GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.1:** *MONDAY 7th AUGUST*

*Photo: Don Harris, UKSC Photo Lab*

*Robert Kraft, President, IAU*

# Welcome to the 24th General Assembly of the IAU!

The General Assemblies are the glue which keeps the IAU together, and this is the third time that we have met in the United Kingdom. When the second General Assembly met in Cambridge in 1925, under the Presidency of W.W. Campbell (a predecessor of mine from the Lick Observatory), there were only 189 participants, three-quarters of the total membership. When the IAU met again in the UK, in Brighton in 1970, that General Assembly was the largest ever in terms of participants: 2255, more than half the total membership. Were we to see the same fraction of members today, our hosts would have had to plan for an attendance in excess of 4500!

After an interval of 30 years, we are again meeting in the UK, this time in the historic 'industrial north' of the country, famous as the seat of the Industrial Revolution which shook the entire world. But we meet also in a country renowned for outstanding scientific and, in particular, astronomical revolutions. From Newton's pioneering work on gravitation and optics, on through the observational discoveries of Halley, Bradley and the Herschels, British astronomers have remained in the forefront of both theoretical and observational advances in virtually all the branches of our science.

The scientific programme of this meeting reflects - in modern terms of course - the foundations laid in countless ways by the work of British astronomers. In Invited Discourse 2 and Symposium 202, for example, we will hear the latest news about the search for planets revolving around distant stars - the latest 'application' of Newtonian mechanics. The far Universe will be explored in Invited Discourse 1, Symposia 201, 204 and 205 and Joint Discussions 2, 9, and 11, as modern observations and theory tackle thorny issues in cosmology, a subject which has been in the forefront of British astronomical thought for generations. We will hear new results derived from high angular resolution studies of galaxies and parts of galaxies, an area pioneered in radio astronomy here at Jodrell Bank. And in Joint Discussions 3, 5 and 8, reports on recent advances in star formation, stellar structure and stellar evolution will be given, subjects to which Eddington made so many fundamental contributions.

Since the IAU last met in the UK, astronomy has moved forward on a broad front. Our British colleagues now have a wide range of observational facilities at their disposal, both on the ground and in space (e.g. Gemini in the optical and MERLIN in the radio domain). The institutional basis for British astronomy is being recast. An earlier tendency toward national scientific independence has been replaced by an increasingly strong emphasis on participation in international collaborative projects in many ways; that is to say, more in the spirit of the IAU itself.

At the University of Manchester, we have found an excellent venue for our General Assembly. A vibrant, modern University, with many young students, and with new buildings which seem to be going up everywhere. Research in astronomy and physics has a vigorous present as well as a strong tradition behind it, perhaps best symbolized to astronomers by the Jodrell Bank Observatory, which is part of the Department of Physics and Astronomy. This is the place where important early studies of pulsars were made, and where the first firm identifications of normal galaxies, such as M31, as radio sources were made. Today Jodrell Bank continues the tradition of excellence symbolized by the names of so many famous physicists posted over the lecture rooms in which we will meet. These include Sir Ernest Rutherford, who first split the atom, and his predecessor Arthur Schuster, who was not only a brilliant physicist but was also General Secretary of the International Research Council, under whose aegis the IAU was founded in 1919. And, of course, the development of the stored-program computer at Manchester fifty years ago affects us all every day.

The next two weeks will be busy and enjoyable for us all, but busiest of all for our Manchester colleagues and their many helpers from all over British astronomy, who have worked so hard to organize a memorable meeting and to make us comfortable in Manchester. On behalf of the IAU, I thank the Royal Society and the Royal Astronomical Society for inviting us to the UK once again. I look forward to a great General Assembly, in which we will learn much that is new - socially, culturally and scientifically!

**Robert P. Kraft**
*President, IAU*

# Remarkable New Planets

The discovery of nine new extrasolar planets will be announced today during the opening session of Symposium 202. Some of these new planets are indeed remarkable, and they display a wide range of properties, including large orbital eccentricities, close-in orbits, and masses as low as that of Saturn. Indeed, one star harbours two Saturn-mass planets, both in tight orbits. The bounty brings the total of known extrasolar planets to 47.

