HIPPARCHOS

The Hellenic Astronomical Society Newsletter
Volume 2, Issue 7

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3rd Advanced Astronomy School
"The Obscured Universe"

National Observatory of Athens - Institute of Astronomy & Astrophysics

National & Kapodistrian University of Athens - Department of Astronomy, Astrophysics & Mechanics

September 20-22, 2010

Astronomers have recently recognised that the most fascinating and violent phenomena in the Universe are taking place in dark regions, hidden from our eyes by thick clouds of gas and dust. The formation of stars, the build-up of galaxies, the growth of supermassive black holes are examples of important astrophysical processes, in which the bulk of their huge energy output is typically absorbed by large quantities of dust. Penetrating the obscuring clouds of dust and gas is therefore imperative for understanding the formation and evolution of the Universe at large.

The goal of the 3rd Astronomy School is to provide a comprehensive review of the key recent developments in the study the obscured Universe using the world's largest ground-based and space facilities and to highlight open problems and challenges for the future.

The school is sponsored by the European Union Marie-Curie program, the National Observatory of Athens and the General Secretary of Research and Technology. Lectures will be presented by astrophysicists from both Greek and International Universities and Research Institutes. The school will take place at the facilities of the Section of Astronomy, Astrophysics & Mechanics of the University of Athens.

Who should attend

The school will be limited to approximately 20 students at the graduate level with an interest in observational Astronomy. Keen undergraduates are encouraged to apply. All students must apply for participation via email to the organizing committee. Limited support for students outside Athens is available. Interested parties please contact the organising committee.

SCHEDULE

Monday 20 to Wednesday 22, September 2010. Lectures will run from 9:00-17:00. Topics covered:

* Stellar evolution
* Origin of cosmic dust
* Accretion history of the Universe
* Star-formation across cosmic time
* Infrared Luminous Galaxies
* Semi-analytic modelling
* Radiative transfer methods
* The dark universe: dark matter and dark energy

LOCATION

National & Kapodistrian of the University of Athens,
Department of Astronomy, Astrophysics and Mechanics, Zografos, Athens,
Seminar room of the Department of Astronomy, Astrophysics.

http://www.astro.noa.gr/ss2010/

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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:
Stellar Gestation and Birth
in the Milky Way

Image obtained with instruments carried on the European Space Agency's Herschel Space Observatory

Observation date: 2010/04/28

Credit & Copyright: ESA / PACS & SPIRE Consortium, Sergio Molinari, Hi-GAL Project

Image
of Herschel
Space Observatory
Credit:
ESA/NASA.

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.

Message from the President

Dear Hel.A.S. members,

The current issue of *Hipparchos* features a variety of science news and reports from conferences together with three review articles regarding very interesting and modern subjects of astrophysics.

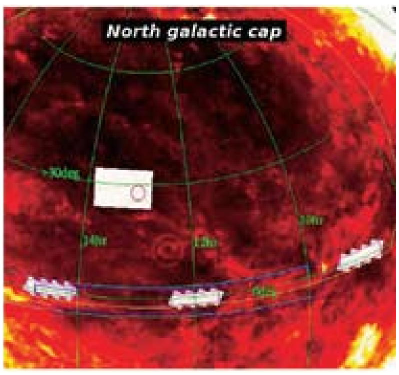
Leonidas Moustakas unveils the mysteries of strong gravitational lensing, a visually amazing phenomenon, which can be used in a variety of ingenious ways. For example, it can be used to study the nature of extremely distant galaxies, from

the very beginning of time, magnified by an intervening cluster of galaxies which act as a gravitational lens obeying Einstein's General Relativity. Also, it can probe the expansion rate of the Universe, an important fact for eventually determining the equation of state of the Dark Energy, one of the most important tasks of cosmological studies.

Kleomenis Tsiganis presents a most interesting review regarding the distribution of main-belt asteroids and their relationship with various collected me-

teorites. He nicely shows that new dynamical models and spectroscopic observations can be used to identify with high significance the parent bodies from which various meteorites originate. He also discusses how such information can provide important information about key dynamical processes that appear to have shaped our solar system.

Finally, Markos Trichas presents the details and workings of the SPIRE instrument (*Spectral and Photometric Imaging Receiver*) on-board the latest ESA success, the HERSCHEL space observatory which was launched about a year ago



(May 2009) and which has the largest single mirror ever built for a space telescope (3.5m). The article also discusses the two major scientific programs (ATLAS and HerMES) which will be accomplished with SPIRE and PACS (the *Photodetector Array Camera and Spectrometer* of Herschel).

From a broader perspective, it is time to reflect for a moment that the present seventh issue of the second volume of *Hipparchos*, marks the end of the second and last 2-year term of five members of the current Governing Council of the Hellenic Astronomical Society (Hel.A.S.). In the four years since the summer of 2006, seven (7) issues of *Hipparchos,* including the current one, have been published. Among them we had two special issues: one devoted to the present (2007) status of the Hellenic observational astronomy with reports on all Hellenic observational infrastructures and the second on the celebrated international year of Astronomy 2009 (IYA09) with excellent popular reviews on the main areas of Astronomy and Astrophysics. Three issues of *Hipparchos* were edited by Kostas Kokkotas and four by Manolis Plionis. We are proud for all of them, since any one of these issues was better than the other. We thank the editors and the contributing authors for their efforts in achieving the high quality of our *Hipparchos* publication.

At a related front, during these four last years another electronic publication of the Society can hardly be unnoticed. Namely, at the beginning of each month we have all been receiving an issue of the electronic newsletter of Hel.A.S. It is remarkable not only that all the e-newsletters were arriving on time on our mailboxes, but also that they were full of important announcements for our members with practical information such as, appointments and departures, job openings, research opportunities, awards, conferences in Greece, etc. We are grateful to Vassilis Charmandaris for preparing carefully and on a constant basis the material of all the 48 e-newsletters and

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JUNE 2010 - TOPICS

1. Short News
2. Upcoming Elections of the Governing Council of Hel.A.S.
3. TenYear Anniversary of the Gerostathopoulio Observatory
4. Third Advanced Astronomy School of Athens
5. School on High Angular Resolution Techniques
6. Upcoming Astronomy Meetings in Greece
7. About this Newsletter

1. SHORT NEWS

On May 12th 2010 an honorary doctorate degree by the Department of Physics of the University of Athens was presented to the Academician Dr. Stamatis Krimigis, as a recognition for his lifelong contribution to the exploration of the Solar System. The President and the CG of Hel.A.S. would like to extend to Dr Krimizis their warmest congratulations on behalf of all members of the Society.

We would like to congratulate Mr. Manos Chatzopoulos, a junior member of Hel.A.S. and graduate student at the Univ. of Texas at Austin (USA), who was awarded the Frank N. Edmonds, Jr. Memorial Fellowship in Astronomy, in recognition and support of outstanding research.

We would like to congratulate Mr. Kostas Dialynas who has recently obtained his PhD from the Department of Physics of the University of Athens, under the co-supervision of Dr. S. M. Krimigis (Academy of Athens) and Prof. X. Moussas (University of Athens). The title of his dissertation was: "The Saturnian magnetosphere as revealed by Cassini/MIMI measurements: Energetic ion spectral analysis and global ENA imaging".

We would like to congratulate Ms. Danae Polychroni who has recently obtained her PhD from the Astrophysics Research Institute, of Liverpool John Moores University (UK) under the supervision of Dr. Toby JT Moore. The title of her dissertation was: "A Multi-Wavelength Study of the Star Formation Processes in the W3 Giant Molecular Cloud". Dr. Polychroni moved to a postdoctoral research position at the Instituto di Fisica dello Spazio Interplanetatio (INAF-IFSI), in Rome, where she is currently working on observations of Star Forming Regions with the Herschel Space Telescope.

2. UPCOMING ELECTIONS OF HEL.A.S.

All Ordinary and Junior members of Hel.A.S. must have already received a letter from the Society which includes the summary of the President on the activities of the current Governing Council during the 2008-2010 term, as well as the ballots and instructions from the Secretary on the voting process. If you have not done this already, please read those instructions carefully and mail your ballots today! It is important that all of us participate in the elections. In order to be considered at the elections, your ballots have to arrive at the hands of the Secretary before the 20th of June 2010. If they arrive after that date they will be destroyed.

A document including the brief CVs of the candidates for the upcoming elections is available online as a PDF file.

for distributing them to all our members having electronic addresses.

Talking about the publications of Hel.A.S. during the last four years, it is worth to also mention some other Society publications on the occasion of the IYA09. At the beginning of 2009 we prepared a very nice volume entitled "The adventure of the Universe, from Galileo till today" (*Η περιπέτεια του Σύμπαντος από το Γαλιλαίο ως σήμερα*), published by the newspaper *Ελευθεροτυπία*. In addition, throughout the year a number of members of Hel.A.S. wrote in a coordinated manner fourteen (14) articles on astronomical issues of interest to the general public, which appeared in the newspaper *Καθημερινή*. Furthermore, the Society coordinated the main astronomical popularization event, which took place at the central Univ. of Athens, and which was under the auspices of the President of the Hellenic Republic and was accompanied by an illustrated booklet on the various talks and their authors. During the IYA09, other activities included the publication of a booklet on light pollution, an issue of concern not only to astronomers but also to everyone who admires and observes the night sky, the collaboration with the Bank of Greece which issued a coin commemorating the IYA2009, and many more. A report on all these can be found in a dedicated webpage of the Society (Newsletters, IYA09).

Last, but not least, it is important to mention the publication of the proceedings of the 9th Hellenic Astronomy Conference by the Publications of the Astronomical Society of the Pacific. Held regularly since 1993, the Hellenic Astronomical Conference, organized by Hel.A.S., is the major scientific event of the Hellenic astronomical community. The 9th Conference of Hel.A.S. took place in the University of Athens, between September 20 and 24, 2009 and coincided with the IYA09. About 150 astronomers from many countries participated in the event, making it the most attended conference of our Society. The scientific program of the conference consisted of 5 plenary talks, 15 invited presentations, 55 contributed papers and about 100 poster presentations carefully selected by the Scientific Organizing Committee of the conference. In addition, there were sessions on ESA (PRODEX) and on Secondary Education. The excellent program of the conference was organized by the Scientific Organizing Committee, members of which were the following: Vassilis Charmandaris (Univ. of Crete), Ioannis Daglis (National Observatory of Athens), Eleni Dara (Academy of Athens), Ioannis Georgantopoulos (National Observatory of Athens), Apostolos Mastichiadis (University of Athens) Margarita Metaxa (Arsakeio High School), Panos Patsis (Academy of Athens), Manolis Plionis (National Observatory of Athens), John Seiradakis (Univ. of Thessaloniki), Nikos Stergioulas (Univ. of Thessaloniki), Loukas Vlahos (Univ. of Thessaloniki), and Emmanuel Xilouris (National Observatory of Athens), while the memorable events of the local organization were coordinated by Panagiotis Niarchos (University of Athens) and the other members of the LOC. The more than 500 pages proceedings summarize the recent progress in Astronomy, Astrophysics, and Space Physics during the IYA09. All registered participants of the conference will soon receive a copy of the Proceedings volume. During the conference, the Society honored two previous Presidents of Hel.A.S., J. Seiradakis (1998-2002 term) & P. Laskarides (2002-2006 term), presenting them with commemorative presents, a replica of the head of the ˝Antikythera youth˝ and of a statue of Prometheus fire-bearing (the original by Pavlos Kougioumtzis).

All of the above facts and events reflect upon the increasing dynamism and maturity of Hel.A.S. as a Society. Reaching the end of the 2006-08 and 2008-10 terms, the current Council has the pleasure to be looking confidently towards a bright future for the Hellenic astronomical community. We hope that the new Council, which will be elected during the General Assembly on the 21st of June 2010, will lead the Society to gain even more momentum and retain its position among the leading professional societies in Greece, making its members around the world proud of Hel.A.S.

Kanaris Tsinganos
Professor of Astrophysics
University of Athens

Herschel First Results

The Herschel space observatory, launched on 14 May 2009, is the fourth `cornerstone' mission in the ESA science programme. With a 3.5m Cassegrain telescope it is the largest space telescope ever launched. It is performing photometry and spectroscopy in approximately the 55-671 μm spectral range, bridging the gap between earlier infrared space missions and ground-based facilities. Currently, Herschel is performing routine observations of the awarded key programmes with all three instruments onboard (PACS, SPIRE and HIFI) in nominal performance.

Herschel's original promise was to study the origin of stars and galaxies as well as keep on searching for water in space. The first observations performed by Herschel suggest that indeed these goals were reached, providing many exciting discoveries already announced during the Herschel First Result Symposium, ESLAB 2010 that took place at ESTEC in Noordwijk (4-7 May 2010).

Amongst many impressive observations, Herschel unveils rare massive stars in the act of forming. Herschel's observation of the star-forming cloud RCW 120 has revealed an embryonic star which looks set to turn into one of the biggest and brightest stars in our Galaxy within the next few hundred thousand years (Fig. 1). It already contains eight to ten times the mass of the Sun and is still surrounded by an additional 2000 solar masses of gas and dust from which it can feed further.

Herschel was also able to reveal a new, previously unresolved, population of galaxies in the GOODS fields. It targeted two regions of the sky (GOODS-North and GOODS-South) with the latter being the most sensitive far-infrared image yet taken by Herschel (Fig. 2). The GOODS fields are designated for studying the distant Universe and have been extensively investigated by other observatories. Herschel resolved the cosmic infrared background into 300 previously unseen galaxies in GOODS-N, and 800 of them in GOODS-S. Together, these galaxies contribute more than half the power to the infrared background in these regions. These galaxies are young,

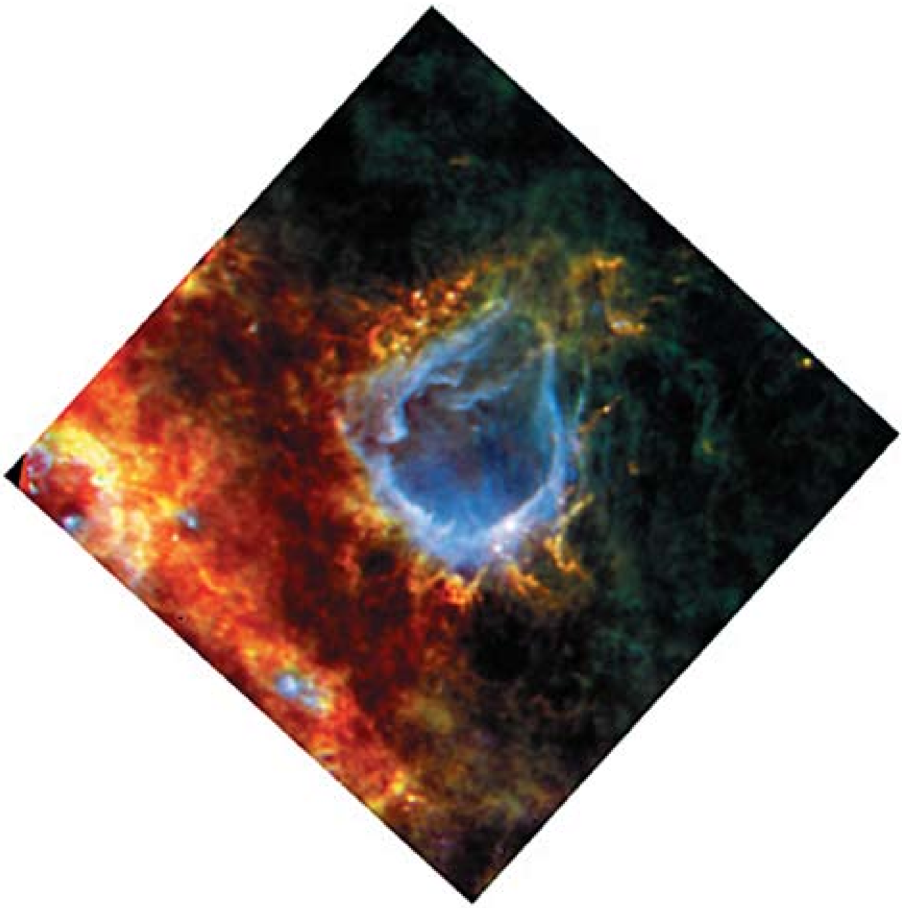


Figure 1: RCW 120 as seen by Herschel. *Copyright: ESA, PACS & SPIRE Consortia, A. Zavagno (Laboratoire d'Astrophysique de Marseille) for the Herschel HOBYS and Evolution of Interstellar Dust Key Programmes.*

