Formation of fine structure of solar type II radio bursts at decametric waves: Analysis of the role of propagation effects

Alexander Afanasiev

Fine structure of solar type II radio bursts is of great interest to solar researchers. The reason for that is that the fine structure is thought to represent a manifestation of the structure of the shock wave (at which type II emission is generated) and contains information about processes occurring during the shock propagation through the near-solar space. In particular, dynamic spectra of decametric type II bursts sometimes demonstrate fine structure in the form of drifting narrow-band emissions (fibers). According to recent investigations, such emissions appear in those events where two coronal mass ejections (CMEs) interact to each other, particularly, when a shock wave driven by one of the CMEs overtakes the other CME. Under such conditions, the appearance of the fine structure may be related to a specific emission mechanism formed due to interaction of the shock wave with the CME plasma. In this case the observed fine structure represents an intrinsic property of the radio source. However, a possibility that the fine structure is formed due to effects of radio emission propagation in inhomogeneous near-solar plasma should not be excluded. From this point of view, the fiber structure of radio bursts can be produced by focusing of the radio emission by an inhomogeneous CME structure, which can have some manifestations in observed emission characteristics (i.e. in the directivity pattern). In this connection, it is important to find ways to identify the fine structure caused by the effects of focusing by means of modern observational instruments. I present modeling results of radio emission propagation through coronal plasma containing large-scale regular structures with increased electron density and small-scale density fluctuations giving rise to scattering of the emission. The calculations, which are based on the Monte Carlo technique, indicate that, in particular, the emission of the fibers should be harmonic. Moreover, the mechanism under consideration suggests that in solar observations from two different points in space the observed sets of fibers can be shifted in frequency with respect to one another or can have different structure. This potentially can be used for identifying fibers caused by the propagation effects. I also present results of preliminary analysis of May 2, 1998 event, which argue in favour of the radio propagation mechanism for the burst fine structure in this event.

The Dust Trail of Comet 67P/Churyumov-Gerasimenko in 2008

Jessica Agarwal

We present observations of the dust trail of the Rosetta target comet 67P/Churyumov-Gerasimenko during 2008 in visible and mid-infrared light. We observed in visible light in July 2008 with the Wide Field Imager at the ESO/MPG 2.2m-telescope on La Silla, and in the mid- to far-infrared (24 and 70 micron) in November 2008 with the MIPS instrument on board the Spitzer Space Telescope. The comet was at heliocentric distances of 2.7 AU in July 2008 and 1.7 AU in November 2008. The observations show the comet nucleus, developing coma, and sections of the dust trail. At 70 micron the trail was not detected, indicating either a significantly elevated colour temperature due to grains large enough to support temperature gradients across their surface, or a decrease of emissivity with wavelength. Such an emissivity effect could be explained by the predominance of small (< 100um) grains in the dust trail that would have to be recently-produced by fragmentation of larger particles.
We constrain the dust size distribution, emission speeds, and production rates as functions of time from iterative comparison of the observations with simulated images.

This work is based on observations made with the MPG/ESO 2.2m telescope at the La Silla Observatory under programme ID 081.A-9019(A), and with the Spitzer Space Telescope under programme ID 50650. Spitzer is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA.

SMART-1 AMIE multispectral cubes – validation sites and the SPA basin

Miguel Almeida, Priscilla Cerroni

Last year I presented the first assessment of the SMART-1 AMIE multi-spectral data. As the AMIE multi-spectral cubes are a derived product of the original images, the first step shown last year was to see if given the data obtained we could derive the cubes.

In this year presentation we will show the resulting derived multi-spectral cubes and the first analysis done with them, namely the comparison with some literature calibration sites, and one of the main objectives of the mission, the SPA basin.

CASSINI-CIRS thermal measurements of Saturn's main rings: probing the ring structure

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Since the Saturn Orbit Insertion (SOI), the Composite Infrared Spectrometer (CIRS) on-board the Cassini spacecraft has acquired a wealth of spatially highly-resolved thermal emission measurements of the Saturn main ring system. The spectra obtained with the far-infrared channel (FP1, 100-600 cm^{-1}) are of particular interest as the bulk of the thermal energy emitted by the ring's particles lies in this wavelength range. As a result, physical temperatures can be retrieved, as well as a filling factor that takes into account the finite optical thickness of the ring and the superposition of different blackbody temperatures within the field-of-view.

The thermal emission of Saturn's ring results from the energy balance between the solar illumination, particle rotational state and albedo, as well as mutual shadowing and mutual heating and possibly energy transfer through vertical particle motion within the ring. We review the current status of data analysis and modeling to probe the ring structure.

Modelling Solar Energetic Particle Events in a wide range of energies (0.3 to 200 MeV protons).

Angels Aran

Abstract

Present models to simulate Solar Energetic Particle (SEP) events describe the associated CME-driven shock propagation in the ecliptic plane starting well beyond the solar wind critical point (i.e. > 18 solar radii from the Sun). However, high energy (> 30 MeV protons) particle acceleration and injection into interplanetary space by shock waves often occurs within the first 18 solar radii. We have developed together with our colleagues at the University of Barcelona and of the K.U. Leuven a model that combines (for the first time) the simulation of the CME-driven shock propagation (from 4 solar radii to 1 AU) with the transport of shock-accelerated particles along interplanetary magnetic field lines to reproduce the particle intensities measured during two intense SEP events.

These two SEP events occurred on 2000 April 4 and 2006 December 13 during the maximum and minimum phases of solar cycle 23, respectively. The simulation of the shock propagation is performed by a 2D MHD model developed by the Centre for Plasma Astrophysics (K.U. Leuven) and the particle transport by the model developed at the University of Barcelona (Lario et al, 1998). With this combined model we reproduce the proton differential intensities measured by the ACE/EPAM, SOHO/ERNE and STEREO/IMPACT instruments, for more than 20 energy channels, between ~0.3 to 200 MeV, and the ~1-4 MeV proton first-order anisotropies measured by ACE/EPAM (provided by D.Lario; Applied Physics Laboratory, JHU). We discuss both the evolution of the injection rate of shock-accelerated particles and the particle transport parameters obtained from modelling both SEP events.

We also present the first steps we are undertaking towards the simulation of SEP events out of the ecliptic by using 3D MHD CME-driven shock propagation models.

Title: LISA Oil-Finder?
Subtitle: Gravity Waves Data Analysis Techniques and the world of Passive Seismic Exploration
Speaker: M. Armano

Abstract:
In this short overview we'll present our work as Scientific Consultant for Geodynamics Research SRL (GDR),
mostly reporting of recent results rooted in our post-doctoral work of 2006-2007. GDR operates in passive
seismic on several Middle-East and Nothern European fields. Passive seismic is a very powerful and promising
technology for the non-intrusive exploration of oil reservoirs. We'll sketch its methods to derive a Power Spectral Density pattern for oil subsoil distributions and show probability maps
derived from the coherence estimator after background noise subtraction. The whole analysis streamline
was designed from the LISA Pathfinder (LPF) time series analysis pipeline and inherited its tools and
methods. The aim of GDR is to build a credible oil indicator for risk reduction, our scientific interest
involves building wave patterns and signal triangulation, aside of advancing LPF data analysis techniques
and testing them on ground applications.

Probing the disks, accretion and formation of pre-main sequence stars using VOSpec.