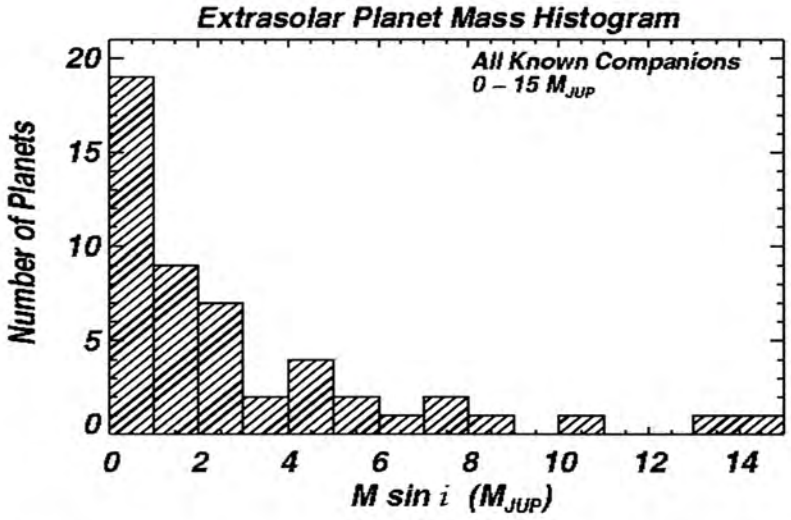
The new and impressive histogram of planetary masses (shown here) reveals increasing numbers of planets toward the lowest masses. There are few planets having masses above a few Jupiter masses. The abundance of low-mass planets suggests that even lower mass planets, of Neptune and perhaps Earth mass, are yet to be found. To date, 27 of the 47 known extrasolar planets have a minimum mass, Msin(i), less than 2 Jupiter masses.

Two particularly remarkable planets are among those to be announced. An international consortium of astronomers led by Dr. Bill Cochran has found Doppler evidence for a Jupiter-mass planet orbiting 3.2 AU from the star Epsilon Eridani, one of the nearest neighbours of the Sun, and featured in science fiction novels. The Doppler period of seven years had been noticed by two other teams at the Canada-France-Hawaii telescope and at the Lick Observatory. The McDonald Observatory velocities, along with new atmospheric diagnostics, provide compelling support for the reality of the planet.

"Detecting a planet orbiting Epsilon Eridani, a star very similar to our own Sun and only 3.22 parsecs from Earth, is like finding a planet in our own backyard," said Cochran. The angular separation between the star and the planet is a full arcsecond, implying that images of the planet may be possible with next-generation techniques. The detection of the planet is difficult, because Epsilon Eridani is a well-known magnetically active star, leaving open the possibility that photospheric motions could cause the Doppler wobble.

The other remarkable new planet orbits the star HD 83443 which apparently has a system of two Saturn-sized planets. Discovered by the team led by Michel Mayor and Stephane Udry, the new system was detected by high-precision Doppler measurements with the CORALIE spectrograph at the 1.2-metre Euler Swiss telescope (ESO-La Silla) as part of the Geneva planet-search project.

Until now, the only full system of planets known around a main sequence star was that around Upsilon Andromedæ, containing three planets. Updated orbital parameters for this triple-planet system will be presented at this meeting by Paul Butler and Debra Fischer, who will also announce three other new planets – all large gas giants moving in highly eccentric orbits.




The new planetary system around HD 83443 is remarkable because it has two low-mass planets, of 0.35 and 0.15 Jupiter masses (1.17 and 0.50 Saturn masses), and both orbit very close to the star, at distances of 0.038 and 0.17 AU.

In the coming year, the number of known sub-Saturn-sized planets will continue to grow. Additional systems of multiple planets are emerging from the surveys of the groups led by Mayor and Marcy, which will permit comparisons of their architecture to that of our Solar System.

**Geoff Marcy**
*University of California, Berkeley, USA*

**Turn to page 2 for welcoming messages from the National and Local Organizing Committees...**

# Welcome...

# ...to the UK

Photo: RAS

*Carole Jordan, Chair, NOC*

On behalf of the National Organizing Committee, I would like to welcome you to the 24th General Assembly of the International Astronomical Union. We are delighted and honoured that the IAU accepted the invitation from the Royal Society and the Royal Astronomical Society to hold this General Assembly in the UK in the millennium year.

One of the strengths of astronomy is that it is still possible to hold an assembly of a significant fraction of the international professional community. In addition to the exchange of scientific ideas, new collaborations and friendships arise out of these meetings, strengthening the bonds between astronomers world-wide. In a world of increasing specialization, the General Assembly also offers the opportunity to hear about recent advances over a broad range of astronomy.

Few nations can afford to have completely national programmes, and the UK relies on international collaboration in both ground and space-based astronomy. In future, many hope that the UK will be able to join the European Southern Observatory.

In recent years surveys have been made of the activities and demographic trends in UK astronomy (see *Astronomy and Geophysics*, Vol. 41). It is pleasing that there is still growth in the number of permanent academic staff. This reflects the interest of the young in astronomy; an increasing number of universities now teach astronomy in conjunction with physics degrees. There has been an even larger increase in the number of post-doctoral research assistants. Many of these are welcomed as young researchers in posts abroad, thus further strengthening international links. We were pleased by the results of an international review of UK physics, including astronomy, which highlighted research in cosmology and solar physics.

The UK has a long tradition of excellent astronomical research, which continues to the present day. The profile of astronomy in the UK can only be raised by the presence of the 24th General Assembly. We hope that the science discussed will serve as an inspiration to all, including the research students generously supported by the Particle Physics and Astronomy Research Council. We also hope that you will enjoy the social events, including the concert by the Royal Liverpool Philharmonic Orchestra this coming Friday.