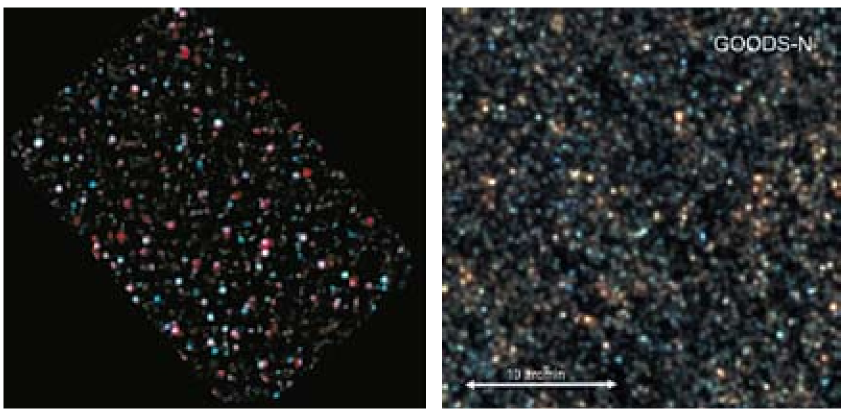


Figure 2: The GOODS-North field as viewed by PACS (left) and SPIRE (right). These are the most sensitive images yet produced by Herschel. *Copyright: ESA/PACS Consortium/PEP Key Programme Consortium.*

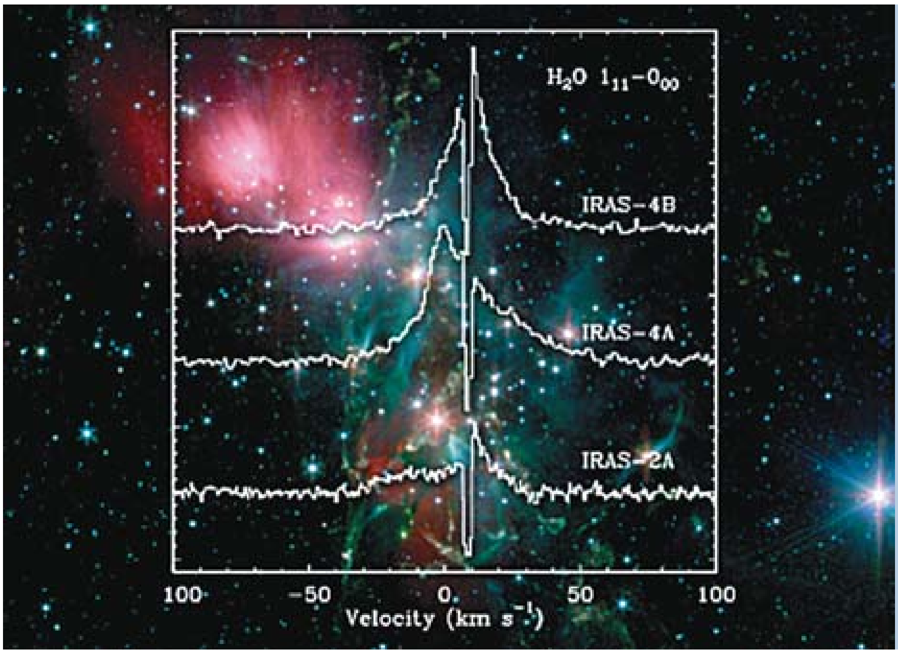


Figure 3: Water lines toward low-mass protostars in the NGC 1333 star-forming region.
Copyright: ESA and the HIFI consortium; L.E. Kristensen for the WISH Key Programme. Background image: NASA/JPL-Caltech/R. Gutermuth (Harvard-Smithsonian CfA).

some of them seen at a time when the Universe was just 16% of its present age and they are forming young stars, in some cases up to thousands every year.

Herschel also discovered the presence of water molecules in various cosmic environments (Fig. 3). With its superb resolution, HIFI can target about 40 different lines, each coming from a different transition of the water molecule and thus sensitive to different temperatures. Early results demonstrate the detection of water in various proto-stellar systems. Along with upcoming data from star-forming clouds throughout the Milky Way, these data will help astronomers understand the mechanisms of star formation in great detail. Beyond our Galaxy, water signatures have been found in nearby galaxies which are known to be undergoing intense bursts of star formation.

A special issue of *"Astronomy and Astrophysics"*, announcing all the interesting Herschel's first results, are expected to be published later this year. Note also that the call of open time for proposals has been released on the 20th of May 2010, offering 6592 hours of Herschel observing time with proposal submission deadline the 22nd of July 2010.

For more information please visit

http://herschel.esac.esa.int/

Manolis Xilouris

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.

Supermassive Black Holes May Frequently Roam Galaxy Centers

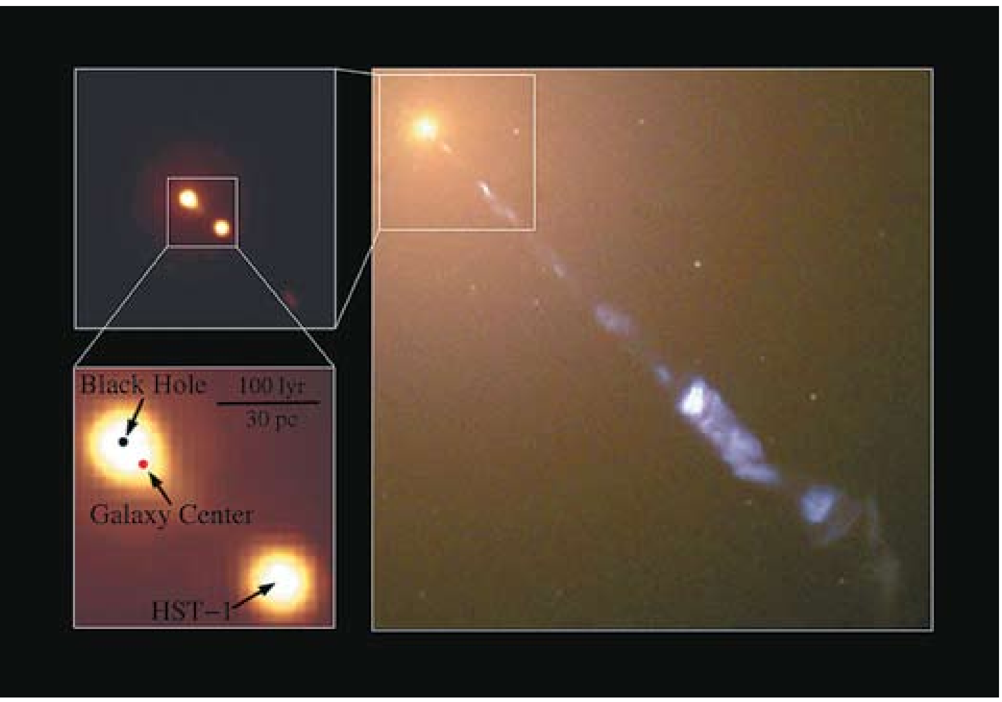
Recent results obtained with the Hubble Space Telescope (ST) have revealed that the supermassive black hole (SMBH) at the center of M87, the most massive elliptical galaxy in the Virgo cluster, is displaced from the galaxy center. The most likely cause for this SMBH to be off center is a previous merger between two older, less massive, SMBHs. "We also find, however, that the iconic M87 jet may have pushed the SMBH away from the galaxy center," said Daniel Batcheldor, Florida Tech assistant professor in the Department of Physics and Space Sciences, who led the paper which will publish in the Astrophysical Journal.

The study of M87 is part of a wider HST project exploring the possibility that what one can find a signpost of a black hole merger, which is of interest to astronomers looking for gravitational waves and those modeling such systems as a demonstration that black holes really do merge. The theoretical prediction is that when two black holes merge, the newly combined black hole receives a 'kick' due to the emission of gravitational waves, which can displace it from the center of the galaxy. Once kicked, a SMBH can take millions or billions of years to return to rest, especially at the center of a large, diffuse galaxy like M87. Jets, such as the one in M87, are often found in a class of objects called Active Galactic Nuclei. It is commonly believed that SMBHs can become active as a result of the merger between two galaxies, the infall of material into the center of the galaxy, and the subsequent merger between their black holes. Therefore, it is very possible that this finding could also be linked to how active galaxies—including quasars, the most luminous objects in the universe—are born and how their jets are formed.

Because many galaxies have similar properties to M87, it is likely that SMBHs are commonly offset from their host galaxy centers. The potential offsets, however, would be very subtle and researchers would rely on the Hubble Space Telescope to detect them. Regardless of the displacement mechanism, the implication of this result is a necessary shift in the classic SMBH paradigm; no longer can it be assumed that all SMBHs reside at the centers of their host galaxies. This may result in some interesting impacts on a number of fundamental astronomical areas, and some interesting questions.

For example, how would an accreting (growing by the gravitational attraction of matter) or quiescent SMBH interact with the surrounding nuclear environment as it moves through the bulge? What are the effects on the standard orientation-based unified model of active galactic nuclei and how have dynamical models of the SMBH mass been centered if the SMBH is quiescent?

Furthermore since current galaxy formation scenarios galaxies are thought to be assembled by a process of merging, one would expect that binary black holes and post coalescence recoiling black holes, like that in M87, are rather common.



Note:

Researchers on the project are Daniel Batcheldor and Eric Perlman, Florida Tech; Andrew Robinson and David Merritt of RIT; and David Axon, dean of mathematical and physical sciences at University of Sussex in the United Kingdom and research professor at RIT. All are authors of the paper, "A Displaced Supermassive Black Hole in M87" to appear in the Astrophysical Journal Letter.

For more information visit the HST Press Release at:

http://hubblesite.org/newscenter/archive/releases/2010/18/

Adapted by Vassilis Charmandaris

Site selected for the European Extremely Large Telescope

On 26 April 2010, the European Southern Observatory (ESO) Council selected Cerro Armazones as the baseline site for the planned 42-metre European Extremely Large Telescope (E-ELT). Cerro Armazones is a mountain at an altitude of 3060 meters in the central part of Chile's Atacama Desert, nearly 130 kilometers south of the town of Antofagasta and about 20 kilometers from Cerro Paranal, home of ESO's Very Large Telescope.

E-ELT the largest optical/infrared telescope in the world will have a primary mirror 42 meters in diameter. The mirror will consist of nearly 1000 hexagonal segments, 1.4m in diameter and 5cm thick. ESO is drawing up detailed construction plans together with the community. Details can be found at

http://www.eso.org/public/teles-instr/e-elt

The E-ELT will address many of the most pressing unsolved questions in astronomy, and may, eventually, revolutionize our perception of the Universe, much as Galileo's telescope did 400 years ago. The final go-ahead for construction is expected at the end of 2010, with the start of operations planned for 2018.

Various factors needed to be considered in the site selection process. The "astronomical quality" of the atmosphere, the number of clear nights, the amount of water vapor, and the "stability" of the atmosphere (also known as seeing) played a crucial role. But other parameters had to be taken into account as well, such as the costs of construction and operations, and the operational and scientific synergy with other major facilities (VLT/VLTI, VISTA, VST, ALMA and SKA etc).

In March 2010, the ESO Council was provided with a preliminary report with the main conclusions from the E-ELT Site Selection Advisory Committee. These conclusions confirmed that all the sites examined in the final shortlist (Armazones, Ventarrones, Tolonchar and Vizcachas in Chile, and La Palma in Spain) have very good conditions for astronomical observing, each one with its particular strengths. The technical report concluded that Cerro Armazones, near Paranal, stands out as the clearly preferred site, because it has the best balance of sky quality for all the factors considered and can be operated in an integrated fashion with ESO's Paranal Observatory. Cerro Armazones and Paranal share the same ideal conditions for astronomical observations. In particular, over 320 nights are clear per year.

Taking into account the very clear recommendation of the Site Selection Advisory Committee and all other relevant aspects, especially the scientific quality of the site, the ESO Council endorsed the choice of Cerro Armazones as the E-ELT baseline site.

For more information visit the ESO Press Release

http://www.eso.org/public/news/eso1018/

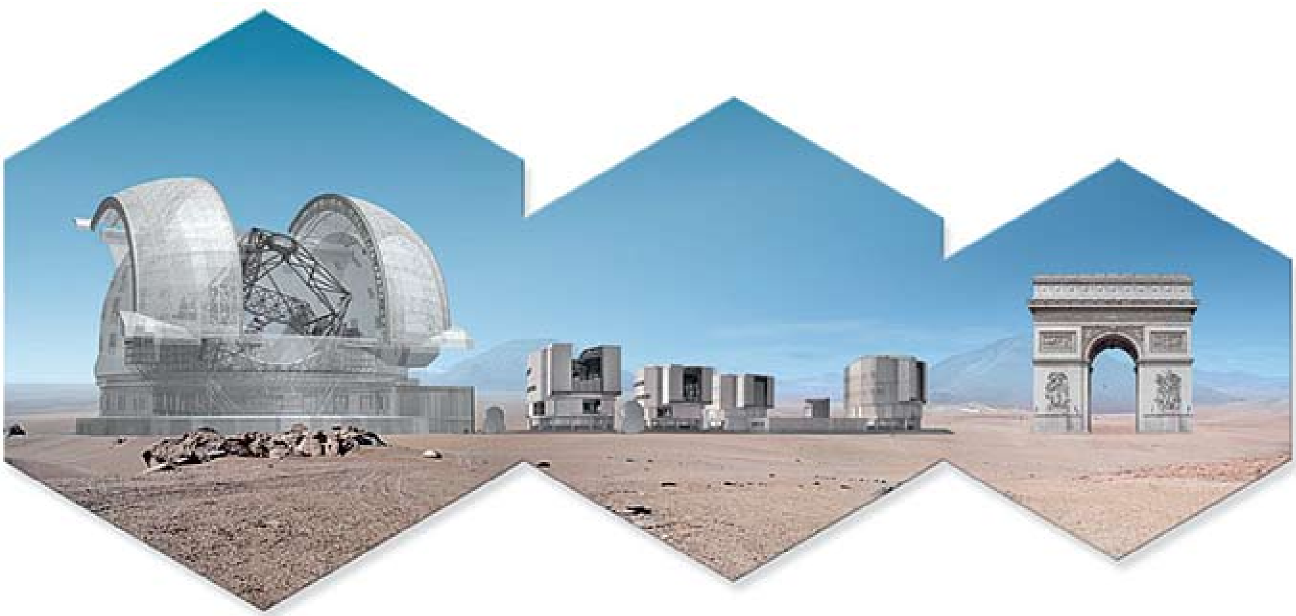


***Figure 1**. An artist's impression of the E-ELT (left), in comparison with the VLT at Paranal, and the Arc de Triomphe, in Paris, France.*

Adapted by Vassilis Charmandaris

Standard Radiation Environment Monitor (SREM) Solar Particle Event Scientific Analysis

The first space-science related ESA-funded project in Greece

Last March the project "SREM Solar Particle Event Scientific Analysis" was successfully completed by the Institute for Space Applications and Remote Sensing of the National Observatory of Athens (NOA/ISARS) in collaboration with the Team of the Athens Neutron Monitor Data Processing Center at the National and Kapodistrian University of Athens (NKUA), under the ESA/ESTEC contract No 21480/08/NL/NR. The contract was signed between the European Space Agency and NOA following the submission of a proposal by NOA/ISARS to a competitive ITT (Invitation to Tender) by ESA. This was the first ever ESA-funded space-science related project in Greece.

The SREM unit (Standard Radiation Environment Monitor) belongs to a second generation of instruments in a program established by ESA/ESTEC to provide minimum intrusive particle radiation detectors on ESA spacecraft for particle radiation alerts and other space weather applications. In the framework of the project, NOA/ISARS carried out investigations on the origin and the characteristics of Solar Particle Events (SPEs), which occurred during selected intervals of the 23rd Solar Cycle with intense solar activity. The purpose of this investigation was to establish the association of SREM-recorded SPEs with their solar sources and evaluate the potential of SREM units as an alarm system for hazardous SPEs.

The SREM unit detects high-energy electrons and protons and bins the measurements in overlapping energy channels. For the estimation of the solar energetic particle (SEP) fluxes, the NOA/ISARS team had therefore to develop and validate a novel method to convert SREM counts into SEP fluxes. The method is based on the Singular Value Decomposition (SVD) technique and includes proper schemes that treat characteristic issues of the detector, such as the overlapping energy bands and the strong correlation between count-rates in SREM channels. The results obtained through this method are consistent with the results derived by other methods used so far for the estimation of SREM fluxes. The main advantage of the new method is that it provides particle flux spectra with enhanced spectral resolution as compared to the Simple Conversion Factor method without requiring any pre-assumption for the spectral form of the particle fluxes. A successful benchmark of the developed method was performed by comparing estimated proton fluxes with independent measurements by other spacecraft. In addition, the derived results reveal unique features that are considered to be characteristic of evolving proton spectra during solar particle events.

