D I S S E R T A T I O C V M
NVNCIO SIDEREO III | 9

P R A G A E — M M V I 24. VIII. — S E R I E S T E R T I A

Progress on SOFIA, 21 August 2006

Edwin Erichson, Sean C. Casey, Universities Space Research Association, SOFIA, USA

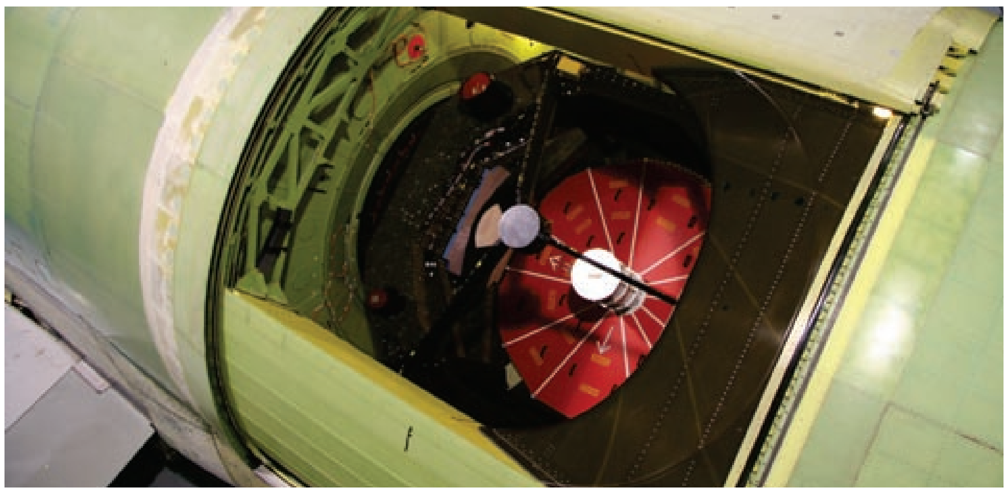
The Stratospheric Observatory for Infrared Astronomy (SOFIA) is the next generation of airborne astronomical observatories. Funded by the NASA (80 %) and the DLR (20 %), SOFIA is scheduled for science flights starting in 2009. The observatory consists of a 747SP modified to accommodate a 2.7-metre telescope with an open port design. Using state-of-the-art technologies, SOFIA will explore the emission of astronomical sources with an unprecedented level of angular resolution (θ [arcsec] = 0.1 × wavelength [μm]) and spectral line sensitivity at infrared and sub-millimetre wavelengths. A 20-year lifetime is envisioned for SOFIA with a base of operation at the NASA Ames Research Center in Mountain View, California. SOFIA will be capable of astronomical observations in both the northern and southern hemispheres.

Progress on the flight system

Since January 2006, significant schedule milestones have been reached: Aircraft structural modifications are complete. Refurbished, higher thrust engines were acquired and installed with German funding from the DLR and the Deutches SOFIA Institut. Rerouted cables to operate the tail control surfaces have been installed and limit-load tested. Functional checks of flight control systems (slats, flaps, ailerons, etc) and landing gear have been completed. The majority of flight-test instrumentation has been installed.

The Ground Vibration Test (GVT) which measures the structural response of the plane to known mechanical excitations was completed in June. Preliminary test results confirm that the modified airframe has the strength and stiffness of the unmodified B747SP. Verification of the GVT results is a critical milestone in certifying that SOFIA is safe for flight.

Minor fuel-tank leaks were corrected, leading to full-power engine run-ups and low-speed taxi demonstrations which were done on Saturday, August 19. The principal remaining tasks for the aircraft system prior to flight testing are: completion of GVT analyses and airworthiness documentation, painting of the aircraft, avionics verification, installation of safety monitoring systems, and flight readiness reviews. With sufficient funding, first closed-door flight is expected early in fiscal year 2007; the first open-door flights are expected about a year later.

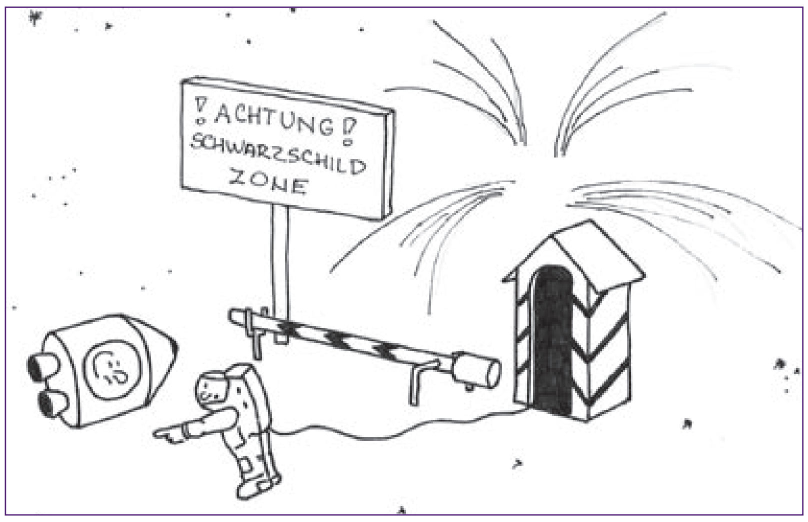


SOFIA 2.5-m telescope (with red cover) in the aircraft, February 2006.

SOFIA taxiing after full-power engine tests in Waco, Texas, August 19, 2006.

Programmatic developments

On July 6, after extensive reviews of the programme, NASA's Administrator Michael Griffin announced that SOFIA should proceed to development completion, with "... the potential for 'Great Observatory' science over its 20-year design life." His remarks are posted at **www.nasa.gov/audience/formedia/speeches/index.html**.
Please visit the SOFIA website: **www.sofia.usra.edu**.
A brief programme summary for astronomers is available at **www.sofia.usra.edu/Science/SOFIA_ProgramSummary/04EricksonDustyConf.pdf** ❐



JD11: Presolar grains as astrophysical tools

Anja C. Andersen, Dark Cosmology Centre, Denmark, John L. Lattansio, Monash University, Australia

With the first discovery of surviving presolar minerals in primitive meteorites in 1987 a new kind of astronomy emerged, based on the study of stellar condensates with all the detailed methods available to modern analytical laboratories. The presolar origin of the grains is indicated by considerable isotopic ratio variations compared with Solar System materials, characteristic of nuclear processes in different types of stars.

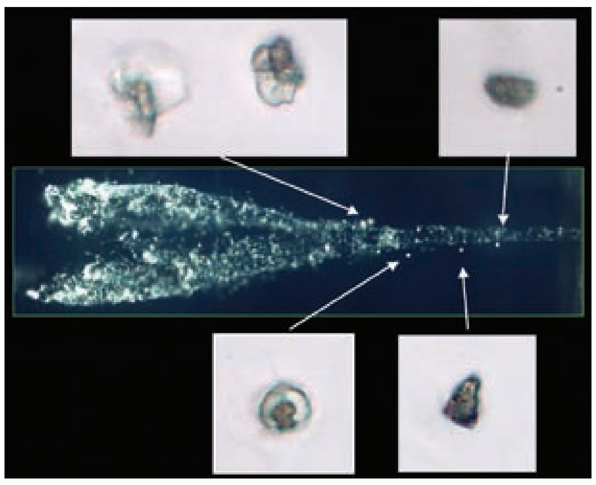
The astrophysical implications of these grains for the fields of nucleosynthesis, stellar evolution, grain condensation, and the chemical and dynamic evolution of the Galaxy has received excellent reviews from the invited speakers and eagerly discussed among the participants between the talks and during the breaks.

The full scientific exploitation of presolar grains is only made possible by the development of advanced instrumentation for chemical, isotopic, and mineralogical microanalysis of very small samples. Unique scientific information derives primarily from the high precision (in some cases < 1 %) of the measured isotopic ratios of various elements in single stardust grains. Known presolar phases include diamond, SiC, graphite, Si_3N_4, Al_2O_3, $MgAl_2O_4$, $CaAl_{12}O_{19}$, TiO_2, $Mg(Cr,Al)_2O_4$, and most recently, silicates. Subgrains of refractory carbides (e.g., TiC), and Fe-Ni metal have also been observed within individual presolar graphite grains. These grain types represent a wide range of thermal and chemical resistance. Many new breakthroughs are expected in the near future as it is now technically possible to extend isotopic laboratory studies to individual particles down to scales of < 100 nm.

The different talks illustrated that the laboratory studies of presolar grains provide crucial contributions to several important areas of astrophysics. For example, studying isotopic compositions of grains that condensed from the ejecta of dying stars provide essential boundary conditions for numerical models of stellar nucleosynthesis. The grains disclose information about nucleosynthesis sites of different elements and the relative abundance of different stellar inputs to the Galaxy (e.g. the supernova II/Ia ratio), as well as constraining the degree of mixing of material from diverse stars in the interstellar medium and the types of minerals produced by stars of different metallicity. The grains also probe the conditions of the solar nebula accretion disk during the earliest stages of Solar System formation.

The results from isotopic studies are currently those that bear strongest on other fields of astrophysics. For one, they allow us to pinpoint the grains' stellar sources among which Red Giant stars play a prominent role. In addition, given the precision of the laboratory isotopic analyses, which far exceeds whatever can be hoped for achieved in remote analyses, they have strong implications for, e. g. the need for an extra mixing process (cool bottom processing) in Red Giants and provide detailed constraints on the operation of the s-process in AGB stars. A non-standard neutron capture process ("neutron burst") may be implied by the small part of the silicon carbide grains which originate from supernovae. The progress in analytical techniques promises more important results in the near future – so stay tuned! ❐

STARDUST sample showing the recovery of grains caught by the aerogel during a space flight. The studies disclosing the fraction of presolar grains present in these samples are ongoing.



Slight changes to the wording of Resolutions 1 and 3 to make their meanings clearer:

Resolution 1:
– Replace "an inertial reference system" with "the Barycentric Celestial Reference System (BCRS)" in *Recommends 4*.
– Add a second note "The time rate of change in the dynamical form factor in P03 is $\dot{J}_2 = -0.3001 \times 10^{-9}$century^{-1}."
– Change "Japanese Maritime Safety Agency (JMSA)" to "Japan Coast Guard (JCG)" in *institutions should receive formal notification*.
– Change "Naval Astronomical Observatory of Japan" to "National Astronomical Observatory of Japan" in *institutions should receive formal notification*.

Resolution 3:
– *Recognizing 3* becomes: 3. the practical utility of an unambiguously defined coordinate time scale that has a linear relationship with TCB chosen so that at the geocenter the difference between this coordinate time scale and Terrestrial Time (TT) remains small for an extended time span,
– In the *Recommends*, "and remains close to Terrestrial Time (TT) at the geocenter for an extended time span," has been changed to: "and, at the geocenter, remains close to Terrestrial Time (TT) for an extended time span,"
– *Note 2* becomes: 2. The fixed value that this definition assigns to LB is a current estimate of $L_C + L_G - L_C \times L_G$, where L_G is given in IAU Resolution B1.9 (2000) and L_C has been determined (Irwin & Fukushima, 1999, *A&A* **348**, 642) using the JPL ephemeris DE405. When using the JPL Planetary Ephemeris DE405, the defining LB value effectively eliminates a linear drift between TDB and TT, evaluated at the geocenter. When realizing TCB using other ephemerides, the difference between TDB and TT, evaluated at the geocenter, may include some linear drift, not expected to exceed 1 ns per year.
– In *Note 3*, "at the surface of the Earth" has been changed to ", evaluated at the surface of the Earth,"

Today's programme: (thursday 24/8)

- Symposia S238, S239, S240
- General Assembly & Closing Session

Convection in the Sun

The Sun provides us with a wonderful means to observe astrophysical convection at close hand. Recent views of solar convection from the Swedish solar telescope (see Figure 1) possess unprecedented resolution, allowing us to see in incredible detail, the formation and dissipation of granules.