Deborah Baines

The Herbig Ae/Be stars are intermediate mass pre-main sequence stars that bridge the gap between the low mass T Tauri stars and the Massive Young Stellar Objects. This is an important mass range for understanding the formation of massive stars, as it is here that the acting star forming mechanism switches from magnetically controlled accretion from disks with inner holes to a not well known mechanism, likely to involve direct disk accretion onto the star. We have started to undertake a comprehensive study of spectral data in the Virtual Observatory (VO) on Herbig Ae/Be and also T Tauri stars using (new developments in) VOSpec, a multi-wavelength spectral analysis tool developed by the ESA-VO Team at ESAC. By studying the line strengths, variabilities and spectral energy distributions, from the X-ray to sub-mm, we aim to gain insights into the accretion rates, processes and disk properties of a large sample of these objects, and to probe the question: Where does the star formation mechanism switch? In this talk I will discuss the initial findings.

Observations of exotica in Globular Clusters: clues on their dynamical state.

Globular Clusters are real touchstones in several fields of stellar astrophysics. As the best approximations in nature of a Simple Stella Population, they are the ideal laboratory to test the validity of standard stellar evolutionary models.
Moreover, the extremely high stellar density of the central regions of the GCs make them the laboratory for the study of the influence of stellar dynamics on "natural" evolution of stars. It is well known that Globular clusters harbor a large amount of exotic objects (like Blue Stragglers Stars), generated by the evolution of primordial binaries or by dynamical processes occurring in clusters. Moreover, recently various clues have emerged that point to the presence of Intermediate Mass Black Holes (IMBHs) in GCs.

Here I will show some observational evidence with the aim to clarify the key role of this exotic populations in the comprehension the dynamical age/state of GCs.

Light Echoes from Historic Supernovae

Stephan Birkmann

As the light from historic supernova explosions travels through space, it gets scattered by interstellar dust. These light echoes can still be observed today, centuries after the brillaint flash of the supernova explosion swept pass Earth. By using 21st century instrumentation on light echoes it was possible to perform a spectroscopic classification of 16th and 17th century supernovae. I will talk on the discovery of the light echoes from these SNe and what one could learn from light echo spectroscopy in the future.

Central Massive Objects in Spiral Galaxies
Torsten Boeker

A large fraction of galaxies of all Hubble types harbor a compact and luminous stellar cluster at or near their dynamical center. In disk-dominated, bulgeless spiral, these nuclear star clusters (NSCs) have been proposed to be an alternative incarnation of a "massive central object", similar to the supermassive black holes (SMBHs) that are common in bulge-dominated galaxies. I will review recent observational and theoretical evidence for such a link between NSCs and SMBHs.

Warm absorbers around the nucleus of the active galaxy UGC 11763
Mónica V. Cardaci

We present a detailed analysis of all data taken by the *XMM-Newton* satellite of UGC 11763 to characterize the different components that are emitting and absorbing radiation in the vicinity of the active nucleus. The continuum emission was studied through the EPIC spectra taking profit of the spectral range of these cameras. The high resolution RGS spectra were analyzed in order to characterize the absorbing features and the emission line features that arise in the spectra of this source. A power law with a photon index $\Gamma = 1.72^{+0.03}_{-0.01}$ accounts for the continuum emission of this source in the hard X-rays from 10 down to 1 keV. At lower energies, a black body model with kT = 0.100±0.003 keV provides a good description of the observed soft excess. The absorption signatures in the spectra of UGC 11763 are consistent with the presence of a two phase ionized material (log U = $1.65^{+0.07}_{-0.08}$; 2.60 ± 0.009 and log N_H = 21.2 ± 0.2; 21.51 ± 0.01 cm^{-2}, respectively) in the line of sight. The physical conditions found are consistent with the two phases being in pressure equilibrium. The low ionization component is more ionized than typically found for warm absorbers in other Seyfert 1 galaxies. There are also signatures of some emission lines: Ovii Heα(r), Ovii Heα(f), a blend of the Neix Heα triplet and Fexviii at λ 17.5 Å.

Planetary transit candidates in the first CoRoT fields

Stefania Carpano

CoRoT is the first space-based observatory dedicated to the photometric search for extrasolar planets. Launched in December 2006, CoRoT continuously monitors ten thousands of stars per observing run, with durations of ~30 days for the “short runs" and ~150 days for the “long runs". The initial run, pointed toward the galactic anti-center (IRa01) lasted exceptionally only for 60 days (from 2008 early February until early April).

I will present some statistics about the planetary transit candidates detected in the first 5-6 runs observed by COROT, reported by the different detections teams settled around the collaborating institutes.

GRBs and their host galaxies: lighthouses to high redshift star formation processes

José María Castro Cerón

Gamma Ray bursts (GRBs) are extremely energetic flashes of gamma rays associated with distant galaxies and observable to very high redshifts. The occurrence of long duration GRBs has been connected with the death of massive stars, and some of them have been spectroscopically linked to type I b/c supernovae. Thus GRBs can act as cosmological beacons marking high z galaxies that harbour intense star formation processes.

Learning about the environment that gives birth to GRBs can provide important clues to better understand this phenomenon and, in turn, the early history of cosmic star formation in the universe. I have used multiwavelength data from the Spitzer Space Telescope to help characterise physical parameters of a sample of galaxies hosting GRBs.

THE EUROPEAN ROBOTIC EXPLORATION OF THE PLANET MARS

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The ESA Mars Express mission was launched in June 2003 and has been orbiting Mars for almost six years providing data with an unprecedented spatial and spectral resolution on the surface, subsurface, atmosphere and ionosphere of the red planet. The main theme of the mission is the search for water in its various states everywhere on the planet by all instruments using different techniques. A summary of scientific results is given below.

The High-Resolution Stereo Colour Imager (HRSC) has shown breathtaking views of the planet, pointing to very young ages for both glacial and volcanic processes, from hundreds of thousands to a few million years old, respectively. The IR Mineralogical Mapping Spectrometer (OMEGA) has provided unprecedented maps of H_2O ice and CO_2 ice in the polar regions, and determined that the alteration products (phyllosilicates) in the early history of Mars correspond to abundant liquid water, while the post-Noachian products (sulfates and iron oxides) suggest a colder, drier planet with only episodic water on the surface. The Planetary Fourier Spectrometer (PFS) has confirmed the presence of methane (also seen in ground-based observations), which would indicate current volcanic activity and/or biological processes. The UV and IR Atmospheric Spectrometer (SPICAM) has provided the first complete vertical profile of CO_2 density and temperature, and has discovered the existence of nightglow, as well as that of auroras over mid-latitude regions with paleomagnetic signatures and very high-altitude CO_2 clouds. The Energetic Neutral Atoms Analyser (ASPERA) has identified solar wind scavenging of the upper atmosphere down to 270 km altitude as one of the main culprits of atmospheric degassing and determine the current rate of atmospheric escape. The Radio Science Experiment (MaRS) has studied the surface roughness by pointing the spacecraft high-gain antenna to the Martian surface. Also, the martian interior has been probed by studying the gravity anomalies affecting the orbit, and a transient ionospheric layer due to meteors burning in the atmosphere, was identified by MaRS. Finally, results of the ionospheric and subsurface sounding radar (MARSIS) indicate strong echoes coming from the surface and the subsurface allowing to identify buried tectonic structures, as well as layers of water-ice and the very fine structure of the polar caps. Also, probing of the ionosphere reveals a variety of echoes originating in areas of crustal remnant magnetism. Mars Express is flying at the closest distance ever of Phobos (less than 100 km), allowing to determine the mass of Phobos with great accuracy, to sound its interior with a radar for the first time, to obtain the sharpest images ever, to observe the satellite in the visible, UV and IR, and to monitor the solar wind interaction with its surface.

Mars Express will be followed by ESA's new Exploration Programme, starting in 2016 with an Orbiter focusing on atmospheric trace gases and in particular methane. The ExoMars rover will follow in 2018 to perform geochemical and exobiological measurements on the surface and the subsurface. Then in 2020, a Network of 3-6 surface stations will be launched, together with an orbiter, in order to investigate the interior of the planet, its atmospheric dynamics and the geology of each landing site. All these Mars Exploration missions will be carried out jointly with NASA.