**Carole Jordan**
*Chair, National Organizing Committee*

# ...and to Manchester

We are glad to see you in Manchester for the two weeks of science and friendly interaction which characterize General Assemblies of the IAU. This is the culmination of more than four years of preparation by the LOC. Our strongest wish is that you will find the visit stimulating and the accommodation comfortable.

A wide choice of scientific meetings is outlined in the Final Programme book included in your Registration pack. We hope you soon become familiar with the venues located on the University of Manchester Campus and the adjacent Royal Northern College of Music. Signposting has been erected to help you. We have been able to place the poster displays close to the lecture theatres where the various sessions are held. The Abstract Book is your guide to the Symposium and Joint Discussion presentations.

A highlight of General Assemblies is the Inaugural Ceremony, which in this case commences at 2:00 pm on Wednesday, August 9. It contains welcome speeches with a special musical programme; it will be held in the outstanding new Bridgewater Hall, which will also accommodate the Invited Discourses and the Symphony Concert on Friday, August 11, specially performed for our meeting.

A social programme includes visits to local places of interest - including Jodrell Bank where you are invited to have tea. An informal reception is offered on Monday, August 7 in the Refectory, and a Civic Reception is being given by the Lord Mayor following the Inaugural Ceremony.

While you are here we hope you discover the many interesting faces of the City of Manchester; several guides have been included in your Registration pack. As for all large modern cities, please remain aware of security.

Again welcome.

**Rodney Davies & Dennis Walsh**
*Co-Chairmen of the Local Organizing Committee*

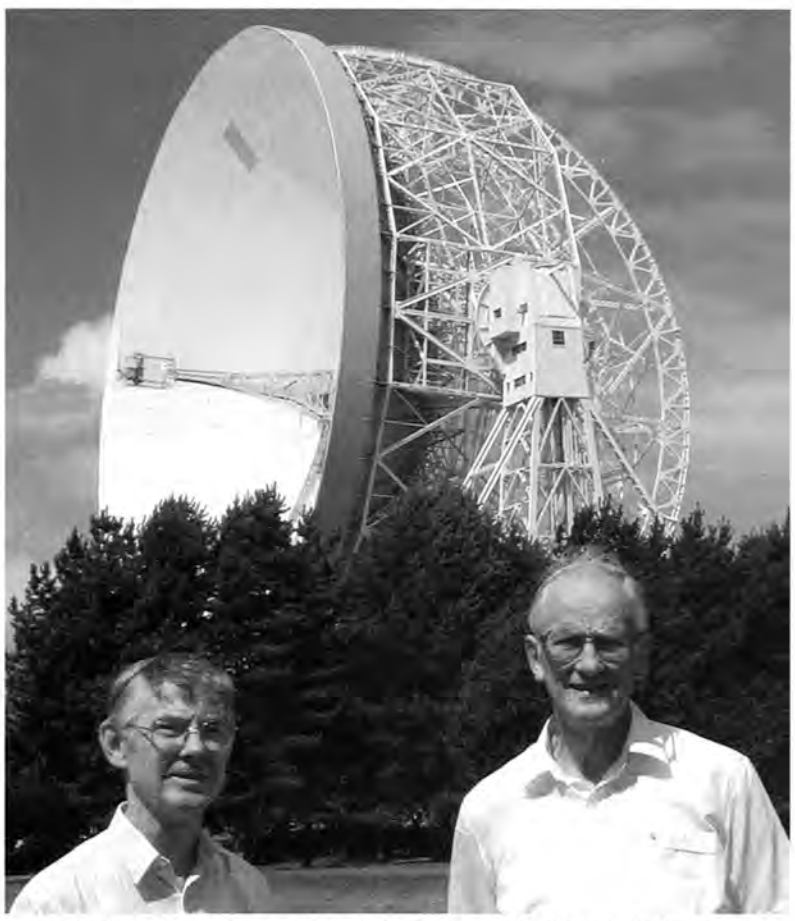


Photo: University of Manchester

*Rodney Davies (right) and Dennis Walsh (left) Co-Chairmen of the LOC, with the famous Lovell Telescope at Jodrell Bank in the background.*

# Global Structure and Evolution of the Solar Interior

Once upon a time the Sun was thought merely to be a simple example of a main-sequence star. And even today, by the standards of many other astronomical objects, it is very simple indeed. That is why astrophysicists have been able to understand it so well, and to make very precise inferences about its internal structure. It has enabled them to address questions in physics of a subtlety that is scarcely rivalled elsewhere in astronomy.

By seismological investigation the sound speed has been measured throughout most of the interior with a precision of 0.01 per cent; the variation of the rate of rotation has been determined, rather less precisely, in the outer 30 per cent (by radius), and large-scale subphotospheric meridional flow and smaller-scale flow around and under sunspots has been detected.