Shravan M. Hanasoge, Stanford University, USA

We witness convection everyday in the form of commonplace activity, like when a liquid is heated in a pan. In contrast to this sort of (laboratory) convection, astrophysical convection lies in a different parameter space, with the Reynolds and Raleigh numbers in the astrophysical case estimated at many orders of magnitude larger than in the laboratory case. In addition to this, properties of convection zones in stellar interiors are controlled by the complicated interaction between nuclear fusion in the core, the star's composition, size and age.

Structure of Solar convection zone

The solar core (extends up to 0.2 $R_\odot$, where $R_\odot$ is the solar radius) generates vast quantities of energy through the process of nuclear fusion via the p-p mechanism. Radiation acts to transport the heat flux from the edge of the solar core to 0.7 $R_\odot$. In the case of the Sun, the convection zone extends from about 0.7 $R_\odot$ to the solar photosphere. The region around 0.7 $R_\odot$ is the start of the ionization zones of many heavy elements (for example, oxygen and nitrogen), resulting in a local increase in the opacities. Radiation becomes much less effective in this region, creating convective instabilities that snowball into convection. Convection thus takes on the task of transporting energy when radiation is no longer able to do so.

Because the most abundant elements (hydrogen and helium) are completely ionized over most of the solar interior, the deep convection zone is only marginally convectively unstable. As one proceeds towards the surface, the local temperature starts falling, resulting in encounters with partially ionized species (for example, the various helium and heavier element ionization zones). The upper-most layers of the convection zone (a little below the photosphere) are highly convectively unstable because of the start of the hydrogen and helium ionization zones.

Above this region and in the atmosphere, the local density is extremely low, therefore the photosphere and atmosphere become optically thin. In this situation, not only does radiation turn into the primary mode of energy transport but layers in this region become convectively stable (because there is no longer a need to support convection). Curiously, when we see granulation, a manifestation of solar convection, we are actually witnessing upper surface convective drafts that overshoot into these convectively stable layers.

Ionization zones play a critical role in influencing the location and extent of convection zones. Atoms and molecules in the process of being ionized can cripple radiative heat transport processes by absorbing and scattering large quantities of photons. In order to maintain a thermal equilibrium in the absence of effective radiative processes, other heat transport mechanisms like conduction and convection must come into play. Conduction is inefficient (in the solar convection zone) because of the relatively long timescales, leaving convection the only viable option.

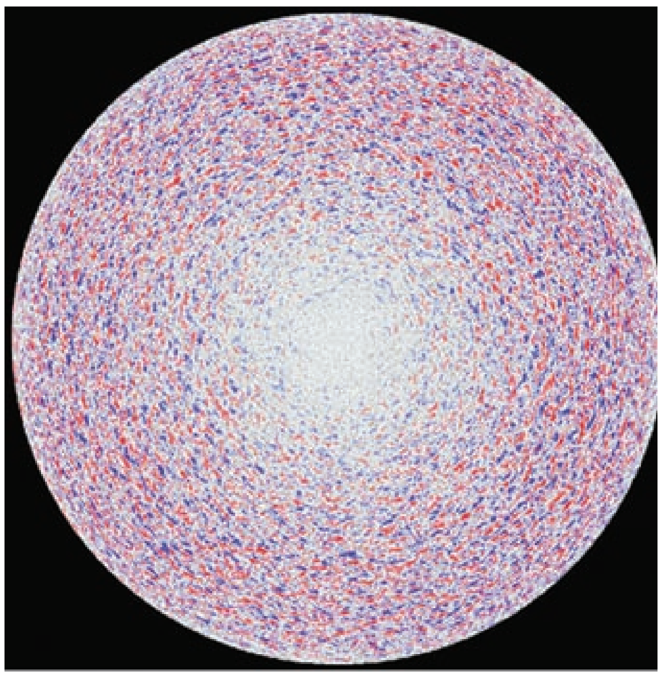


Fig. 2. Supergranules litter a de-rotated full disk image of the Sun (taken with MDI/SOHO)

The magnitude of the heat flux in need of being transported is another factor that affects the formation of convection zones. For example, the core temperature of certain massive stars is so high that the CNO cycle becomes the predominant source of energy. It is known that the energy generation in the CNO fusion cycle is extremely sensitive to temperature, varying as the sixteenth power of temperature. Consequently, the energy producing core is a very small sphere that produces an incredible amount of heat flux. At such large values of heat flux, radiation alone is unable to transport the heat flux, resulting in the layers outside the core become convectively unstable.

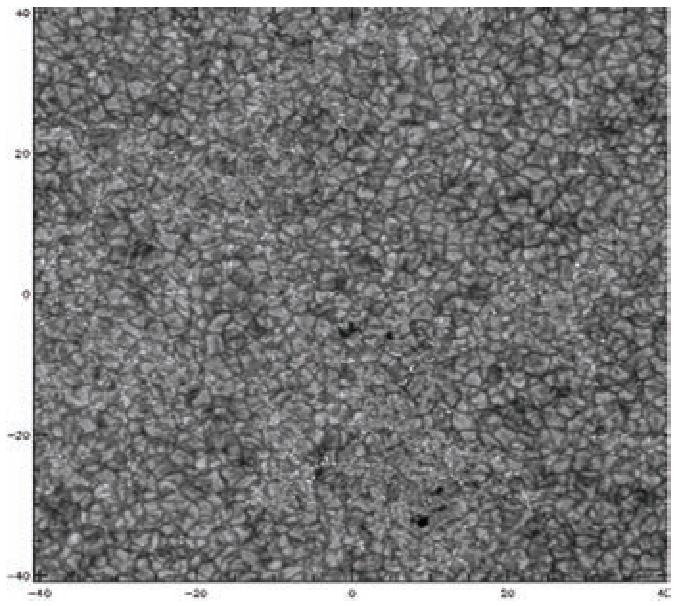


Fig.1. Solar granulation, taken with the Swedish telescope

Mostly supergranulation

It is well known that the solar power spectrum shows a peak at around l = 120, corresponding to a scale of approximately 30 Mm, the average size of a supergranule. It is believed that supergranulation (also mesogranulation and the much debated giant cell convection) is a manifestation of large scale coherent convective behaviour. Apart from granules at scales of 1 Mm, convective structures at two distinct scales, mesogranules at 7–10 Mm and supergranules at 30 Mm, make an appearance. Lifetimes of mesogranules are of the order of a few hours, while supergranules (see Figure 2) have lifetimes of approximately 24 hours. The uncomfortable and still unanswered (or inconclusively at best) questions of how and why meso- and supergranules appear and the governing mechanisms behind these structures are still subjects of controversy.

Why 30 Mm?

Modeling a supergranule is a Herculean task, requiring the intricate physics of radiation, ionization, turbulent convection, shock formation and dissipation, magnetic field effects etc. While it has only recently become feasible to compute the full physics of supergranulation, several researchers (Simon, Title, & Weiss; Mark Rast) have attempted to answer existential questions regarding supergranulation by performing kinematical simulations. In these simulations, numerous ‚granules', modeled by finite sized fluid mechanical constructs (like a source-sink pair), that possess a lifetime of somewhere between 5 and 10 minutes are placed at random distances from each other. By introducing specific rules such as: "Given that these granules are too close to each other, they must merge" or "If a granule decays, it is replaced by another granule at a random location" and so on, it has been observed that these "granules" start behaving in a coherent manner and larger scales emerge as a consequence of their interaction. As expected, these larger scales are sensitive to the rules that govern granule placement, decay etc. of ‚granules' and are inconclusive for the reason that they do not include the full physics.

Traveling wave convection

Supergranules seem to exhibit the interesting phenomenon of traveling wave convection. Gizon, Duvall & Schou were able to establish that supergranules have a traveling wave component with a phase speed of roughly 66 m/s, thus possessing the property of pro-grade super-rotation. Recently, Green & Kosovichev, using stability analyses, have shown that subsurface radial shear is a probable cause of the traveling wave-like behaviour.

Bob Stein and collaborators are currently involved in the task of simulating a supergranule; perhaps they will soon be able to answer the questions of how and why.

Numerical simulations surface convection

The solar near-surface layers are both physically and numerically difficult to model. The Reynolds and Raleigh numbers are very high, creating a highly multi-scale situation. Not only must radiative effects be taken into account, but the rapid drop in fluid pressure renders magnetic field effects significant. Together with difficulties in choosing appropriate boundary conditions, this multi-phenomena, multi-scale problem is very challenging. Nordlund and Stein's pioneering efforts in the area of numerical computations of solar surface convection have proved quite successful. Results (such as emergent intensity, line profiles etc.) from their calculations are practically indistinguishable from high resolution data of solar convection (see Figure 3). To a high degree of precision, they are able to recover a large number of spectral lines and splittings thereof, p mode eigenfrequencies and are able to match acoustic wave production rates. More recently, magneto-convection simulations have been performed by Stein and Nordlund, and the MPI, Lindau – University of Chicago group (MURAM).

It is curious to note that in contrast to the sun, where the Reynolds number is estimated to be of the order 10^{12}, the Reynolds number of these simulations only go up to a few thousand. The Raleigh number of the simulation is also many orders of magnitude smaller than in the Sun. This leads to the interesting question of how such excellent agreement is obtained when the parameter regimes are so different. It might point to the possibility of the lack of small scale turbulence. There are multiple reasons to explain this excellent agreement between simulations and data, and the seeming lack of small scale turbulent activity, as discussed by Spruit. One reason is the rapid decrease in density, which results in a flow expansion that subsequently 'dilutes' the effect of tightly coiled, small scale vorticity. Another reason is the extremely low gas density in the atmosphere that places a tight restriction on the stress that the solar surface can take.

Simulations of interior convection

Anelastic simulations of interior convection by Gilman and Glatzmeier; and Miesch *et al.* are another set of milestones in computations of convective activity. Note that the interior presents an entirely different set of challenges that must be dealt with appropriately: a large difference in density between the surface and the bottom of the convection zone and a wide range of length and timescales. The anelastic approximation succeeds in narrowing the range of timescales so as to allow computations of interior convection in a reasonable period of time. The simulations go up to only about 0.97 $R_\odot$, and consequently do not resolve the convective activity at the surface.

Interior convective cells possess turnover times of about a month in contrast to the timescale of 10 minutes at the surface. The estimated thermal timescales of these convective cells is of the order of 10^5 years. This presents serious numerical issues and solving the full problem with current computational abilities is not yet possible.

Interior convection is thought to play an important part in the distribution of angular momentum and the consequent differential rotation that the outer convective envelope exhibits.