Such network-orbiter combination represents a unique tool to perform new investigations of Mars, which could not be addressed by other means. In particular, i) the internal geophysical aspects concern the structure and dynamics of the interior of Mars including the state of the core and composition of the mantle; the fine structure of the crust including its paleomagnetic anomalies; the rotational parameters (axis tilt, precession, nutation, etc) that define both the state of the interior and the climate evolution; ii) the atmospheric physics aspects concern the general circulation and its forcing factors; the time variability cycles of the transport of volatiles, water and dust; surface-atmosphere interactions and overall meteorology and climate; iii) the geology of each landing site concerns the full characterization of the surrounding area including petrological rock types, chemical and mineralogical sample analysis, erosion, oxidation and weathering processes to infer the geological history of the region, as well as the astrobiological potential of each site. To complement the science gained from the Martian surface, investigations need to be carried out from orbit in a coordinated manner, such as i) global atmospheric mapping to study weather patterns, opacity and chemical composition; ii) a detailed map of the crustal magnetic anomalies from lower orbit (150 km); iii) study of these magnetic anomalies need to be studied in light of the magnetic field induced by the solar wind interaction with the upper atmosphere of the planet. The Network Mission concept is based on the fact that some important science goals on any given terrestrial planet can only be achieved with simultaneous measurements from a number of landers located on the surface of the planet (primarily internal geophysics, geodesy and meteorology) coupled to an orbiter.

The long-term goal of Mars robotic exploration in Europe remains the return of rock and soil samples from the Martian surface before Humans go to Mars. For further details on Mars Express science results: **http://sci.esa.int/marsexpress/**

Study of planetary environments

Fabrice Cipriani, Olivier Witasse, Didier Martin, Francois Leblanc, Jean-Jacques Berthelier, R.E. Johnson

We study the interaction between the solar wind and/or magnetospheric plasmas with planetary surfaces and atmospheres. A variety of cases exist in the solar system. Our research focuses on the moons Europa, Ganymede, and Phobos, but could also be applied at asteroids, Mars, Venus, Enceladus etc… The work is divided into two very complementary activities: numerical modelling of the planetary environments and exospheres, and hardware related activities: more precisely, testing of an ion source, a major element of mass spectrometers devoted to key measurements of exospheres.

The presentation will focus on the status of our Research Proposal (2007/2008) which aimed at developing and testing an Ion Source based on Carbon Nanotube Field Emitters. This project has been initiated in order to demonstrate the interest of considering such Ion Source to be integrated into a new generation of mass spectrometers/pressure gauges for future planetary exploration missions. In situ sampling of tenuous media as planetary exospheres is a powerful tool related to major scientific issues regarding atmospheric/surface/sub-surface composition end evolution of such planetary bodies in the Solar System. Such topics will typically be addressed by missions under study as Marco Polo, EJSM, TSSM, and future Martian probes. Results from the models will also be presented, especially some recent simulations for the Martian moon Phobos.

The OLIMPO experiment as a components separator of the microwave sky

Luca Conversi

The high galactic latitude sky at millimeter and submm wavelengths contains significant cosmological information, about the early universe (through the Cosmic Microwave Background) but also about the process of structure formation in the Universe through the far infrared background produced by early galaxies and the Sunyaev-Zeldovich effect in clusters of galaxies.

While the Planck mission is on its way to produce full sky maps in this frequency range, deeper maps of selected low-foregrounds patches of the sky can produce complementary and important information. Here we analyze the performance of a balloon-borne survey covering a $10^\\circ \times 10^\\circ$ patch of the sky with a few arcminutes resolution and very high pixel sensitivity.

We simulate the different components of the mm/submm sky (i.e. CMB anisotropy, SZ effect, FIRB and interstellar dust) using the current knowledge on each of them, and combine them, adding detector noise, to produce detailed simulated observations in four observational bands. We then analyze the simulated maps and estimate the performance of the instrument in extracting the relevant information for each of the components.

We find that the CMB angular power spectrum is recovered accurately up to $\ell \sim 2000$. Using the Sunyaev-Zel'dovich effect, most of the galaxy clusters present in our input map are detected (60\% efficiency overall). Our results also show that much stronger constrains can be set on far infrared background models.

Temporal evolution of the stellar mass function of Galactic clusters

Guido De Marchi
ESA, Space Science Department, Noordwijk, Netherlands

I will show that one can obtain a good fit to the present day stellar mass functions of a large sample of young and old Galactic clusters with a tapered Salpeter power law distribution function with an exponential truncation of the form $dN/dM \propto m^{\alpha} [1 - exp(-m/m_c)^{\beta}]$. The average value of the power-law index α is –2, very close to the Salpeter value (–2.3), whereas the characteristic mass m_c is in the range 0.1 – 0.6 M_{sun} and does not seem to vary in any systematic way with the present cluster parameters such as metal abundance, total cluster mass or central concentration. However, the characteristic mass m_c shows a remarkable correlation with the dynamical age of the cluster, namely $m_c \sim 0.1 + 0.5 (t/t_{dis})^{0.5} M_{sun}$, where t is the cluster age and t_{dis} its dissolution time. The small scatter seen around this correlation is likely due to uncertainties on the estimated value of t_{dis}.

We attribute the observed trend to the onset of mass segregation via two-body relaxation in a tidal environment, causing the preferential loss of low-mass stars from the cluster and hence a drift of the characteristic mass towards higher values. If dynamical evolution is indeed at the origin of the observed trend, it seems plausible that globular clusters, now with $m_c \sim 0.35\ M_{sun}$, were born with a stellar mass function very similar to that measured today in the youngest Galactic clusters and with a value of m_c around 0.15 M_{sun}. This is consistent with the absence of a turn-over in the mass function of the Galactic bulge down to the observational limit at 0.2 M_{sun} and argues for the universailty of the initial mass function of Population I and II stars.

Multi-point measurements of the cusp region: Cluster observations and simulations

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The polar cusp, together with the magnetopause, are the magnetospheric regions in direct contact with the shocked solar wind flowing continuously from the Sun. Therefore any changes in the solar wind plasma reaching the magnetopause induce changes in the polar cusp with a delay of a few minutes to a few tens of minutes. For instance a change of the interplanetary magnetic field (IMF) direction from South to North will displace the polar cusp poleward and at the same time will change the injection of ions from the subsolar magnetopause to the magnetotail lobes. In the mid and low-altitude cusp a spacecraft will then observe a reversal of the dispersion in energy of the ions. We will use Cluster string of pearl configuration in the mid-altitude polar cusp to investigate the temporal variations of ion injections in the polar cusp. In the period from July to September, the Cluster spacecraft follow each other in the mid-altitude cusp with a delay of few minutes up to one hour. A few examples of cusp crossings will be presented to illustrate the influence of solar wind changes in the polar cusp. We will show that a sudden change in the IMF direction from South to North produces a double cusp crossing. By opposition, a change of the IMF from North to South produces a temporal injection on the equatorward side of the cusp and an erosion of the magnetosphere. Finally, we will show that when the interplanetary conditions are stable with the IMF pointing Northward or Southward for more than 10 min the polar cusp ion dispersion stays constant. MHD and large-scale particle simulations as well as ground-based measurements will also be used to complement the Cluster data.