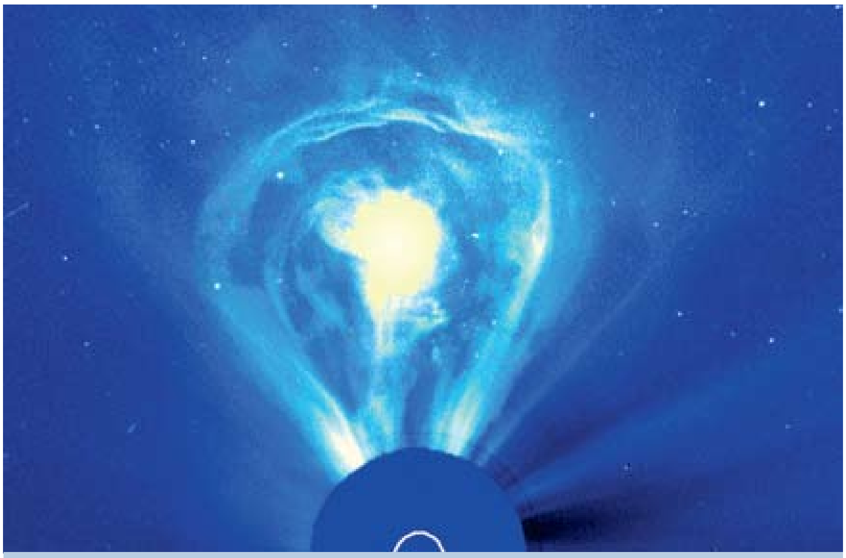


Figure 1: Coronal mass ejections, such as this one that was observed by SOHO, are often the first stage of a Solar Particle Event.

An extensive scientific analysis has been performed on the solar origin and characteristics of the SREM-detected SPEs. The SPE-originating solar events, i.e. solar flares and/or CMEs (Figure 1), were identified for SPEs that occurred during four periods of the 23rd solar cycle showing intense solar activity. This preliminary association led to a more detailed scientific analysis for the six SPEs that occurred during the January 2005 and December 2006 time intervals. Temporal and spatial characteristics of associated solar flares and/or CMEs have been thoroughly investigated through a synthesis of multiple space-based observations covering a wide range of the solar electromagnetic spectrum from radio to visible and X-rays. Our analysis has clearly demonstrated the importance of complementary radio/optical/X-ray observations for a deeper understanding of the physical characteristics of the SREM recorded solar energetic particle fluxes. Special attention has been paid to the January 20, 2005 and December 13, 2006 solar particle events, which produced significant Ground Level Enhancements on the surface of the Earth, providing a unique opportunity for a coherent analysis of the onset, evolution, propagation and physical characteristics of these events from the solar surface to geospace.

The SREM project team: Ioannis A. Daglis (project coordinator), Anastasios Anastasiadis, Ingmar Sandberg, Kostas Tziotziou, Ioannis Panagopoulos (NOA/ISARS), Helen Mavromichalaki, Thanasis Papaioannou, Maria Gerontidou

Ioannis Daglis

Collector's Coin issued by the Bank of Greece commemorating the IYA2009

The Hellenic ministry of Finance and the Bank of Greece, in collaboration with the Hellenic Astronomical Society, has issued a 10€ collector's coin to mark the International Year for Astronomy 2009, which is the 400th anniversary of Galileo's first astronomical observation with a telescope. The design features from one side an artistic view of a spiral galaxy, seen face-on, and from the other the Hellenic's republic sign surrounded by stars of various sizes.

The coin comes within a beautiful jewel case that features the Antikythera Mechanism, images of galaxies and planetary nebulae, an image of the modern 2.3m *Aristrachos* Telescope of the National Observatory of Athens, as well as an image of Galileo-Galilei and parts of his writings as a background.

In the images below you can see the coin as well as its case. The coin can be purchased from any branch of the Bank of Greece.

Manolis Plionis

Strong gravitational lensing by galaxies

by Leonidas Moustakas
JPL/Caltech, USA, Pasadena

Everything flows -- Heraclitus

Abstract

Strong gravitational lensing is a phenomenon that was long predicted by Einstein, Zwicky, and others, confirmed observationally in 1979, and which is now rapidly coming of age as a powerful tool. Gravitational lensing has many applications to fundamental problems in physics and astrophysics. As a quick overview list, with observations of strong gravitational lenses, it is possible to study extremely magnified galaxies from as far back as the dawn of cosmic time, measure the expansion and acceleration rate of the universe, determine the internal structure and the dark matter distribution within the central portions of distant galaxies, and even set meaningful measurements of the particle nature of dark matter. It is also a visually stunning phenomenon, which open many opportunities for engaging the public's interest at many levels. In this brief article, I set the stage for strong lensing, show some of the recent progress in the field, and give some indication for what this new decade holds.

The "deflection of starlight" by gravity is an idea that is at least as old as Newton, and the amount of deflection predicted by General Relativity was famously confirmed by observations of stars behind the Sun by Sir Arthur Eddington during the total solar eclipse of 1919 [1]. The same principle as this deflection leads to a prediction of a spatial distortion and magnification of the apparent images of background sources that may be fairly aligned with a foreground massive lens object. The case where distant galaxies are distorted by the gravitational effect of massive structures or objects in the foreground is characterized as "weak gravitational lensing" [2] and is a subtle and difficult (though powerful) measurement to make [3]. *Strong* gravitational lensing, however, leaves an unmistakable impression: multiple rays of light from the chance background galaxy or quasar can be focused simultaneously such that we see the same object multiple times.

A cartoon of how strong gravitational lensing works is shown in Figure 1. The scenario involves a fortuitous alignment of a massive distant galaxy and an even more distant luminous source behind the first galaxy. In some cases, then, multiple rays of light from the luminous source (shown on the left) may be focused to our point of view by the massive lensing galaxy (shown second from the left). It will then appear as multiple objects, which are generally several or even many times brighter than they would have appeared had they not been lensed. Different lensed configurations may form, depending on the details of the size of the more distant source, and the precise alignment (or slight misalignment) between the lens and the source. This is graphically illustrated in Figure 2, which shows the most basic and common configurations seen in nature: a two-image lens, a four-image lens, and the spectacular Einstein Ring [4,5].

In 1936, an amateur astronomer convinced Einstein to work out how this kind of multiple-imaging lensing may happen. Einstein did so, and in his paper on the calculation he commented, "Of course, there is no hope of observing [the] phenomenon directly [as described] in this publication Mr. Mandl squeezed out of me. It is of little value, but it makes the poor guy happy" [6]. Fritz Zwicky expressed a much more prescient view in 1937 [7], with a prediction for observations of strong lensing, and how these could be used to infer the masses of galaxies and of galaxy clusters.

Since the first discovery of the strong lens Q0957 in 1979 [8], the field has moved along at an increasingly rapid pace. It is worth emphasizing the strong lensing is extremely rare, since it can only manifest when the alignments are just so, behind objects that are just massive and concentrated enough. This chance alignment only happens for about one in one thousand galaxies. The difficulty has long been in recognizing these galaxies, especially since the lensed images, even if they are highly magnified, may be difficult to see in contrast with the light from the lensing galaxy itself. One elegant way that this was dealt with in the 1980s and 1990s involved searching at wavelengths where the lensing galaxy would simply be invisible, and concentrating on searching for bright multiple images directly.

This was the approach of the most productive lens-search project for many years, the Cosmic Lens All-Sky Survey [9] (CLASS). This survey discovered 22 radio-bright lenses by systematically searching for multiple-image configurations in snapshots of more than 11,000 radio sources. By the nature of the search, these lenses are all active galactic nuclei (AGN), and in optical and near-infrared imaging observations they are all un-resolved and point-like. Between this survey and about an equal number of serendipitous discoveries, most galaxy-scale strong lenses featured distant luminous AGN being lensed into two or four images. All of these have been imaged with the *Hubble Space Telescope* [10], showing all of the configurations we see in Figure 2.

Multiply imaged AGN can be applied to solve many astrophysical problems. The most famous of these is the measurement of the expansion rate of the universe, Hubble's constant. A remarkable feature about AGN is that their flux can vary dramatically on even very short timescales. The images of a multiply imaged lensed AGN have a distinctive property. Partly because of the slightly different path lengths that light travels for each image (as shown in Figure 1), and partly because each of these rays goes through slightly different depths of the lensing potential well, the light travel time will be slightly different for each lensed image. That means that as the AGN fluctuates in brightness, those changes will be seen at slightly different times in each lensed image, resulting in a measurable *time delay* [11].

It was realized decades ago that these time delays will be related to the real distances involved, following a physical scale that is set by the Hubble constant [12,13]. With ensembles of multiply imaged AGN with well-measured time delays, it is in fact possible to measure many of the cosmographic parameters, including the acceleration of the universe [14]. Such strong lensing time delay based measurements would be a completely complementary method to others being explored currently, including using distant Supernovae and weak lensing surveys [15]. Potentially even more exciting is the possibility that sufficiently precise determinations of the time delays in one or more varying and multiply imaged AGN could lead to measurements that could teach us about the very nature of the dark matter that fills the universe [16,17].

The challenge for many years has been the lack of large numbers of strong lenses from one or more homogeneous and systematically undertaken surveys. This has only recently begun to change with the advent of the Sloan Digital Sky Survey [18] (SDSS). The SDSS has imaged hundreds of millions of galaxies over a full quarter of the sky, including spectroscopy for nearly one million galax-

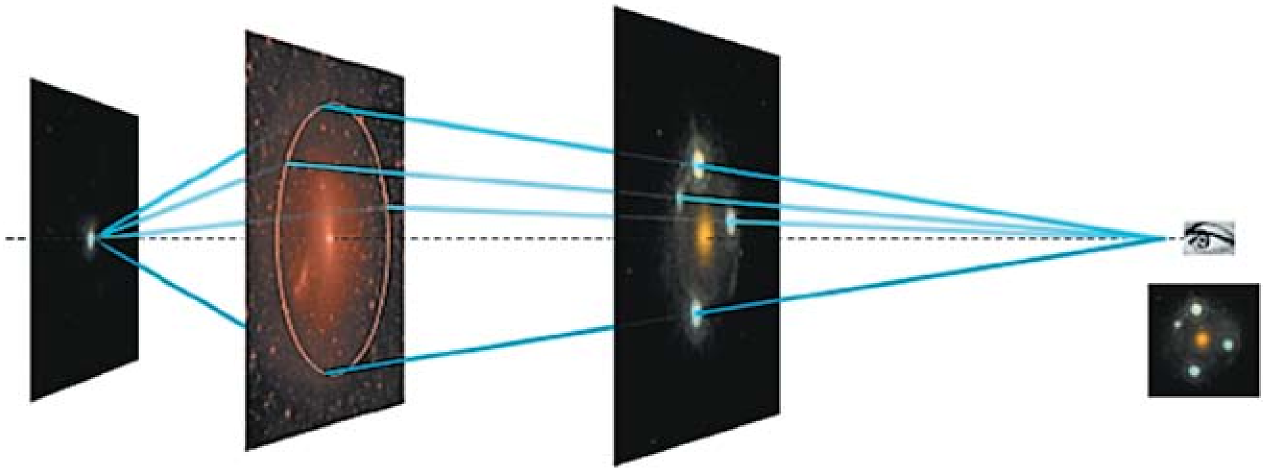


Figure 1. This depicts a cartoon of a strong gravitational lens diagram. Light from the source on the left may be gravitationally focused into multiple images by a sufficiently massive and concentrated object (such as a galaxy or a cluster of galaxies), to form something like the four-image lens shown on the right. The lens shown is the image of a real strong lens, J0924+0219, as observed by the Advanced Camera for Surveys on the *Hubble Space Telescope* (Kochanek GO-9744). The lensing galaxy is represented by a slice of the Via Lactea dark matter simulation, which shows the clumpiness of dark matter on galactic scales [27].

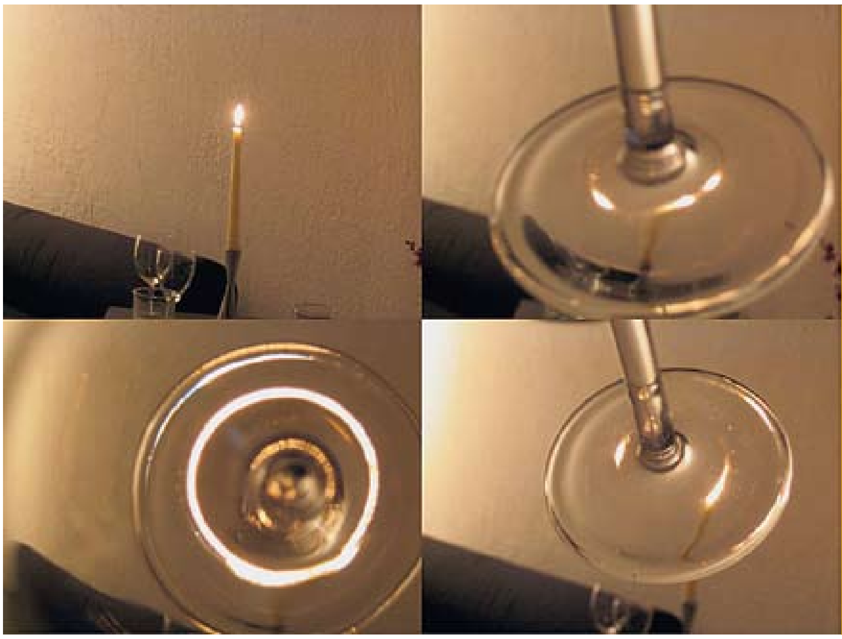


Figure 2. An example of how the strong gravitational lensing effect may be emulated with a simple home experiment. The base of the stem of a wineglass has lensing properties fairly similar to the gravity from a massive galaxy. The "source" at the top left is a candle. By arranging the base of a wine glass at different angles, we may reproduce the main multiple image configurations we see in nature, on cosmological scales. At the bottom right, we see a double image, and at the top right, four images. At the bottom left, if we look down the optical axis of the wine glass, we see a full Einstein Ring form. These images are courtesy of Dr. Phil Marshall; see a video version of this demonstration at [28].

ies and of more than 100,000 luminous AGN.

This extremely rich data set from the SDSS has given rise to several independent strong lens-searching efforts, two of which have been particularly efficient. The first of these concentrates on strongly lensed AGN, the SDSS Quasar Lens Search [19] (SQLS). This effort has used a combination of the SDSS recorded colors, morphology, and spectroscopy, to discover more than forty new multiply imaged AGN, nearly doubling the number known. Each of these makes for a new laboratory to study the applications of time delays to problems of cosmology and astrophysics, and their uniform selection opens up new possibilities for statistical studies using this class of strong lenses.

Another effort has exploited the SDSS spectroscopy in a completely different way. The Sloan Lens ACS (SLACS) survey [20], has been pursuing a systematic search for strongly lensed *galaxies* rather than AGN. There has long been the realization [21] that in the case of objects that are aligned in the sense we have been describing, it is sometimes possible to detect features from both of them in a single spectrum. Since the SDSS spectroscopic dataset is truly vast, even if only some one in one thousand galaxies are lined up just so, there could be up to hundreds of strong lenses to discover. The SLACS project has undertaken a systematic search for such lens candidates, following many of them up with imaging from the *Hubble Space Telescope*, with spectacular results. Nearly one hundred new strong gravitational lenses have been discovered the past several years [22], nearly doubling the numbers of strong lenses known to date. Many of these have been found to be nearly textbook Einstein Rings, as shown in the montage of Figure 4. Before SLACS, only a few Einstein Rings were known. The discovery potential with such objects is vast.