Conclusions

We have gained many valuable insights into the nature of convection through close observations of the sun. As demonstrated by the work of Nordlund and Stein, the state of art in convection simulations is sophisticated enough that we are able to compare simulations with actual data and expect to get excellent agreement. Indeed, it is remarkable that we can look at a pan of heated water and say with confidence: "That's probably how the Sun works too!"

References:

1. For an excellent introduction to astrophysical convection zones, see Erika Bohm-Vitense, Volume 3 in her series on Stellar Astrophysics
2. Convection in stellar envelopes: a changing paradigm, H. C. Spruit, 1996 (on arXiv)
3. Convective modes in the sun's subsurface shear layer, Green & Kosovichev, ApJL, 2006
4. Scales of Granulation, Mesogranulations, and Supergranulation, Mark Peter Rast, ApJ 2003
5. Modeling Mesogranules and Exploders on the solar surface, Simon, Title & Weiss, ApJ 1991
6. Wavelike properties of supergranules, Gizon, Duvall & Schou, Nature 2003
7. Realistic Solar Convection Simulations, Stein & Nordlund, Solar Physics 2000
8. Compressible convection in a rotating spherical shell, Gilman & Glatzmeier, ApJS 1981
9. Three-dimensional Spherical Simulations of Solar Convection. I. Differential Rotation and Pattern Evolution Achieved with Laminar and Turbulent States, Miesch, Elliott, Toomre, Clune, Glatzmaier, & Gilman, ApJ 2000

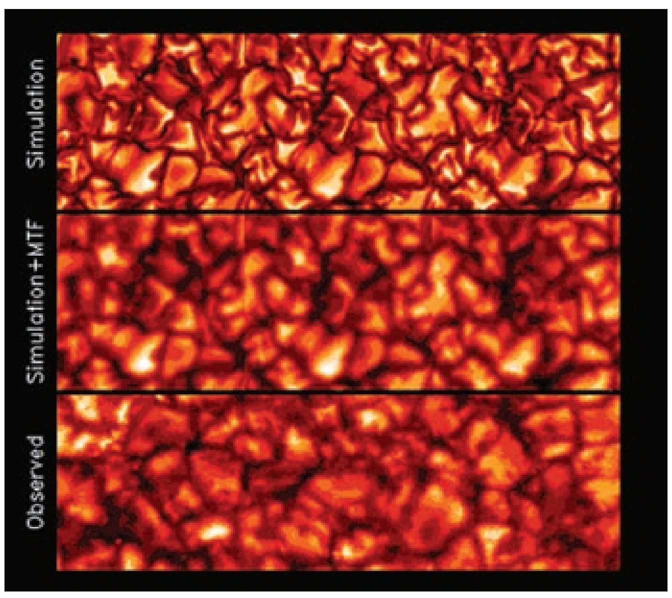
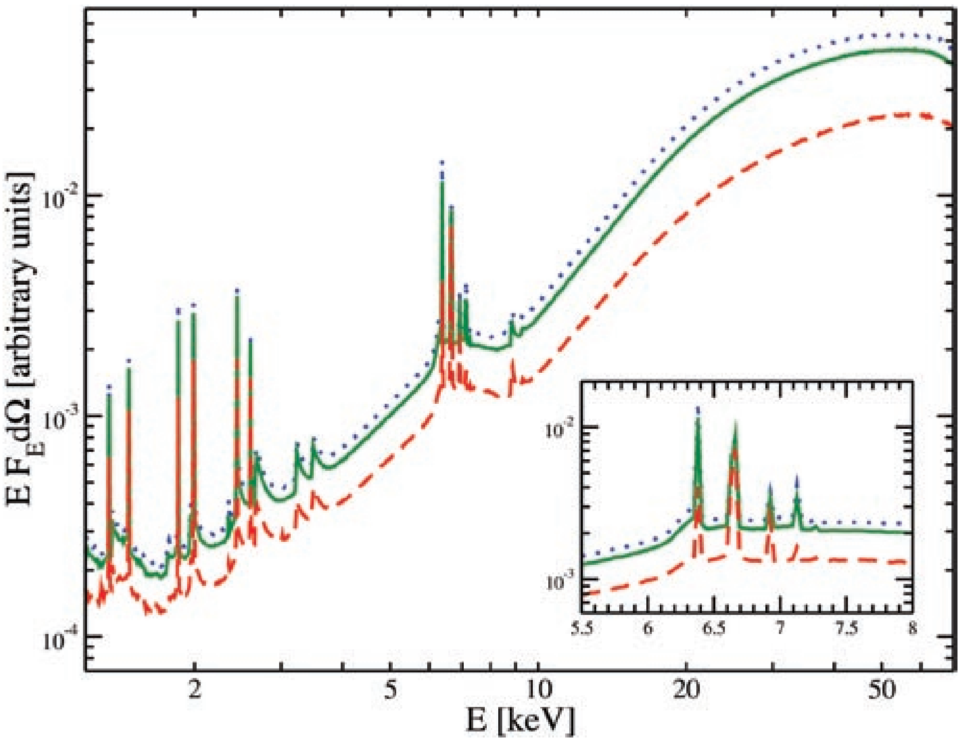


Fig. 3 Comparison of simulations with data (from simulations by Nordlund and Stein).



X-ray spectrum as computed for a spot orbiting around a rotating black hole at a distance of 18 gravitational radii. The spot arises on the disk surface following an intense irradiation by a flare. The mass of the black hole is 108 solar masses and its Eddington accretion rate is 0.001 in dimensionless units. Different curves distinguish observer's line of sight inclination: i = 13 deg (blue), i = 39 deg (green), and i = 71 deg (red). The inset enlarges the resolution near the iron K alpha line.

Weighing massive black holes with spots?

Black holes have only two parameters: masses and spins (we disregard the charge because astronomical black holes are thought to be almost neutral) so it might seem to be quite simple to characterize the black holes which reside in various objects. The reality is far more complex and the measurement of the mass and angular momentum of black holes is a hot issue.

Bożena Czerny, Michal Dovčiak, Anne-Marie Dumont, René Goosmann, Vladimír Karas, Giorgio Matt, Martine Mouchet, Agata Różańska

Various methods have been developed, aimed either for stellar-mass black holes in Galactic sources or for massive black holes in centers of galactic nuclei. However, all approaches inherit certain important assumptions that lead to systematic uncertainties, on top of the simple measurement errors. A good illustration of the issue is the vivid discussion of the ultraluminous X-ray sources: do they contain intermediate black hole masses or are they super-Eddington ~ 10 solar-mass objects? The way out is to develop independent methods and check the consistency of the results.

The existence of transient hot spots on the surface of an accretion disk offers an interesting opportunity for black-hole mass and spin measurements of massive black holes. Such spots are likely to form due to the sudden magnetic-field reconnection events in the accretion disk corona, similarly as happens in the case of the solar corona. Field reconnection generates hard X-ray emission which irradiates the disk surface and creates the hot spot. The radiation of the spot consists of the continuum emission and emission lines, in particular a strong iron line complex in the X-ray band. On their way toward an observer the line photons follow the complicated trajectories as described by general relativity, so both the mass and the black hole spin leave imprints that can be searched in the observed spectra. This kind of analysis can be performed with present-day technology.

The shape of the line detected by X-ray instruments allows us, in principle, to determine the black hole mass, the black hole spin and the inclination angle of an observer with respect to the disk surface. This basically simple idea is not so simple in practice. Usually not a single spot but rather hundreds of them coexist on the disk surface. Unfortunately, the current X-ray observations are still orders of magnitude away from the spatial resolution necessary to individually resolve separate flares. Also the locally emitted radiation is not a single monochromatic line but a whole complex of lines formed by ions at various ionization states. However, we can overcome these difficulties by addressing the time-dependent issue and by performing detailed modeling of both the local (intrinsic) emissivity of the gas and the time-dependent light propagation as described by general relativity. Such advanced models are currently under study – an example is shown in figure. The method is applicable in practice to massive black holes since it is necessary to follow the time evolution of a single flare, with the lifetime frequently shorter than the local Keplerian time close to an inner edge of the disk, ranging from milliseconds for Galactic black holes to minutes and hours for active galactic nuclei. In another article of Nuncius Sidereus III (#6), Ramesh Narayan describes a different way towards similar goals: measuring parameters of stellar-mass black holes.

Current instruments allow for just a limited applicability of the method because they still suffer from limited resolution and the actual number of photons per flare lifetime is small. Future missions with surface areas 100–200 times larger will bring spots into a full light. ❐

A search for life in the universe

Jayant V. Narlikar, Inter-University Centre for Astronomy & Astrophysics, Pune, India

While the more glamorous programme of contacting the extraterrestrials (ETs) through radio messages goes on, here is an alternative to finding if we are alone in the universe. This alternative is less ambitious but may still provide the answer sooner.

A century or so ago Arrhenius had suggested that life maybe travelling across space in microbial form, an idea that was followed up in the 1970s by Fred Hoyle and Chandra Wickramasinghe. Known as 'panspermia', these viruses and bacteria were proposed by them as being ubiquitous, occupying vast stretches of interstellar space. Some of them may travel towards the Earth, riding piggyback in frozen mantles on comets. As they approach the Sun, the comets develop tails which may sometimes brush the upper reaches of the Earth's atmosphere. These events according to Hoyle and Wickramasinghe (H&W) help transfer the microorganisms to the Earth, since they would descend to the Earth's surface eventually. Indeed H&W suggested that such input served as seeds for life on Earth: so we may all be ETs!

The panspermia hypothesis was severely criticised on the grounds that the panspermia would not survive UV, X-ray or γ-ray radiation in space. This criticism has been countered to some extent by laboratory experiments showing that the bacteria mutate and learn to survive even if subjected to radiation doses. So can we test the H&W hypothesis by direct experiment.

Such attempts are being made and in 2001, a payload attached to a balloon was sent up to a height of 41 km above the Earth's surface to collect samples of air. The National Balloon Facility at Hyderabad, India was used. The samples were brought down to Earth and analyzed by biologists. The entire process of collection and analysis was performed with the highest regard to avoiding contamination. Biological analyses by labs, one in Hyderabad, and the others in Cardiff and Sheffield, UK, showed evidence of living cells and bacteria in some of the samples. The question is where are they from?

Some bacteria show unusual resistence to UV-radiation. All are known species although there are some differences from their known terrestrial counterparts. While all this is consistent with the H&W hypothesis, can one definitely rule out that these bacteria reached 41 km height from the surface of the Earth? As of now we do not know of any process that could transport terrestrial material to such heights; even volcanic ash does not rise above 25 km.

Clearly further experimentation is needed. A second balloon flight was arranged last year the results from which are being analyzed.

This work is being supported by the Indian Space Research Organization. ❐

The COROT mission

Ian Roxburgh, University of London and LESIA, Observatoire de Paris

COROT (COnvection, ROtation and planetary Transits) is a high-precision long-duration photometry satellite mission, devoted to detecting planets around other stars and to measuring the oscillations of stars. It is led by the French Space Agency (CNES) with the participation of Austria, Belgium, Brazil, Germany, Spain, and the European Space Agency (ESA). Launch is scheduled for November this year from Baikonur.