EuroGeoMoonMars campaign results

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We describe Instruments technology and Robotics results from the EuroGeoMars campaign in Utah Desert Research station (from 24 January to 28 February 2009). The goal of the mission was to demonstrate instruments from ExoGeoLab pilot project [1], to support the interpretation of ongoing lunar and planetary missions, validate a procedure for surface in-situ and return science, study human performance aspects, and perform outreach and education projects [2]. The EuroGeoMars&Moon campaign included four sets of objectives:

1) Technology demonstration aspects: a set of instruments were deployed, tested, assessed, and training was provided to scientists using them in subsequent rotations
2) Research aspects: a series of field science and exploration investigations were conducted in geology, geochemistry, biology, astronomy, with synergies with space missions and research from planetary surfaces and Earth extreme environments.
3) Human crew related aspects, i.e. (a) evaluation of the different functions and interfaces of a planetary habitat, (b) crew time organization in this habitat, (c) evaluation of man-machine interfaces of science and technical equipment;
4) Education, outreach, communications, multi-cultural & public relations

Several science and exploration instruments were either brought from Europe or lent by US collaborators. Most were deployed and installed during the technical crew week (24-31 Jan):

- geology: drilling equipment, Ground Penetrating Radar (GPR), Raman Spectrometer, Visible Near Infrared Spectrometer (VIS/NIR), Magnetic Susceptibility Meter (all lent by NASA-Ames), X-ray Diffractometer/X-ray Fluorescence Meter (XRD/XRF) (by inXitu Co), sampling collection and curation, scientific and HDTV cameras for field and lab studies (lent by ESTEC ExoGeoLab), installation of geochemical lab;
- engineering supporting projects: rover (lent by Carnegie Mellon Univ.), visualization tests for rover, camera system and image data for outreach.

SMART-1 and lunar RSSD research results

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We present a synthesis of lunar science and exploration RSSD research results from SMART-1 innovative instruments and advanced technologies.
SMART-1 lunar science investigations include studies of the chemical composition of the Moon, of geophysical processes (volcanism, tectonics, cratering, erosion, polar studies) for comparative planetology, and high resolution studies in preparation for future steps of lunar exploration.
SMART-1 has been useful in the preparation of Selene Kaguya, the Indian lunar mission Chandrayaan-1, Chinese Chang’E 1, the US Lunar Reconnaissance Orbiter, LCROSS, and subsequent lunar landers. SMART-1 has contributed to prepare the next steps for exploration: survey of resources, monitoring polar illumination, and mapping of sites for potential landings, international robotic villages and for future human activities and lunar bases.

Estimating a digital terrain model for a peak of (almost) eternal light close to the lunar south pole from SMART-1/AMIE images

Björn Grieger[(1)] Detlef Koschny[(2)]

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The SMART-1 spacecraft was launched on 27 September 2003 and reached its lunar baseline science orbit on 13 March 2005 for a nominal science period of six months and one year extension. During these 18 months, the AMIE camera [1] aboard the spacecraft acquired about 32.000 images. SMART-1 operated in an eccentric polar orbit. At the perilune close to the south pole, the image resolution achieved is better than 50 meters per pixel.

The south polar area is considered as possible target for future lander missions. Of particular interest is the availability of sunlight on the surface over extended periods of time. Because of the low obliquity of the Moon's rotation axis, it was suspected that there may be peaks which are illuminated most of the year. Theoretically, there could even be one so-called peak of eternal light which is illuminated all the time. Because of the polar orbit of SMART-1, the polar areas could be imaged frequently. During the 18 month of science operation, images over a wide range of illumination conditions have been acquired. These allow to search for peaks with favourable lighting.

We have discovered a peak which is illuminated in almost all images which captured it. It is located at 137°W, 17 km from the south pole. There are 113 AMIE NONE filter images of this location. Only in four images, the peak is dark, in the other 109, it is illuminated. The four images where the peak is dark were taken at very similar illumination conditions, with subsolar longitude close to 45°W and subsolar latitude close to 1.5°N. Thus the incidence angle is always very close to 91.5° — the highest occurring value — when the peak is dark. This indicates that the peak may be the highest one in the area, although the light is not completely eternal.

Five images with "small" incidence angle (i.e., close to the smallest occurring value of 88.5°) and diverse subsolar longitudes were selected to estimate the topography in the vicinity of the found peak with a concerted shape from shading approach. Combining several images does not only provide more illuminated area but does also much better constrain the generally ill-posed shape from shading problem. The observed surface brightness does only depend on the slope in the downsun direction, *not* crosswise to it, thus from one image one can only compute profiles in the downsun direction, but the elevation of these profiles relative to each other is unknown. With our approach combining information from different illumination directions, we directly compute a full 3D Digital Terrain Model (DTM), not just profiles. Starting out from a flat surface, the elevation values of the grid points of the DTM are iteratively adjusted to yield slopes between these points which are compatible with the observed brightnesses in *all* images.

Particularly for the planning of future lander missions, the retrieved DTM is of great interest. It has also been used for outreach purposes by producing a movie of a simulated fly over.

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First Analysis of Gravitational Microlensing Observations with Parallax by OSIRIS

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The galactic mass function contains contributions from different types of objects, i. e., main sequence stars and brown dwarfs, white dwarfs, neutron stars, and black holes [1]. While the mass function is of great scientific importance, it is still subject to debate [2]. By far most of the objects contributing to the mass function are so faint that they are not directly observable. Microlensing events provide the only means to detect faint objects in the galactic disk and to estimate their masses.

Such microlensing events caused by a foreground object acting as gravitational lens on a background star exhibit a well known characteristic light curve. When this lightcurve is measured with sufficient coverage and accuracy, the impact parameter, the time of maximum magnification, and the time scale of the event can be estimated. While the former two parameters are just related to the particular geometry of the observation, the time scale is related to the mass of the lens object, but depends also on the projected velocity of the observer relative to the source-lens line of sight and on the distances of lens and source. Because neither the velocity nor the distances are known in general, the lens mass can not be directly estimated. By imposing assumptions on the probability distributions of distances and relative velocities, one can compute a probability distribution for the lens mass [3], but this is usually so broad that it is hardly of any use for a particular event [1]. However, observations of many events provide statistical constraints on the galactic mass function.

The degeneration of the problem can be reduced by a second observer about 1–2 AU from the Earth. Such an observer can measure a parallax effect, i. e., he sees the event at a different time with a different maximum magnification, i. e., with a different impact parameter (but with the same time scale). This allows to estimate the Einstein radius in the observer plane, and thus the observer's velocity, providing an additional constraint. The problem is still degenerated, but the probability distribution for the lens mass is much narrower now. This allows a gross estimation of the lens mass [4], and it poses much stronger constraints on the mass function than an event without measured parallax.

Between 2008-Sep-07 and 2008-Oct-04, the Osiris camera aboard the Rosetta spacecraft observed eight fields in the galactic bulge, each seven times, which cover $l = -5^\circ \ldots +11^\circ$ and $b = -5^\circ \ldots -3^\circ$ in galactic coordinates. About 25 microlensing events which may have been observed by Rosetta have been identified from ground based observations. About ten of these have a base brightness brighter than 17 magnitudes in I, enabling sufficient photometric accuracy for the Osiris camera.

To date, six microlensing events have been photometrically analyzed, and for five of these the events could be confirmed on the Osiris images. For three events, the parameters were estimated by fitting the respective model light curves to the observed lightcurves.

