe, the birthplace of stars. The IRAS "All-Sky Survey" (Figure 1) has been the reference point for many exciting discoveries for the decades that followed.

One of IRAS' biggest successes was the discovery of a new class of luminous in the infrared (but otherwise boringly faint in the optical) galaxies, dubbed the Ultraluminous Infrared Galaxies (ULIRGs, e.g. Sanders et al. 1988, Figure 2).

With IR luminosities in excess of $10^{12} L_{\odot}$ ULIRGs are by far the most luminous objects in the local Universe with a space density likely comparable to that of quasars (e.g Sanders & Mi-

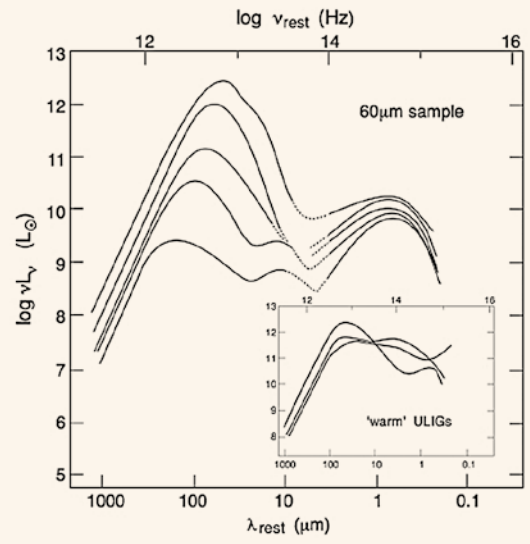


Figure 2. Variations of the mean SEDs (from submillimetre to UV wavelengths) with increasing infrared luminosity LIR for a 60 micron sample of infrared galaxies. (Insert) Examples of the subset of ~15% of ULIRGs with "warm" infrared colours (ie $f_{25}/f_{60} > 0.3$). Data are from Sanders et al (1988). Figure taken from Sanders & Mirabel (1996).

rabel 1996). The most enigmatic issue in research in ULIRGs has been the source of their extreme luminosity be it star-formation processes or emission originating from a central active galactic nucleus (AGN). We now know that in most ULIRGs the answer lies in a combination of both these processes. Alongside IRAS, the James Clerk Maxwell telescope from the ground, first with the old UKT14 bolometer and later with the revolutionary SCUBA (Submillimeter Common User Bolometer array) worked its way through the obscuring dust in the nuclei of these most luminous galaxies (e.g. Rigopoulou et al. 1996).

IRAS' successor, the Infrared Space Observatory (ISO, 1995-1998) pushed the limits even further and gave us a glimpse of the obscured Universe out to redshift 2. The ISOCAM deep surveys established that a large fraction of the star formation in the high-redshift Universe takes place in obscured sites (e.g Rowan-Robinson et al., 1997, Franceschini, Berta, Rigopoulou et al. 2003). Additionally, these deep surveys showed that in fact about 70% of the co-moving star formation rate density (SFRD) at 0.5<z<1.5 is obscured by dust (e.g. Chary & Elbaz 2001). The revised "Madau" plot (Figure 3) summarises nicely the new emerging picture: the cosmic star formation rate increases steeply between current epoch and z~1, and remains flat up to at least z~4.

ULIRGs were also at the centre of ISO's investigations through the discovery of the Poly-Aromatic Hydrocarbons (PAHs, e.g. Rigopoulou et al. 1999) as a proxy for pinpointing intense starburst activity in their centers. As if by coincidence, ISO's successes were complemented by the hugely successful surveys carried out with the Sub-millimetre Common User Bolometer Array (SCUBA, Holland et al., 1997). The first detections of submillimetre luminous high-redshift galaxies in the Hubble Deep Field North (e.g Hughes et al. 1998) were followed by many more (e.g. Ivison et al. 1999, Smail et al 2002) and established the sub-millimetre wavelength regime as an important means of discovering obscured high-redshift galaxies. The path to exploring the "obscured Universe" was now clear.

Late 2003, saw the launch of the third and most promising infrared satellite, the Spitzer Space Telescope (SST, Werner et al. 2004). With a huge leap in sensitiv-

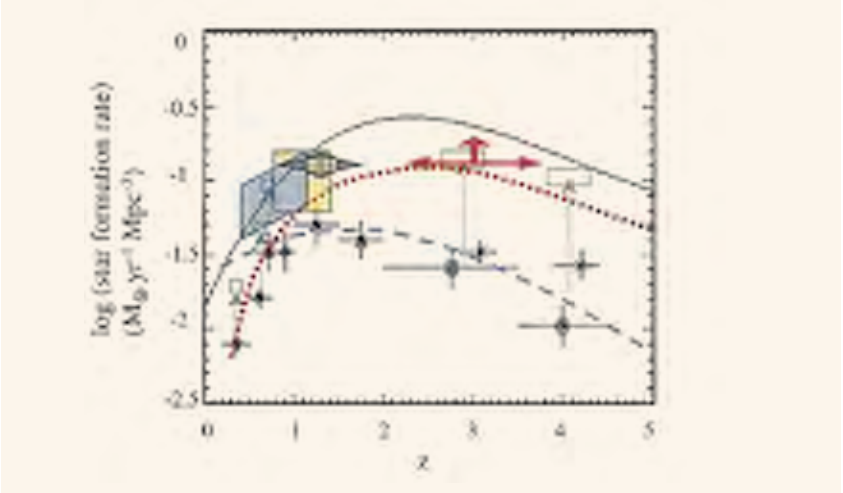


Figure 3. Cosmic Star Formation Rate (per unit comoving volume, h=0.6,q0=0.5) as a function of redshift. Black symbols denote the star formation history deduced frqom (non-extinction corrected) UV data. Upwards pointing green arrows same as beforebut with extinction appliqed. Green four arrow symbol denotes H-alpha NICMOS observations. Red symbol, SCUBA observations (Hughes et al. 1998). Black continuous line marks the total star formation rate deduced by COBE. Light blue and dotted red curves are models from Guiderdoni et al. Filled light blue and yelloe boxes denote star formation rates from ISOCAM (Figure from Cesarsky & Genzel 2000).

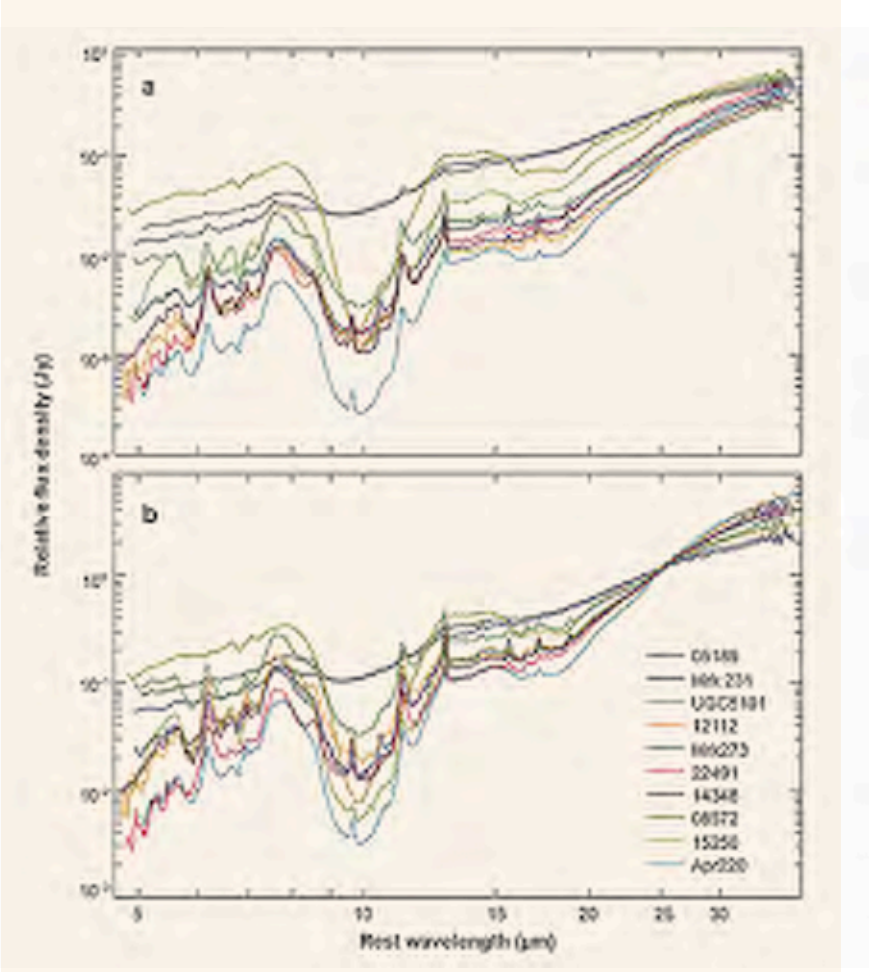


Figure 4. Spectral energy distribution of 10 ULIRGs selected from the IRAS Bright Galaxy Sample. Top panel: The spectra are normalised at 60 microns. Bottom panel: The spectra are normalised at rest-frame 24 microns. Note the substantial dispersion in slope, silicate absorption depth and prominence of aromatic features (from Armus et al. 2007).