The greatest results from SLACS have come from the detailed study of the internal structure of the lensing galaxies, which is uniquely possible with the information that the strong lensing provides. Using this relatively large and quite homogeneous sample of new strong lenses, it has been found that the combined radial distribution of stars and dark matter is on average a scale-free isothermal-like profile [23], which must connect to

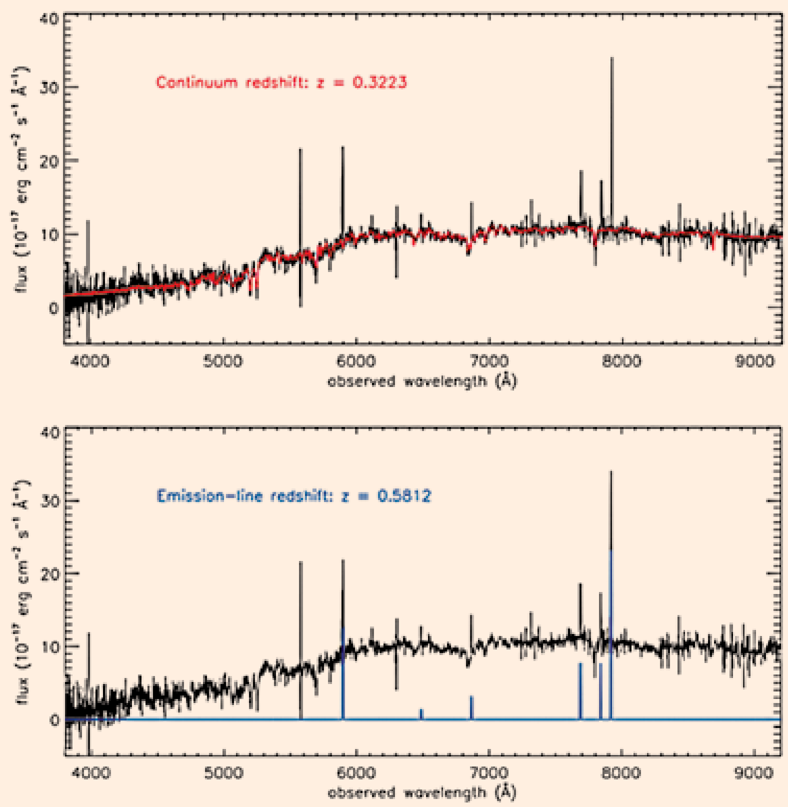


Figure 3. Both panels show SDSS spectroscopy of a quite normal, massive, early-type galaxy (the black line), with flux versus wavelength. The top panel highlights the formal fit to the spectrum one expects for an early-type galaxy; this is shown in red. There are clearly several "anomalous" features, several dramatically prominent emission lines. The bottom panel shows that these emission lines are perfectly fit by the template of a star-forming galaxy, which is at *higher* redshift than the early-type galaxy, which is to say that these features (shown in blue) are coming from a galaxy *behind* the early-type galaxy. With a galaxy precisely aligned behind a known very massive galaxy, there is an extremely high probability that the more distant galaxy may be strongly lensed, and what remains to confirm this hypothesis is high resolution imaging, which is performed the most efficiently with the *Hubble Space Telescope* [20]. These figures are courtesy of Prof. Adam Bolton.

how the dark matter and baryonic matter (stars plus gas) interplay during the formation process of these galaxies. The robust lensing-based *total* mass measurements of the lensing galaxies has also led to new and exciting insight into the origin of the Fundamental Plane scaling relations of early-type galaxies. It has been found that dynamical measurements of early-type galaxies is a robust and reliable proxy for their actual mass [24], which helps calibrate many other surveys that use information that is easier to obtain – in galaxies which happen to not be lenses!

The beauty of large samples of interesting objects is that it allows for serendipitous and unanticipated discoveries. One such discovery from the SLACS Survey was the Double Einstein Ring, shown in Figure 5. This is an object that has *two* lensed galaxies behind the massive foreground galaxy, a veritable jackpot chance alignment [29]. This type of lens was not expected to be found, since the pure by-chance alignment of two background galaxies should have had a probability close to the product of the probability of even one being aligned in this fashion, i.e. 1:1000 x 1:1000, or one in one million. Far fewer objects than that were parts of this particular survey. It was realized that Nature provided us with a remarkable boost: the gravity from the *first* lensed galaxy (the one resulting in the rather prominent near-Einstein Ring in Figure 5) actually helps to additionally focus the light from the *second*

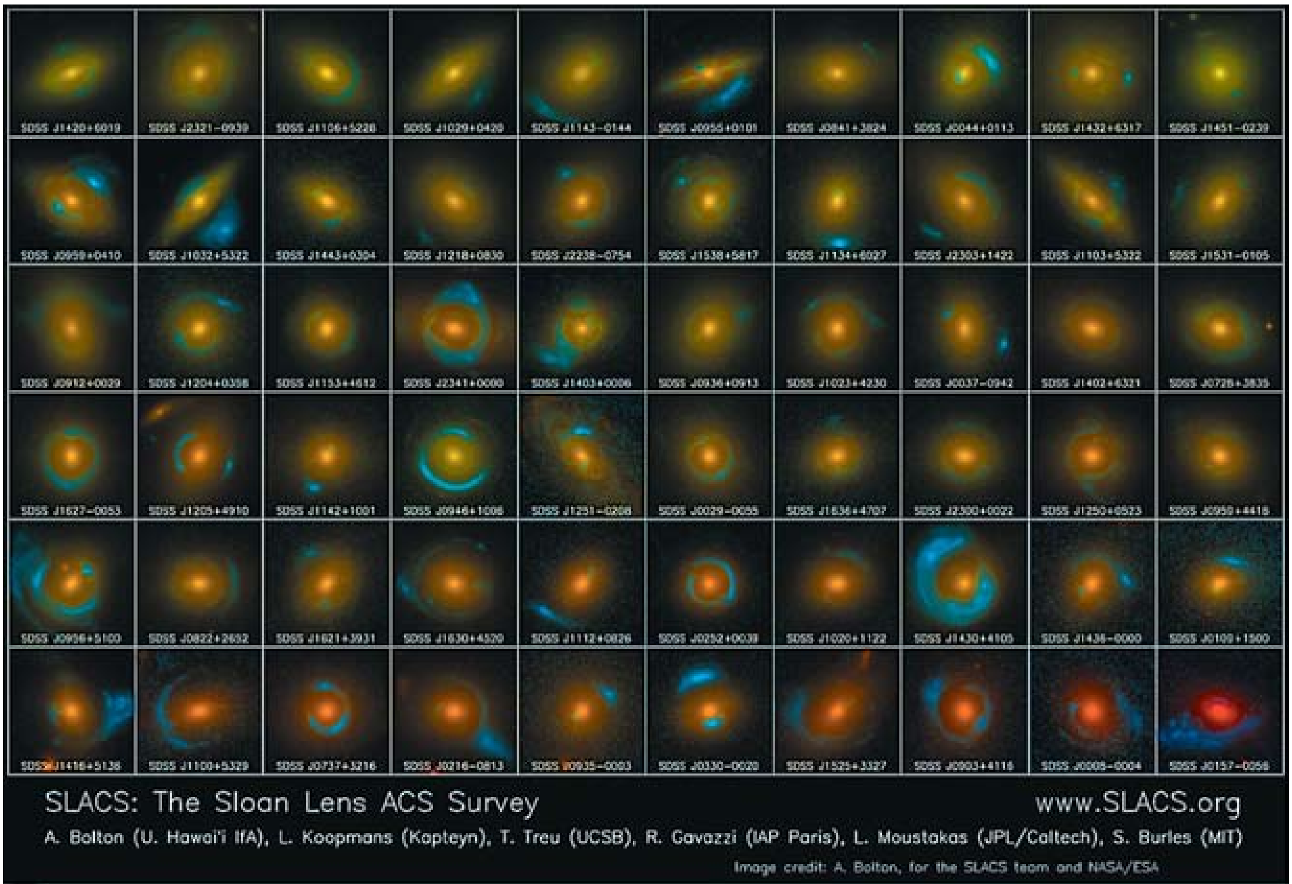


Figure 4. This is a montage of many of the galaxy-scale strong gravitational lenses discovered by the SLACS Survey. The color scheme, chosen for enhanced visual contrast, is such that the lensing galaxies are shown with the orange/red colors, and the background, lensed galaxies are depicted as shades of blue. The majority of these are complete or near-complete Einstein Rings. Credit: Prof. A. Bolton for SLACS and NASA/ESA.

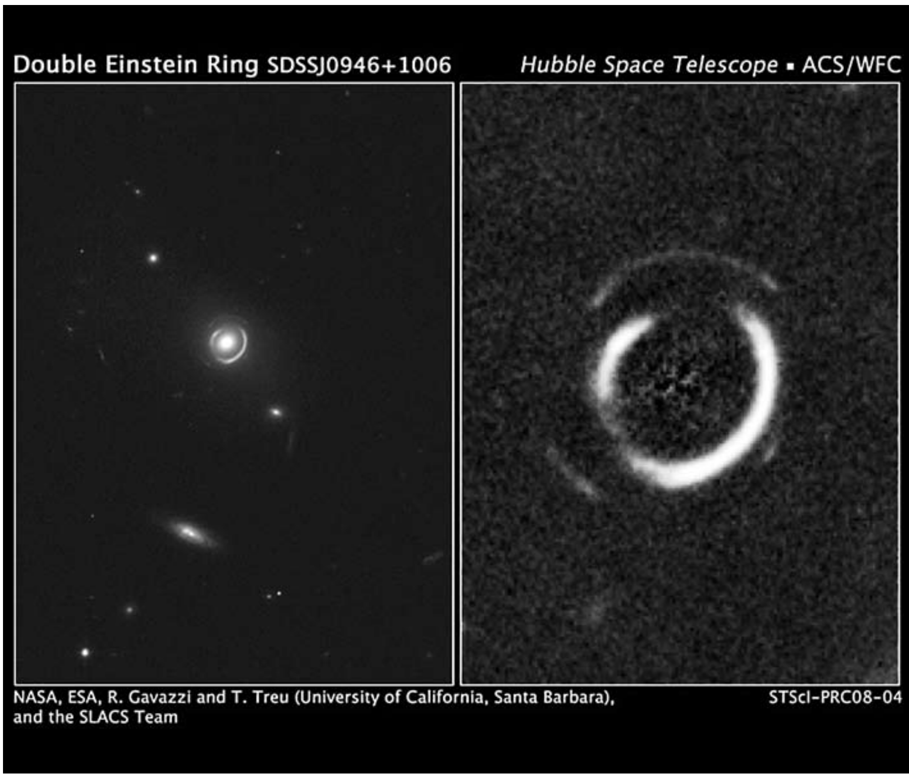


Figure 5. The SLACS "jackpot" lens, the first Double Einstein Ring [29]. The most natural explanation for this "bulls-eye" double ring is for *two* galaxies being aligned behind the massive foreground, lensing galaxy. The object is visible in the *Hubble* image on the left, and in the right panel the object is shown with the foreground, lensing galaxy subtracted off for visual clarity. This is a remarkably rare occurrence, though in future lens surveys, many similar systems will likely be discovered. Image: STScI-PRC08-04.

lensed galaxy (the fainter larger-radius lens in Figure 5). This bodes well for future surveys of large numbers of lenses; such double Rings should be somewhat more common than naively expected at first. These objects have many possible applications. One example is given here, though there are more.

Referring back to Figure 1, there is clearly a characteristic radius at which images (or a Ring) will appear. This will depend mainly on two things. First, on the amount of the lensing mass and on how concentrated it is. Second, on the relative distances between the observer (us), the lens, and the lensed source. Greater lensing mass will result in larger characteristic radii; so will greater relative distances. So, if the second ring in the double Einstein Ring is known to be at a greater distance (which may be estimated through its colors), the specific characteristic radius, the "Einstein Radius" in fact, is a measurement of the total mass enclosed in the lensing galaxy within that radius. Since there are two such measurements in this one galaxy, there is an immediate and direct measurement of its total-mass profile.

The 2000s have been a very productive decade for the discovery of many new strong gravitational lenses. But more than that, there has been an increasingly sophisticated approach to analyzing and applying these new samples to some of the most profound problems in physics and astrophysics. While the theory and analysis methods continue to develop, there is still a burning need for ever-larger samples, uniformly selected. This new decade promises to witness an explosion of new lenses. From the ground, the Large Synoptic Survey Telescope will be able to identify nearly 2,000 new galaxy-galaxy strong lenses, and some 10,000 new galaxy-AGN strong lenses [25]. Through other ground- and space-based surveys this decade, including through just-begun sky surveys, several thousand additional lenses will be found [26]. Seeing what has been done just the past decade with emerging technology and techniques, the future for the 2010s is quite bright. Look out for groundbreaking work in cosmography, galaxy formation and evolution, and even on the detailed nature of dark matter!

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New insights on the asteroid-meteorite connection

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Abstract

In this paper we present a short review of recent results, devoted to understanding the distribution of main-belt asteroids in certain classes of spectral type (i.e. their composition) as well as the "genetic" relationship between different types of asteroids and collected meteorites. As we will show below, spectroscopic observations and dynamical models can be combined to greatly enhance the significance of parent-body identification for meteorites. Conversely, careful examination of the distribution of asteroids in specific spectral classes can yield important information about key dynamical processes that once shaped our solar system, or still act on Near Earth Asteroids.

Introduction: the asteroid-meteorite relationship

The vast majority of meteorites are believed to originate from the asteroid belt. Collisions between asteroids (occurring on time-scales of ~10^7 y) produce the so-called *asteroid families*, along with large numbers of very small fragments (dust), which can reach the Earth, following one of a multitude of possible dynamical routes.

Identification of the parent body of a specific meteorite greatly increases the importance of the meteorite; collecting a meteorite suddenly becomes equivalent to having undertaken a successful sample-return mission to a specific asteroid! However, unambiguous identification of a meteorite's parent body is a formidable task, in general being possible only for a limited class of "special" meteorites (e.g. lunar meteorites).

The main way of comparing meteorites and asteroids is by obtaining their *reflectance spectra* in the visible and infrared band. However, it is frequently the case that the reflectance spectrum of a meteorite can be equally similar to several possible parent bodies. Thus, additional information is usually needed, in order to make a definite match. In the following we will see that combining spectral and dynamical information can increase a lot our confidence on a positive identification. We note that the "inverse problem" is also frequently studied in labs: given our knowledge on the geochemistry and petrology of different meteorite classes and knowing an asteroid's spectral "class", what combination of known "meteoritic" materials can produce the observed spectrum of the asteroid? Again, the answer is rarely unique.

On a statistical level, asteroid spectra can be classified into a small number of *spectral types* [1]. Combining information on asteroid spectra with meteorite data, we see that the composition of a main-belt asteroids (between 2.0 and 3.5 AU) may vary quite a lot; from primitive, organic-rich to geologically evolved (e.g. metallic or enstatite) materials. What is of great interest though is the distribution of spectral types throughout the asteroid belt (Fig. 1). Although a mixing of taxonomic types is seen, a general trend – a dichotomy – is apparent: primitive asteroid types (C and D/P) are predominant in the outer asteroid belt, while evolved asteroid types (S, M and E) are concentrated in the inner belt.

The "traditional" explanation for the large compositional differences within the asteroid belt is that they can be attributed solely to compositional and temperature variations in the protoplanetary nebula. The mixing of spectral types is then attributed to dynamical excitation and re-distribution of asteroids in the belt, during the epoch of planet formation [2]. However, it is difficult to imagine such radical initial differences within an annulus of only ~1.5 AU. As we will see in the following, at least part of the dichotomy can be attributed to the dynamical evolution of the early solar system.

One should keep in mind that asteroid reflectance spectra are not "clean": asteroid surfaces suffer from *space weathering*, an effect produced by the incident solar radiation. Space weathering results in a systematic "reddening" of asteroid surfaces and therefore systematic alteration of their reflectance properties. Meteorites, on the other hand, are recently ejected asteroid fragments, as indicated by their short cosmic-ray exposure ages. Thus, they constitute particles of freshly-exposed asteroid material and should not show severe signs of space weathering. This is at the heart of the well-known "ordinary chondrite problem"; the most common meteorites falling on Earth (80%) are classified as *ordinary chondrites* and have no spectral ana-

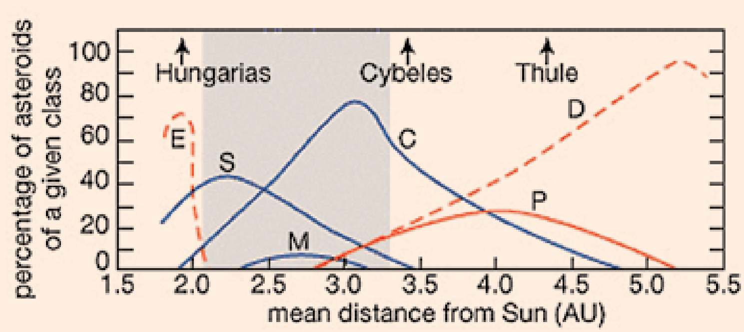

Figure 1. Distribution of main-belt asteroids in spectral classes (S=silicate, C=carbonaceous, D/P=dark, primitive, M/E=metallic, enstatite), as a function of semi-major axis. The percentage of main-belt asteroids belonging to each of the main spectral classes is given.

logue in the main asteroid belt! This surprising observation is attributed to space weathering. However, spectral matches of ordinary chondrites with "un-weathered" asteroids do exist, but *only* among NEAs (the so-called Q-types). As we will see below, the solution to this puzzling problem is again related to the dynamics of a specific class of NEAs.