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ABLATION AND DRAG MODELLING OF METEORS AND BOLIDES

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In this study we will consider a method for evaluating meteoroid parameters from observational data, and some of its applications [1]. The study takes an approach that models the fireballs' mass and properties based on the rate of body deceleration in the atmosphere as opposed to the luminosity. An analytical model of the atmospheric entry is calculated using published data of observations, by selecting parameters describing drag and ablation of meteors and bolides along the luminous segment of the trajectory. One of the specialties of the model is the possibility of considering a change of body shape during its motion in the atmosphere. The correct mathematical modeling of meteor events is necessary for further estimates of the key parameters of the meteoroids, including deceleration, the extra-atmospheric mass, the terminal mass, the ablation coefficient, the effective enthalpy of evaporation of entering bodies, the temperature, etc. With this information, one can use models for the dust influx onto Earth to estimate the number of meteors visible from a camera with a given sensitivity.

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The X-ray view of compact radio galaxies: new clues on the origin of the radio power in the Universe

Matteo Guainazzi

Parsec-scale extragalactic radio sources are believed to be compact because they are young. Common wisdom suggests that they represent the early stages in the life of large-scale radio structures. In this talk we will review the main results of our recent Chandra and XMM-Newton programs aiming at observing sizeable, complete samples of compact radio AGN. The results of these campaigns bear an impact on several aspects of our understanding of past, present and future in these sources: the physical processes responsible for their Spectral Energy Distribution; the influence of the ambient gas where the baby jets evolve on their growth; the duty cycle of their radio activity; and the ultimate fate and endpoints of their evolution.

Study and application of superresolution techniques to the images from the OSIRIS cameras onboard Rosetta

Leila Khallefi

Superresolution is a method which overcomes the limits of optical systems by creating a high resolution image through the combination of a set of lower resolution images of the same target. Application of such methods can substantially improve the quality of images taken by interplanetary spacecraft. However, the rapid change of viewing geometry imposes challenges on the application of superresolution techniques in planetary science.

A study using the images of Asteroid (2867) Steins taken during Rosetta's flyby in Sept. 2008 from the OSIRIS scientific camera system is underway . As a result we expect to highlight the potential of superresolution algorithms to increase the resolution of the images. In addition the perspectives for image enhancement during Rosetta's prime mission at Comet 67P/Churyumov will be discussed.

SILBO - double-station meteor observations on the Canary islands

Detlef Koschny

ESA/RSSDs Meteor Research Group (MRG) is currently preparing to set up a meteor observing station on the Canary islands. The project is called SILBO (Spanish Islands Long Baseline Observatory) and consists of two camera stations, one on Teneriffe, one on La Palma. The cameras will monitor a volume in the atmosphere a about 100 km altitude for meteors, and the resulting data will allow the computation of the meteoroid orbits. This will contribute significantly to the understanding of the distribution of dust in the solar system. The presentation will give an overview over the hardware setup, the detection software and data processing pipeline, and the underlying scientific goals.

Understanding Cyclotron Lines in the Spectra of Accreting Neutron Stars

Peter Kretschmar

Cyclotron lines are formed through transitions of electrons between discrete Landau levels in the accretion columns of accreting neutron stars with strong (10^12 G) magnetic fields. We summarize recent results on the formation of the spectral continuum of such systems, describe recent advances in the modeling of the lines based on a modification of the commonly used Monte Carlo approach, and discuss new results on the dependence of the measured cyclotron line energy from the luminosity of transient neutron star systems.

Investigation of the First Rosetta Flyby Target: E-type Asteroid (2867) Steins

Michael Kueppers

During the Rosetta flyby of Asteroid (2867) Steins on 5 September 2008 the OSIRIS cameras provided the first spatially resolved photometric observations of an E-type Asteroid. The spectral range between 245 nm and 990 nm was covered by low and medium bandwidth filters with a maximum spatial resolution of 80 m/pixel. The large phase angle coverage (0.3 - 140 degrees) was ideal for photometric studies.

The geometric albedo of Steins at 631 nm is 0.40 ± 0.01 and the G-Parameter in the Bowell system is 0.45, both are typical of E-type asteroids. The visible spectrum is slightly reddish, in agreement with ground-based observations. A sharp drop-off in reflectance is observed towards the hitherto unexplored near-UV region, consistent with Steins being composed of iron poor silicates. We explain the strong phase reddening seen in the data with the increasing contribution of multiple scattering to the reflected intensity at higher albedo at red wavelengths.
No photometric variations were found over the surface of Steins. Space weathering is either unimportant on the surface or saturation has been reached everywhere. Preliminary photometric modelling of the surface of (2867) Steins suggests that the brightness is consistent with an enstatite composition only if the surface is composed of particles larger than 100 µm.

A crater of 2.1 km diameter is seen close to the south pole of asteroid Steins (5.3 km diameter). The existance of the crater suggests that Steins is porous, otherwise the impact would have destroyed the asteroid.

A superresolution algorithm has been developed to increase the resolution of the images acquired during the Steins flyby. It can also be applied in future mission phases (flyby of Asteroid Lutetia in 2010 and rendezvous with comet Churyumov-Gerasimenko in 2014).

An unshrouded view of our lively Galactic bulge

Erik Kuulkers

The Galactic Bulge region is a rich host of variable high-energy X-ray and gamma-ray point sources. These sources include bright and relatively faint X-ray transients, X-ray bursters, persistent neutron star and black-hole candidate binaries, high-mass X-ray binaries, etc.. Since 2005 we have a program to monitor the Galactic Bulge region regularly and frequently with the gamma-ray observatory INTEGRAL. As a service to the scientific community the high-energy light curves of sources present are made available through the WWW at http://isdc.unige.ch/Science/BULGE/. We show the ongoing results of this exciting program.

Spitzer SAGE Studies of Massive Stars in the Magellanic Clouds

Daniel Lennon

We present catalogs of massive stars in the Large and Small Magellanic Clouds with accurate spectral types compiled from the literature, and photometric catalogs for subsets of these stars, with the goal of exploring their infrared properties. The photometric catalogs consist of stars with infrared counterparts in the Spitzer SAGE survey database for which we present uniform photometry from 0.3-24 microns in the UBVIJHKs+IRAC+MIPS24 bands. The resulting infrared color-magnitude diagrams illustrate that the supergiant B[e], red supergiant and luminous blue variable (LBV) stars are among the brightest infrared point sources in the Magellanic Clouds, due to their instrinsic brightness, and at longer wavelengths, due to dust. We detect infrared excesses due to free-free emission among numerous OB stars, which correlate with luminosity class. We confirm the presence of dust around supergiant B[e] stars, finding the shape of their spectral energy distributions (SEDs) to be very similar, in contrast to the variety of SED shapes among the spectrally variable LBVs. We find the infrared colors for Wolf-Rayet stars to be independent of spectral type and their SEDs to be flatter than what models predict. We compare color and infrared excess differences between LMC and SMC samples and attribute these to the differing metallicities of these galaxies. The results of this study provide the first comprehensive roadmap for interpreting luminous, massive, resolved stellar populations in nearby galaxies at infrared wavelengths.

Dynamical masses for Eps Indi Ba,b, the nearest known brown dwarfs

Mark McCaughrean

We present new astrometric results for the closest known brown dwarf binary to Earth, Eps Indi Ba,b at a distance of 3.6224 pc. The relative orbital motion of the brown dwarfs (spectral types T1 and T6) has been monitored with high precision since June 2004 with the VLT NACO near-IR adaptive optics system. With data for more than half the orbit now, we obtain an accurate (<1%) total dynamical system mass of 121 Jupiter masses, considerably in excess of earlier determinations based on evolutionary models. We have also been monitoring the absolute astrometric motion of the system since August 2005 against a network of field stars using the VLT FORS2 optical imager with the aim of determining the individual masses. Our relative orbit solution predicts periastron passage in early 2010 and shortly thereafter we should be able to determine the absolute masses to better than 5% in a model independent way. In combination with other very-well determined parameters for the system, Eps Indi Ba,b will serve as a vital benchmark against which evolutionary models for brown dwarfs can be calibrated.