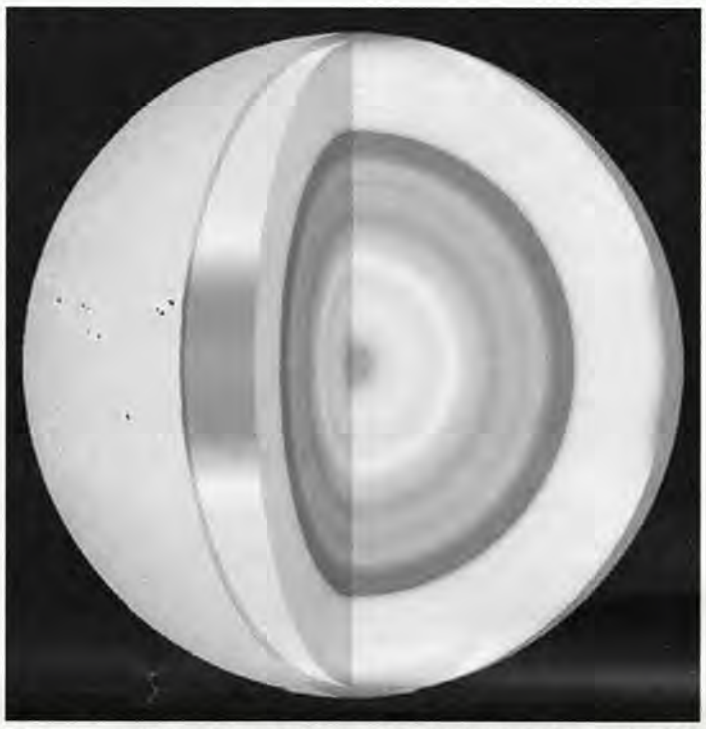


Photo: SOHO, ESA and NASA

*Cutaway revealing variations in the rate of rotation inside the Sun, as deduced from measurements by the MDI instrument aboard SOHO.*

Aside from the intellectual challenge of measuring the inside of a star, there are other important reasons why one should wish to investigate the global structure of the Sun. One is to study the properties of matter under conditions too extreme to reproduce in a controlled manner on Earth. Another is to study the dynamics of a particular star as a means of understanding the structure and evolution of stars in general. An example of the first is the estimation of the sizes of interacting atoms and compound ions in a dense plasma through their van der Waals-like influence on the equation of state. An outstanding example of the latter is the dynamics of the solar cycle, which is also critical to our understanding of solar-terrestrial relations. What are the dominant processes that drive and control the cyclic variation? Are they confined to the convection zone and its immediate environment, as most solar physicists believe, or do they extend to the very core of the Sun? Does the magnetic field play an essential rôle in the dynamics, or is it merely a passive tracer of fluid motion deep in the Sun's interior?

New clues for unravelling the dynamical processes will be discussed in the opening session of IAU Symposium 203. We observe that sunspots block the light emitted from the photosphere, causing temporary diminution of the total irradiance. Yet why is it that the mean solar irradiance is greater at sunspot maximum than it is at sunspot minimum? It is not difficult to guess a mechanism, but only with a combination of detailed and accurate irradiance observations and concurrent seismological diagnosis can one test the plausibility of the guess. The newly discovered 1.3-year oscillation near the base of the convection zone now appears to extend much more deeply into the radiative interior. Is this a key to understanding the longer 11-year cycle, or is it a wholly separate phenomenon? Issues such as these demonstrate clearly that the early simplicity of stellar physics is but a foundation for the rich scientific enquiry that lies ahead.

**Douglas Gough**
*Institute of Astronomy, University of Cambridge, UK*

# IAU Symposium 201 New Cosmological Data and the Values of the Fundamental Parameters

Photo: UCSB and NASA/NSF

*The BOOMERANG Telescope being readied for launch in Antarctica, with Mt. Erebus as a backdrop. The BOOMERANG Telescope made the first high resolution survey of the tiny 100ppm temperature variations in the cosmic microwave background.*

It has perhaps often been said that cosmology is entering into a new era, but that must surely be true as a description of the current situation. Recent advances in instrumentation and techniques mean that cosmology is moving rapidly from what might be called a 'data starved' science, into one which is at last 'data rich'. High quality large data sets are now becoming available in several different areas, and at the same time a new theoretical paradigm, of a Universe dominated by vacuum energy as well as matter, is becoming standard. In this context, the aim of Symposium 201 is to bring together experimenters, theorists, observers and interpreters from around the world, to present and discuss the latest data, and to look critically at this new paradigm, and whether it really fits with and is justified by the data. The values of the fundamental parameters, such as the expansion rate, age and density of the Universe, are a significant focus for the meeting, since our relative lack of knowledge of them in the past has been an important indicator of our state of knowledge in cosmology. There is now a real chance of these parameters being measurable to an accuracy of a few percent in the near future - a very significant change.