Planets around other stars will be detected by measuring the small decrease in light from a star as a planet transits in front of the star blocking out a small fraction of the light. The science goal is to detect and characterise the properties of large terrestrial-like and more massive gaseous planets around other stars, and so advance our understanding of the formation and evolution of planetary systems.

The oscillation properties of stars will be determined from long duration measurements of the light from a star, which, when analysed by taking a power spectrum of the observed time series of the flux, will yield the oscillation frequencies and line widths of the oscillation modes. The oscillation frequencies of a star are determined by its interior structure and hence this will enable us to test and advance our understanding of stellar evolution.

There is also a guest investigator programme for the use of the seismology data for non-seismology goals, and the planet search data for objectives other than searching for planets. COROT has a 28-cm off-axis telescope with an 8 square degree field of view and CCD camera. The camera has 4 CCDs two of which, in each field of view, are devoted to measuring on the order of 12,000 stars mostly of spectral types A, F, G, K and magnitudes 11–16 to search for planets; the other two are devoted to monitoring of the order of 10 brighter stars with magnitudes in the range 5–10, of many spectral types and luminosity classes, to study their oscillation properties. COROT should yield unprecedented precision on oscillation frequencies with errors 0.1–0.3 μHz, giving the actual frequencies to a precision of 1 part in 10,000.

COROT will stay on one field of view for up to five months and observe up to six such fields. Three in the direction of the galactic centre and three in the anti-centre direction. Additionally it will spend intervals of up to one month on other fields during the change over from centre to anti-centre direction. Some of these one-month observations are open to the guest investigator programme.

It is an exciting time at the dawn of a revolution in stellar and planetary physics, and the IAU community impatient that delays in the successfull launch be resolved expeditiously. ❐

2006 Grote Reber Gold Medal Awarded to Professor B. Y. Mills – *K. I. Kellermann*

The 2006 Grote Reber Gold Medal was awarded to Professor Bernard Mills, one of the early pioneers of radio astronomy, in a special ceremony during the August 17 meeting of the Interdivisional WG on Historical Radio Astronomy. Mrs. Crys Mills received the medal on behalf of her husband who was unable to attend. Prof. Mills was honored for his innovative contributions to the development of radio telescopes and for his pioneering investigations of the radio sky which led to the first estimates of the radio galaxy luminosity function and helped to define their spatial distribution. The Grote Reber Medal was established by the Trustees of the Grote Reber Foundation to honor the achievements of Grote Reber, and is administered by the Queen Victoria Museum in Launceston, Tasmania in cooperation with the U.S. National Radio Astronomy Observatory, the University of Tasmania, and the CSIRO Australia Telescope National Facility. The medal is awarded for lifetime innovative contributions to radio astronomy. Nominations for the 2007 Medal may be sent to Martin George, Queen Victoria Museum, Wellington St, Launceston, Tasmania 7250, Australia or by e-mail to: **martin@qvmag.tas.gov.au** to be received no later than Nov. 15, 2006. ❐

From the hill of Galileo to the borders of the Universe: The International Year of Astronomy

Franco Pacini, IAU President (2000–2003)

The first astronomical observations were made by Galileo around the end of 1609: with his small telescopes (now conserved in the Museum of History of Science in Florence) he was able to show that the Moon is covered with mountains, craters, plains. A few weeks later, early in 1610, he saw that Venus had phases like the Moon; Jupiter was surrounded by four little "stars", its satellites; Saturn had "ears"; the Milky Way was composed of a multitude of weak stars.

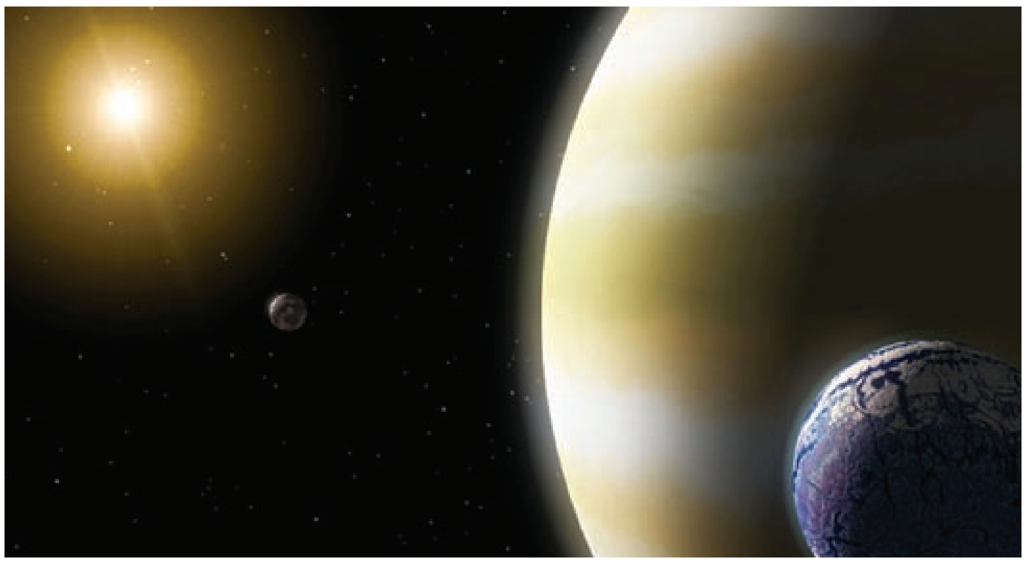
Galileo's observations demonstrated that the Earth is not the only world in the Universe. The importance of this discovery in the history of human civilization is probably without comparison because of its implications for science, philosophy and religion. His findings were condemned by the Church and Galileo was confined in exile in a country house where he spent the last eleven years of his life (1631–1642). This house, named "Il Gioiello" (The Jewel) is located very close to the Arcetri Observatory, in the

outskirts of Florence and it has been recently restored. It has also been proposed that, next to this house of Galileo and to the Arcetri Observatory, a neighbouring castle be transformed into an interactive Science Center devoted to contemporary astronomy. These realizations on the Arcetri hill would form a sort of "City of Galileo" and a tribute to this great scientist.

Galileo also advocated the need for scientists to communicate their discoveries in a way which everybody can understand, in practice by using the Italian language and not Latin. We can almost say that he was an early supporter of the need of scientific communication.

Three years ago, in Sydney, the General Assembly of IAU voted a resolution requesting that UNESCO and the United Nations declare 2009 The Year of Astronomy. On behalf of IAU, the Italian Government put this request on the floor of the UNESCO Assembly where this initiative was unanimously endorsed in October 2005. As a next step the Year of Astronomy will be discussed by the U.N. General Assembly later this year and, hopefully, approved.

Some years ago, in a document of the US National Academy of Sciences, there was a statement comparing the development of astronomy in the 20th century with the discoveries which occurred at the time of Galileo. The Year of Astronomy should be an ideal occasion to communicate to the general public the beauty and the importance of contemporary astronomy, and show how our science has been a fundamental component of the various civilizations which developed in all parts of the world.



Left: Illustration courtesy of NASA/JPL

Extrasolar giant planets and brown dwarfs (as seen from Arizona)

Extrasolar Giant Planets (EGP) and Brown Dwarfs, often commonly referred to as Sub-stellar Mass Objects, are among the most fascinating topics in present-day astronomy.

Ivan Hubeny, University of Arizona

Although people have suspected for centuries (for instance, Giordano Bruno in the 16th century) that extrasolar planets should exist and it seemed quite natural that less massive and less luminous objects than late M dwarfs may exist, mankind had to wait till 1995 when the first bona fide discoveries of both those classes of objects were announced. Interestingly enough, both discoveries (51 Peg b for planets, and Gliese 229b for brown dwarfs) were announced on the very same day! Today, there are about 200 extrasolar planets and over 100 brown dwarfs discovered and confirmed, and this number will certainly grow rapidly in the coming years.

Soon after these discoveries, several groups around the world initiated an effort to model these objects in order to understand their physical and chemical nature. While with brown dwarfs the spectra were taken already in the initial years, there seemed to be little hope to observe spectra of EGPs any time soon, essentially because it is very hard to achieve a sufficient instrumental sensitivity to extract light from the planet in the glare of the central star. Nevertheless, already in 2000 the first planetary transit (of the now famous planet HD 209458b) was observed, and since the transit depth was found to be somewhat different in and out of the Na I D lines, this in fact gave the first "spectrophotometric" information about an EGP atmosphere. And, in 2005, another milestone was reached when by observing secondary eclipse spectra of two EGPs, HD 209458b and TR-ES-1 and subtracting them from the out-of-eclipse spectra, one in fact could obtain the first true spectroscopic information about these objects.

Our group in Arizona has embarked on a systematic effort of modeling atmospheres of EGP's and brown dwarfs (which in fact are the same objects from a physical point of view; they differ only by their origin, and by the fact that planets must, by definition, be in the vicinity of a star, and are thus irradiated by it). Since I joined the group in 2002, we have modified my stellar atmosphere computer program TLUSTY designed originally for much hotter stars, and combined it with an extensive package of state equation solver in the presence of molecules and condensates, and molecular opacities that were being developed for several years at the University of Arizona.

There were many numerical challenges: an efficient and stable treatment of convection, effects of strong irradiation, a necessity of treating various cloud species, with a self-consistent cloud position and particle sizes, and an interplay between clouds and convection (which on Earth sometimes leads to hail, tornadoes, and other violent phenomena, so it is not surprising that this is numerically challenging under much more extreme conditions, even with various simplifications).

A public release of the secondary eclipse observations for both systems was scheduled on March 24, 2005.

Our group obtained preprints of both articles a few days before the release, so we took our models computed for the known basic parameters of the system (radii of the parent stars and planets, stellar spectral types, and the planet-star distances; we did not do any specific fitting, or tweaking the parameters), and prepared a short paper to ApJ letters to show the theoretical analysis of these data. We planned to submit it also on March 24, but when the date was approaching we were not sure whether we should hurry and submit it, or wait a few more days and submit it a bit later. But we finally decided to work faster, and submitted it indeed on 24th. This proved to be a good decision, because the following day we found out that a competing group in NASA Ames had also submitted a paper on 24th! It illustrates that this is indeed quite an active field.

Recently, we submitted another paper dealing with predicted spectra of other transiting planets which were already observed, but data were not reduced yet, so we made predictions about how the spectra should look, and now we are waiting with trepidation to see how they will actually look. However, the agreement between the observations and theory for the 2005 eclipses were already surprisingly good, taking into account an early age of the field, and all the uncertainties in the theoretical description. This indicates that the young field of modeling EGP and brown dwarf atmospheres is on the right track, and has a bright and exciting future ahead. And, from the personal point of view, it is now a good time to be a theorist, because unlike in the mature field of stellar spectroscopy where the theory is still hopelessly behind observations, we are ahead, and our predictions are appreciated even by observers who may use them to better design future observations. ❐

JD16: Nomenclature, precession and new models in Fundamental Astronomy – applications and scientific contribution to astronomy

N. Capitaine, J. Hilton, J. Vondrák

This Joint Discussion covered both concluded works and prospects for the future.