Spitzer c2d Legacy Results: A New Large Sample of Disks with Inner Holes

Bruno Merin

We present Spitzer IRS spectra and IRAC/MIPS photometry, optical spectroscopy, and 1.3mm continuum observations of young stars with circumstellar disks with large inner holes of the size of our Solar System, discovered in the `Cores to Disks' (c2d) Spitzer Legacy
Program. Out of the objects in the initial sample of 40, SED modeling identifies 34 as disks with large inner holes, or ``cold disks'', of which 28 were previously unknown.
This paper presents a robust method of identifying cold disks based on their photometric
Spectral Energy Distributions (SEDs) slopes (such that $\alpha_{K-24} < -0.3$ and $\alpha_{8.0-24} > 0$) rather than the more commonly used infrared spectra. The sample of cold disks present disk masses typically one order of magnitude smaller than those around TTauri stars and a bimodal distribution of mass accretion rates, from negligible to similar to the mean mass accretion rate in T Tauri stars. Based on their accretion and disk mass properties, 28\% of the classified sample (7 objects) are compatible with a photo-evaporation or a circum-binary disk scenarios, while the other 72\% (18 objects) are not. The non-accreting cold disks have inner holes smaller than 15 AU, flared outer disks and lack emission from PAH molecules in their IRS spectra. They have masses between 0.4 and 1.2 M$_\odot$ and slightly younger ages than the second group. These properties suggest clean inner holes in primordial low-mass disks, and therefore are compatible with these objects being photo-evaporating or hosting an unresolved binary companions. The accretting cold disks have inner disk holes from 0.5 to 50 AU around settled and evolved outer disks. Their IRS spectra show a great variety of features from amorphous and crystalline silicates and PAHs. They have a broader distribution of stellar masses than the group above (0.2 to 2.4 M$_\odot$). PAH features are significantly more common (40\%) in cold disks than T Tauri stars ($<$10\%).
These properties evidence the presence of both gas and dust in the inner holes, with the potential interpretation of the systems as a result of currently growing proto-planetary systems in the holes.

Observational Evidence and Models for Expansion in SSS Spectra of Novae

Jan-Uwe Ness

Classical Nova outbursts occur in accreting white dwarf binaries and are powered by nuclear burning on the white dwarf surface. Radiation pressure leads to the ejection of previously accreted material and perhaps some dredged-up white dwarf material. The ejected shell is optically thick and acts like a stellar atmosphere. As the expansion continues, the density structure changes, essentially yielding a shrinking photosphere. This processes exposes successively hotter material, until an X-ray photosphere can be observed, yielding an effective temperature of 3-8x10^5K. We present X-ray grating spectra that show that at this time of evolution, the expansion, and thus mass loss, is still continuing. This is evidenced by significant blue shifts in the absorption lines. Standard stellar atmosphere models are thus not suitable to model the X-ray spectra, because radiative transport in moving ejecta will yield different observable spectra. We present first result from expanding atmosphere models in comparison with static atmosphere model results, which indicate that the results are indeed significantly different.

The Star Formation History of Young Clusters in the SMC

A. Nota (STScI/ESA), E. Sabbi (STScI), M. Tosi (INAF), M. Cignoni (INAF) & Gallagher J. (Univ. Wisconsin)

Hubble observations at optical wavelengths have been used to study the stellar content and derive the star formation history for a number of young clusters in the Small Magellanic Cloud. We present some results of this study and discuss their implications for our understanding of cluster formation and evolution.

RGS high resolution spectra of active galactic nuclei

Achille Nucita

According to the well established scenario for AGNs, the main properties of the energy output from the central part of an active galaxy is driven by the accretion onto a SMBH.

The characteristics of the observed radiation depend on the SMBH surrounding regions, i.e., geometry of the accretion flow, density and nature of the matter, and on the presence of an accretion torus, an halo, an accretion disk and gas clouds spread around.
The view of sight plays a crucial role in this case since, depending on it, different signatures are seen.

In the last years, we started to study RGS high resolution spectra of a sample of AGNs in order to get information on the SMBH accretion mechanism. Details on the analysis conducted on several interesting cases will be given.

The contribution of XMM-Newton to the 2-10 keV source counts at bright fluxes

Richard Saxton

Over the last four decades, the statistical properties of the extragalactic X-ray sky in the classical 2-10 keV band have been revealed through a wide variety of missions and surveys. The early shallow all-sky surveys of Uhuru, Ariel V and HEAO-1 have been complemented in more recent times by both medium sensitivity wide-area surveys (e.g. ASCA, BeppoSax, 2XMM) and very deep, pencil-beam studies (Chandra, XMM-Newton).

The XMM-Newton slew survey (XMMSL1) currently covers 40% of the sky down to a flux limit of 4E-12 ergs/s/cm2 (2-10 keV), which nicely fills in the gap between the currently available shallow and medium-deep surveys. Through use of simulations we derive the "corrected" X-ray 2-10 keV source counts from the XMMSL1 catalogue and consider the match with previous surveys. The various source populations which comprise the slew survey are investigated and a comparison is made with current model predictions for AGN and clusters of galaxies.

Chaotic terrains and the determination of paleo-surface heat flux on Mars

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Introduction:

The surface heat flux is a good indicator of the internal activity of a planet. On Mars direct measurements are so far not possible. Therefore, other techniques to constrain heat fluxes are necessary. Until now, the prime technique has been the analysis of extensional tectonic surface features [1,2]. However, this method only yields heat fluxes in tectonically active regions which exhibit higher fluxes than other areas. Nevertheless, the values of geothermal gradients in the range of 14 to 80 K/km for a period about 3 to 4 Ga ago have been inferred, which correspond to heat fluxes of 28 to 160 mW m^{-2} if a thermal conductivity of 2 $Wm^{-1}K^{-1}$ for the basement is assumed. We use the new model developed by [3] to infer the surface heat flux in Aram Chaos in the Noachian-Hesperian.

Model:

To derive the surface heat flux we use the geometry and scenario for Aram Chaos as proposed in [3]: The chaotic terrain is situated in a crater partially filled with an ice layer, covered by an overburden of rock units (sediments). Due to the insulating effect of the sediment, the ice layer will melt under certain conditions. This may eventually (after maybe hundreds of millions of years) lead to the collapse of the overburden, associated with a catastrophic outburst, creating the chaotic terrain. The conditions under which melting takes place in this scenario are calculated in our

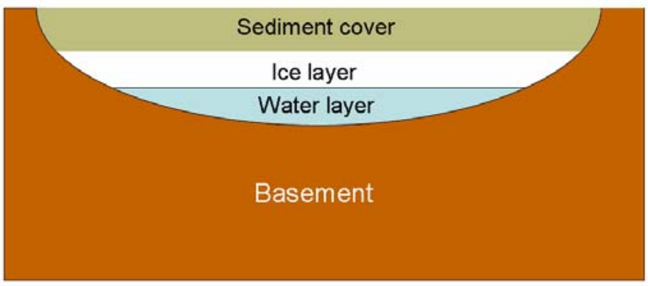

Fig. 1: Model setup (add scale to figure)

numerical model. In this model the thickness of the sediment cover, the geothermal gradient and the thermal conductivity of the sediment are varied. Geologic analysis of the crater [3] has yielded a possible thickness of the water layer before the outburst in the range of 1000 m to 2000 m with 1500 m being the likeliest value. Therefore, we try to identify the parameter combinations which result in a melt layer of equivalent thickness.