ity over space and ground, SST lived up to its promises allowing us to get an unprecedented glimpse into the nature of star forming galaxies. Building on ISO's Legacy, Spitzer pushed the limits in research into the energetics of ULIRGs. Spitzer's Infrared Spectrograph (IRS, Houck et al. 1996) demonstrated the unique power of mid-IR spectroscopy to measure relative contributions from AGN based on fluxes from high excitation lines. Wide variations in the strength of aromatic features and silicates suggest that there is no such thing as a "standard" ULIRG spectrum (Armus et al. 2006, Figure 4). A plethora of new features such as ices, crystalline silicates and molecules typically found in the galactic dense Interstellar Medium (ISM) have now been routinely observed in ULIRGs.

But Spitzer's main breakthrough comes from studies of the high redshift Universe. Spitzer observations at 24 microns proved to be by far the most sensitive channel for detecting distant galaxies, many of those being ULIRGs at redshifts up to z~3. Spectroscopic followup revealed a large fraction of those showing emission features although sample selection plays an important role (e.g. Yan et al. 2005, 2007, Huang et al. 2008 etc). Interestingly, a large fraction of z~2 sources discovered through deep 24 micron surveys are found to contain AGN. At higher redshifts, Spitzer studies of Lyman Break Galaxies (LBGs) reveal their diversity with a sizeable number of LBGs appear to be "redder" and more massive (Rigopoulou et al. 2006, Magdis et al. 2008). Another class of objects with similarly large masses the Distant Red Galaxies (DRGs) are found to contribute 10-30% of the total Star Formation Rate (SFR) in the 1.5<z<3 regime. Submillimetre-bright galaxies are in general bright in the mid-infrared with the majority of their emission being related to star formation processes (e.g. Valiante et al. 2007, Pope et al. 2008). All of Spitzer's exciting findings in the high-z Universe are summarised in Figure 5 (figure5.jpeg): LIRGs and ULIRGs seem to dominate the energy production accounting for about 70% of the total energy density at z~1. As we move to higher redshift the infrared luminosity density becomes flat and remains so until z~3.5

In the far-infrared domain, Spitzer surveys at 70 microns set the first inroads into the exploration of the "thermal peak" of high redshift galaxies. Several studies (e.g Symeonidis, Rigopoulou et al 2007) indicate that the 70 microns population is dominated by starbursts with a small fraction 15-20% of obscured AGN with a mean redshift of ~0.7. With infrared luminosities in excess of 10^{11} $L_{\odot}$ the majority of the 70 micron sources are Luminous Infrared galaxies (LIRGs).

And although the Spitzer 'cryogenic' mission is due to end in April 2009, Spitzer will continue to have its full sensitivity in the two IRAC channels 3.6 and 4.5 microns. A two year approved "warm Spitzer mission" will utilize these wavelengths for deep extragalactic surveys providing a "short wavelength" counterpart for the next infrared mission that is just around the corner.

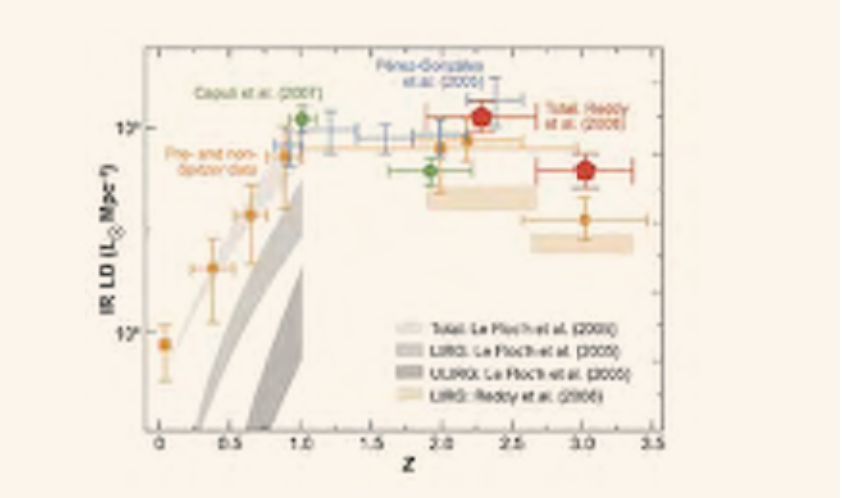


Figure 5. The infrared luminosity density (IR LD) as a function of redshift up to z=3.5. The orange points represent pre-Spitzer data. Spitzer-based data include results from Reddy et al, Caputi et al. Perez-Gonzalez et al and LeFloc'h et al. The grey bands indicate the total, LIRG, and ULIRG contribution to the total IR LD at z<1. Above z~1 the IRLD flattens till about z~3.5 in accordance with earlier findings by ISO (from Soifer, Helou & Werner 2008).

Upcoming Infrared and Millimetre Missions

Early 2009 (currently scheduled for April 09) an Ariane 5 launcher will carry ESA's latest Infrared Satellite into space. The Herschel Space Observatory (HSO), a 3.5-m aperture telescope is primarily designed to observe the "cool Universe" (Figure 6). Through its unique imaging/photometric capabilities longwards of 70 microns HSO has the potential to discover the earliest epoch proto-galaxies, revealing the cosmologically evolving AGN-starburst symbiosis, and unravelling the mechanisms involved in the formation of stars and planetary systems. Designed primarily as a survey telescope, the HSO will, for the first time, push the frontiers into the relatively unexplored far–infrared/submm regime, a crucial domain to observe the "peak of the infrared" activity for many high redshift objects. A major strength of HSO is its photometric mapping capability for performing unbiased surveys related to galaxy and star formation. Two large surveys HERMES and PEPS will be conducted as part of the Guaranteed Time Observations. Additionally, several other large programs will be carried out under HSO's Open Time Key Programs (OTKP for more details on HSO programs see http://herschel.esac.esa.int/Key_Programmes.shtml).

Figure 6. The Herschel Space Observatory (picture courtesy of ESA).

But besides deep far-infrared surveys HSO is bound to make significant contributions in the field of high redshift ULIRGs. Although numerous detailed studies of low-z ULIRGs exist (see previous paragraphs), little is known about the properties of high-z ULIRGs, their formation and evolution. As is evident from Figure 1, the Spectral Energy Distributions (SEDs) of ULIRGs peak in the 50-100 μm range (in rest-frame). For redshifted ULIRGs the peak of their SED will fall in the HSO prime bands (70 to 500 microns). Thus, HSO observations will allow us to measure the peak energy released from these objects and make accurate measurements of their bolometric luminosities.