The main purpose was to discuss recent and future IAU resolutions on reference systems. The International Celestial Reference Frame (ICRF) and its realization, the International Celestial Reference System (ICRS), were adopted by the IAU at its 23rd General Assembly in 1997. At the 24th IAU GA in 2000, a number of additional Resolutions were passed concerning the definition of the celestial and terrestrial reference systems and transformations between them. These resolutions contain several new concepts. Implementation of these resolutions requires a consistent and well defined terminology that is recognized and adopted by the astronomical community. Working Group for Nomenclature for Fundamental Astronomy was to make related educational efforts for addressing the issue to the larger community of scientists. Two Resolutions on new terminology and an improved definition of Barycentric Dynamical Time (Resolutions 2 and 3) submitted to the IAU 2006 General Assembly were discussed.

Discussion of the IAU 2000A precession-nutation at the 25th IAU GA in 2003, revealed a requirement for a new precession model that was both dynamically consistent and consistent with the IAU 2000A nutation model and an improved definition for the ecliptic. The Division 1 Working Group on Precession and the Ecliptic was created to address these requirements. This WG has selected a new, high-accuracy precession model to replace the IAU 2000 precession. A proposal to adopt this precession model has been submitted to the IAU 2006 GA (Resolution 1). This resolution has been presented and discussed along with proposals for next generation models.

Other improvements in astrometric models and catalogues were discussed. Effects such as Earth rotation, nutation, light deflection, and relativistic transformations, with potential for various scientific applications were presented, emphazing the recent progress in observations (Earth dynamics, spacecraft observations and planetary ephemerides, time synchronization and navigation in deep space). Presentations about future space astrometric missions, like GAIA and SIM, were also discussed.

The complete program including the list of posters is available on the JD16 web page at **syrte.obspm.fr/iauJD16/** ❐

Galaxies win!

If, at some moment, you are feeling strong enough to lift your abstract book, please open it and notice that, by a wide margin, S235 on galaxy evolution, attracted the largest number of submissions (477). Star formation (S237) was second with 249 abstracts, third binary star (S240) with 220, and black holes (S238) fourth with 181.

Very possibly, more events on galaxies, large scale structure, and cosmology should have been scheduled. Your Division Presidents, who recommended the current program will pass on this small discovery to their successors, who will recommend Symposia and Joint Discussion for 2009.

Your job, of course, is to put forward proposals for exciting JDs and Symposia programs. Indeed if your favorite topic is not on the program here, it may be because there were no proposals.

Virginia Trimble,
Outgoing President of Division XII

United Nations and the International Heliophysical Year

The organizers of the Heliophysical Year (IHY) and the United Nations Committee on the Peaceful Use of Outer Space (UNCOPUOS) have joined hands to promote heliophysical science activities throughout the world by deploying scientific instruments in the developing countries.

Nat Gopalswamy, International Coordinator, IHY, NASA's Goddard Space Flight Center, USA

The IHY 2007 program is an international collaborative effort to understand the external drivers of planetary environments in the solar system. This will be a major international event of great interest to all the nations in the world. The IHY 2007 will coincide with the fiftieth anniversary of the International Geophysical Year (IGY) held during 1957–1958. IGY produced an unprecedented level of understanding of Earth's Space Environment, and witnessed the start of the Space Age with the birth of the discipline of Space Science. For the first time, it became possible to study the cosmos with *in situ* observations. IHY is the logical step to expand our focus to include the heliosphere in which Earth and Sun have a central place. During IGY 1957, humans were sticking their heads above Earth's atmosphere; during IHY 2007 they will stick their thumb into the local interstellar medium. This is indeed true because the Voyager 1 spacecraft recently crossed the termination shock enclosing the solar system and is getting ready to venture into the local interstellar medium. The ultimate objective of IHY is to set up collaboration that utilize ground and space based assets to further the science achievements in all heliophysical disciplines: solar physics, polar physics, geophysics, space physics, and heliospheric physics with a strong emphasis on cross-disciplinary science.

One might wonder what is "Heliophysics". This is a new word coined to broaden the concept "geophysics," extending the connections from the Earth to the Sun and interplanetary space. It represents the universal physical processes within the heliosphere. Remember, the only thing we knew about space was the ionosphere before IGY. One of the first major achievements of the space age was the discovery of Earth's magnetosphere by James Van Allen using the Explorer 1 mission. Van Allen witnessed the rapid expansion and maturity of the space exploration and passed away the week before this IAU General Assembly at the age of 91. The discovery of the ubiquitous solar wind by Gene Parker in 1958 led to the concept of the heliosphere as a region pervaded by the solar wind. The subsequent discovery of coronal mass ejections (CMEs) by NASA's OSO-7 in 1971 demonstrated that the changes on the Sun have serious consequences throughout the heliosphere.

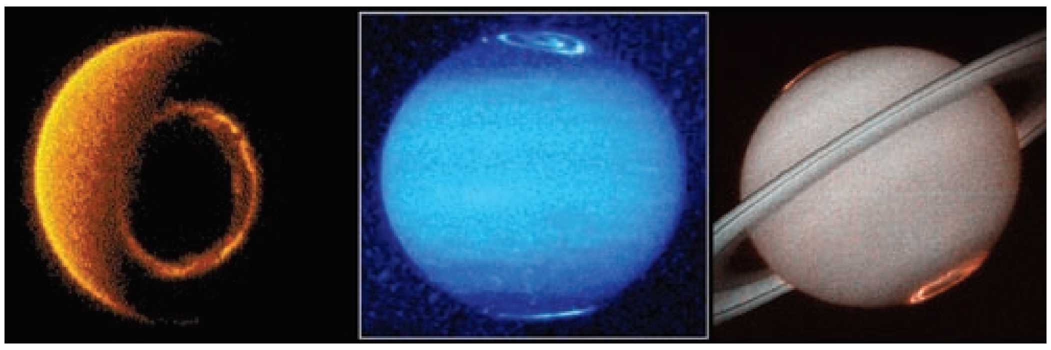
The IHY-UN joint venture is known as the United Nations Basic Space Sciences (UNBSS) initiative. Under this program, scientists from developed countries or those who are willing and able, donate instruments to study heliophysical processes to developing countries. These instruments will be used for scientific research and for university level education for young people from developing counties. These deployments will serve as nuclei for a sustained development of scientific activities in the host countries.

The UNBSS program is one of the four key elements of IHY: Science (coordinated investigation programs or CIPs conducted as campaigns to investigate specific scientific questions), Instrument development (the IHY/UNBSS program), Public Outreach (to communicate the beauty, relevance and significance of space science to the general public and students), and the IGY Gold program (to identify and honor all those scientists who worked for the IGY program).

The UNBSS is not new to the astronomy community. This program is in existence since 1991 and facilitated deployment of telescopes for astronomical research and education in developing countries. Since 2005, this program has focused on deployment of instruments suitable for heliophysical studies. Currently, about a dozen instrument concepts have been approved. Deployment of radio telescopes has started at three locations in the world to continuously monitor radio bursts from the Sun related to CMEs. H-alpha flare monitor telescopes will also monitor mass motions, waves, and visible emissions related to CMEs. Chains of magnetometers will be deployed in Africa to augment the existing chains in the developed world to study the dynamics of geospace plasma changes during magnetic storms and auroral substorms as a response to various solar wind changes. Instrument networks are being established in Africa that will monitor ionospheric disturbances; other plans include mapping of the ionosphere above Africa using inexpensive GPS receivers. In addition to these Sun-Earth connection experiments, an international space weather network is being planned, which will utilize the connection between the solar system and our Galaxy via cosmic rays. Ground-based instruments to detect secondary particles (neutrons, muons) from galactic cosmic rays reaching Earth's atmosphere and can identify the passage of CMEs at Earth by monitoring the intensity of these secondary particles.

The IHY/UNBSS program is also linked to the other elements of IHY: the instrument networks will participate in the CIP campaigns, thus contributing to the global science. It is also related to the outreach program because students get trained in operating and using the instruments. Another element of the outreach program are the IHY schools on universal physical processes in the heliosphere. Host scientists and their students will be invited to attend these IHY schools, so that they can be exposed to the broader aspects of heliophysics.

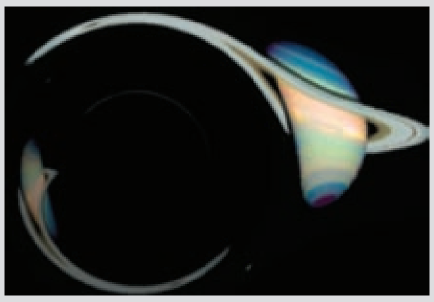
The IHY/UNBSS program is a unique opportunity for enhanced international collaboration in understanding the external processes that affect Earth's environment and human society. With the availability of electronic communication and data transfer, it is a lot simpler to coordinate observations from space and ground than it was possible in 1957. The IHY/UNBSS program can enhance the investigations of instrument donors by providing additional data from remote locations. Observations from these instruments will be used not only by the instrument provider but also by the host, thus enhancing the science return. Involvement of students will build the next generation scientists and explorers and draw them from the extended global pool. ❐



One of the best examples of universal heliophysical process: planetary aurora, physical processes in vastly different environments: Aurora from Earth (left), Jupiter (middle) and Saturn (right). IHY will study universal processes in the solar system such as this (image credit: NASA).

Visualization of the black hole spacetimes

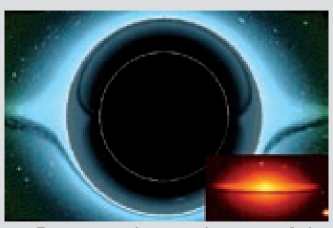
Pavel Bakala, Stanislav Hledík, Zdeněk Stuchlík, Silesian University, Opava, Czech Rep.



Black hole as a gravitational lens: two images of Saturn seen by a static observer.

Dramatic optical effects appear in the vicinity of black holes. Computer visualization of these effects is still a challenge. We have developed a new computer code solving this "virtual astronomy" task: What would be the view of the Universe for observers near a black hole or a compact star? Optics in strongly curved spacetimes is markedly different from the flat spacetime optics such as we experience it in our everyday life. By using a general relativistic description of propagation of light, our code displays distortions of the optical projection, multiple images of objects in the distant universe, Einstein rings, the change of color caused by gravitational frequency shift, location of circular photon orbits, and other characteristics of strong gravity.

The recent cosmological observations indicate accelerated expansion of universe caused by dark energy which acts as an effective cosmological constant. This can be described by the Schwarzschild–de Sitter spacetime, and we employed this spacetime in our computations. We investigated the dependence of the optical projection on the value of the repulsive cosmological constant. The black hole can be observed as a black region on the observer sky. The ray-tracing core of the code can be used for modelling other optical effects in strong gravity: light-curves, power spectra and spectral line profiles of the radiation of rotating neutron stars with hot spots on the surface.



Computer-distorted image of the galaxy M104 'Sombrero' lying behind the black hole as seen by a radially falling observer at a distance of 10 gravitational radii from the black hole horizon.