Results:

The results indicate that surface heat fluxes of at least 20 mWm^{-2} are necessary to explain the observed features. Lower values would require extremely low thermal conductivities or an improbable thickness of the sediment overburden. The most reasonable choices of sediment thickness and thermal conductivity give heat fluxes of 25 to 35 mWm^{-2}. For certain combinations of sediment thickness and thermal conductivity even higher values up to 45 mWm^{-2} cannot be ruled out completely. As the sedimentation rate was probably quite low so that the ice/water layer was probably in a thermal equilibrium with its surroundings all the time, geothermal gradients higher than 45 mWm^{-2} would result in large volumes of melt even with limited sedimentary cover. However, if the overburden increased in thickness rapidly, then even values higher than 45 mWm^{-2} could lead to the observed results.

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The Cluster Formation History of M82

Linda Smith

The M81 group of galaxies provides an excellent laboratory for studying galaxy-galaxy interactions and the ensuing violent episodes of star formation. The starburst galaxy M82 is believed to have suffered a close encounter with M81 some 250 Myr ago which triggered the current nuclear starburst. We present HST imaging and Gemini-North spectroscopy of massive star clusters distributed across the disk and central regions of M82. These data represent the largest spectroscopic dataset to date for extragalactic young clusters. We derive ages and radial velocities for these clusters, and find that M82 has been actively forming massive clusters for the last 50-270 Myr, with a peak close to 140 Myr. We discuss these results in the context of the last interaction with M81 and the propagation of cluster formation from the disk to the nucleus.

Probing the mass accretion process in the Large Magellanic Cloud

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Invetigating the star formation histories of the Magellanic Clouds (MCs) is one of the most obvious goals in the study of nearby galaxies, for it keeps a record of the past interactions between both the Clouds and the Milky Way, which are still to be properly unveiled.
Moreover, the MCs are also a rich laboratory for studying of star formation and evolution thanks to the simultaneous presence of a wide variety of interesting objects such as pre-main sequence stars (PMS), red clump giants, carbon stars, planetary nebulae, etc.

In the past two decades, many authors have demonstrated that such studies are indeed feasible using deep Hubble Space Telescope (HST) optical imaging.
In particular, we have recently presented a novel method to determine the PMS mass accretion rate (Macc) of PMS stars that relies solely on HST photometry. The knowledge of the Macc is of paramount importance to constrain the models of star formation and early stellar evolution and has so far mostly relied on spectroscopy, which has proved hard or impossible to obtain in dense, distant star-forming regions.

We have now started a pilot project aiming at applying this technique to the existing and extensive HST photometry of star-forming regions in the Milky Way and MCs. The first results of this study in the Large Magellanic Cloud have already increased by a factor of five the current sample of PMS stars with a measured Macc. Based on this sample, we find indication that the accretion rate decreases by an order of magnitude within the first 10 Myr and Macc in the LMC are systematically higher, by up to a factor of ten, than those reported for Galactic PMS stars of the same age but agree with those measured for G-type stars of comparable mass, thus indicating that Macc is a strong function of stellar mass.
Moreover, we find evidence that PMS objects near the youngest hot stars are both less numerous and fainter in H_alpha emission, suggesting that massive stars can considerably erode nearby PMS circumstellar disks by enhanced photo-evaporation.

Particle flux in the range 1mm to 10m - SPOSH-IR

H. Svedhem, D. Koschny

The flux of interplanetary particles in the size range 1mm to 10m is poorly constrained due to insufficient data, - the larger bodies can be observed remotely by ground or space based telescopes and the smaller particles are measured by in situ impact detectors in space. An infrared video rate imager in Earth orbit would enable a systematic characterisation of the flux of this range by monitoring the trace of light these bodies emit during atmospheric entry (very bright meteor/fireball) for an extended period and over a large area. Due to the low flux of particles in this range a very large detector is required. With this method a large portion of the earth atmosphere is in fact used as a huge detector. Such an instrument has never flown in earth orbit. The only sensors of a similar kind fly on US defence satellites for monitoring launches of ballistic missiles. The data from these sensors, however, is inaccessible to scientists.

An alternative method to study the interplanetary flux in this size range is to observe particles impacting on the Moon. This can be done by using the same type of instrument. Ground based observations of spacecraft with precisely known mass and velocity impacting on the moon are used as calibration for impact light emission allowing reliable estimates of the particle flux.

We have developed a bread-board version of such an instrument, SPOSH-IR, funded by RSSD research funds. The instrument is based on an earlier TRP developed instrument (SPOSH- Smart Panoramic Optical Sensor Head) for operation in the visible range, but with the sensor replace by a cooled IR detector and new adapted optics. This work has proven the concept of the instrument and of automatic detection of meteors/bolides in the visible wavelength range. The extension of this instruments into the near infrared domain opens up great possibilities of detection of a larger population of impacting particles of lower velocity or lower density that normally are not detectable in the visible range.

The hardware has been built by Jena-Optronik, Jena, Germany and was delivered early August. Initial testing will take place in August-September.

A suitable space flight opportunity has been identified. The SPOSH-IR will fit well, with regard to science, physical accommodation and programmatics, into the suite of instruments in the ASIM package due to fly as a Columbus External Payload in 2012. Additional back-up flight opportunities have been identified as well.

This talk will summarize the scientific background, describe the instrument and give some results from the first field tests from August 2009.

Multi-point aspects of the magnetopause boundary layer under northward IMF

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On the 11th July 2006, during a period of northward IMF, the Geotail, Double Star 1 and Cluster spacecraft all crossed the magnetopause region within 2 hours (UT) of one another while separated by many hours in local time. During this time large-scale oscillations were observed in both ground based and spacecraft data. We utilize these numerous measurements to examine the extent and evolution of fluctuations in and around the magnetopause boundary layer. This works is being carried out as part of an International Space Science Institute (ISSI) working group on 'Comparative Cluster-Double Star measurements of the Magnetotail'.

Geochemical variability seen by the Mars Exploration Rovers and acid-fog alteration modelling

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Since January 2004, the twin rovers Spirit and Opportunity of the Mars Exploration Rover (MER) mission have been investigating their respective landing sites at Gusev Crater and Meridiani Planum, making use of the Athena Science Payload [1]. This scientific payload includes the Alpha Particle X-Ray Spectrometer (APXS) [2] whose role is to determine the elemental composition of the material found at the Martian surface. After more than 5 (terrestrial) years and several km driven by both rovers, the complementary suite of instruments has characterized diverse geological sites, and the APXS instruments have analyzed ~350 samples of rocks and soils, providing abundances for at least 16 chemical elements.

The adequacy of mathematical tools such as Principal Component Analysis (PCA) to highlight and interpret compositional variations provided by the APXS multidimensional dataset has been recently demonstrated. Taking into account the available chemical information simultaneously, PCA was used as an unsupervised tool to identify and characterize the different families of samples encountered by the rovers [3]. Along with hierarchical clustering a robust classification of samples can be performed, shedding light on the petrogenetic relationships between them, and this classification can be related to their spatial/stratigraphic organization [3,4], a prerequisite if one wants to compare this in-situ chemical information with orbital data. This analysis was found to be particularly useful in the case of samples from Gusev where a high diversity of rock types has been observed in the Columbia Hills, this variability being attributed to a combination of geological processes including aqueous alteration, igneous fractionation, impact and volcanic processes [3,5].

We also used another statistical approach based on Blind Source Separation (BSS) to characterize the components of soils and rocks. In order to be able to (chemically) interpret these components we used an algorithm constraining the positivity of the sources [6,7]. Thanks to this method, we propose an estimation of the composition hematite-rich spherules encountered at Meridiani Planum [8]. These spherules, nicknamed 'blueberries', have been observed in both rocks and soils of Meridiani but determining their composition remains a challenging question because their are smaller than the field of view of the instruments of the Athena Science Payload.