The meeting begins with a review of the current status of cosmology by Malcolm Longair, and then covers the topics of the early Universe, cosmic microwave background astronomy, large scale structure, determination of the Hubble Constant, evidence for a non-zero cosmological constant, dark matter, the overall density and geometry of the Universe, how to 'put it all together' and the rôle of new experiments and ideas in cosmology. We are very fortunate in having some of the key researchers in each of these areas at the meeting.

**Some expected highlights and points for discussion include:**

1. There has been tremendous development recently in early Universe physics, and there is a real chance of being able to use the spatial spectrum of cosmic microwave background (CMB) anisotropies to test ideas such as the origin of the Universe in a 'singular instanton' and even aspects of M-theory.
2. Experimental advances in CMB astronomy mean for the first time that high-resolution maps of significant areas of the sky are becoming available. The results from the balloon-borne BOOMERANG and MAXIMA experiments have confirmed an overall picture of a spatially flat Universe (one at critical density). However, there is possible evidence of a clash between what the CMB power spectrum shows, and standard nucleosynthesis values of the baryon density of the Universe. Results from new interferometer CMB experiments could shortly resolve this.
3. Large scale structure surveys such as the Anglo-Australian 2dF and U.S. Sloan survey are starting to yield their first results, which will be discussed at the meeting. Big improvements in our knowledge of the matter power spectrum and of the evolution of clustering should follow. The size of such data sets, and the new and forthcoming CMB data sets mean that we will need special techniques for analyzing and exploiting these data.
4. Values of the Hubble Constant and of the overall density of the Universe (Omega) are at least starting to converge between different techniques, although the estimate of Omega using clusters of galaxies remains somewhat controversial and the nature of the dark matter remains unknown. New results on gravitational lensing, where first detections of weak lensing from large scale structure have recently been reported, will also be discussed in these sessions.
5. Some of the most exciting results in cosmology recently have come from the observations of Type Ia supernovæ, which have given strong evidence for a non-zero cosmological constant. These results will be discussed in detail by members of the two teams responsible for the discoveries, and there should be good opportunity for examining the underlying assumptions in the method, and whether they are justified.
6. Are the various cosmological indicators concordant with each other and what are the best values of the parameters when data sets are combined? These topics will be discussed on the final day, along with descriptions of the new instruments which cosmology needs to refine current answers.
7. On the final afternoon, we are lucky to have Martin Rees providing an assessment of 'New theoretical insights and outstanding problems', Virginia Trimble giving a review of the posters presented at the meeting, and Jim Peebles to make stimulating concluding remarks.

**Anthony Lasenby**
*Cavendish Astrophysics Group, University of Cambridge, UK*

# IAU Symposium 202 Planetary Systems in the Universe:

## Observation, Formation and Evolution

Planets orbiting other stars are a hot topic, and form an exciting part of Symposium 202 on planetary systems, which runs from Monday to Thursday of the first week. We expect several announcements of new discoveries, and media coverage. Leading authorities will review the latest advances in and future prospects for our understanding of all aspects of the 'observation, formation and evolution' of planetary systems. Substantial time has been allocated for discussion of those talks and of the 109 poster papers, which concentrate on particular bodies of work. An interesting aspect is that all the discoverers of extrasolar planets are attending the symposium.

We are now in a rapid growth phase for our knowledge of planetary systems, with the actual detection of such planets and a growing body of observations of dust disks round stars, coupled with extensive plans for future ground and space-based searches. This is happening alongside rapid growths in our knowledge of the details of our own Solar System, and in our theoretical understanding of planetary systems.

One of the pleasures of this field is that we know so comparatively little, so that each new technical development in observational capacity brings unexpected results which recast the whole field – as for example the discovery of Jupiter-mass planets close into their parent stars. Planetary systems science seems to be entering into its 'golden age', possibly as fruitful as that of cosmology in the 20th century.

But what should such a symposium cover? The problem is that there are so many aspects: star and planet formation, dust disks, comets, asteroids, the history of the Solar System, planetary interiors and atmospheres, magnetohydrodynamics of the solar nebula, and the origin and distribution of life on planets. When a group of us decided to propose this symposium to the IAU, we decided to concentrate on areas of rapid and allied progress - planet discoveries, dust rings, formation and orbital evolution theory, and future searches. These are complemented by constraints from our Solar System and from brown dwarf observations. We decided not to cover biology. Even at this early stage in planetary systems science the field is now too active for one meeting to cover all aspects.

By keeping this focus in mind, we hope that the people who have decided to attend, and whose expertises cover many disciplines, will be interested in the talks and posters outside their particular areas, and that true interdisciplinary fertilisation will occur. In addition to this aim of spreading knowledge, we also hope that the participants will find the discussions useful in guiding their future work, especially in the definition of future search programmes.