Origin of the Geminids meteor shower

Annual meteor showers are an impressive astronomical phenomenon. They occur on specific dates every year (e.g. the *Leonids* in November and the *Perseids* in August are among the most famous ones), when the Earth crosses one of the nodes of the mean stream orbit. Almost all meteor streams are associated with the activity of known comets, which produce large numbers of small meteoroids (by sublimation of volatiles) every time they pass through perihelion.

Among all known meteor streams there is one that stands out: the December stream of the *Geminids* (see Fig. 2). Although not as impressive-looking as e.g. the *Leonids*, the *Geminids* are unique in nature, because they are associated to a Near-Earth Asteroid and not a comet: asteroid *(3200) Phaethon* [3]. Because of its association to the *Geminids*, Phaethon was thought to be a dormant or extinct comet, although cometary activity has never been observed for Phaethon. However, its spectral type (*B-type*, a sub-group of the C-complex) makes it different from all recently-studied main-belt comets (e.g. Elst-Pizarro), which are of D/P-type. B-types are though to be relatively rich in volatiles. In principle, this renders Phaethon capable of undergoing sporadic episodes of activity, provided that it approaches the Sun close enough.

Asteroid (3200) Phaethon has an extreme NEA orbit: its perihelion distance currently has a value of only q=0.24 AU (orbital integration shows even smaller values of ~0.12 AU about 2,000 years ago), which means that it approaches the Sun closer than most NEAs. Thus, it is reasonable to think that Phaethon can become active while passing through perihelion (although it would be extremely difficult to observe), if its temperature exceeds the sublimation limit of its volatiles. Also, another interesting orbital feature of Phaethon is that its inclination with respect to the ecliptic is very large (~40 degrees). As we shall see below, this provides strong indication of its origin.

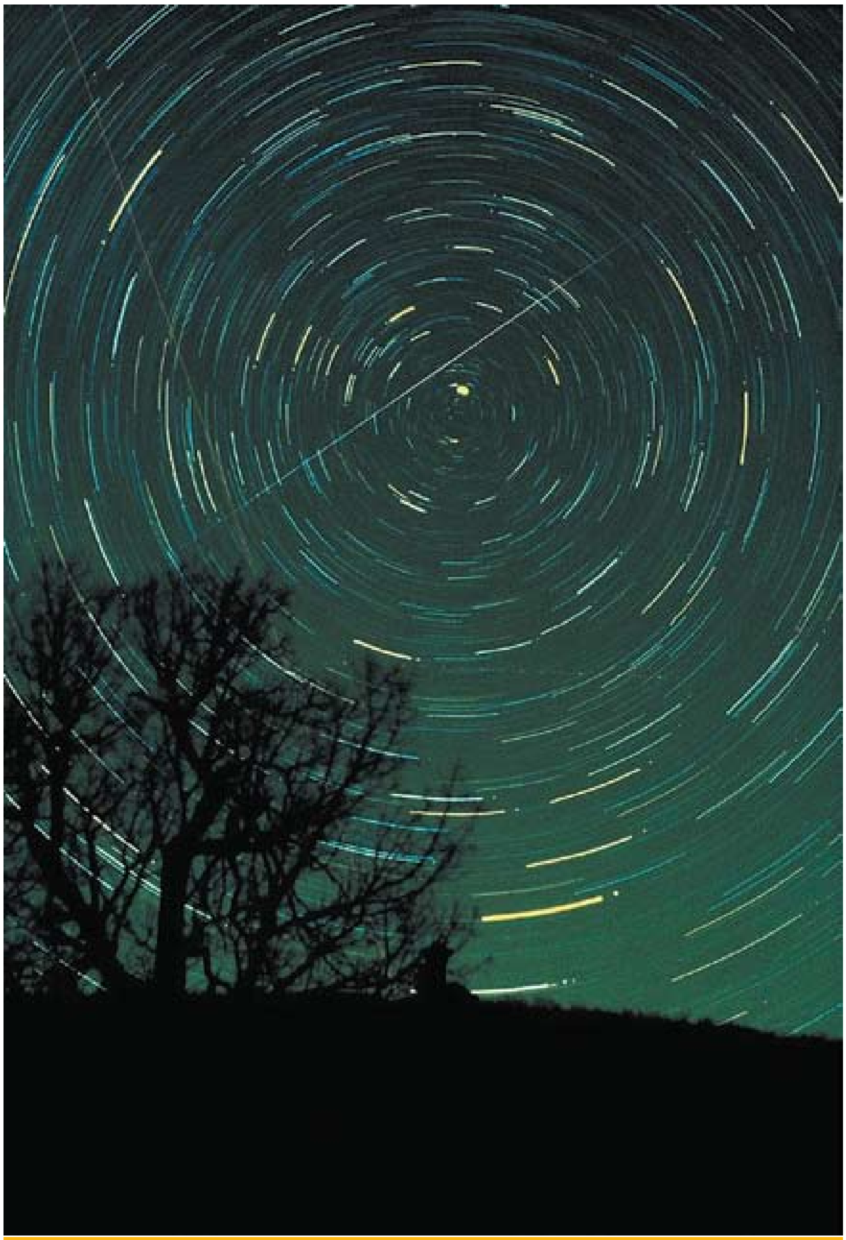

Figure 2. Star trails and a Geminid meteor over Brasstown Bald mountain, Georgia, in 1985. Author: Jimmy Westlake

Phaethon is a ~5-km (in diameter) NEA and thus a recent main-belt "escaper" (less than 10 My ago – the dynamical lifetime of NEAs), originating from the region of some unknown, main-belt, B-type asteroid; these are not very common in the main belt (especially large ones). It may be possible therefore to identify its parent body, i.e. the "grandparent" of the *Geminids*. Moreover, the number of candidates may be narrowed down, by searching for observed features that reveal recent break-up events, i.e. *asteroid families* around large B-type asteroids. Of course, Phaethon can be a piece of any isolated (large) B-type asteroid in the main belt, but the probability that it was generated during a family-forming event is much higher, as the number of 5-km objects that would be produced during such a break-up would be very large.

As was shown by [4], the only large main-belt B-type asteroid that has a well-defined dynamical family around it is asteroid *(2) Pallas*. What is more intriguing however is that the spectra of Phaethon and Pallas are strikingly similar, in

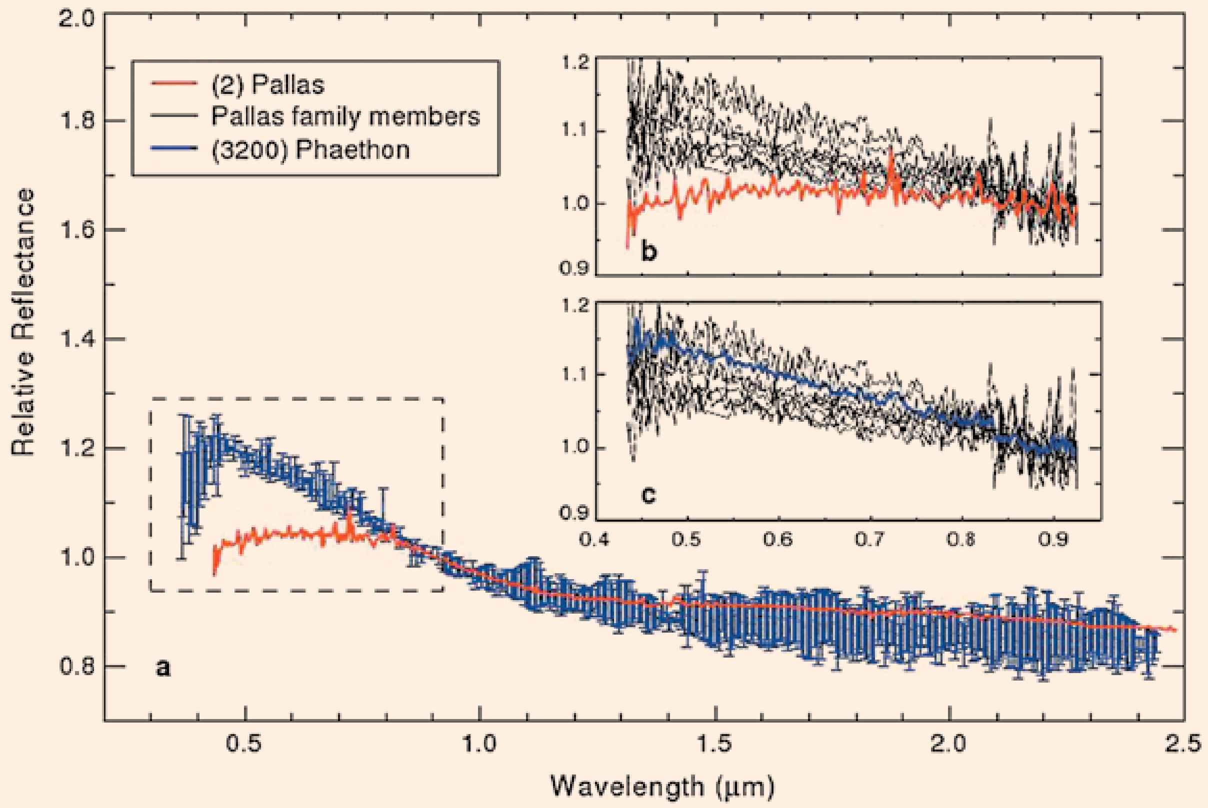

Figure 3. Reflectance spectra of Phaethon (blue), Pallas (orange) and some members of the Pallas dynamical family. Note the similarity of (i) the IR spectra of Phaethon and Pallas (panel a) and (ii) the visible spectra of all small (~5-20 km) Pallas family members and Phaethon (panel c).

the infrared (see Fig. 3). Differences in the optical wavelengths can be attributed to size-dependent effects (the size of regolith grains that are retained on an asteroid's surface during a family-forming event depends on the size of the asteroid). When comparing Phaethon's visible spectrum with those of the observed members of the Pallas family (of similar size), we see that the match is excellent. In fact, [4] showed that the visible spectrum of Phaethon is statistically much closer to those of the Pallas members, than to any other B-type asteroid in the main-belt.

The spectral similarity between Phaethon and Pallas is quite robust. However, although it paints Pallas as the prime suspect for being Phaethon's parent body, it does not constitute enough proof, by itself. In particular, one has to show that there exists a viable dynamical pathway, through which it is possible to bring material from the neighbourhood of Pallas (at 2.77 AU) to the orbital space that Phaethon currently occupies. Indeed, this was shown by [4], who used extensive numerical integrations to show that a sizeable fraction of Pallas fragments (created at the time of formation of the Pallas family) could fall into a nearby mean motion resonance with Jupiter, have their eccentricities increased and subsequently reach the NEA space, under the effect of repeated close encounters with the Earth. Moreover, they showed that these fragments would reside on orbits with preferentially large inclination values (such as Pallas itself) and would preferentially occupy the orbital elements region that is currently spanned by the mean orbit of (3200) Phaethon (see Fig. 4).

The work of [4] makes a convincing case about the origin of the Phaethon-Geminids complex. Moreover, it provides a method for reducing the size of the available parameters space, when searching for the parent body of a meteor/NEA. This method can be applied to NEAs that are currently being considered as possible targets for future sample-return missions.

Origin of the primitive D/P-type asteroids

Dark, primitive-type asteroids are abundant in the outer asteroid belt. Moreover, they constitute the vast majority of the *Hilda* asteroids (at ~4 AU, the 3:2 resonance with Jupiter) and the *Trojans* (at 5.2 AU). Their reflectance spectra look very similar to those of main-belt comets and Kuiper-belt objects; loosely speaking, they look like "de-volatilized" comets. It is difficult to imagine that D/P-types were formed in roughly the same region of the solar system as the S-types (or even the C-types). Moreover, if they formed *in situ*, it is difficult to understand why they look so similar to the Trojans (let alone the Kuiper-belt objects).

One way to reconcile these diverse observations is to assume that D/P types did not form where they are observed today but, instead, they were formed at much larger heliocentric distances and were later on transported into the main asteroid belt. However, as with the Pallas-Phaethon story, one has to show that

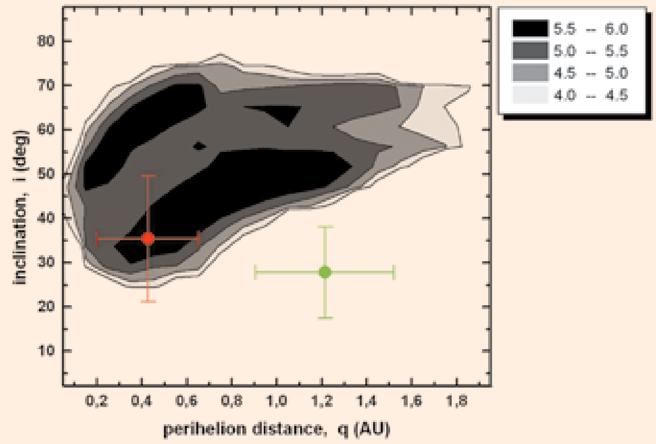

Figure 4. The red point (resp. crosses) shows the mean value (resp. standard deviation) of perihelion distance (*q*) and inclination (*i*) of Phaethon's orbit, taken from a 20-My orbital integration. Asteroid *Rudra* (another B-type NEA) is also shown in green. The intensity of the black/grey-shade indicates the time spent by 'Pallas fragments' that become NEAs in the respective bin of the (*q*,*i*) space (in years; logarithmic scale, shown on the right). Clearly, Phaethon moves inside a region that has the highest probability (black) to be visited by Pallas fragments.

an efficient transport mechanism exists that could reproduce the observed numbers and orbital distribution of D/P-types. This was in fact demonstrated in a recent paper by [5].

The main drive behind the work of [5] was the recent publication of the so-called "Nice model" [6,7,8]; this model describes the evolution of the young planetary system. The basic assumption in the Nice model is that the outer planets were originally formed closer to each other and much closer to the Sun than currently observed (within ~15 AU); an assumption needed in order to reconcile the formation time scales of Uranus and Neptune to the short lifetime of the proto-planetary gaseous disk (among other things, see [6-8] for details). A sizeable disk of planetesimals (estimated to ~50 Earth masses in total) existed at that time in the region that is currently labelled as "Kuiper Belt". For this reason, *outwards migration* of the planets could not have been avoided, as they had to interact gravitationally with the debris disk. As shown in [6], this process is not "smooth"; resonances between the planets can lead to large-scale instabilities and planet-planet scattering (a process that is assumed to have shaped most extra-solar systems). The disk of debris acts as a "suspension spring", exerting dynamical friction on the planetary orbits, gradually suppressing the instability. The system finally settles down when most of the disk particles have been scattered away and the planets reach their final orbits, which look very similar to their current ones.

While most of the material of the outer disk is scattered outside the solar system (on hyperbolic orbits), a small fraction penetrates the inner solar system; in [8] it was shown that this is the most likely projectiles source for the Late Heavy Bombardment (LHB) of the Moon. The question asked by [5] was whether some of these primitive ("Kuiper-belt"-like) bodies could have been captured in the region of the main asteroid belt and still survive today (as D/P-type asteroids).

The answer to the above question is: *yes!* A small fraction of these Kuiper-belt intruders are captured into mean motion resonances with Jupiter, their orbital eccentricity temporarily decreasing. However, as the motion of Jupiter is not perfectly "smooth", some of the trapped particles can fall out of resonance, thus becoming permanently trapped on low-eccentricity orbits, inside the main belt. This process is not equally effective throughout the main belt. As the integrations of [5] showed (see Fig. 5), the incoming objects can only reach down to 2.6 AU (in semi-major axis); this matches almost exactly the inner edge of the observed D/P-types distribution. At the same time, a large number of trans-neptunian planetesimals are captured in the Hildas' and Trojans' region (as also shown in [7]).

The results of [5] show that the current orbital distribution of D/P-types is reproduced remarkably well by inflowing "Kuiper-belt" objects, during the same episode that presumably shaped the orbits of the outer planets and initiated the LHB of the inner solar system (according to the "Nice model"). More important, simulations of collisional fragmentation performed by [5] suggest that also the correct size-frequency distributions (number of asteroids $n(D)$ having diameter D) of (a) outer-belt asteroids, (b) Hildas and (c) Trojans are all recovered at the same time.

The conclusion of [5] was that the asteroid belt was "invaded" by D/P-type objects, which are therefore not indigenous but were formed in the proto-Kuiper Belt. We note that, the total number of captured objects in the (collision-less) simulations of [5] is much larger than the one inferred from observations. However, one should take into account that bodies composed of primitive, organic-rich, materials are probably much more fragile than S- or C-type asteroids. Taking this into account, [5] showed that collisions would decimate the intruders, bringing their numbers down to the observed ones, after ~4 Gy of collisional evolution.