Another exciting possibility in probing the ISM in high-z galaxies is provided by the spectroscopic capabilities of Herschel. To-date very little is known about the conditions that prevail in the ISM of high redshift systems. Low-ionization-state far-infrared (FIR) emission lines play an important role in cooling star-forming regions, and they allow us to infer the flux of rest-frame ultraviolet (UV) photons. Studies have shown that [C II], the ground-state fine-structure line of singly ionized carbon (2P3/22P1/2, = 157.7409 microns), is the dominant cooling line in gas-rich star-forming regions (e.g. Stacey et al. 1991). It is thus expected to be a probe of star formation in young galaxies. In some nearby galaxies the [CII] line accounts for as much as 1% of the far-IR luminosity (Stacey et al. 1991, Nikola et al. 1998; Mochizuki 2000). Unexpectedly however (and quite surprisingly), results from ISO on a handful of local ULIRGs have indicated much lower fractions (Malhotra et al. 2001, Luhman et al. 2003), the well known [CII] deficiency problem in ULIRGs. The spectroscopic capabilities of HSO will allow us to investigate the [CII] deficiency problem in ULIRGs as a function of redshift providing, at the same time, important clues on the condition of the ISM in high redshift luminous systems. Combining the [CII] line with other fine structure lines such as [OI] 63, 88 microns, [NII]. we can derive various physical properties of the ISM, such as ionization parameter, temperatures and electron density of the gas.

But the launch of HSO will likely coincide with another exciting facility becoming available in early 2009, the second generation Submillimeter Common User Bolometer Array, SCUBA-2, a large format bolometer array, will begin commissioning and operation on the JCMT. SCUBA-2 will offer simultaneous imaging of a 50 sq. arcmin field of view at 450 and 850 microns with improved sensitivities. It will perform deep surveys of selected areas of sky to an unprecedented depth following from the successes of its predecessor, SCUBA. About 50% of the SCUBA-2 available observing time has already been allocated to six large programs the so-called "Legacy Surveys" (http://www.jach.hawaii.edu/JCMT/surveys.html). Amongst them, the largest SCUBA-2 Legacy program, the so-called tri-national Cosmology survey, has already been approved with 950 hrs spread over two years, to survey at 850 and 450 microns a suite of fields carefully selected based on the availability of high quality auxiliary multiwavelength data.

The goals of such surveys are multiple. Amongst them a crucial question is that of the evolution of the submm luminosity function. SCUBA-2 deep surveys will provide enough dynamic range in luminosity, sufficient number of sources, adequate redshift information and the necessary SED information in order to calculate the bolometric luminosities to allow the cosmological evolution of the submm luminosity function to be delineated. We will then be able to refine the "Madau/Lilly" plot and establish the link between obscured and visible star formation over the cosmic history. Although recent submm surveys (such as SHADES, e.g Coppin et al. 2008) have made significant advances in estimating the submm luminosity function, the large area surveys afforded by SCUBA-2 will provide more sources so that the cumulative source counts over a wider range of luminosities can be constrained at both low and (especially) high flux density ends. This is particularly important

Figure 7. An artist's impression of the full ALMA array. To the right is the Atacama Compact Array (courtesy of A. Beasley, ESO).

since such bright submm sources are either local galaxies or rare high redshift such as galaxies undergoing intense star forming activity with SFRs in excess of 1000 $M_{\odot}$/yr.

SCUBA-2 will likely work alongside the HSO to provide submm counterparts for the majority of the HSO far-infrared detected sources thus significantly extending their SEDs. Given that the Infrared Background Light (IBL) peaks at 200 microns (COBE results, e.g. Fixsen et al. 1998) SCUBA-2 surveys and in particular the improved sensitivity of the 450 microns channel will detect sources closer to the peak wavelength. I expect that these sources will be at lower redshifts (1<z<2) and/or have different (hotter) dust temperatures (in comparison to the submm-bright sources detected at 850 microns.

And while the HSO and SCUBA-2 will work towards unravelling the activity taking place in obscured sites in the Universe, preparations are already underway for the Atacama Large Millimetre Array (ALMA), currently to become available in mid-2011. ALMA will be the largest mm/submm imaging array of telescopes in the world (Figure 7). With ~50 movable antennas ALMA will be the forefront instrument for further pushing the frontiers of the cool Universe. ALMA's capabilities make it the instrument of choice for unique investigations.

Constraining the properties of the molecular gas in objects at the end of cosmic re-ionization is clearly of key importance as such observations will provide (i) the available "fuel" for star formation, (ii) will help constrain the dynamical mass of the systems and will thus allow to put these objects in the evolutionary context for galaxy formation at early epochs. Typically, at low and high redshifts CO emission is used as a tracer for molecular gas. With ALMA we will be able to measure the high-J transitions out to very large redshifts. An alternative tracer of the interstellar medium and one of the most significant cooling lines of the ISM is the fine structure line [CII]. Given its wavelength 158 microns [CII] studies in the local Universe are limited to satellite missions. With ALMA we will be able to observe [CII] emission from higher redshift objects thus complementing studies scheduled to be carried out with the HSO.

ALMA has of course not been designed to serve as a typical "survey" instrument. However, its unprecedented sensitivity makes an ALMA deep survey such an obvious project. One highly uncertain aspect in the study of high-z submm galaxies is their redshift distribution. Optical redshifts remain problematic for the majority of such sources, and can be misleading due to possible mis-identifications. ALMA's capabilities for line/continuum searches can overcome this problem. An unbiased high sensitivity survey with ALMA in either 1mm or 3mm is likely to yield high redshift sources undetected at other wavelengths. Whereas current generation large field of view bolometer arrays (like SCUBA-2) are capable of surveying large fields they suffer in sensitivity. ALMA will explore a range of star formation rates much lower than those of currently detected sub-mm sources. With a proposed sensitivity level of 0.1 mJy, such a survey should be able to find few hundreds continuum sources, depending on the applicable cosmological model. Such a deep survey will be possibly complemented by line surveys (e.g. at 650 GHz) which will provide (i) redshift confirmation (ii) dynamical masses and observations of other molecular lines such as HCN or CI.

But the study of the "Obscured Universe" does not end there. More space missions are well underway for operating by the end of the next decade such as the James Webb Space Telescope (JWST) while new are being selected for study/implementation such as the Space Infrared Telescope for Cosmology and Astrophysics (SPICA). The goal remains the same: investigate and understand the conditions under which the first seeds assembled that later on became the first proto-galaxies.

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The exploration of Titan and the Saturnian System by Cassini-Huygens

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Saturn's largest moon, Titan, has been a fascinating world at every stage of its exploration. For three decades after the hazy atmosphere was discovered from ground-based observations in the 1940s, debate followed over whether it was a thin layer of methane or a dense shield of methane and nitrogen. Voyager 1 settled the matter in favor of the latter in 1980, but the details it discovered about the atmosphere raised even more intriguing questions about the nature of its hidden surface and the sources of methane to re-supply the atmosphere. The simplest possibility, that an ocean of methane and its photochemical product ethane might cover the globe, was cast in doubt by Earth-based radar studies, then eliminated by HST observations and adaptive optics imaging in the near infrared from large Earth-based telescopes in the 1990s. These data, however, did not reveal the complexity of the surface that Cassini-Huygens would uncover. The Cassini-Huygens mission is a fruitful collaboration between ESA and NASA which investigates the kronian system since 2004, bringing immense new insights on the primary planet, its rings and its satellites. It has thus been instrumental in enhancing our understanding of the environment around Saturn for the past 4 years, and the mission was extended for at least another 2 years, until 2010. One particular target of Cassini-Huygens was Titan, that was also visited by the Huygens probe in January 2005.

It is at first surprising that the most Earthlike body in the solar system is Titan. Indeed, if Titan orbited the Sun rather than Saturn, we would have no hesitation in calling it a planet in its own right. This strange world is larger than the planet Mercury and has a nitrogen atmosphere like that of Earth, yet denser and laden with an organic smog that hid its surface from view until Cassini-Huygens approached it in early 2004, and later in 2005 when Huygens revealed to us an extraordinary Earth-like landscape.