Description of the code and examples can be found in Proceedings of the recent Workshop on Black Holes and Neutron Stars (Opava 2005), available also in NASA/ADS Abstract Service. ❐

Deceased members of the Union

The IAU General Secretary regrets to report the following names of Individual Members of the IAU whose death has been communicated to the IAU Secretariat since the General Assembly in Sydney in July 2003.
Oddbjørn Engvold, IAU General Secretary

John G. Ables, Tateos A. Agekjan, Ko Aizu, Lawrence Hugh Aller, Gennadij V. Andreev, Horace W. Babcock, John N. Bahcall, James Gilbert Baker, Norman H. Baker, Vassilios Barbanis, Arvind Bhatnagar, Richard G. Bingham, J. G. Bolton, Hermann Bondi, Semion Ya Ag Braude, Nina M. Bronnikova, Anton Bruzek, William Buscombe, Bruno Caccin, Alastair G. W. Cameron, Henri Camichel, John H. Carver, Vittorio Castellani, Joseph W. Chamberlain, Nikolaj S. Chernykh, Yves Chmielewski, Rafael Cid Palacios, G. Colombo, Alan H. Cook, Pierre Cugnon, N. Dallaporta, Leverett Davis Jr, John Alan Dawe, Willem de Graaff, T. de Groot, Juan J. de Orus, Chr. de Vegt, Aleksandr N. Deutsch, Lorant Dezso, Jerzy Dobrzycki, Geoffrey G. Douglass, Robert A. Duncan, Richard B. Dunn, Nikolai Dzubenko, Hans Elsaesser, Donald J. Faulkner, Walter A. Feibelman, Michel C. Festou, Mikhail S. Frolov, Igor A. Gerasimov, Daniel Gerbal, Robert Glebocki, Nüzhet Gokdogan, Thomas Gold, Friedrich Gondolatsch, Shumo Gong, S. I. Gopasyuk, Vitalij G. Gorbatsky, Fumihiko Hagio, Anton Hajduk, R. Glenn Hall, Emilios Harlaftis, Gerald S. Hawkins, Wulff D. Heintz, Helmut Wilhelm Hellwig, Hartmut Holweger, Reiun Hoshi, Charles Latif Hyder, George R. Isaak, Theodor S. Jacobsen, Tadeusz Jarzebowski, Mihkel Joeveer, Zdenka Kadla-Mikhailova, Henry Emil Kandrup, Boris L. Kashscheev, Sidney Kenderdine, Vera L. Khokhlova, Michael J. Klein, I. G. Kolchinskij, N. S. Komarov, Vladimir A. Kotelnikov, John D. Kraus, L. Kresák, Petr G. Kulikovskij, Barry James LaBonte, Trudpert Lederle, Michael James Ledlow, Vojtěch Letfus, Jacques R. Levy, J. Virginia Lincoln, Alexander M. Lozinskij, Per E. Maltby, Gyorgy Marx, Janet Akyz Mattei, Cornell H. Mayer, Paul J. Melchior, Marie-Odile Mennessier, Klaus Metz, Rolf Mewe, Harry C. Minnet, Ljubisa A. Mitic, Vasilij I. Moroz, Philip Morrison, Mirta B. Mosconi, Andreas B. Muller, C. A. Muller Jr., Sergij Musatenko, Saken O. Obashev, Franco Occhionero, J. Beverley Oke, Mikhail Orlov, J. Oro, Ludwig F. Oster, Lucia Padrielli, John L. Perdrix, Charles L. Perry, Alain Peton, Jack H. Res. Fel. Piddington, A. Keith Pierce, Girolamo Pinto, John Polygiannakis, Jason G. Porter, John M. Porter, Neil A. Porter, Kevin H. Prendergast, Helen Dodson Prince, Yurij P. Pskovskij, Tamara B. Pyatunina, Gibson Reaves, James Ring, Ralph Robert Robbins, Brian J. Robinson, Marcello Rodono, Douglas H. Sampson, Hans Schmidt, Egon H. Schroeter, William M. Sinton, Akira M. Sinzi, George M. Sisson, Humphry Montague Smith, Mattheus A. J. Snijders, Gunnar Sorensen, Arnold A. Stepanian, Gerard A. Stevens, Jürgen D. Stock, Ronald Cecil Stone, Aleksandr A. Stotskii, Winardi Sutantyo, Peter A. Sweet, J. T. I. Tavares, Volodymyr Telnyuk-Adamchuk, Dirk Ter Haar, Richard Q. Twiss, Anne B. Underhill, Seppo I. Urpo, J. van Nieuwkoop, Paul Verbeek, Franco Verniani, Jean-Pierre Vigier, Yurij I. Vitinskij, Richard L. Walker Jr., Dennis Walsh, Willem Wamsteker, Lai Wan, James A. Westphal, Fred L. Whipple, Raymond E. White, John R. Winckler, Kiyoshi Yabuuti, Boris F. Yudin, Shigeru Yumi, D. Zulevic.

Interview with Jocelyn Bell Burnell: A Woman and pulsars

Jana Olivová

It can be said, I think, that your discovery of pulsars has changed astronomy. How has the discovery influenced your own scientific career?

It made it possible for me to have a scientific career. At the stage when I was a young woman, it was expected that women stopped work when they got married. And they certainly stopped work when they had children. And so women did not have careers unless they stayed single. I wanted both to have a family life and the career. And it was quite difficult, but I judged that if I had not had the discovery of pulsars as a young woman, I would not have been able to continue and I would not be here in Prague today.

Has the situation changed for women since that time?

Yes. I think it has changed since then. I see in Britain my generation as being at the turning point, the change-time, because women older than I did not expect to have careers, women younger than I do expect to have careers, and it has been my generation that has brought about that change. That has been at the cutting edge. So some things have changed but I think not enough and not fast enough yet.

Since the discovery of pulsars you have worked in many fields of astronomy. Which of them did you find the most exciting?

I have been very fortunate. I have had to change field many, many times because my husband moved for his job many, many times. And each time he moved I moved as well and nearly always to a different branch of astronomy. So I worked in gamma ray astronomy, X-ray astronomy, infrared astronomy, millimetre astronomy, and radio astronomy. I moved to X-ray astronomy just as the subject was booming and I worked on a very exciting satellite. I moved to infrared astronomy just as the subject took off, I was in at the beginning of millimetre wave astronomy. So I have had a lot of excitement. My moves in some ways have been very well timed.

You have discovered pulsars while doing research into quasars. Now you are focusing on microquasars. Do you expect you can make such a surprising discovery again?

No, I do not think one should be expected to make two discoveries of that magnitude in a life-time. Many people do not even make one. And that has perhaps been one of the downsides of making a discovery like that so early in your career because people then say: OK, what next? And it is very hard to follow that.

So does the Universe still keep some surprises for you?

Yes, many surprises. And surprisingly, the field of pulsars still has many, many surprises. It is perhaps even more exciting and more active than it has ever been in the past. And that I do find surprising, because it is 40 years! And after forty years you might expect the subject to be settling down, to be interesting, but to be mature. Pulsars – whoops! Excitement! Surprise! Innovation! It never stops!

What exactly are those surprises that the pulsars still hold for you?

Well, some of the most exciting results they have recently discovered are a double pulsar, a binary system where both stars are pulsars. Very fortunately this binary system is almost edge-on, the orbital plane is close to the line of sight. So we are seeing forms of eclipse as the two pulsars orbit each other. And that is very interesting. They are discovering a number of transient objects, some of which seem to be pulsars, but pulsars which only give one pulse every ten, every twenty, every fifteen periods – and the spacing between the pulses is different each time. And it looks as if there are a lot of those as well. So at a stroke we have doubled the pulsar population in the galaxy. There are interesting results on the masses of neutron stars coming in, we are finding some neutron stars that are much lighter, less massive, than we had previously found – and also some that are heavier. These high-mass and low-mass neutron stars will really stretch our understanding of what the neutron stars equation of state is, what it is made of, how it is structured. So many, many fascinating results are still coming in.

Scientific work also brings disappointments. What was the greatest disappointment you suffered in your career?

I cannot think of a single one, but certainly I found it quite frustrating that I kept having to change field as my husband moved for his job. And the way I would get jobs was to write a begging letter to an institution in the area where we were going to live. And then you have got the kind of job that you get when you write a begging letter. I became much more powerful when I was able to apply for jobs because of WHAT they were, not WHERE they were. So being a woman with responsibilities for a family has been frustrating. I think that is perhaps the main negative that I remember in my life.

Have those frequent changes in your field of research brought you more positive, or more negative experiences?

It brought many positive things. It means I have experience of all these different kinds of astronomy. So at meetings like this one I can go and attend talks on a whole range of topics and have some background. So that is really good. It also means I have ex-colleagues all across the spectrum, all around the country. The downside is that each time you change your field of research you have to learn the new field. And of course this affects your publication rate, your output. So there were positives and negatives. And I think it is hard to choose which is dominant; there are both there in my life.

I think that every person has his or her wishes for what he or she would like to achieve. What is your greatest wish in your profession?

Well, I am now officially retired, and so the time for wishes is past. I am very much enjoying this phase of life, I have a visiting position at Oxford University which is very lively, very dynamic group, and I am enjoying having the freedom to work on what I choose, to accept invitations to lecture, if I choose – or not if I do not. So I am very satisfied with life as it is. ❐

SPS5: Astronomy for the developing world

Proposal to establish a Third-world Astronomy Institute comes nearer to reality

John Hearnshaw, University of Canterbury, New Zealand

Special session 5 took place on Monday and Tuesday and covered all aspects of astronomy in developing countries. There were 16 invited talks, 25 contributed oral talks and about 20 posters. The presenters came from 37 different countries, and many of these were from developing countries. What is more, 280 people registered their interest in participating in the session, and these came from 61 countries, which represents an impressive global participation and world-wide interest in developing astronomy in many countries which are just entering into education and research programs in astronomy.

A highlight of the first session on Monday was the first invited talk by Jayant Narlikar (India), when he outlined his dreams of establishing a Third-world Astronomy Institute or Network (TWAI or TWAN). This would be an institute modelled on the International Centre for Theoretical Physics in Trieste and a place where astronomers from developing countries could go on short visits and enjoy world-class facilities for astronomy research, education and conferences. This goal appears to have come a step closer with the agreement to establish such an international centre at IUCAA (the Inter-University Centre for Astronomy and Astrophysics in Pune, India), with the support of the director of ICTP in Trieste. The support of the IAU for this initiative from the incoming president, Catherine Cesarsky, was warmly received. SPS5 had talks from astronomers in all the major regions of the developing world, including Latin America, the Far East, central Asia, Africa, and eastern Europe. It was impressive how many positive accounts of new programs in teaching and research were presented.

One theme was the relation between IAU Commission 46 (Astronomy teaching and development) and other agencies such as the UN Office for Outer Space Affairs, COSPAR, the program for the International Heliophysical Year 2007 and the Japanese ODA program (which donates small telescopes to developing countries). All these collaborative programs were discussed at the session, and hopefully a high degree of co-ordination between these programs will ensue.

Other international projects such as ADS and various Virtual Observatory projects in developing countries will have a major impact on astronomy in developing countries in the near future. In fact their influence is already having a big impact.

Although many astronomers in developing countries still struggle to do research and obtain financial support for facilities and international conference travel, the impression left from SPS5 is that much progress is being made. Commission 46 is reaching out to help many astronomers across the globe; a real difference is being made, and there is a feeling amongst many astronomers from developing countries that they are now part of a world-wide global community.