So how is the symposium structured? The first day is mostly on the present searches for planets - the successful radial velocity programmes, and the microlensing, transit and imaging programmes. From late Monday to the end of Tuesday, Solar System constraints and the theory of the formation and orbital evolution of planets, together with planet structure theory will be discussed. Then from Wednesday to Thursday morning the discussion will be of the theory and observation of proto-planetary and planetary disks. From Thursday morning to Thursday afternoon, future search programmes will be covered, including ground- and space-based missions.

Photo: Greg Bacon, NASA/STScI

*Artist's impression of a planet around the star 79 Ceti.*

**Alan Penny**
*Chair SOC*
*Rutherford Appleton Laboratory, UK*

**... for Symposium 203 see page 4**

IAU Symposium 203

# Recent Insights into the Physics of the Sun and Heliosphere:

## Highlights from SOHO and Other Space Missions

The highly successful SOHO (ESA/NASA), Yohkoh (ISAS) and TRACE (NASA) missions have given us a 'new view' of our star. Studies of solar processes are a key to understanding the physics of stars in general; studies of solar activity are also critical for our understanding of 'space weather' in the vicinity of the Earth, and for the prediction of Earth-based consequences of solar events.

These missions are providing high resolution imaging and spectroscopy of the solar atmosphere, detailed measurements of the mass outflow from the Sun, and techniques for studies of the solar interior. This co-ordinated attack on solar physics has provided a breathtaking view of the Sun, with its highly complex, dynamic atmosphere, its dramatic flare and mass ejection processes, and its interior structure. The 24th General Assembly in Manchester is a timely international meeting to bring together the new results from these missions.

The first session is concerned with helioseismology - the study of the solar interior through the analysis of vibrations of the surface. SOHO is leading the way into a new era in this field, and this will be summarized at the start of the session. Scientists have been able to 'map' the differential rotation of the Sun: the striking results include the detection of the tachocline, a layer of dramatic change in the rotation rate within the body of the Sun, located some 30% of the way in to the core. This could be extremely significant for studies of the production of the complex solar magnetic fields which dominate the activity detected in the solar atmosphere. The SOHO helioseismology effort includes measurements of 'local area' vibrations at sites on the Sun, and this has been used to investigate the structure of the Sun just below the surface. Recent results include the detection of a sunspot prior to its visible formation at the surface.

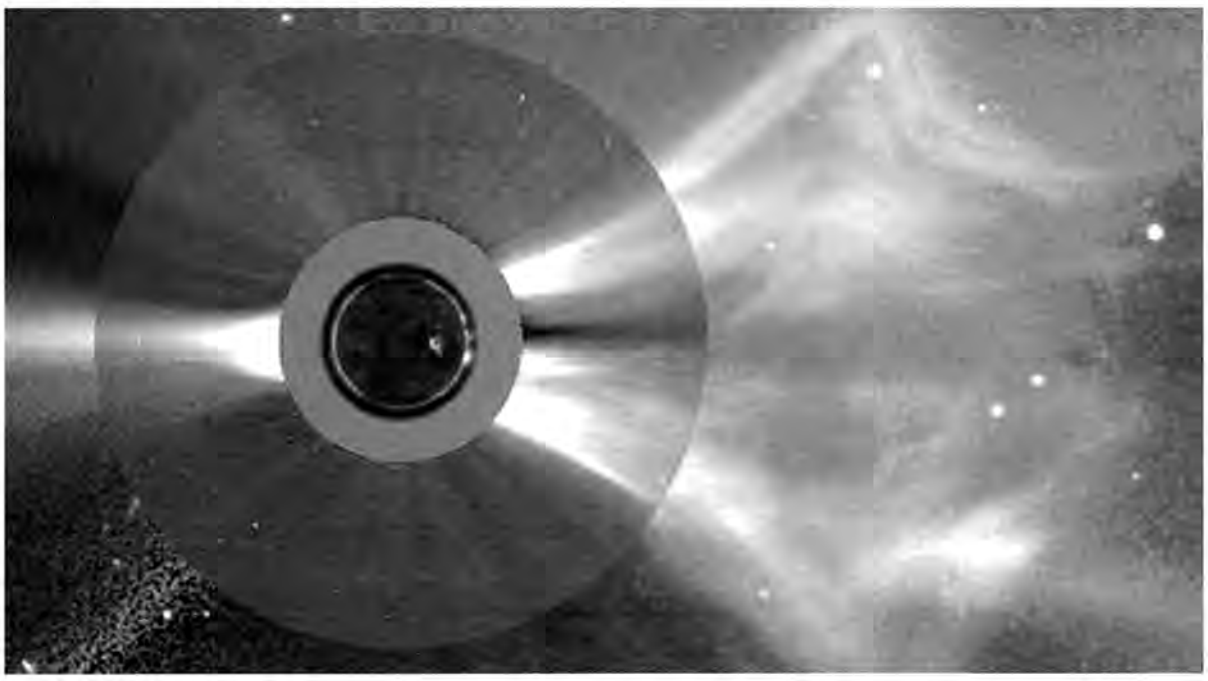


Photo: SOHO, ESA and NASA.