Far from the Sun, methane plays the active role on Titan that water plays on Earth, acting as a condensable greenhouse gas, forming clouds and rain, and pooling on the surface as lakes. Titan's icy surface is shaped not only by impact craters and tectonics, but also by volcanism in which the lava is liquid water ("cryovolcanism"), by rivers of liquid methane, and by tidally driven winds that sculpt drifts of aromatic organics into long linear dunes. Channels likely carved by liquid methane and/or ethane, lakes and seas of these materials, vast equatorial dune fields of complex organics made high in the atmosphere and shaped by wind, intriguing hints of volcanic flows of aqueous materials across an icy crust, and a dearth of impact craters suggest a world with a balance of geologic and atmospheric processes that is the solar system's best ana-

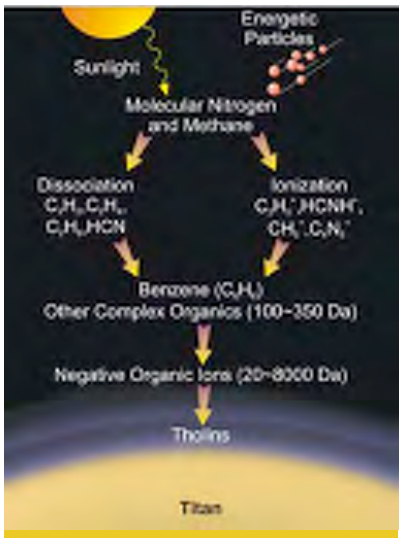

Figure 1. Organic processes in Titan's upper atmosphere resulting in the formation of complex positive and negative ions.

log to Earth. In addition, deep underneath Titan's dense atmosphere and active, diverse surface Cassini instruments data strongly suggest the presence of an interior ocean thought to be largely composed of liquid water.

A key characteristic of Titan is its massive inventory of organic chemicals. When Voyager 1 flew past Titan in the early 1980s, it verified the presence of methane in a thick background atmosphere of nitrogen. Even more interesting was the detection of a host of more complex hydrocarbons and nitriles that resulted from the photolysis and energetic particle bombardment of the atmosphere and the thick organic haze that both scattered and absorbed visible and infrared photons, thereby playing an important role in determining the satellite's thermal structure. Titan is an organic paradise that is certain to tell us much about the chemical evolution that may lead to life. Water ice and carbon dioxide ice has been reported to exist currently on the surface. Transient episodes of melting of the water ice by either geologic activity or impacts would expose organics to aqueous alteration, as well as contact with carbon dioxide, leading potentially to reaction pathways that mimic those that occurred on the pre-biotic Earth. No other place in the solar system has this type of ongoing chemistry. The Cassini-Huygens era of investigation has furthered our understanding of Titan as the largest abiotic organic factory in the solar system. The abundance of methane and its organic products in the atmosphere, seas and dunes exceeds by more than an order of magnitude the carbon inventory in the Earthís ocean, biosphere and fossil fuel reservoirs (Lorenz et al. 2008a).

The structure of the upper atmosphere of Titan was defined by the Cassini Ultraviolet Imaging Spectrometer (UVIS), which observed the extinction of photons from two stars by the atmosphere of Titan during the second Titan flyby. A mesopause was inferred at 615 km with a temperature minimum of 114 kelvin. Six species were identified and measured: methane, acetylene, ethylene, ethane, diacetylene, and hydrogen cyanide at altitude ranges from 450 to 1600 kilometers. The higher order hydrocarbons and hydrogen cyanide peak sharply in abundance and are undetectable below altitudes ranging from 750 to 600 km, leaving methane as the only

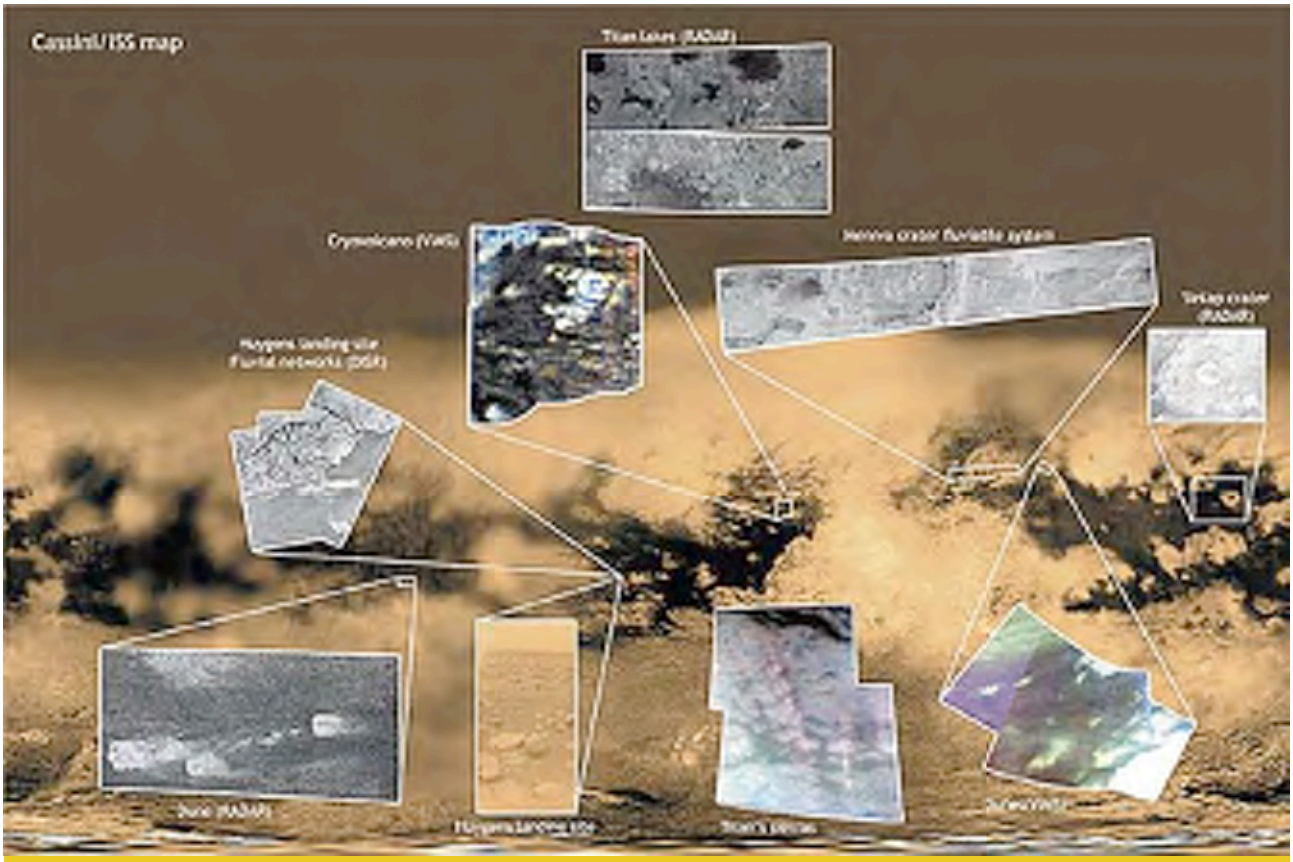

Figure 2. The diversity of Titan's surface: geological features discovered by Cassini-Huygens, many of which remain to be explained. *(Credit: Univ. Nantes & CIGAL/LESIA)*

identifiable carbonaceous molecule in this experiment below 600 km.

The direct analysis of the ionosphere by the Ion Neutral Mass Spectrometer (INMS) during the closest Cassini flybys of Titan shows the presence of many complex organic species, in spite of the very high altitudes (1100-1300 km) (Waite *et al.*, 2007). Extrapolation of the INMS measurements (limited to mass up to 100 Daltons) and of CAPS data, strongly suggests that high-molecular-weight species (up to several 1000 Daltons) may be present in the ionosphere *(Fig. 1)*. This new data –if confirmed– revolutionize the understanding of the organic processes occurring in Titanís atmosphere, with a strong implication that ionospheric chemistry plays a role in the formation of complex organic compounds in Titanís environment, which was not envisaged before (Waite et al., 2007). Thus, it appears that Titan is a chemical factory in which the formation of complex positive and negative ions is initiated in the high thermosphere as a consequence of magnetospheric-ionospheric-atmospheric interaction involving solar EUV, UV radiation, energetic ions and electrons.

Venus and Mars both approach end states of volatile loss processes – in Venus' case the water was lost because greenhouse temperatures near the sun failed to keep it below an adequate cold trap, while on Mars the weak gravity and magnetic field may have allowed substantial losses to occur. The few known isotopic ratios in Titan's atmosphere attest to re-supply and loss processes, with different results for the nitrogen and carbon reservoirs. The latter, in the form of methane greenhouse gas and surface liquid deposits, makes an appropriate analog for the Earth's water.