This has another interesting implication for the so-called *micro-meteorite (μ-meteorite) problem*: while S-type asteroids constitute a large fraction of main-belt asteroids, the vast majority of μ-meteorites are of primitive composition (similar to carbonaceous chondrites; the ratio of ordinary to carbonaceous μ-meteorites is ~0.16). On the other hand, very few meteorites in our macroscopic sample are compositionally similar to the μ-meteorites.

The work of [5] offers a solution to this long-standing problem. Since D/P-type (primitive) bodies are more fragile, they produce large amounts of micron-sized particles. Such small particles can migrate very efficiently, under the effect of Poynting-Robertson (P-R) drag,

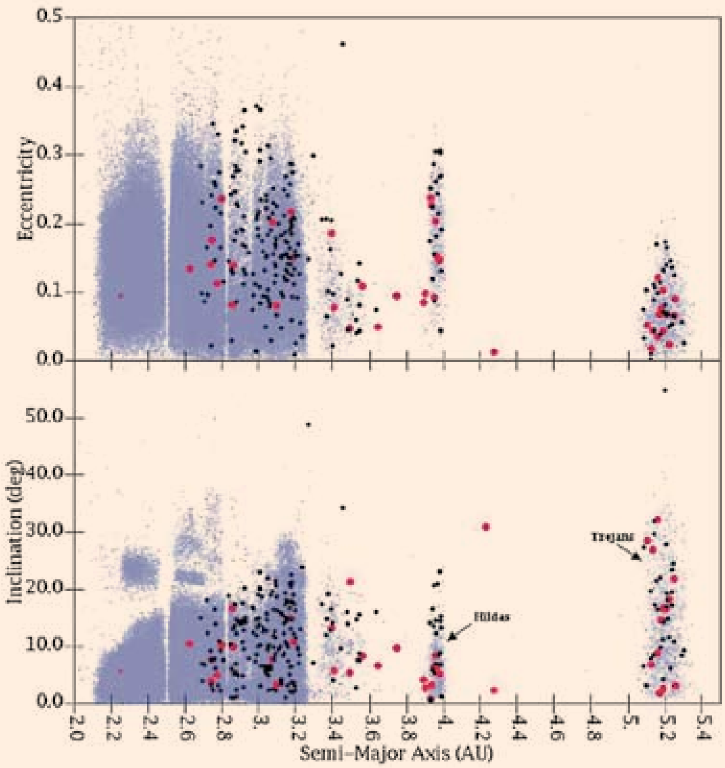

Figure 5. Orbital distribution of asteroids, projected on the semi-major axis vs eccentricity plane (top) and semi-major axis vs. inclination plane (bottom). Violet dots are all the catalogued asteroids, red dots are the known (observed) D/P-types and black dots are the objects that were trapped in the asteroid belt, in the simulation of [5]. The distributions of observed and "captured" D/P-types look remarkably similar.

reaching the Earth within a few thousand years. This can explain the over-abundance of carbonaceous μ-meteorites. On the other hand, larger fragments do not migrate very fast (P-R drag is a size-dependent force). Hence, when produced in the outer parts of the asteroid belt, the probability that they fall inside a powerful resonance with Jupiter, have their eccentricities increased and eventually get ejected from the system (after suffering an encounter with Jupiter) is very large. Moreover, even if some *cm*-sized fragile particles would manage to reach the Earth, they would most likely not survive (intact) the passage through the Earth's atmosphere.

Dynamical shuffling of NEA surfaces

As mentioned in the introduction, the vast majority (~80%) of meteorites collected on the surface of the Earth are *ordinary* chondrites (OC). Curiously enough, no spectral analogues to OCs are found among main-belt asteroids. The only "telescopic" analogues to OCs are the "unweathered" (Q-type) NEAs. It is difficult though to imagine that the most populous class of meteorites originates from only a small fraction of the NEAs. S-type (silicate) asteroids are the most populous spectral group among the NEAs and therefore the most likely source of OCs.

The solution to this problem was recently given by [9]. The authors begin by stressing the fact that S-type asteroids are indeed the most probable source of OCs. However, this same class of asteroids suffers the most from space weathering, which "reddens" the surfaces of these asteroids. Thus, it would be practically impossible to find the spectral signature of an ordinary chondrite among S-type NEAs.

But then, what are these *Q-type* NEAs that look so much like OC meteorites? The answer is given by their dynamics – and implied by their name. [9] showed that all NEAs classified as Q-types have had deep encounters with the Earth – within the distance of the Moon! – sometime during the last ~1 My. Conversely, *no* other NEA had had such deep Earth-encounters during the same period. This result is astonishing! It implies that Q-type asteroids actually look "un-weathered" only because their surface is being "reset", every time they pass close to the Earth. Provided that such deep encounters occur frequently enough (compared to the space-weathering time scale) a fraction of NEAs will always present a "fresh" surface.

As [9] concluded, the most likely mechanism responsible for re-setting the surfaces of NEAs is the *tidal stress* that surface-particles feel, as the asteroid swings-by the Earth. Even though these stresses probably produce only "micro-seismic" events, they are enough to shuffle the surface regolith (within just a few μm from the surface), thus bringing un-weathered material in sight. The mechanism of [9] can (and hopefully will) be tested, during the expected close approach of the (formerly) potentially hazardous asteroid *Apophis*.

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The SPIRE Instrument on HERSCHEL

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Abstract

The SPIRE instrument is one of the three instruments onboard ESA's Herschel Space Observatory launched on 14th of May 2009. SPIRE is fully functional with performance and scientific capabilities matching or exceeding pre-launch estimates. SPIRE has already completed the Science Demonstration Phase (SDP) observations of its Guaranteed Time and Open Key Time programs. The largest projects to be performed with Herschel are HerMES and ATLAS with their first results already been published.

Herschel Space Observatory

Herschel is the fourth cornerstone mission in the European Space Agency (ESA) science program. It is capable of performing imaging photometry and spectroscopy in the far-infrared and submillimetre part of the spectrum, covering approximately the 55-672 μm range and thus bridging the traditional space infrared range with the ground-based capabilities.

Herschel's key science objectives emphasize fundamental issues connected to the formation and evolution of galaxies and stars and stellar systems. However, Herschel will be an observatory facility and its unique capabilities will be available to the entire astronomical community for a wide range of observations.

Herschel (Pilbratt et al. 2010), which was jointly developed by the ESA, the three instrument consortia, and NASA/IPAC, is equipped with a passively cooled 3.5m diameter classical Cassegrain telescope. The science payload, which is housed in a super-fluid helium cryostat, complements two medium resolution spectro-photometers (PACS and SPIRE) and a very high-resolution heterodyne spectrometer (HIFI).

Herschel was launched into a transfer trajectory towards its operational orbit around the Earth-Sun L2 point by an Ariane 5 ECA, shared with the ESA cosmic background mapping mission Planck, on 14th May 2009. It became fully operational about 6 months after launch and it is estimated that it will offer 3 years of routine science operations. Almost 20,000 hours of observing time will nominally be made available for astronomy. Of this, 32% is guaranteed time and the remainder is open time which will be offered to the worldwide general astronomical community through a standard competitive proposal procedure.

The Spectral and Photometric Imaging Receiver (SPIRE)

SPIRE (Griffin et al. 2010) is designed to exploit Herschel's advantages for observations in the sub-millimetre: its large (3.5 m), passively cold (~85 K), low emissivity telescope (~1%). SPIRE consists of a three-band imaging photometer and imaging Fourier Transform Spectrometer (FTS). The photometer is capable of carrying out broad-band photometry ($\lambda/\Delta\lambda \sim 3$) in three spectral bands centred on 250, 350 and 500 μm, and the FTS uses two overlapping bands to cover 194-671 μm (447-1550 GHz).

The photometer is designed to have three principal observing modes: point source photometry, field (jiggle) mapping and scan mapping. The first two modes involve chopping and jiggling with the SPIRE beam steering mirror and nodding using the telescope. In practice, because of the excellent performance and simplicity of the scan-map mode, it is the optimum for most observations. Although its efficiency for point source and small map observations is low, it provides better data quality, and over a larger area, than the chopped modes, and can produce a sky background confusion limited map in a total observing time that is still dominated by telescope slewing overheads. In scan-map, the telescope is scanned across the sky at 30 or 60"/s. The scan angle is chosen to give the beam overlap needed for full spatial sampling over a strip defined by one scan line, and to provide a uniform distribution of integration time over the area covered by the scan. One map repeat is normally constituted by two scans in orthogonal directions to provide additional data redundancy and cross-linking. Herschel can implement simultaneous five-band photometric scan mapping in SPIRE-PACS parallel mode. Data are taken simultaneously in the three SPIRE bands and two of the PACS bands, providing a highly efficient means of making multi-band maps of large areas (at least 30' x 30'). Scan speeds of 20 or 60"/s are available in parallel mode. The SPIRE detector sampling rate in this mode is reduced to 10 Hz to keep within the data rate budget, with minimal impact on the data quality.

The standard operating mode for the FTS is to scan the mirror at constant speed (nominally 0.5 mm/s) with the telescope pointing fixed, providing an optical path rate of change of 2 mm/s due to the factor of four folding in the optics. Radiation frequencies of interest are encoded by the scanning motion as detector output electrical frequencies in the range 3-10 Hz. The maximum scan length is 3.5 cm, corresponding to an optical path difference of 14 cm. Three values of spectral resolution are adopted as standard: high, medium, and low, giving unapodised resolutions of 0.04, 0.24, and 0.83 1/cm respectively (corresponding to 1.2, 7.2, and 25 GHz). For point source observations with the FTS, the source is positioned at the overlapping SSW and SLW detectors at the array centres; but data are acquired for all of the detectors, providing at the same time a sparsely-sampled map of the emission from the region around the source. Likewise, a single pointing generates a sparse map of an extended object. Full and intermediate spatial sampling can be obtained using the SPIRE BSM to provide the necessary pointing changes between scans while the telescope pointing remains fixed. Regions larger than the field of view are mapped using telescope rastering combined with spatial sampling with the BSM. Full details of the SPIRE observing modes are given in the SPIRE Observers Manual (2010).

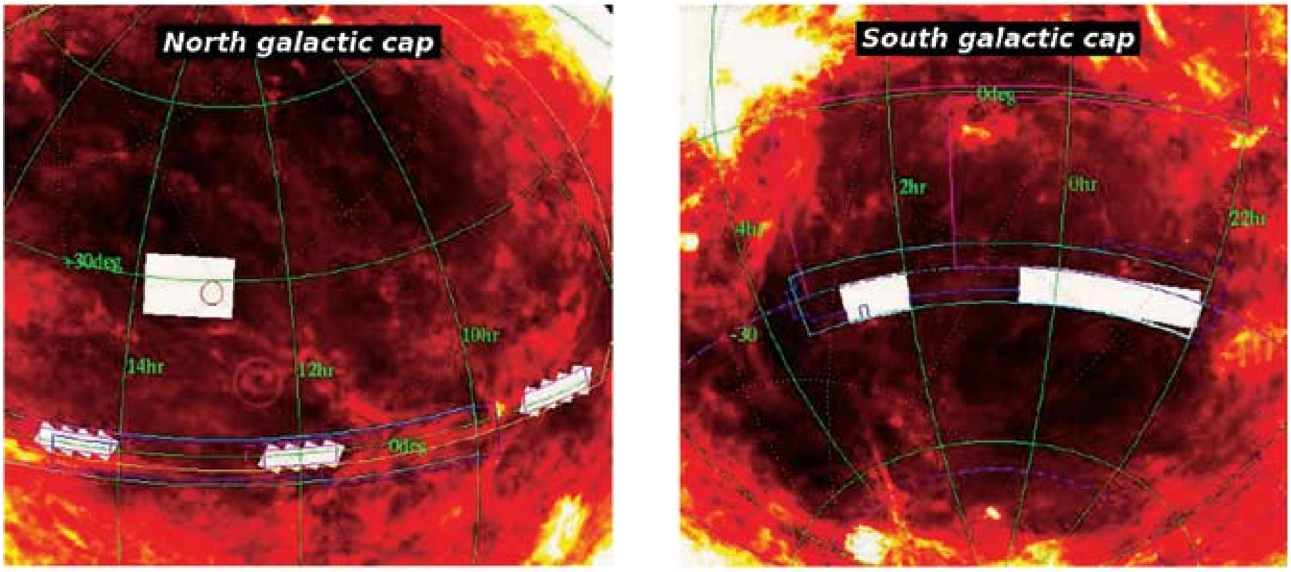

Figure 1. The position of the ATLAS fields shown as white blocks, superimposed on the IRAS 100 μm map of the sky.

The architecture and operation of the photometer pipeline is described by Griffin et al. (2008), and the spectrometer pipeline is described by Fulton et al. (2008). Photometer data are processed in a fully automatic manner, producing measured flux density timelines (Level-1 products) and maps (Level-2 products). The pipeline includes conversion of telemetry packets into data timelines, calculation of the bolometer voltages from the raw telemetry, association of a sky position for each detector sample, glitch identification and flagging, corrections for various effects including time constants associated with the detectors and electronics, conversion from detector voltage to flux density, and correction for detector temperature drifts. The Level-1 products are calibrated timelines suitable for map-making. Maps can be made either with the maximum likelihood map-making algorithm MADmap (Cantalupo et al. 2010) or by naive mapping, involving simple binning of the measured flux densities. The pipeline can also be run in an interactive mode, with selectable parameters associated with deglitching, baseline removal and map pixel size. Standard map pixel sizes of (6, 10, 14)" are adopted for the (250, 350, 500) μm bands. The most important aspect of the Level-1 data quality that must be addressed prior to map-making is the amount of residual thermal baseline drift on the timelines. At the time of writing, the standard data products are naive maps generated with pre-treatment of the Level-1 timelines to remove these residual drifts. The results are high-quality maps, with a low level of scan-related artefacts and with sky structures preserved over large spatial scales (degrees). Work continues to improve further the map-making process, in particular to automate the Level-1 timeline treatment step prior to creation of the maps. Once that has been completed, the potential advantages of MADmap in producing further enhancements will be investigated. The FTS pipeline processes the telemetry data producing calibrated spectra. It shares some elements with the photometer pipeline, including the conversion of telemetry into data timelines and the calculation of bolometer voltages. Steps unique to the spectrometer are: temporal and spatial interpolation of the stage mechanism and detector data to create interferograms, apodisation, Fourier transformation, and creation of a hyper-spectral data cube. Corrections are made for various instrumental effects including first- and second-level glitch identification and removal, interferogram baseline correction, temporal and spatial phase correction, non-linear response of the bolometers, variation of instrument performance across the focal plane arrays, and variation of spectral efficiency.