*A composite of three images of a large Coronal Mass Ejection. The images are from the EIT and LASCO C2/C3 instruments aboard SOHO.*

Most helioseismology studies are concerned with the 'global' Sun. One feature which intrigues solar physicists is the variability of the solar radiation output. The so-called solar 'constant' actually varies, and this means that the amount of radiation received at the Earth also varies. The Symposium also attempts to bring in the solar-stellar connection by including stellar 'asteroseismology' and 'variability' discussions.

The following sessions concentrate on the complex solar atmosphere, with emphasis on multi-wavelength observations. The SOHO/Yohkoh/TRACE combination gives us the ability to image solar plasmas at temperatures from tens of thousands of degrees Celsius to tens of millions of degrees Celsius. Talks will focus on the striking fine-scale structure and variability of the solar atmosphere, which is governed by hierarchies of magnetic loops in a continuous state of change. Spectroscopic observations, made in concert with the high-resolution imaging, are able to provide details of plasma conditions within the Sun's atmosphere. As with weather maps, we are able to determine temperatures, densities, flow speeds and even what the gases are made of. These results enable theoreticians to develop models to aid our understanding of the complex atmosphere. In particular, we want to explain the outstanding mysteries of the Sun, such as (1) why is the solar corona so hot (millions of degrees) when the 'surface' is at 6000 degrees, and (2) how does the solar atmosphere generate the solar wind? Also high on the list of outstanding questions are those concerned with the processes leading to solar flares. In these ways, the community is attempting to understand the basic processes which occur in a stellar atmosphere.

A large part of the discussion will be devoted to solar mass ejection. This is important for solar-terrestrial interactions; mass ejections can cause severe problems for power distribution, satellite control, navigation and global telecommunications companies, for example. With these spacecraft, we are able to observe solar mass ejections as never before and have had considerable success in predicting those which are Earth-directed. In parallel with this, there is a great deal of research into the onset processes of these eruptive events; can we predict them? This basic research has great potential for practical applications.

The later sessions of the Symposium move out into the heliosphere, with discussions not only of the ejection signatures in space, but also on the solar wind signatures and the nature of our local interstellar medium.

This meeting covers an enormous area. Much of the work being presented is in an early state, and in many cases the talks should be regarded as status presentations. Solar physics is enjoying something of a golden age; new results are surfacing each day.

**Richard Harrison**
*Rutherford Appleton Laboratory, UK*

# Room Changes

Due to the unfortunate flooding of Theatre B in the Roscoe Building, all sessions of Joint Discussion 5 'Mixing and Diffusion in Stars' and the Special Session on 'Astronomy for Developing Countries' have been moved to the Cordingley Theatre in the Architecture Building. This building is located in the north-western corner of the University Campus, adjacent to the North-West Car Park.

The loss of Roscoe B, and various other difficulties, have necessitated the implementation of modified arrangements for the display of Poster Papers. These were summarized on the loose sheet showing the modified Table 1 inserted into the front of the Abstracts Book. However, in case you have mislaid it, here is the full list of changes:

### Table 1 (mod.) Modified Arrangements for Display of Poster Papers

| | | Building | Display from | Remove by | Display from | Remove by |
|---|---|---|---|---|---|---|
| **S201** | | RNCM | 0800, 7th | 1400, 11th | | |
| **S202** | (31P-X.16P) | Crawford | 0800, 7th | 1100, 9th | | |
| **S202** | (87P-X.33P) | Crawford | 1230, 9th | 1300, 12th | | |
| **S203** | | Roscoe | 0800, 7th | 1300,12th | | |
| **S204** | | RNCM | | | 0800, 14th | 1300,18th |
| **S205** | | Roscoe | | | 0800, 14th | 1300,18th |
| **JD1** | | Schuster | 0800, 7th | 1400, 11th | | |
| **JD2** | | Schuster | 0800, 7th | 1400, 11th | | |
| **JD3** | | Comp. Sci. | 0800, 7th | 1400, 11th | | |
| **JD4** | | Crawford | 1230, 9th | 1300, 12th | | |
| **JD5** | | Arch. | 0800, 7th | 1600, 11th | | |
| **JD6** | | Comp. Sci. | 0800, 7th | 1400, 11th | | |
| **JD7** | | Roscoe | 0800, 7th | 1300, 12th | | |
| **JD8** | | RNCM | | | 0800, 14th | 1300,18th |
| **JD9** | | Roscoe | | | 0800, 14th | 1300,18th |
| **JD10** | | Crawford | | | 0800, 14th | 1300,18th |
| **JD11** | | Schuster | | | 0800, 14th | 1300,18th |
| **JD12** | | Crawford | | | 0800, 14th | 1300,18th |
| **JD13** | | Schuster | | | 0800, 14th | 1300,18th |
| **JD14** | | Comp. Sci. | | | 0800, 14th | 1300,18th |
| **SPS** | | Arch. | | | 0800, 14th | 1300,18th |