However, the best atmospheric analogies are between Titan and Earth (Coustenis and Taylor, 2008). Most obvious, is the existence of a hydrological cycle involving methane clouds, rain and at least transient rivers. The possibility of such a cycle had been noted as soon as the proximity of Titanís surface conditions to the methane triple point had been noted in Voyager data, and the first evidence of clouds emerged in spectroscopic data and in Hubble Space Telescope (HST) images, reported since 1995. Another analogy with the Earth relates to the polar stratosphere. Titan was observed by Voyager to have a UV-dark 'polar hood,' a dark haze cap over the winter pole. This cap was seen in high-phase-angle images to stand above the main haze deck, and connect with the detached haze layer. Circulation models are able to reproduce this behavior. While connected to the detached haze at high altitude, the region is dynamically isolated by the circumpolar vortex. On Earth, the corresponding circumpolar winds isolate the winter stratosphere from the rest of the atmosphere: the catalytic surfaces of polar stratospheric clouds that form in the winter night cause the destruction of ozone whose concentration becomes locally depleted —the ozone hole.

Measurements throughout the atmosphere, both remotely and in situ, have indicated the presence of numerous hydrocarbon and nitrile gases, as well as a complex layering of organic aerosols that persists all the way down to the surface of the moon (Coustenis et al. 2007; Tomasko et al. 2005; Israel et al., 2005), although their molecular composition remains to be determined. Radar observations suggest that the ultimate fate of this aerosol precipitation is the

generation of expansive organic dunes that lie in an equatorial belt. These sand dunes are remarkable in being exactly the same size and shape as linear (longitudinal) dunes on Earth such as those found in the Namibian and Saharan deserts. This type of dune forms in a fluctuating wind regime, which on Titan may be provided by the tides in the atmosphere due to Saturnís gravitation acting over Titanís eccentric orbit.

Radar-bright channels (probably cobbled streambeds like that at the Huygens landing site) have been observed at low and mid-latitudes (Lorenz et al. 2008a), while channels incised to depths of several hundred meters are seen elsewhere, and at high latitudes radar-dark, meandering channels are seen that suggest a lower-energy environment where deposition of fine-grained sediment occurs. Fluvial modification of the surface was very evident at the Huygens landing site *(Fig. 2)*. Not only were steeply incised channels a few kilometers long and ~30 m across observed in the bright highland, but the knee-height vista from the probe after landing showed rounded cobbles characteristic of tumbling in a low-viscosity fluid. Radar and near-infrared imagery has revealed channels on much larger scales than those seen by Huygens. Furthermore, beginning in July 2006, there were a series of flybys of the high northern latitudes of Titan during which the RADAR imaged a variety of very dark features that have been interpreted to be liquid-filled basinsóilakesî. The features range in size from less than 10 km^2 to at least 100,000 km^2. They are confined to the region poleward of 55°N. To date some 655 such features have been identified and mapped (Fig. 2) and it has been hypothesized that the dark lakes are filled with liquid, most probably ethane.

All of the above provide circumstantial support for the hypothesis that the dark lakes are filled with liquid, but a definitive demonstration must await identification of liquid methane or ethane, or both, in the lakes, from the Cassini VIMS instrument. Liquid methane is difficult to detect given the large abundance of gaseous methane that dominates much of the near-infrared

Titanís tectonism is not well understood. A number of very-large-scale linear features are seen optically (Porco et al. 2005), notably the dark dune-filled basins. Smaller-scale ìvirgaeî are also seen

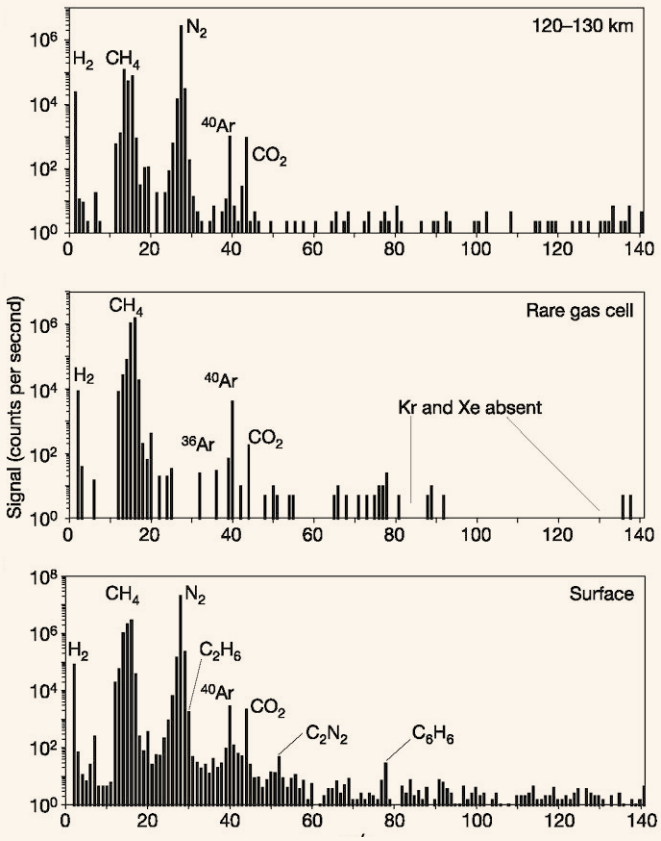

Figure 3. Mass spectra taken by the GCMS on Huygens indicating the presence of different organics and the detection of some noble gases and not others in Titan's atmosphere and surface *(from Niemann et al., 2005)*

but are not understood. Radar imagery of some of these features has not helped in their interpretation and is not yet sufficiently widespread to evaluate tectonic patterns, although some linear mountain ranges have been detected, several forming a chevron pattern near the equator. Near-IR imagery by Cassini VIMS has also shown long ridges (Fig. 2). An outstanding mystery is the nature of the large bright terrain Xanadu and its adjoining counterpart Tsegihi region. These areas are distinct optically, and they have unusual radar properties. SAR imagery shows Xanadu to be extremely rugged, much like the Himalayas on Earth, although the mountain-forming process(es) on Titan has (have) not been robustly identified and may differ from place to place.

Cryovolcanism is a process of particular interest at Titan because of the known astrobiological potential of liquid water erupting onto photochemically produced organics. Several likely cryovolcanic structures have been identified in Cassini near-infrared and radar images. Although evidence for active volcanism has not yet been widely convincing, there are apparent surface changes in Cassini data that require explanation.

An important Cassini finding needs to be underscored—at all spatial scales, there are structures seen in radar images that correlate with those in the near-IR, however, there are also structures that do not correlate at all. Radar and optical data thus tell us very complementary things about Titan's surface, and consequently a follow-on mission requires high-resolution global coverage by both techniques. In the near-IR, high-resolution coverage is particularly lacking from Cassini because of the short, rapid flybys. While the surface is spectrally diverse the identification of surface materials in the spectral windows Cassini is able to observe has proven challenging, making the extension to slightly longer wavelengths (in the region from 5 to 6 microns) highly desirable.

Titan's overall density (1.88 g/cm^3) requires it to have roughly equal pro-

portions of rock and ice. After its accretion, Titan was probably warm enough to allow differentiation into a rocky core with a water/ice envelope, but whether an iron or iron–sulfur core formed during the subsequent evolution remains uncertain. Thermal evolution models suggest that Titan may have an icy crust between 50 and 150 km thick, lying atop a liquid water ocean a couple of hundred kilometers deep, with some amount (a few to 30%, most likely ~10%) of ammonia dissolved in it, acting as an antifreeze. Beneath lies a layer of high-pressure ice. Cassini's measurement of a small but significant non-synchronous contribution to Titan's rotation is most straightforwardly interpreted as a result of decoupling of the crust from the deeper interior by a liquid layer (Lorenz et al. 2008b).