The interpretation of the PCA results, highlighting that the compositional variability of Meridiani rocks is dominated by variations in sulphur content, also led us to explore a simple geochemical model of acid fog alteration of Martian basalts, assuming either equivalent alteration of all phases or preferential alteration of certain phases. The secondary mineralogies predicted by the model were broadly coherent with compositions measured by the MER rovers [3]. Following these encouraging results, we have now performed more detailed modelling, refining the hypotheses and taking into account reaction kinetics, the mineralogies being calculated as a function of time [9]. Considering the role of brine circulation and evaporation, the results of this model appear to account for chemical and mineralogical observations made by Opportunity at Meridiani, suggesting an alteration occurring in highly acidic brines and involving small amounts of water over a short period of time.

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Mid-infrared spectroscopy: a useful tool for studying the composition of asteroids?

Pierre Vernazza

While spectroscopy in the visible near-infrared range (VNIR, 0.4-2.5 μm) has proven to be a powerful tool for constraining the surface composition of certain asteroid classes (e.g. A-, S- and V- classes), it has not always been able to reveal the composition of the observed body (e.g. what is the composition of the two largest asteroids, namely (1) Ceres and (2) Pallas ?). A solution to this problem may be reached by extending the wavelength coverage. Indeed, spectroscopic observations in the mid-infrared wavelength range (8-13 μm) have been quite successful in constraining the surface composition of Mars (e.g. Milam et al. 2004; Milam et al. 2007). In principle, one may expect the same success with asteroids. Here we want to demonstrate for the first time whether mineralogical information can be obtained for asteroids from the mid-IR range. To do so, we seek to compare and model the mid-infrared (mid-IR, 8-13 μm) spectral properties of S-type asteroids which have a nearly identical composition (within 5%) as deduced from a compositional analysis in the VNIR range. By observing the properties of "identical" asteroids, we seek to test if composition can be uniquely revealed in the mid-IR.

Physical Properties and Evolution of protoplanetary disks

Silvia Vicente

Abstract:

Circumstellar disks are the birth sites for planetary systems and an understanding of the evolutionary properties of disks around young stars is thought to be an essential part of understanding our origins. Protoplanetary disks have been in the past years the focus of intensive observational studies that made use of the most sophisticated techniques and facilities. In particular, ground-based instruments equipped with adaptive optics (classical and multi-conjugate) on 8-10m class telescopes, together with the Hubble Space Telescope (HST), provided the subarcsecond resolution and the high sensitivity and contrast required to spatially resolve protoplanetary disks and to image details of their structure in the optical and in the near-IR. These new developments have yield new insight on the structure, properties and evolution of protoplanetary disks.

In this talk, I present my ongoing research work on protoplanetary disks which is mainly dedicated to the study of the physical properties and evolution of *proplyds* or photoevaporating protoplanetary disks. These are a special class of low-mass Young Stellar Objects (YSOs) found embedded within or near a HII region and are usually identified as comet-shaped photoionized envelopes with bright ionization fronts facing the source of external UV radiation and extended tails pointing away from it.

The data used in this work combines ground-based near-IR images, obtained with the VLT/NAOS-CONICA and MAD adaptive optics provided instruments, with optical images from the HST/ACS and WFPC2 instruments.

Understanding galaxy evolution through measurement of element abundance ratios

Jakob Walcher

The abundances of heavy elements in galaxies are a signature of their past evolution, in particular their star formation history. Measuring these abundances from the integrated spectra of galaxies is, however, a challenging task, dependent on accurate modelling and fitting procedures. I will present recent advances both in the modelling and the fitting, that allow improved abundance determinations in local early-type galaxies. The emerging picture is one where early-type galaxies assemble their main stellar body early, but add a second component from minor merging later on in their history. I will also present preliminary results from a work aimed at obtaining the stellar abundance ratios for galaxies at redshift 1.

The Thermal Evolution of Mercury: Implications for Volcanism, Topography and Geoid

R. Ziethe, J. Benkhoff

Introduction

Among the terrestrial planets Mercury is not only the smallest, but also the densest (after correction for self–compression). To explain Mercury's high density it is considered likely that the planet's mantle was removed during a giant impact event, when proto–Mercury was already differentiated into an iron core and a silicate mantle [1]. A thin silicate shell was afterwards re–accreted. This special structure should result in a special evolution, too. Since the arrival of a spacecraft at the enigmatic planet is not to be expected before 2011 (MESSENGER) or 2019 (BEPI COLOMBO) we might already prepare ourselves for the upcoming results and perform tests that allow some anticipation of the measured data. We introduce a numerical model and try to answer the following questions: How does the thermal evolution of Mercury differ from those of other terrestrial planets? To what extent and how long did molten zone in the mantle survive? What is the thermal state of Mercury's mantle today? Can we conclude from the topography and geoid onto the (past) interior dynamics?

Model

The hermean mantle is modelled as an internally and bottom heated, isochemical fluid in a spherical shell. The principle of this convection model is widely accepted and is used for various models of thermal evolution of terrestrial planets, e.g., the Earth [2], Mars [3] or the Moon [4]. We are solving the hydrodynamical equations, derived from the conservation of mass, momentum and energy. A program originally written by S. Zhang is used to solve the temperature field $T(r, \vartheta, \varphi)$ [5], which employs a combination of a spectral and a finite difference method. Beside the large core as a heat source another energy source is provided by the decay of radioactive elements. The viscosity of the mantel material dependes exponentially on the inverse temperature.

Results

The model shows the typical behaviour of a one–plate–planet, meaning the surface is not broken into several tectonic plates but the outside is a single rigid shell. The thermal evolution is generally charaterized by the growth of a massive lithosphere on top of the convecting mantle. The lower mantle and core cool comparatively little and stay at temperatures between 1900 K and 2000 K until about 2.0 Ga after the simulation was started. The stagnant lid comprises roughly half the mantle after only 0.5 Ga. Since the rigid lithosphere does not take part in the convection anymore, the heat coming from the interior (due to the cooling of the large core) can only be transported through the lithosphere by thermal conduction. This is a significantly less effective mechanism of heat transport than convection and hence the lithosphere forms an insulating layer. As a result, the interior is kept relatively warm. Because the mantle is relatively shallow compared to the planet's radius, and additionally the thick stagnant lid is formes relatively rapid, the convection is confined to a layer of only about 200 km to 300 km. Convection structures are therefore relatively small structured. The flow patterns in the early evolution show that mantle convection is characterized by numerous upwelling plumes, which are fed by the heat flow from the cooling core. These upwellings are relatively stable regarding their spatial position. As the core cools down the temperature anomalies become colder but not less numerous.

In our calculations, a region of partial melt in the mantle forms immediately after the start of the model at a depths of roughly 220 km. While in the entire lower mantle the temperature exceeds the solidus, the highest melt degrees can be found in the upwelling plumes. The partial molten region persists a significant time (up to 2.5 Ga). How long the partial molten zone actually survives depends strongly on the initial conditions of the model. For instance, an outer layer with a reduced thermal conductivity would keep the lower mantle significantly warmer and a molten layer survives longer.

Discussion and Conclusion

Due to the weak constraints of important parameters (e.g. sulfur content of the core, mantle rheology, amount and distribution of radiogenic heat sources, planetary contraction, thermal conductivity, etc) numerous models are required to understand the importance and influence of the mentioned variables. The models variety is huge and more investigations of the results on initial parameters are yet to be performed. Although rather preliminary our results are in general consistent with [6]. The special interior structure of Mercury compared to the other terrestrial planets makes his thermal history very unique. Future work will cope with the thorough investigation of several parameters and their influence on the model outcome.

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