ATLAS

The Herschel ATLAS (Eales et al. 2010) has been allocated 600 hours of time, making it the largest key project that will be carried out with Herschel in Open Time. For all of its science goals described later on, the final sensitivity of the survey is not critical and it is more important to survey the greatest possible area of sky. As a result, the ATLAS team has chosen to use the maximum possible scan rate for the telescope (60 arcsec/sec). For its science programme, it is important to make observations with PACS and SPIRE, and therefore ATLAS has chosen to use the Herschel's parallel observing mode that allows simultaneous observations with both cameras. Of the two possible combinations of photometric bands for PACS (Poglitsch et al. 2006), ATLAS has chosen to observe at 110 and 170 μm rather than at 70 and 170 μm mostly on the grounds of sensitivity; the noise at 70 and 110 μm should be fairly similar but galaxies, even at low redshift, are generally brighter at the longer wavelength. Although this combination will be worse for estimating the temperature of the dust, models suggest that it is still feasible to obtain useful measurements of the temperature of the dust in low-redshift galaxies. The ATLAS team has chosen to observe fields in the northern and southern hemispheres and on the celes-

Table 1. HerMES fields

Name	Area /sq. deg.	Fields	RA	Dec	Depth in Band /mJy 75	110	170	250	350	500
Clusters-1	0.01	Various				2.8	4.0	2.8	3.7	3.3
Clusters-2	0.04	Various (see table 7)				4.4	6.2	3.5	4.7	4.1
Level-1	0.04	GOODS-S	3.5	-28	2.2	1.0	1.0	3.9	5.2	4.6
Level-2	0.04	GOODS-N	12.6	62	2.2	2.8	3.0	6.7	9.0	7.9
	0.25	GOODS-S	3.5	-28	2.2			6.7	9.0	7.9
Level-3	0.25	GOODS-S	3.5	-28	2.2	6.2	6.7	10.4	14.0	12.3
	0.25	Groth Strip	14.3	53	2.2	6.2	6.7	10.4	14.0	12.3
	0.25	Lockman (ROSAT/XMM)	10.8	58	2.2	6.2	6.7	10.4	14.0	12.3
	0.25	Lockman (Owen)	10.8	58	2.2	6.3	7.7	10.4	14.0	12.3
	0.25	XMM-LSS (UDS)	2.3	-5	2.2	6.3	7.7	10.4	14.0	12.3
Level-4	2.0	COSMOS	10	2	6	9.8	10.5	10.4	14.0	12.3
	1.0	XMM-LSS (UDS)	2.3	-5	18	10.9	13.3	10.4	14.0	12.3
	1.0	XMM-LSS (VVDS)	2.5	-4.5	18	10.9	13.3	10.4	14.0	12.3
Level-5	8	CDFS	3.5	-28	18	31.3	35.7	10.9	15.2	12.8
	11.0	Lockman	10.8	58	18	31.3	35.7	10.9	15.2	12.8
	3.0	XMM-LSS	2.4	-4.75	18	31.3	35.7	10.9	15.2	12.8
Level-6	9.0	ELAIS S1	0.6	-44	18	70.0	79.9	24.4	33.9	28.6
	9.0	XMM-LSS	2.4	-4.5	18	70.0	79.9	24.4	33.9	28.6
	11.0	Lockman	10.8	58	18	70.0	79.9	24.4	33.9	28.6
	9.0	ELAIS N1	16.2	55	18	70.0	79.9	24.4	33.9	28.6
	4.5	ELAIS N2	16.6	41	18	70.0	79.9	24.4	33.9	28.6
	7.0	NDWFS/Bootes	14.5	34	18	70.0	79.9	24.4	33.9	28.6
	4.5	FLS	17.3	60	18	70.0	79.9	24.4	33.9	28.6
	7.0	0444astrof	4.7	-53	18	70.0	79.9	24.4	33.9	28.6
	8.0	CDFS	3.5	-28	18	70.0	79.9	24.4	33.9	28.6

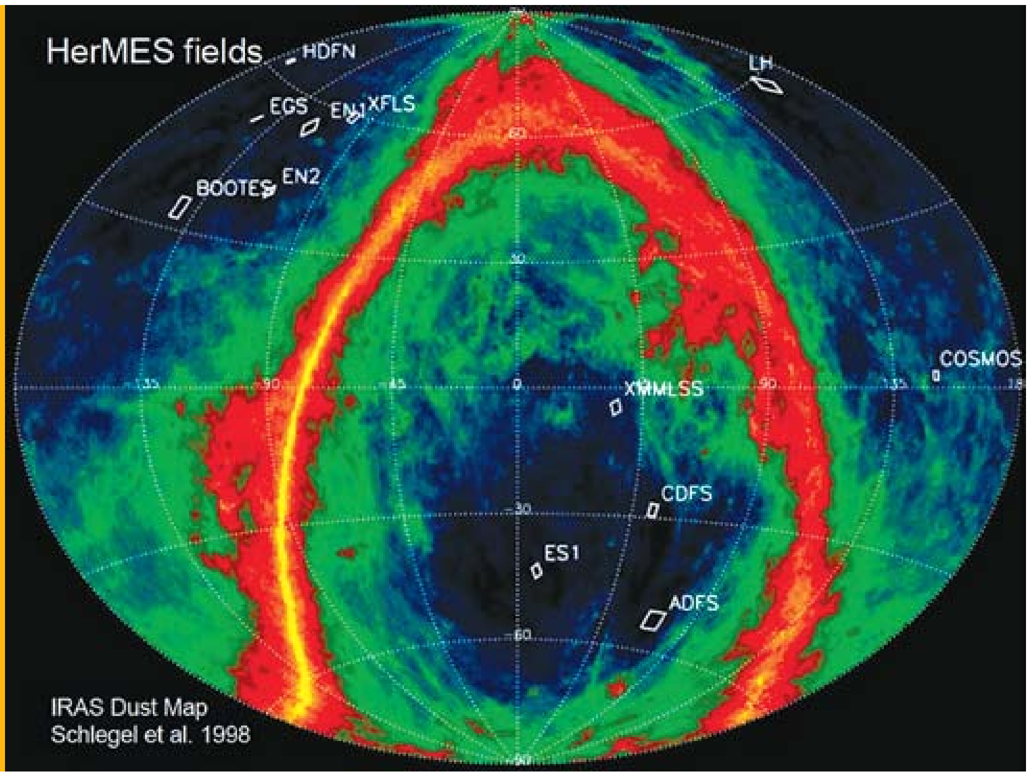

Figure 2. HerMES fields superimposed on the IRAS dust map of the sky.

tial equator in an effort to maximise the amount of complementary data and to minimize the amount of confusing emission from dust in the Galaxy, this last determined from the IRAS 100 μm maps. The fields (Figure 1) which cover a total area of 510 square degrees are:

- The NGP field, close to the northern galactic pole covering 150 square degrees.
- The three GAMA fields (Driver et al. 2009), each one covering 36 square degrees.
- The two SGP fields, covering a total of 250 square degrees close to the south galactic pole

Angular resolution of the observations will be approximately 8, 12, 18, 25, 36 arcsec at 110, 170, 250, 350, 500 μm respectively while 5σ sensitivities for the five bands should reach down to 67, 94, 45, 62 and 53mJy respectively which in combination with the wealth of ancillary multi-wavelength data will allow ATLAS to meet its key science goals.

HerMES

HerMES (Oliver et al. 2010), the Herschel Multi-tiered Extragalactic Survey is the largest project to be performed with Herschel, consisting of six separate surveys of different depths and areas (Table 1, Figure 2). It will utilize 850 hours of SPIRE time and 650 hours of PACS time. HerMES is designed to sample the high luminosity objects, which are bright but rare, in the wide shallow tiers, and the lower luminosity galaxies, which are faint but common, in the deep narrow tiers. HerMES will chart the formation and evolution of infrared galaxies throughout cosmic history. HerMES's nested set of fields will bring unprecedented depth and breadth to the study of infrared galaxies. HerMES will be used to measure the bolometric emission of infrared galaxies, study the evolution of the luminosity function, measure their clustering properties, and probe populations of galaxies below the confusion limit through lensing and statistical techniques. HerMES is closely coordinated with the PACS Evolutionary Probe survey. It will make maximum use of ancillary surveys from radio to X-ray wavelengths to facilitate redshift determination, rapidly identify unusual objects, and understand the relationships between thermal dust emission and other emission mechanisms. HerMES will provide a rich data set legacy for the greater astronomical community to mine for years to come.

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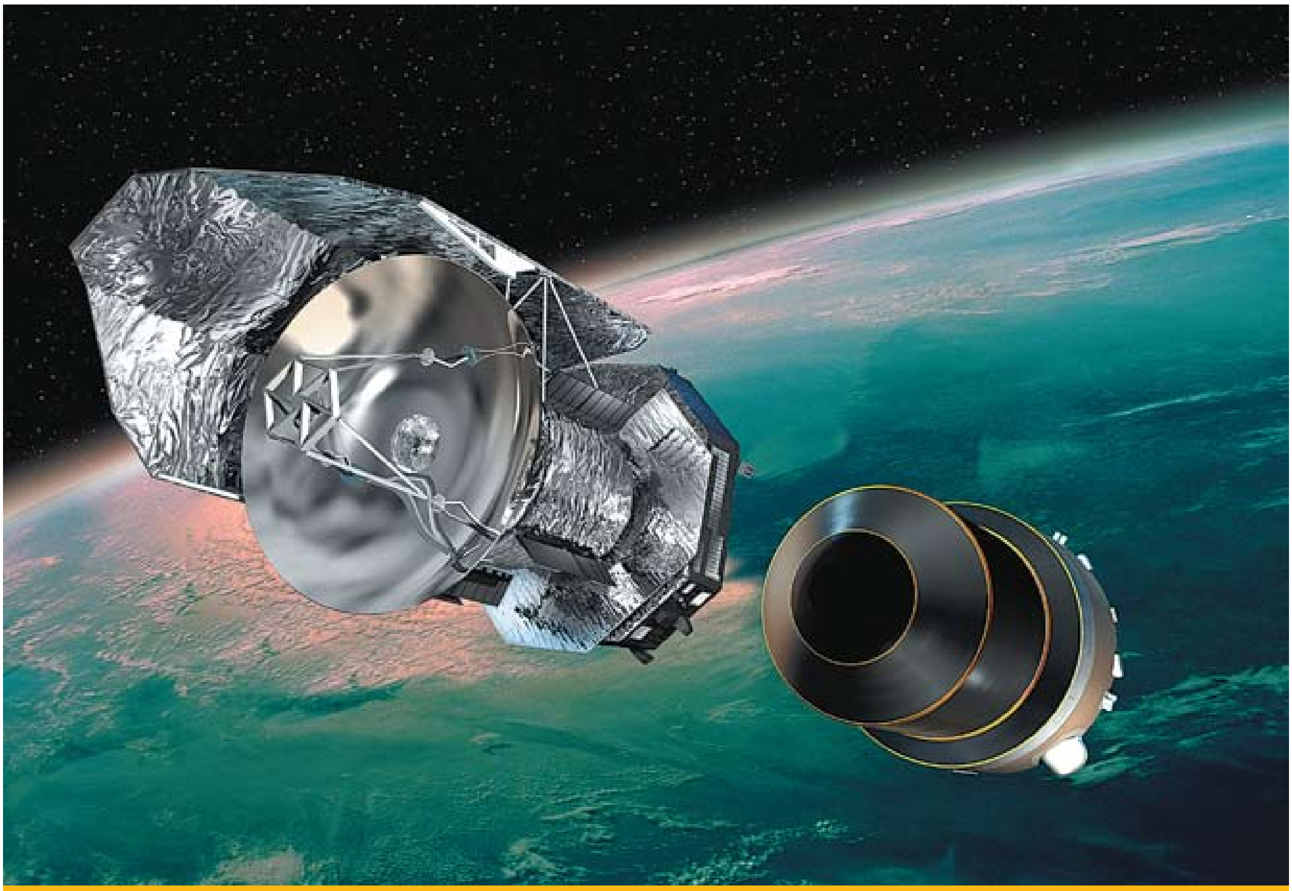


Figure 5. Artistic illustration of the Herschel Space Observatory (Illustration : ESA - D. Ducros, 2009)

The 9th Hellenic Astronomical Conference

Athens, 20-24 September, 2009

by Kanaris Tsinganos, Despina Hatzidimitriou, Titos Matsakos

Held regularly since 1993, the International Conferences of the Hellenic Astronomical Society (Hel.A.S.), the professional Society of Greek astronomers, are a major scientific event by themselves.

The conferences, which take place every two years in a different part of Greece, typically bring together well over 100 scientists with research interests in Astronomy, Astrophysics, and Space Physics. The 9th International Conference of Hel.A.S. took place at the University of Athens, between September 20 and 24, 2009 and coincided with the festive International Year of Astronomy 2009 (IYA09). About 200 astronomers from many countries participated in the event. The purpose of the 9th Astronomical Conference was to summarize the recent progress in Astronomy, Astrophysics and Space Physics during the landmark year 2009 for Astronomy, which was an occasion to celebrate and reflect on 400 years of changing perspectives of the Universe. The scientific program of the conference consisted of plenary, invited and poster presentations which were carefully selected by the Scientific Organising Committee of the conference from among numerous submissions.

In addition, there were sessions on ESA (PRODEX) and on the teaching of Astronomy in Secondary Education. Thus, this Volume contains a selection of the proceedings of the 4-day international astronomical conference divided in 6 sessions.

The first session is devoted to the Sun, the Planets and the Interplanetary Medium and contains 27 invited and contributed papers on theoretical studies and analysis of observations from the Heliosphere. First, the emergence of magnetic flux from the solar interior in active regions and the modification of the coronal magnetic field in response to this emergence is presented as one of the most important processes, responsible for many solar dynamical phenomena, such as flares, coronal mass ejections, solar jets, etc. These phenomena in turn and the fluxes of their associated energetic particles

have an impact on the interplanetary medium, the propagation of cosmic rays and the magnetospheres of the Earth and the other planets, as observed from several satellites and ground stations.

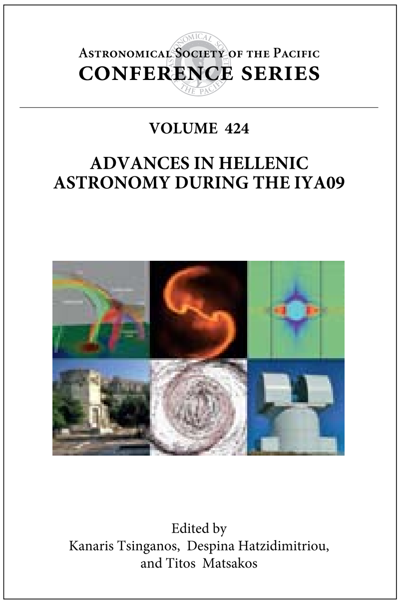
For example, analysis of DEMETER observations for the temporal evolution of energetic electron precipitation is reported as a promising tool for earthquake prediction research. Finally, there are presentations on new satellite projects, such as a novel solar coronagraph onboard the Proba 3 ESA formation flying satellites to observe at high spatial resolution the solar coronal with conditions similar to those occurring during total solar eclipses.

The second session is devoted to Stars, Exoplanets and the Interstellar Medium. It includes 23 invited, contributed and poster papers, encompassing a wide range of subjects, from star formation processes in molecular clouds to pulsar physics. The session begins with a thorough review of the physical properties of neutron stars, the most compact objects which can be observed directly, as well as of models for soft gamma-ray repeaters and anomalous X-ray pulsars. There is also a discussion on the structure of the pulsar magnetosphere, studied through time dependent three-dimensional numerical simulations of a rotating dipolar magnetic field. Furthermore, pulsed thermal emission from accreting pulsars is presented. Star formation and young stellar objects constitute another area of active recent research. The two different star forming modes (triggered and quiescent) in the giant molecular cloud W3 are studied via multiwavelength observations. The formation of low-mass stars and brown dwarfs by gravitational fragmentation of unstable discs are discussed.

Moreover, observations and modeling of outflows in class 0 protostars are examined, with the emphasis on the relative influence of the molecular and atomic components of the jet, while another contribution looks into the generation of entropy in jet-launching discs.

Further contributions include studies of different types of binary stars, of cataclysmic variables, of flares in red dwarfs, of hot emission-line stars, of planetary nebulae and luminous blue variables and of supernova remnants. Prelimimary results of a new campaign for the discovery of Hot Jupiter Planets orbiting Sun-like stars are also presented.

The third session with 31 papers is devoted to Extragalactic Astrophysics and Cosmology. A wide range of subjects are covered in this part, from resolved galaxies to superclusters of galaxies and cosmic acceleration. Starting from the local universe, studies related to the star formation history and stellar populations in nearby galaxies are presented, often using multiwavelength approaches.



Modeling of the bars of dusty spirals, star formation processes in galaxies from molecular cloud to kpc scales and molecular gas properties in luminous infrared galaxies in particular, are also discussed. A group of contributions are dedicated to ESA's GAIA mission, including the description of an optimized library of synthetic galaxy spectra and the construction of an unresolved galaxy classifier, specific to the mission.

Active galactic nuclei (AGNs) and their properties, including variability and microvariability studies, occupy a significant portion of the session. There are also contributions referring to the evolutionary sequence of AGN activity, the properties and evolution of AGN jet ridge lines, X-ray obscured AGNs, the angular clustering of hard X-ray AGNs, the X-ray flaring behaviour of blazars, as well as cosmic ray acceleration and neutrino production in AGNs.

Galaxy evolution is the subject of the Lockman Hole Multi-Wavelength Survey. Studies of clusters of galaxies include Hickson Compact Groups, observed with Swift and Spitzer, and X-ray observations of clusters and superclusters of galaxies.

Gamma-Ray-Burst afterglows have also been addressed and their synchrotron and SSC emission is analysed. Finally, on the front of Cosmology, cosmic acceleration is addressed in an invited presentation, which attempts to weight the validity of a large number of dark energy models, using recent measurements of the expansion rate of the Universe, the clustering of galaxies, the CMB fluctuations as well as the large scale structure formation.

Another vital question addressed is the determination of the total amount of light produced since the Universe was born.

Extragalactic background light (EBL) is essentially the time-integral of the light production and re-processing in the Universe, but it is very difficult to measure. A new non-parametric method for measuring the Cosmic Infrared Background and setting limits to the Cosmic Optical background, is presented.

Another composite session is devoted on Dynamical Astronomy and Relativistic Astrophysics. In Dynamical Astronomy, stickiness is reviewed in a system of 2 degrees of freedom with an application in the outer spiral arms of strong barred-spiral galaxies.

The results of the first multi-scale, hydrodynamical simulations of mergers between galaxies with central supermassive black holes (SMBHs) are discussed to investigate the formation of SMBH binaries in galactic nuclei. Aspects of the dynamics of a small gyrostat acted upon by the Newtonian forces of two big bodies of equal masses which rotate around their center of mass are next presented. Other papers deal with Galactic dynamics, such as the orbital structure and asymptotic orbits in barred-spiral galaxies, the orbital behavior at the neighborhood of stable periodic orbits in 3D galactic potentials, or, response models of barred-spiral galaxies.