Information on the past evolution of Titan's interior and atmosphere is also available (though scarce) through the accurate measurements of the different volatile compounds present in today's atmosphere and onto the surface. The evolution of Titan's atmosphere operates on two quite different time scales. The longest timescale represented is the billion-year time scale commensurate with the origin and subsequent evolution of the overall system. This time scale is best studied by measuring the noble gas concentrations and their isotopic abundances, as well as the nitrogen and carbon stable isotope ratios. Cassini-Huygens has provided some important information in this regard. The abundance of the radioactively derived ^{40}Ar has indicated that only a few percent of the total volatile inventory has been outgassed from the interior *(Fig. 3, from Niemann et al. 2005)*. Whereas the relatively low abundance of the primordial ^{36}Ar isotope suggests that nitrogen was not delivered during Titan's initial formation as molecular nitrogen, but more likely as ammonia that underwent subsequent chemical conversion into N_2—the predominant constituent of Titan's present day atmosphere. Furthermore, the enrichment of ^{15}N in N_2 to that of ^{14}N relative to a terrestrial reference suggest that as at Mars Titan has lost most of its nitrogen over the course of its evolution (Waite et al. 2007). This is substantiated by the measurement of isotopic separation in the upper atmosphere measured by the Cassini INMS and the escape of methane and hydrogen inferred from the altitude structure of these species in Titan's upper atmosphere. Moreover, the non-detection of neon, krypton and xenon by Huygens raises fundamental questions about Titan's origin and evolution: have these compounds never been incorporated in Titan's building blocks, or have they been lost or recycled and hidden at the surface and in the interior since Titan's formation? The accurate measurements of the abundances of these noble gases and of their isotopic ratios will provide important clues about the origin and evolution of Titan, and about the overall role of escape, chemical conversion, outgassing and recycling in the evolution of Titan's atmosphere. In particular, the detection of radiogenically-derived isotopes of neon, xenon and krypton will constrain the evolution of the rocky core and the outgassing history of Titan. All these, must await new surface analysis techniques such as noble gas enrichment cells, which were not present on the Huygens GCMS.

The second time scale of relevance at Titan is that related to the irreversible conversion of the methane in the atmosphere into higher-order organic/nitrile compounds that eventually end up deposited on the surface of Titan. The measured value is near that of our terrestrial reference indicating that methane is resupplied and converted at a rate that prevents the buildup of the heavier isotope over time as is the case of nitrogen. The source of the resupply is a mystery that a future mission must address.

A final, and perhaps unexpected, analogy could be made between Titan and many extrasolar planets, if moons like Titan orbit the "hot Jupiters" that have been discovered. These moons would be close enough to the star to have the warmth necessary to develop a "habitability zone" or at least enough to be able to host advanced organic chemistry. Indeed, many of the known planets are close enough to their primary star to be tidally locked and thus rotate synchronously. However, nonzero eccentricity (as for Titan) may mean that there nonetheless are significant tidal effects.

To answer these remaining vital questions, a new mission (Titan Saturn System Mission, TSSM) was proposed and studied for the past year by both ESA and NASA. This new mission would bring the required long-term exploring capabilities combing an orbiter and two in situ elements (a montgolfière and a lander) with state-of-art technology and instruments (see www.lesia.cosmicvision/tssm/tssm-public).

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Astronomical Data Analysis V
Crete, 7-9 May 2008

Vassilis Charmandaris, ***Univ. of Crete*** *(on behalf of the Scientific and Local Organizing Committees)*

Held regularly since 2001, the Astronomical Data Analysis (ADA) conference series is focused on algorithms, signal and data processing. The fifth ADA conference took place near the city of Heraklion in the island Crete (Greece) on 7-9 May 2008. It was co-organized by the French Atomic Energy Commission (CEA/Saclay), the Institute of Computer Science of FORTH, the Departments of Physics and Computer Science of the University of Crete.

The conference, which was attended by 77 researchers from all over the world, covered a range of innovative themes, including curvelet transforms, and clustering in cosmology, while at the same time remained closely linked to front-line open problems and issues in astrophysics and cosmology. Since the Herschel and Planck Space Telescopes are expected to be launched by the European Space Agency in early 2009, the fifth ADA conference focused in particular on: inverse problems such as map-making and component separation, and on multi-wavelength data analysis. Furthermore, as recent developments in harmonic analysis, especially the "compressed sensing" theory, may have major impact on the way we collect, transfer and analyze the data, the conference had among its invited speakers Emmanuel Candes (Caltech, USA), a world expert in this field in order to diffuse these new ideas in the astronomical community.

For more information regarding the conference as well electronic versions of the presentations visit:

http://www.ics.forth.gr/ada5

The 13th Conference "Recent Developments in Gravity" (NEB XIII)

Thessaloniki, 4-6 June, 2008

Nikolaos Stergioulas, ***Aristotle Univ. of Thessaloniki***

The 13th conference in the series "Recent Developments in Gravity" (NEB XIII) took place in Thessaloniki last June and was organized by the relativity group of the Department of Physics, at the Aristotle University of Thessaloniki.

The conference was attended by more than 115 participants, about half of which came from outside Greece, bringing together nearly all Greek researchers in the areas of relativity, gravity and cosmology. It also attracted a large number of participants from all continents, underlining the international character of the conference, which is organized every two years by the relativity community in Greece. The plenary talks and parallel sessions covered the following topics:

- Gravitational Waves
- Relativistic Astrophysics
- Alternative Theories of Gravity
- Mathematical Relativity
- Cosmology
- Quantum Gravity

The plenary speakers were:

A. Ashtekar (Penn-State), **G. Ellis** (Cape Town), **V. Frolov** (Alberta), **J. Hough** (Glasgow), **P. Laguna** (Penn-State), **R. Loll** (Utrecht) and **D. Psaltis** (Arizona). In addition, a number of keynote speakers gave invited review talks: *N. Batakis* (Ioannina), *T. Christodoulakis* (Athens), *S. Cotsakis* (Aegean), *P. Kanti* (Ioannina), *L. Perivolaropoulos* (Ioannina), *M. Plionis* (NOA-Athens), *J. Pullin* (Louisiana), *G. Siopsis* (Tennesee) and *M. Tsamparlis* (Athens).

The proceedings of the conference will be published in the online IOP Journal of Physics: Conference Series and will also be accessible from the web site http://www.astro.auth.gr/~neb-13. At the end of the conference, 80 participants agreed to form the "Hellenic Society for Relativity, Gravitation and Cosmology" which will be complementary in its objectives and scope to HEL.A.S.

The conference was sponsored by the following institutions: Aristotle University of Thessaloniki, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, Research Committee of A.U.Th., Ministry of Macedonia and Thrace, Ministry of Education and Religious Affairs, John S. Latsis Public Benefit Foundation, ILIAS Network, Municipality of Thessaloniki, Prefecture of Thessaloniki and British Council Greece.

The next, 14th conference in this series will be organized in the summer of 2010 by the relativity group of the University of Ioannina.

The Central Kiloparsec: Active Galactic Nuclei and their Hosts

Crete, 4-6 June 2008

Emmanuel Angelakis, ***Max-Planck-Institut fuer Radioastronomie, Bonn***

The 5th of a series of workshops sponsored by the EU Consortium *RadioNet*, an *Integrated Infrastructure Initiative* funded under the *Sixth Framework Program*, took place in Ierapetra, Crete between 4th and 6th of June 2008. The meeting was entitled "The central kiloparsec: Active galactic nuclei and their hosts".

The organization was supported by the VLBI group of the *Max-Planck-Institut fuer Radioastronomie* in Bonn. The chairman of the organizing committee was E. Angelakis while the scientific committee was chaired by A. Lobanov and included prestigious colleagues from around the globe. In particular, M. Georganopoulos, A. King, A. Merloni, D. Merritt, H. Netzer, S. Rawlings and M. Volonteri. Remarkable has been the support of the local municipality and the voluntary help of the local community.

Although the meeting was initially meant to host a very limited number of participants (strictly less than 50), the response of the community was beyond any expectation with 110 contributions. Hence the organizing committee did everything possible to eventually accommodate, 80 astronomers from 53 different institutes in 19 countries across four continents attended the meeting. They contributed 10 invited review talks, 34 talks and 32 posters. The workshop focused on mainly four major topics; supermassive black holes and the nuclear environment in galaxies; star and gas in the central regions of galaxies; the nuclear outflows and their effect on the galactic environment and the cosmological co-evolution of AGN and their hosts. More specifically the talks have been focusing on topics such as, the synthetic picture of AGN, the extreme vicinity of SMBH, accretion disks and coronae in AGN, disk-outflow and molecular tori connection, stars, gas and relativistic jets in the nuclear regions, SMBH and their galactic hosts, AGN feedback and many more. The proceedings will be published in the *Memorie della Societa Astronomica Italiana.* All the contributions can be accessed online at http://www.mpifr-bonn.mpg.de/div/vlbi/ckp08/ .