It is to be hoped that these trends can continue. ❐

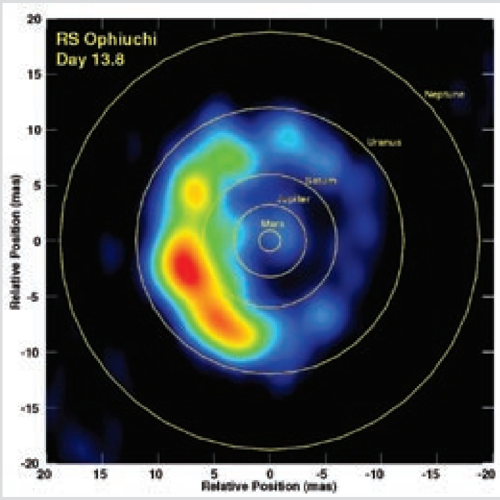
The 2006 outburst of the recurrent nova RS Oph

Mike Bode (Liverpool John Moores University), Stewart Eyres (University of Central Lancashire)

RS Oph comprises a white dwarf in orbit with a red giant star. The current outburst (the first since 1985, but at least the sixth recorded since 1898) was first observed by Japanese amateur astronomers on Feb 12th. Observations across the spectrum with a fleet of facilities on the ground, and in space, were initiated within a few days. In particular, the Swift satellite began an intensive campaign of X-ray and UV-optical observations. Extensive radio monitoring included Very Long Baseline Interferometry with both the VLBA and EVN.

In the first month, the X-ray emission observed by Swift was consistent with that from shocks arising as the high velocity material ejected from the surface of the white dwarf impacted the pre-existing wind of the red giant. The evolution of the remnant was then like that of a supernova remnant, but evolving extremely rapidly (see Bode *et* al., 2006, ApJ, in press, astro-ph/06046218). Radio interferometry taken only 14 days after the outburst resulted in a very high spatial resolution image of the expanding shock wave, consistent with the interpretation of the X-ray data (see O'Brien *et* al., Nature, **422**, 279 and attached illustration).

Around a month after outburst, the nature of the X-ray emission changed radically, with a new soft X-ray source dominating the spectrum. This new emission most likely originates from the revealing of the nuclear burning source on the white dwarf surface. It had been proposed that the white dwarf in this system is very near the Chandrasekhar mass above which it would undergo a supernova explosion. One of the major questions that is still to be answered is whether or not mass is gradually being added to the white dwarf so that it is moving inevitably towards this limit. Continuing analysis of these observations will help to answer this very important question. In June 2007, a conference dedicated to this remarkable object will be held at the University of Keele, UK. ❐



VLBA image of RS Ophiuchi taken at 6 cm 13.8 days after outburst showing non-thermal emission associated with shocks moving through the red giant wind. RS Oph lies at a distance of 1600 pc. Superimposed are the sizes of the orbits of the outer planets of our Solar System at this distance to give the impression of the spatial scales being probed by these observations.

Future asteroid impact threats

The current highly successful Spaceguard Survey of Near Earth Asteroids (NEAs) will soon be supplemented by new, more powerful surveys. While the probabilities for an impact in the next four decades remain low, many of the newly discovered asteroids may appear, for a time, to pose a significant threat of impact. Astronomers thus face two challenges. In addition to the technical problem of calculating the many asteroid orbits, we also need to develop better ways of communicating the impact risk to the public.

David Morrison, NASA Astrobiology Institute

Today the Spaceguard Survey is seeking to find 90 % of the Near Earth Asteroids with diameters greater than 1 km by the end of 2008. Asteroids larger than 1 km pose the greatest threat because an impact this large affects the entire planet, not just the country where the impact takes place. There are approximately 1,100 NEAs this large, and Spaceguard has found approximately 800 of them to date. Such surveys should allow any impact threats to be identified decades in advance, enough time for mitigation strategies.

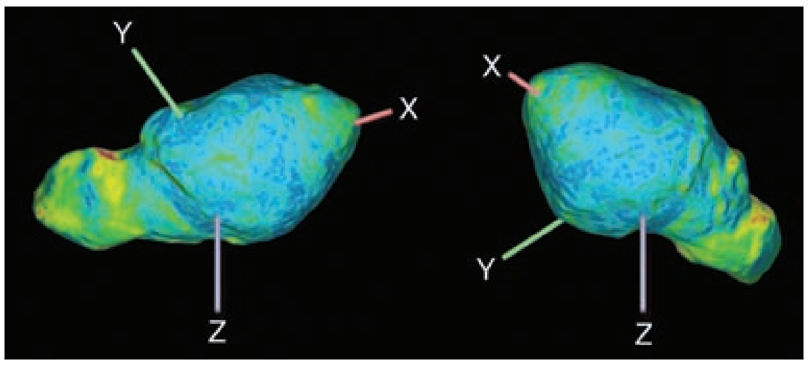
In the United States, there is increasing interest in extending the Spaceguard Survey to smaller asteroids, which hit Earth more frequently. Several committees of the U.S. National Academy of Science have recommended construction of large search telescopes to extend the completeness limit to 300 m NEAs. Most recently, the U.S. Congress has given NASA increased responsibility for dealing with potentially hazardous NEAs and has asked for a plan for a Spaceguard Deep Survey down to 140 m diameter. NASA's response is expected to consider both space-based and ground-based searches. The congressional mandate is to find 90 % of these sub-km NEAs by 2020.

The shift from emphasis on the NEAs larger than 1 km to the sub-km NEAs will have important implications. The number of NEAs larger than 140 m is approximately 100,000, and there may be as many as a million that are as large (60–70 m diameter) as the object that produced the Tunguska explosion in 1908. Discovery rates in the new surveys will have to be 100 times faster than the current Spaceguard System, and the orbit calculations and archiving of data will scale in the same way.

There is likely to be increased interest in the characterization of NEAs, and of space missions (such as Don Quixote) to investigate them, stimulated by the higher discovery rate. However, because so many of the new objects will be faint, the pressure will be upon the largest telescopes, where observing time (especially unscheduled time to observe a newly discovered NEA) is at a premium. There will also be increased opportunity and demand for ground-based planetary radar investigations.

The rate of discovery of "interesting" NEAs (such as Apophis and 2004 VD_{17}) that might be noticed by the public and the media may increase from about once per year to once per week. We can expect dozens of discoveries that appear, from preliminary orbits, to pose a potential threat. (For every NEA that collides with Earth, there are 100 that have a 1 percent chance of collision.) Both astronomers and the media will need to develop better ways of communicating the risk without raising unrealistic public concerns.

Recognizing this communication challenge, the IAU has created a small committee of experts to advise the IAU President and General Secretary concerning impact threats. Though this committee, we hope that the IAU can play a more visible part in placing the impact hazard in perspective. We must strike a balance between minimizing public concern while recognizing that the NEA survey can, at any time, identify a real asteroid on a collision course with Earth.



Radar-derived shape of near-Earth asteroid Toutatis. Credit: S. Ostro, JPL

The IAU EC Advisory Committee on "Impact Threats to the Earth" consists of: David Morrison (NASA Ames Research Center) (Chair), Richard P. Binzel (Dept Earth/Planetary Science, MIT), Andrea Carusi (IASF-INAF, Rome), Andrea Milani (University of Pisa – NEODys team), Don Yeomans (NASA/JPL/Caltech SENTRY team). ❐

Women in Astronomy Working Lunch

Monday 21 August, 2006 – *Anne Green*

The second Women in Astronomy Lunchtime Meeting was held on Monday 21 August with more than 250 participants. The meeting was hosted by the WG for Women in Astronomy, established at the 2003 IAU-GA, and was attended by the current President, the Presidents-Elect for this and the next GA, the General Secretary and Vice-Presidents, many senior astronomers, as well as students and young astronomers. We congratulated incoming President, Catherine Cesarsky, the first woman to hold the position.

Lunch was preceded by a Business Meeting attended by an overflow audience of participants. One important issue is the collection of global statistics and the wider community will be surveyed with a concise and consistent set of questions relevant to all countries. For this, we need National Representatives who will take responsibility for obtaining the statistics. Many surveys already exist and new ones are planned.

IAU gender statistics give an incomplete picture, but we cannot be satisfied with recent numbers showing 13 % women of 8,000 members in 39 countries, although an encouraging 22 nations recorded an increase since the previous GA.

The meeting theme was "Career Development for Women" with keynote speakers Dr Sunetra Giridhar of the Indian Institute of Astrophysics, Bangalore, and Dr Patricia Knezek, Deputy Director of the WIYN Observatory, Arizona. Participants received a flyer with the 1992 Baltimore Charter for Women in Astronomy, IAU statistics and five suggested topics for discussion at tables and in the Plenary session. A summary of comments follows:

1. Unequal Opportunity – has discrimination gone underground? Many participants want more flexible criteria for appointments, for more women in senior positions and for the visibility of women at conferences to increase. Sadly, subtle discrimination is still a problem at several institutions.

2. Mentoring & Self-confidence – do women network effectively? Many young women astronomers expressed the need for role models and effective mentoring and strategies to build self-confidence. Anecdotal evidence suggests women base applications on their achievements rather than on their potential (a more male approach).

3. Family responsibilities – is there an easier time for having children? Many noted that the provision of childcare at workplaces and conferences is critical. While maternity leave is now frequently offered, childcare at conferences and workplaces is often lacking. Women are still (generally) the primary caregivers with greater vulnerability for research disruption and mobility limitations.

4. Dual careers – equal advancement of two careers is extremely difficult. Lack of mobility affects women more than men. How can we encourage more options for partners? Can we embrace non-standard career paths as acceptable? The two-body issue is seen as problematic for many women.

The following action items will be submitted to the incoming IAU Executive, with the WG keen to assist: ensure adequate representation for women on Science Organising Committees and as invited speakers for Symposia and make the provision of childcare at meetings, either supplied or paid for, a priority. Finally, the meeting was an excellent if brief opportunity to exchange ideas and experiences, made possible through generous support from the US IAU National Committee for Astronomy and the NOC of the Prague GA, for which we are greatly appreciative. See you again in Rio! ❐

SPS3: The Virtual Observatory in action – new science, new technology, and next generation facilities

Andy Lawrence, Francoise Genova

The development of the Virtual Observatory (VO) is one of the very few truly global endeavours of astronomy. The IAU General Assembly is therefore a natural place to assess the status of the VO and present its progress to the community. Three years ago in Sydney, a Joint Discussion presented dreams, visions, and early technical progress. Projects from around the world had just formed the International Virtual Observatory Alliance (IVOA). This year in Prague it was therefore exciting to hold a full three day Special Session, where scientists from all over the world described working systems, presented early science results using VO tools, and held vigorous debates on both the opportunities and pitfalls before us.

The VO is and must remain science-driven, but technical solutions are what makes the vision achievable. The heart of the concept is the agreement of standards – for data, for description of services, for how software modules bolt together. The IVOA constructs and debates these standards, but they are then approved and held by the IAU. The standards and protocols need to be simple enough that busy data centres and other service providers will implement them but strict enough that we can actually achieve our vision of "data at your fingertips". Unless data is published through VO interfaces, then there is no VO. We had several talks from data centres and from national projects about the progress and the difficulties in achieving this. Much of the debate was about striking the balance between risk and sustainability. It was widely agreed that the centrality of data centres on future astronomy, and the need to fund them properly, is not yet fully appreciated by funding agencies, or indeed by astronomers in general.