In Relativistic Astrophysics. the dynamics of neutron star oscillations and instabilities is reviewed in the context of gravitational waves, while the European pulsar timing array network again for detecting cosmological gravitational waves in the nano-Hertz regime is also discussed.

The fifth session is devoted on Astronomical Infrastructures. There were contributions describing the instrumentation and the science capabilities of the Aristarchos Telescope, the Virtual Observatory, the Cherenkov Telescope Array, the new teaching telescope at the University of Patras, as well as the University of Athens stellar spectrograph. There were also contributions related to the importance of Distributed Telescope Networks, the construction of an ultrafast three-beam photon counting photometer at the Hellenic Naval Academy and aspects of the optomechanical design of the planned new Greek 1.4 m Constantine Caratheodory Telescope.

The last (sixth) composite session is devoted on the History and Education in Astronomy. In the History of Astronomy, it is appropriate to start with papers on ancient astronomical monuments in Athens, or, the large water-clock of Amphiaraeion in Attica, before reviewing the more general role of Astronomy in culture, history, science, religion, etc. In the last subpart on Education in Astronomy, the role of Astronomy in education is analyzed for achieving an integrated concept of education that enables individuals to adapt to a rapidly changing social, economic and cultural environment. In particularly for students, astronomical activities are presented which would motivate them to study physical sciences through astronomy, and also how to initiate younger children into basic astronomical concepts and phenomena. Finally, a Greek campaign for light pollution awareness is also discussed.

This was a very successful conference organised during the IYA09 in the historic city of Athens, home of several ancient Greek astronomers.

The conference served not only to showcase some of the achievements of Hellenic astronomers, but also allowed to hear from, discuss and debate the recent findings of world-class scientists in astronomy.

The conference itself would not have been possible without the contribution of many people. In particular, we should acknowledge the Scientific Organising Committee consisting of Kanaris Tsinganos (Chair, University of Athens), Vassilis Charmandaris (University of Crete), Ioannis Daglis (National Observatory of Athens), Eleni Dara (Academy of Athens), Ioannis Georgantopoulos (National Observatory of Athens), Despina Hatzidimitriou (University of Athens), Apostolos Mastichiadis (University of Athens), Margarita Metaxa (Arsakeio High School), Panos Patsis (Academy of Athens), Manolis Plionis (National Observatory of Athens), John Seiradakis (University of Thessaloniki), Nikos Stergioulas (University of Thessaloniki), Loukas Vlahos (University of Thessaloniki) and Emmanuel Xilouris (National Observatory of Athens) for all their efforts in putting together an excellent programme. Also, it is our pleasure to thank the chairman of the Local Organising Committee (LOC) Panagiotis Niarchos (University of Athens) and the members of the LOC for all their successful organizational efforts.

All meetings require local support and Financial assistance for the conference and the publication of the proceedings was provided by the Greek Ministry of Education and Religious affairs, the Academy of Athens, the Univ. of Athens and the National Observatory of Athens.

Modern Challenges in Nonlinear Plasma Physics

A conference honouring the career of K. Papadopoulos

Halkidiki, 15-19 June, 2009

by Loukas Vlahos

Over the last few decades the advances in the many and varied branches of plasma physics have been breathtaking and it is only fitting to slow down once in a while to meet and discuss such advances from an interdisciplinary perspective. Naturally the conference organizers decided to limit the scope of the meeting to just three of the many sub-disciplines: solar, geospace, and laboratory plasma science. Even so this choice was really stretching our timetables and we were obliged to leave out of the program a large number of truly fascinating developments.

The conference concentrated on the diverse and exciting developments in plasma physics, but also focused on one of the few people who have contributed significantly, over a long time, to this progress. The original motivation of the meeting was for a group of former graduate students and postdocs of Prof. Konstantinos Papadopoulos to celebrate his long, productive, and ongoing career. Dennis is widely known not only for his

personal achievements and contributions to plasma and other fields of physics, but also for being an energetic and clear-thinking science leader. His enthusiasm and inventiveness has been a source of inspiration for many of us and we are truly glad to acknowledge it.

The first day started with three reviews on solar corona plasma, geospace plasma coupling and strongly nonlinear space and fusion plasmas. The issues discussed during the rest of the day were the building blocks of nonlinear plasmas and some statistical approaches.

The second day was dedicated to magnetic reconnection, plasma waves and turbulence, while the first poster session was held during the afternoon.

The fourth day dealt with structures in plasmas and their stability (phase-space structures, structures in space and solar plasmas and structures in active experiments), followed by the second poster session. The lectures of the last day concerned dynamic and interactive plasmas in space and in the lab. After three summaries on geospace, solar, interplanetary and lab plasmas, Prof. Dennis Papadopoulos closed the conference.

The total number of the conference participants was more than 100, including both active scientists and students.

Additional information regarding the conference can be found in the website

http://www.astro.auth.gr/~vlahos/kp/

Gamma in Z: Gamma-ray Diffuse Emission Meeting in Zurich

November 16-20, 2009

by Vasiliki Pavlidou

It is a familiar story in astrophysics: diffuse emission encodes a lot of information, and can revolutionize our understanding of the universe. In the microwave band, the unprecedented success story is well known. The spectrum of the cosmic microwave background (CMB) established its black-body nature and its origin as the faint echo of the hot and dense early days of the Universe; its anisotropy properties at different angular scales established the flatness of the Universe, and today are the primary observational constraint on cosmological parameters, confirming, among others, the existence of non-baryonic dark matter and of dark energy. Now, a satellite observing the cosmos at the other end of the electromagnetic spectrum, the Fermi Gamma-ray Space Telescope, could bring about a repeat of this story in a similarly exciting way. Groups in Europe, the United States, and Japan, have been pursuing independently studies on how the cosmic gamma-ray background (CGB) could reveal information, again through its spectrum and anisotropy properties, about cosmic accelerators, supernova explosions in the high-redshift universe, and, most excitingly, about the nature of dark matter, which may be producing gamma-rays in the Fermi energy range (which extends from 100 MeV to hundreds of GeV) through self-annihilations.

Figure 1. Workshop Dinner; credit: Fabio Iocco

With Fermi operating spectacularly and Fermi data pouring in, several research groups, including our own at Caltech, have come together to combine expertise and push the envelope of information mining in the cosmic gamma-ray background. Some parts of the analysis are similar with CMB studies, but in the case of the CGB there are additional challenges: much poorer angular resolution; much fewer photons; different foregrounds; multiple contributing source classes. The multi-group, multi-institution collaboration includes researchers from Caltech (Pavlidou, Ando), Ohio State (Siegal-Gaskins), Institut D'Astrophysique de Paris (Pieri – now at Padua, Bertone – now at ITP in Zurich, and Fornasa), Università di Roma (Branchini), Stockholm University (Cuoco), University of Texas at Austin (Komatsu), and the University of California, Santa Cruz (Profumo). Supported by NASA, the Institute of Theoretical Physics (ITP) at the University of Zurich, and the Center for Cosmology and Astroparticle Physics (CCAPP) at Ohio State, our plan has been to organize a series of intra-collaboration meetings to exchange analysis tools and know-how, ensure that our models and expectations for different scenarios about spectrum and anisotropy properties of the CGB converge, and be ready to extract maximal information from the Fermi-observed CGB, as soon as a large enough number of photons has been collected. Each meeting lasts for a week, and is combined with a one-day workshop with more general contributions invited from the Diffuse Gamma-Ray Emissions and the Indirect Dark Matter Searches communities.

The first of these meetings was held, with great success, on the week of November 16-20, 2009, at ITP in Zurich. Topics that were highlighted during the collaboration meeting included diffuse gamma-ray emission from dark mater annihilations in the Milky Way halo and in nearby cosmic structure; gamma rays from faint, unresolved active galactic nuclei and star-forming galaxies; the spatial fluctuations expected from each class of sources contributing to the CGB; redshifting effects and foregrounds that may lead to false positives in the search of a dark matter annihilation signal in the CGB; and novel techniques which may allow us to decompose the CGB spectrum into its constituent components in a model-independent fashion.

The more general one-day workshop was held on 18 November, and included contributions from representatives of the Fermi collaboration Aldo Morselli and Andy Strong, who talked about non-CGB searches of dark-matter annihilation signals, and diffuse emission from the Milky Way respectively. Mirko Boezio and Marco Cirelli discussed the promise and problems of detecting a signal of annihilating dark matter in cosmic-ray signals. Paco Prada presented how constrained cosmological simulations, aiming to model the dark-matter distribution in the nearby universe as closely as possible, can help us make more robust predictions about dark matter signals from neighboring cosmic structures. Fabio Iocco presented combined current astrophysical and cosmological constraints on different dark matter candidates, and I gave an overview of our intra-collaboration progress on using the spectrum and anisotropy of the CGB to look for the nature of dark matter to our external workshop participants.

The general feeling of the meeting was that, although the dark matter puzzle is still unsolved, we have many pieces, and several very good ideas on how to look for more. Between Fermi observations, cosmic-ray experiments, and the much-awaited data from LHC, the hope is that finding the corner pieces of the puzzle is not far from reach. In the meantime, we await with excitement for Fermi to collect more diffuse photons, and we look forward to our next collaboration meeting – this time, at the Ohio State University, in Columbus, starting June 21st 2010.

Figure 2. Collaboration meeting: Shin'ichiro Ando is deriving the gamma-ray anisotropy properties for a signal from dark matter annihilations in the Milky Way dark matter halo substructure. Credit: Fabio Iocco

Additional information regarding the conference can be found in the website
http://www2.iap.fr/users/bertone/GinZ/

Astronomy with Mega-structures: Joint Science with E-ELT and SKA

Agios Nikolaos, Crete, 10-14 May 2010

by Dimitra Rigopoulou, Oxford University & Rutherford Appleton Laboratory, UK

The week of 10-14 May 2010 brought together two of the traditionally oldest communities in Astronomy, optical and radio. The purpose of the meeting was to discuss strategies for joint science ventures to be undertaken making use of the mega-facilities that are about to come online in the next decade or so. The name of the meeting ˝Megastructures in Astronomy: Join science with E-ELT and SKA˝ reflects the way the international astronomical community across the entire electromagnetic spectrum is coming together to make use of the new extremely sensitive facilities that will dominate the horizon at the end of the next decade. The European Extremely Large Telescope (E-ELT) and the square Kilometre Array (SKA) have been picked out as particularly high-priority projects for the future. Alongside the ATACAMA Large Millimetre Array (ALMA), the James Webb Space Telescope (JWST) the Space Infrared Telescope for Cosmology and Astrophysics (SPICA) and the International X-ray Observatory (IXO) these facilities mark the dawn of a new era in Observational Astrophysics/Cosmology.

The meeting brought together a plethora of experts from the radio all the way to gamma-rays, both theoreticians and observers and was organised around five scientific themes, each focusing on the impact of the new facilities in each field: Exo-Planets and Astrobiology; The Local Universe; Extreme Objects; Galaxy formation and the Young Universe; Cosmology and Fundamental Physics. Particular emphasis was placed on scientific areas that profit from synergies at various wavelengths such as the high redshift Universe and the hunt for extra-solar planets. Representatives from the European Southern Observatory (ESO) presented a detailed account of the plan for the construction of the largest telescope in the world (42m in diameter) which is to be located at the Armazones site in Chile as well as the first light instruments due for selection in mid-June. Likewise, plans for phase 1 and 2 and the technological challenges that will be presented during the construction of the Square Kilometer Array (SKA) were discussed. The meeting developed around defining a set of ìhigh-priorityî scientific projects that will benefit from the availability of such facilities. The proceedings will be published by the Crete University Press (CUP) and will be available towards the end of the year. The meeting was funded by FP-7 programs OPTICON and RADIONET and the University of Oxford.

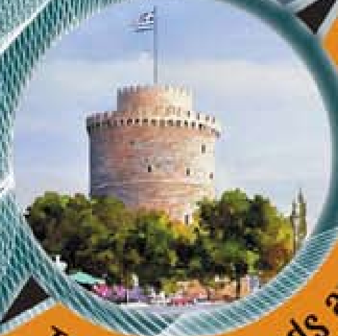
http://www.physics.ox.ac.uk/users/Karastergiou/Greece2010/home.html

International Conference

Thessaloniki, Greece 12 - 16 July 2010

Nonlinear Dynamics and Complexity:

Dedicated
to the 60th birthday
of Tassos Bountis



Theory, Methods and Applications

Overview

The scope of this conference is to gather world-leading experts, as well as young scientists, in order to present current developments and discuss future perspectives on Nonlinear Dynamics and Complex Systems.

The conference will act as a catalyst for research in nonlinear dynamics and its applications, providing a venue for established scholars to interact - not only with each other, but also with the junior scholars that play an essential role now and in the years to come

Topics

Chaos and Complexity in biological and physiological systems
Celestial Mechanics and Stellar Dynamics
Dynamical Systems: Analytical and Numerical Methods
Electrical Circuits
Nonlinear Hamiltonian Dynamics and Statistical Mechanics
Nonlinear Waves, Discrete Breathers
Soft Matter and Granular Materials
Synchronization and Chaos Control

Organizing Committee

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Skokos Ch. (Dresden)
Tsiganis K. (Thessaloniki)
Voyatzis G. (Thessaloniki)

Contributed talks and posters are invited from all areas of dynamics and complex systems science.

Early registration deadline: **31 May 2010**

Scientific Program Committee and Main Speakers

Bezerianos A. (Patras)
Casati G. (Como)
Chua L. (Berkeley)
Contopoulos G. (Athens)
Dvorak R. (Vienna)
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Vrahatis M. N. (Patras)

http://nonlinear.web.auth.gr/

Invited Speakers

Aifantis E. C. (Thessaloniki)
Aubry S. (Paris)
Baesens C. (Warwick)
Basios V. (Brussels)
*Benettin G. (Padova)
Chandre C. (Marseille)
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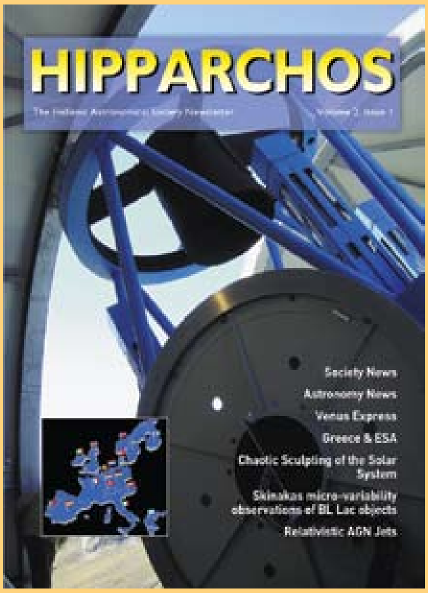
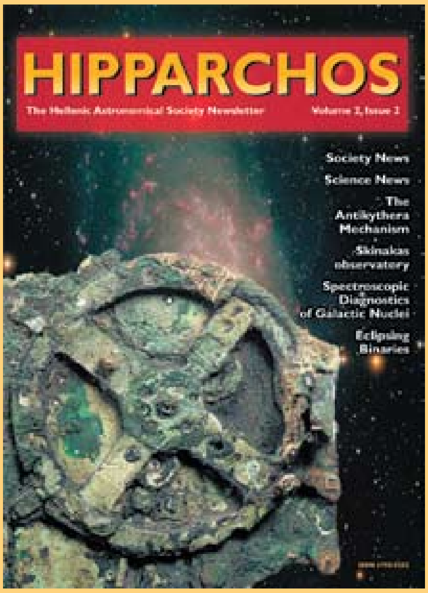
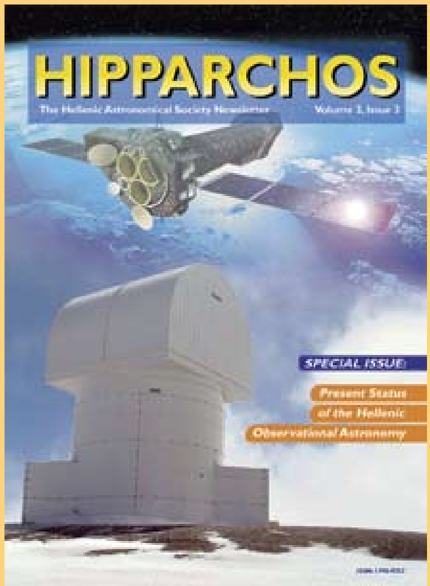


Volume 2, Issue 1, January 2006



Volume 2, Issue 2, March 2007



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