The meeting was concluded with a talk to the public of Ierapetra by Professor M. Georganopoulos which was received with unprecedented enthusiasm and substantial interest.

The Cosmic Odyssey of the Elements

Aegina, 23 – 27 June 2008

Pepe Vilchez, ***Instituto de Astrofísica de Andalucia, Granada***

The history of the element production in the universe resembles much a cosmic Odyssey. The fresh, newly synthesized elements follow a many step, long journey until they can reach the places where we see them now in the cosmos. This cosmic odyssey still is far from being well understood.

After the original primordial abundance production of the light elements during the Big Bang, heavier elements (familiarly called "metals") were formed by nucleosynthesis in stellar interiors or during stellar explosions. Nowdays it is well established that galaxies have been gradually enriched in those elements along their particular evolutionary histories. This fact is unambiguously indicated by the chemical abundances observed both in stars and in the interstellar medium.

To address these main problems, from 23 to 27 of June 2008 an international conference was organized in Aegina jointly by the Observatoire de Meudon (France), Dept. of Astronomy University of Athens and National Observatory of Athens (Greece), and the Instituto de Astrofisica de Andalucia (CSIC, Spain).

The main conference topics included:

- *Element production in stars*
- *Segregation, dispersal & mixing in galaxies*
- *Interplay of solid, molecular, atomic & ionized phase*
- *Primordial stars*
- *Chemodynamical evolution of galaxies*
- *The chemical enrichment of the Universe*

A sample of the questions that were discussed follows below:

- How long do the nuclei ejected by supernovae stay in a very hot and tenuous phase, visible only with X-ray telescopes?
- Do they rather stay within their parent galaxies, or do they escape into in the intergalactic medium, progressively enriching it?
- Do they travel from one galaxy to another?
- Is the dispersal of elements a purely galactic process or does it work also at intergalactic scales?
- How does the matter lost in stellar winds finally becomes part of the interstellar medium?
- Are metal-rich pockets produced in the interstellar medium? How large and long lived would these metal-rich pockets be and what would be their physical status and composition?
- By what what mechanisms would they be destroyed, until complete small-scale mixing of fresh elements into the pre-existing interstellar medium?
- Do the nuclei pass a long time imprisoned in dust grains or molecules, before finding themselves again "naked" in the stellar interiors, and prone to be transformed into another species in the stellar factories?
- Do most of them –or a fraction– end up in the form of so-called dark matter, yet invisible but known to be there?

Such are questions, among many others, that one asks oneself and to which science has no definite answer so far.

The purpose of this meeting was to gather researchers from all fields of astronomy, observational and theoretical, who are interested in these questions and can help providing new clues. This conference was designed as a small well focussed meeting to facilitate the scientific interchange among researchers.

In addition to the rich scientific sessions covering the topics of the conference, the organization included several cultural sessions in the evenings, scheduled to provide the real flavour of the Hellenic culture and civilization to the nearly one hundred participants coming from all over the world.

The SOC & LOC were pleased to announce that this experience was a great success. We look forward to repeat it again soon, possibly visiting other places of HELLAS.

For more information on the conference visit: http://www.luth.obspm.fr/aegina08/index.html

Protostellar Jets in Context

Rhodes, July 7-12, 2008

Kanaris Tsinganos, ***University of Athens***

Protostellar Jets in Context was the theme of an international astrophysics conference organized last July at the island of Rhodes, Greece at the initiative of the University of Athens, Group of Theoretical Astrophysics and the JET-SET European Research and Training Network *(RTN)* **(**www.jetsets.org**)**. The main goal was to review the recent advances in theoretical and computational modelling, high-resolution observations, and laboratory experiments for our understanding of jets and outflows from young stars. The connection with accretion disks and the similarities with outflow phenomena in other astrophysical contexts were also explored.

Topics that were discussed include:

- *The jet/wind-launching region*: Theories, observations, and numerical simulations that addressed the origin of atomic and molecular jets and winds in young stars, the physics of the star/disk interaction zone, the connection with accretion disks and the role of jets in removing angular momentum from the protostellar object.
- *The propagation, cooling, stability, and environmental impact of jets* on scales from the stellar envelope to the parent cloud: Large-scale numerical simulations of collimated outflows including AMR codes and cluster/grid technologies. Observations and models of bipolar outflows, from the X-ray to the sub-mm regime. The origin of knots in jets.
- *Laboratory experiments* that reproduce, in a scaled manner, key aspects of the dynamics of astrophysical jets relevant to their formation, collimation and interaction with the interstellar medium. Experimental benchmarks for HD and MHD codes and radiative transfer in jets**.**
- *Similarities and differences between protostellar jets and their astrophysical siblings*, for example outflows in planetary nebulae, pulsar jets, jets from symbiotic stars and compact binaries, as well as the collimated large-scale relativistic outflows associated with AGNs and GRBs.

The conference brought together about 150 scientists from Europe, USA, Russia, Asia, Mexico, Latin American countries and Australia. It contained both invited and contributed talks, as well as poster sessions. The 12-member scientific organizing committee (SOC) was co-chaired by K. Tsinganos (Greece) and T. Ray (Ireland) and consisted of J. Bally (USA), S. Cabrit (France), S. Edwards (USA), S. Lebedev (UK), Mario Livio (USA), Mark McCaughrean (UK), Silvano Massaglia (IT), Alex Raga (Mexico), K. Shibata (Japan), F. Shu (USA), X. Tielens (NL). The local organizing committee (LOC) consisted of K. Tsinganos (Chair), T. Matsakos, P. Rammos, M. Stute and N. Vlahakis.

The conference opened with two invited reviews, one by M. Livio (Space Telescope Science Institute, USA) who presented a general/unified theoretical picture for jets in Astrophysics, and the other by J. Bally (Univ. of Colorado, USA) who reviewed the wealth of the spectacular recent observations of protostellar jets.

The 1st Session dealt with the star-jet-disk system and it included invited reviews on: The star-jet-disk system and angular momentum transfer (L. Hartmann, Un. of Michigan, USA), Hot inner winds from T Tauri stars (C. Johns-Krull, Rice Un, USA), Accretion disks and their instabilities (J. Stone, Princeton Un., USA), Theory of Wind-Driving Protostellar Disks (A. Konigl, Un. of Chicago, USA) and the Advection of Magnetic Fields in Accretion Disks (R. Lovelace, Cornell Un, USA).

The 2nd Session was devoted on jet launching and it included invited reviews on: Disk-wind models (J. Ferreira, Obs. de Grenoble, France), Can stellar jets efficiently brake T Tauri stars? (C. Sauty, Obs. de Paris, France), X-wind models (M. Cai, Academia Sinica, China), Star-disk interaction (M. Romanova, Cornell Un., USA), Similarities of the launching mechanism in protostellar/AGN jets (R. Matsumoto, Kyoto, Japan), Laboratory jets (S. Lebedev, Imperial College, UK), Jets in the MHD context (N. Vlahakis,

Un. of Athens, Greece), Jets from stellar mass black holes (N. Kylafis, Un. of Crete, Greece).

The 3rd Session dealt with observational constraints on jet launching and included invited reviews on: Class 0 and Class I jets (B. Nisini, Rome Italy), Resolved inner jets from T Tauri stars (F. Bacciotti, Florence, Italy), Observational challenges to ejection models in YSOs (S. Cabrit, Obs. De Paris, France), Similarities/differences of AGN/YSO jets (S. Massaglia, Torino, Italy).

The 4th Session addressed jet propagation, stability, interaction with the environment and X-ray emission with invited reviews on: The KH-Instability and the propagation of stellar jets (E. Trussoni, Torino, Italy), Shock formation in jets (A. Raga, Un. of Mexico), Magnetic fields in jets (P. Hartigan, Rice Un. USA), Jet kinematics (J. Eisloffel, Tautenburg, Germany), Jets from white dwarfs (J. Sokoloski, Columbia, USA).