New astronomical facilities and big survey projects, as well as holders of large and diverse existing archives, all seem to realise that this is the way science will be done in the future, and so their plans must accommodate the VO – and unlike three years ago, scientists representing these projects even seem to understand what "VO compliant" actually means! As well as implementing specific access protocols, it means providing "science ready data" and standardised tools for exploring and analysing the data. Some of the most fascinating talks were about such science tools – multi-dimensional plotters, spectral fitters, image stackers, on-demand reduction pipelines – and technical advances that enable these tools to interoperate. These tools are being written by scientists from outside the VO projects, a sure sign that the VO is taking off.

As VO-ready datasets and VO-aware tools emerge, the first astronomers are beginning to do VO-enabled science. This was perhaps the most exciting part of the meeting, with talks on quasars, brown dwarfs, asteroids, solar flares, and more. Of course, this still comes from a keen band of "early adopters", and there was much feedback that systems and tools need to be easier to use. National projects, summer schools, helpdesks, and so on can all help; but it seemed clear that the concept was going to work. We only have a few years to impress people; if the VO works, it will soon be invisible. There isn't really a thing called the VO. Its just a consistent and transparent way of doing things. One problem is that it may then be hard to track useage statistics and convince our paymasters that it is a success.

Two interesting concerns emerged during the meeting. The first is that a new breed of "data scientists" is emerging, equivalent to astronomers who specialise in developing new instruments. It is important for the future of astronomy that the work of these data scientists is credited, and that they have a sensible career track. The second concern is data quality. Because the VO enables people to easily access, analyse, and combine a wide variety of previously specialised data, there is a danger that much naive nonsense will result. Some suggested that only the best datasets should be "allowed in", or that the IVOA should be the "data police". Majority opinion agreed that this is both impractical and against the spirit of the VO; but it is a problem that the IVOA must address. The solution must be in agreeing on the ways that data and resources are characterised, so that people or software can make judgements on data quality. We look forward to meeting in Rio to see what the VO will have matured into. ❐

Final Version of Resolution on the Definition of a Planet

At the second session of the General Assembly which will be held 14:00 Thursday August 24 in the Congress Hall, members of the IAU will vote on the resolutions presented here. There will be separate sequential votes on Resolution 5A and Resolution 5B. Similarly, there will be separate votes on Resolutions 6A and 6B. Resolution 5A is the principal definition for the IAU usage of "planet" and related terms. Resolution 5B adds the word "classical" to the collective name of the eight planets Mercury through Neptune. Resolution 6A creates for IAU usage a new class of objects, for which Pluto is the proto-type. Resolution 6B introduces the name "plutonian objects" for this class. The Merriam-Webster dictionary defines "plutonian" as: *Main Entry: plu•to•ni•an – Pronunciation: plü-'tO-nE-&n – Function: adjective – Usage: often capitalized – : of, relating to, or characteristic of Pluto or the lower world.* Resolutions Committee members will be available at the IAU Exhibit (situated in the exhibition area, 2nd floor of Congress Hall, Foyer 2) from 13:00–13:30 today (Thursday). However, only minor corrections can be accommodated at this stage. A French version of the Resolutions will be available at the door.

IAU Resolution: Definition of a Planet in the Solar System

Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particular, to the designation 'planets'. The word 'planet' originally described 'wanderers' that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.

Resolution 5A

The IAU therefore resolves that planets and other bodies in our Solar System be defined into three distinct categories in the following way:

(1) A planet[1] is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

(2) A dwarf planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape[2], (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

(3) All other objects[3] orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

[1] The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
[2] An IAU process will be established to assign borderline objects into either dwarf planet and other categories.
[3] These currently include most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs), comets, and other small bodies.

Resolution 5B

Insert the word "classical" before the word "planet" in Resolution 5A, Section (1), and footnote 1. Thus reading:
(1) A classical planet[1] is a celestial body . . .
and

[1] The eight classical planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

IAU Resolution: Pluto

Resolution 6A

The IAU further resolves:
Pluto is a dwarf planet by the above definition and is recognized as the prototype of a new category of trans-Neptunian objects.

Resolution 6B

The following sentence is added to Resolution 6A:
This category is to be called "plutonian objects."

Discussion on Resolution 5B

250 words for

Compromise. Achieving a planet definition has been all about compromise. There are two equally valid descriptions of what should be the principal criterion for defining a planet. One is dynamical, an object that has "cleared out its zone." The other is based on the physical nature of the body itself. The pendulum of argument has swung both ways during the General Assembly discussions. But now it has swung too far.

Resolution 5B is all about finding the middle ground. Using qualifiers gives equal status to both points of view and leaves open the possibility to define other types of planets in our Universe. Resolution 5B restores the "global and cultural points of view" that the Planet Definition Committee had responsibility to achieve. The public recognizes Mars, for example, as a "planet" not because it has cleared out its zone, but because it is a fascinating world.

To illustrate why Resolution 5B is cultural, and not silly semantics, consider how you must answer two questions: How many planets are there? Is Pluto a planet? A vote in favor of 5B yields: "There are 8 classical planets and many dwarf planets yet to be discovered" and "Pluto is a planet, but in the dwarf planet category." These answers highlight and communicate the tremendous revolution of new discoveries in our outer Solar System. Further, it saves enormous public backlash by still being able to say the words "Pluto is a planet, but". Do not underestimate the global cultural importance of these first four words. The word "planet" deserves to be shared equally.

250 words against

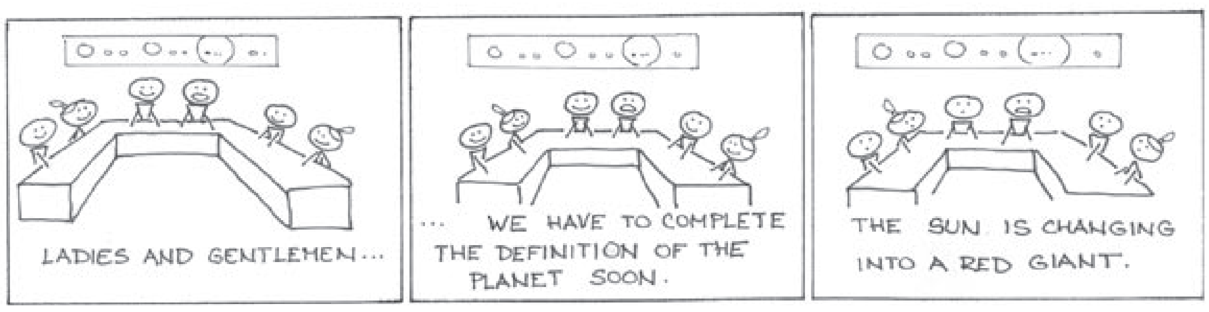
Resolution 5B represents a small but significant change to Resolution 5A.

The key issue is the definition of "planet". Resolution 5A is close to the version agreed by consensus on Tuesday evening where it was made clear that three distinct categories of objects orbiting the Sun were being defined: planets, dwarf-planets, and small bodies. The logical implications from the rules of grammar cannot be ignored. By using the name "planet" with two different adjectives "classical" and "dwarf" a larger category of planets is implied. This contradicts the first paragraph of both Resolutions 5A and 5B and transforms three distinct categories into two (planets and small bodies) and two sub-groups of planets.

To the question "is Pluto a planet?" the two resolutions give different solutions – "Yes" for 5B and "No" for 5A. To the question "How many planets are there?" Resolution 5A gives 8, Resolution 5B currently gives 12 and soon at least 50.

The total number of planets may not matter to scientists, it is critical for education and the dissemination of science. For scientists, it is relevant that dynamical and cosmogonical criteria, which are now the source for the definition of planets, would in Resolution 5B be relegated to a secondary role. In Resolution 5A the arguments from geophysics and from dynamical astronomy are given equal weight. Such a balanced solution had received very strong support in the meeting of Division III (Planetary Systems Science) and the Planet Definition Information Meeting.

Resolution 5B is misleading and should be rejected.



Brief information

- **C46: Teachers Day – Olomouc**, the historical Moravian centre of cultural and scholarly tradition (university, old astronomical clock) is the site of an annual meeting "Fare of physics invention". The opening day August 28 is reserved for reports and discussions on highlights of the 26th GA. More than 100 Czech physics teachers and several C46/41 members will participate.
- The international conference "**Galaxies in the Local Volume**" will be held in 2007, July 8 to 13, at the Australian National Maritime Museum (ANMM) in Darling Harbour, Sydney. More information at **www.atnf.csiro.au/research/LVmeeting/** and from Baerbel Koribalski, **Baerbel.Koribalski@csiro.au**
- **2006 IAU General Assembly podcast –** Astronomers from Jodrell Bank Observatory interview those at the conference about their experiences. Each interview is edited and published on the same day and stored in our archive at **www.jodcast.net/archive/.** Contact: **jodcastfeedback@jb.man.ac.uk**.
- You can watch today's **General Assembly online** at **www.astronomy2006.com/tv** from 14:00.

Please, check again our **electronic supplement to No. 9** available at **astro.cas.cz/nuncius** for articles by Alexander Gusev and Natalia Petrova about Russian project "Moon 2012+", by Heino Falcke about long-wavelength telescopes on the Moon, by Irina Kitiashvili about pulsar PSR B1828-11, by Wayne Orchiston about history of radioastronomy, by Carolina Ödman about UNAWE project (astronomy for underprivileged children) and a scientific biography of Kees de Jager and his friendship with Zdeněk Švestka written by Helen Sim. There were also minor corrections done in "**Planet Redefinition Proposal**" supplement.

"Nothing is so firmly believed as what we least know."
Michel de Montaigne (1533–1592)

Secret diary of secret agent F.R.Og

August 23: I love Earthlings. Metaphorically! They're so poetic and naive. How lovingly they speak about black holes and how beautiful surroundings they create for them. They even make movies about them. I don't have a heart to tell them how we, at rybníček, talk about black holes. "Supermassive black-hole waste damp not massive enough!" "Stellar-mass black holes destroyed the interstellar road!" No, Earthlings are not yet ready for the reality. By the way, I begin to think my mission here will fail. My boss will not be happy. I'm afraid the NRAO magic cube won't satisfy him, he's so narrow-minded. And has no children.

NOMENCLATURE FILLER

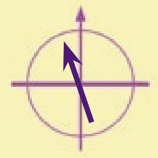
9. From Confusion to Clarity: *objectname* and *object* are useful tools when publishing

Hélène R. Dickel

The Astrophysical Journal (and Supplement), Astronomical Journal, and Astronomy & Astrophysics kindly request that authors use the ***objectname*** (for ApJ, ApJS and AJ) and ***object*** (for A&A) LaTeX command to link the astronomical objects discussed in their work to the general interest tools developed in the community. At that time, you should provide the reference for the designation of the object or source. For further details, refer to the Instructions to authors of the particular journal.

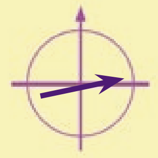
Thursday 24/8
9 °C / 48 °F
morning minimum
25 °C /70 °F
afternoon maximum


First sunny, then becoming overcast with some rain


SSE winds 3 m/s (7 mph)

Friday 25/8
8 °C / 46 °F
morning minimum
20 °C /68 °F
afternoon maximum


Cloudy with rain mainly in the evening


WSW winds 4 m/s (9 mph)

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