The 5th Session was on molecular outflows and injection of turbulence by jets with invited reviews on: Observations of molecular outflows (R. Bachiller, Madrid Spain), Modelling of molecular outflows (T. Downes, Dublin Un., Ireland), Jets and turbulence (A. Frank, Rochester Un., USA), Prospects for Outflow and Jet Science with ALMA (J. Richer, Cambridge, UK).

Finally, on more general subjects there were presentations in the last Session on: The Antikythera Mechanism: Astronomy and technology in ancient Greece (J. Seiradakis, Un. of Thessaloniki, Greece), The International Year of Astronomy 2009: An opportunity for European Astrophysicists (T. Lery, European Science Foundation), "People" Programme: The Marie Curie Actions in FP7 (R. Bilyalov, EU/DG for Research).

The pdf files of the presentations can be downloaded from the conference website at the URL: http://conferences.phys.uoa.gr/jets2008/. The proceedings of the conference will be edited by Kanaris Tsinganos and Tom Ray and will be published by Springer-Verlag in 2009.

The participants enjoyed the conference and their stay in Rhodes, as it was indicated by their warm messages, among which the following: *"This is just to congratulate you for the excellent conference in Rhodes. The science programme was extremely good, and the logistic organization was exemplary. Congratulations are due also to the Jetset project, as it is being very successful in its original goals to produce a lot of new science and a full new generation of European jet researchers!"* (R. Bachiller, Madrid), or, *"Just a note to you all as leaders of the meeting. It was one of the best organized and most fun (scientifically and otherwise) conferences I have attended"* (A. Frank, New York)".

I should also thank the LOC (in particular Titos Matsakos and Matthias Stute) as well as several students of the University of Athens who participated and helped organize this memorable conference.

Challenges in Infrared Extragalactic Astrophysics

Crete, 15-19 September 2008

Vassilis Charmandaris, *Univ. of Crete* *(on behalf of the Scientific and Local Organizing Committees)*

The scope of this four day workshop was to bring together a number of nearly 35 experts on infrared extragalactic astrophysics to discuss the outstanding questions in the field, as well as how planned experiments using future facilities, such as the Herschel Space Telescope and SPICA may address them. Emphasis was given on how one can apply the knowledge derived from studies of the local universe to understand the properties of galaxies at higher redshifts. The workshop took place near the city of Heraklion in the island Crete (Greece) on 15-19 September 2008, and was funded by the CEA/Saclay (France) and the European Union 7th Framework Program "ASTROSPACE".

For more information on the conference as well electronic versions of the presentations visit: http://www.physics.uoc.gr/~vassilis/irmtg08

AGN Advanced Astronomy School

Pendeli Astronomical Station, National Observatory of Athens, 22-24 September 2008

Antonis Georgakakis, *IAA, National Observatory of Athens*

In recent years an increasing body of observational and theoretical work has placed Active Galactic Nuclei (AGN) at the forefront of astrophysical research. These systems, which are powered by accretion of material on supermassive black holes at the centres of galaxies, represent natural laboratories to explore physics under extreme conditions, form cosmic beacons which can be used to probe the early Universe, play a key role in the formation and evolution of galaxies, while their large scale distribution provides important constraints on fundamental cosmological parameters.

These developments have motivated the organisation of an Advanced Astronomy School on the "Many Faces of Active Galactic Nuclei" by the Institute of Astronomy and Astrophysics of the National Observatory of Athens (NOA). The goal was to provide to MSc and PhD students, with an interest in astronomy, a comprehensive review of the key recent developments in the study of AGN and to highlight open problems and challenges for the future.

The lectures took place in September 2008 at the premises of NOA at Pendeli. The topics covered included the Accretion History of the Universe, AGN radiation processes, jet dynamics, the role of AGN in the evolution of galaxies, the interplay between massive black holes

and their environment on kpc and Mpc scales and cosmology with AGN. The School attracted a total of 20 students from Physics and Mathematics departments of the major Greek Universities.

The lectures were presented by astrophysicists from both Greek and European Universities and Research Institutes, including Prof. Michael Rowan-Robinson (Imperial College), Prof. Kirpal Sandra (Imperial College) and Dr. Andrea Cattaneo (Potsdam). The presentations are available at http://www.astro.noa.gr/xrayschool.

The organisers acknowledge financial support by the British Council, the Ministry of Education, the National Observatory of Athens and the General Secretary of Research and Technology.

Visit our website
http://www.helas.gr

The above web server contains information, both in greek and english, about the Hellenic Astronomical Society (Hel.A.S.), the major organization of professional astronomers in Greece. The Society was established in 1993, it has more than 220 members, and it follows the usual structure of most modern scientific societies. The web pages provide information and pointers to astronomy related material which would be useful to both professional and amateur astronomer in Greece. It contains a directory of all members of the Society, as well as an archive of all material published by the Society such as the electronic newsletters, past issues of "Hipparchos", and proceedings of Conferences of Hel.A.S. The server is currently hosted by the University of Thessaloniki.

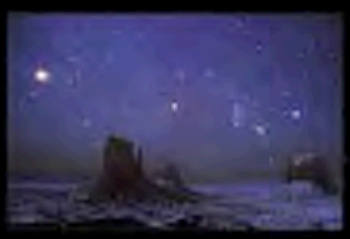
The eternally peaceful sky looks the same above all regions and nations. One World, One Sky!

The World at Night (TWAN)

www.twanight.org

Initiated in 2007, TWAN, a global program by Astronomers Without Borders, produces and presents a collection of stunning photographs and time-lapse videos of the world's most beautiful and historic sites against a nighttime backdrop of celestial objects. Each image also reveals a story. The similarity of the night sky above diverse cultural and historic landmarks demonstrates that humanity is one family living on a small planet amidst the vast ocean of the Universe. The sky connects us not only around the world but also through time. Druids at Stonehenge, priests at the Egyptian pyramids and Mesopotamian ziggurats – they saw the same sky we do today. The work of ancient observatories in Mexico and Peru is now carried on by the giant telescopes and technology of modern observatories. TWAN captures the sky above both.

The International Year of Astronomy 2009 (IYA2009) has designated TWAN as a Special IYA2009 project. With its eye-catching images, TWAN supports other IYA2009 projects and international programs as well. TWAN is a long-term project with major presence at IYA2009 activities worldwide. UNESCO World Heritage Sites are given priority as TWAN main sites but thousands more landmarks must be considered. Celestial events bring new opportunities for unique scenes at TWAN locations. Careful planning and a keen eye honed by years of experience go into each image. Geographic location, altitude, local topography, light pollution and many more factors must be considered in preparing for a photo session.



TWAN photographs resonate with viewers on an instinctive level, as well as sparking the imagination. Familiar landmarks provide a context viewers relate to, even among city dwellers who have never gazed in wonder at the Milky Way.

TWAN images also show that the night sky can be enjoyed with nothing more than the unaided eye. A clear dark night shows us what we are missing when we lose those dark sites – an essential part of our environment that must be preserved.

The night sky above us has no visible borders, and is shared by all the people of Earth. It is a bridge that connects us, helping to create understanding, sympathy and, ultimately, friendship. When borders vanish, political and cultural differences become irrelevant. This is the message that Astronomers Without Borders was created to spread.

If you have a supportive venue

TWAN is seeking venues for major exhibitions worldwide during IYA2009. TWAN exhibitions will be held throughout the International Year of Astronomy 2009 at a variety of venues worldwide. Some exhibitions will feature presentations and workshops by TWAN team members. The exhibitions are designed to be shown either indoors or outdoors in interesting settings and can be standalone or in conjunction with other IYA2009 exhibits and activities. If you have suggestions for local, national or regional centers that may be appropriate and supportive for a TWAN exhibition, large-screen presentation and educational workshop, please send an e-mail to TWAN at:
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TWAN products

Beside exhibitions, TWAN will interact with the media and publishers. Companion books and DVDs based on the images are already in the works.

ASTRONOMERS WITHOUT BORDERS

The World at Night TWAN

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—***The Times Literary Supplement***