# Editorial

*Northern Lights* is the official IAU newspaper for this 24th General Assembly. It will have a short lifetime – only eleven issues – but, we hope, a productive one. Throughout, I will be assisted by Patrick Moore, Associate Editor; Chris Lintott, our Editorial Assistant; and Pam Rivers and Chris Bedford, our two designers. The Newspaper Office is situated in Seminar Rooms A and B of Crawford House (marked no. 2 cn the University map on p. 20 of the Final Programme). In addition, Patrick Moore and I may also be contacted at the Palace Hotel.

We are most grateful to those people who contributed material at very short notice for this first issue. We welcome contributions, comments and general assistance, such as reporting on meetings and other activities. If you feel so inclined, do please contact any of the Editorial team. Our aim is to make *Northern Lights* a really useful and worthwhile part of the 2000 General Assembly.

**John Mason**
*Editor, Northern Lights*

# Networking Lunch for Women Astronomers

The Royal Astronomical Society's Committee for Women in Astronomy and Geophysics invites you to an informal lunchtime meeting to discuss the various issues which particularly affect women astronomers.

**When – Tuesday, August 8 from 12:30 - 2:00pm**
**Where - The Niels Bohr Common Room.** This is situated on the 6th floor of the Schuster Laboratory (marked no. 3 on the University map on p20 of the Final Programme booklet in the Registration pack).

**Who** - Any interested GA24 participants, including male astronomers and non-astronomer partners.
**How** - If you have already notified us of your interest, you should find a ticket in your mailbox (located in the Whitworth Hall). Otherwise, please pick up a ticket from the box below.
**Catering** - We will provide a light buffet lunch. Those delegates who have already ordered a pre-packed meal are welcome to bring it with them.
Local Organizers: **Myfanwy Bryce, Althea Wilkinson, Phillipa Browning**

# Free Concert

*The main cultural event of the General Assembly will be a concert by*
**The Royal Liverpool Philharmonic Orchestra,**
conducted by Vernon Hadley
**on Friday, August 11th at 8pm at The Bridgewater Hall**

The programme will include the Elgar 'Cel o Concerto (soloist, Alice Neary), and pieces by Arnold, Elgar, Delius, Vaughan Williams and Walton.
This concert will be free to all Participants and Registered Guests.
You will find a ticket in your conference bag.

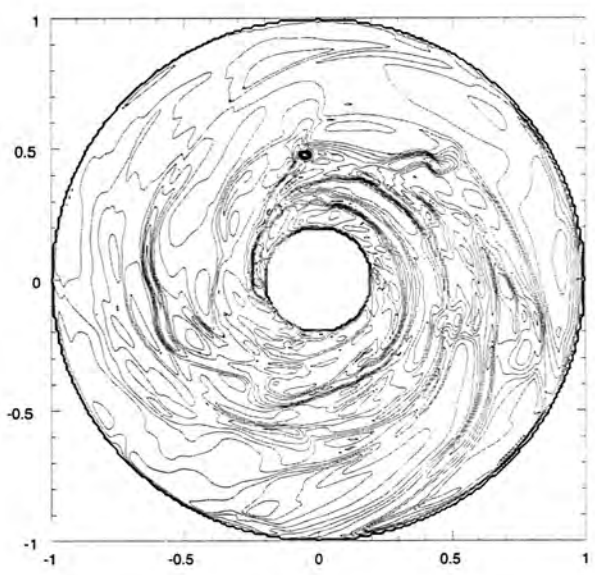
# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.2:** *Tuesday 8th AUGUST*


# How do you get hot Jupiters?



*A theoretical calculation of a 20 AU radius disk instability mechanism for gas giant planet formation in a disk of mass 0.09 $M_\odot$ comparable to that of the solar nebula. The disk has broken up into a massive ~5 $M_J$ clump at 12 o'clock.*

The discovery of 51 Pegasi's 'hot Jupiter' in 1995 launched a new era: the era of the discovery and characterization of planets in orbit around other solar-type stars. Including the new discoveries announced on Monday, at Symposium 202 (Planetary Bodies in the Universe), there are now roughly four dozen extrasolar gas giant planets known, but with none of them resembling Jupiter and Saturn in terms of their orbital parameters. Surprisingly, the planets with orbital periods greater than those of the close-in, hot Jupiters are all quite eccentric, unlike our Solar System's gas giant planets. The hot Jupiters, with orbital periods of a few days, have now been joined by 'hot Saturns'. The short orbital periods of these objects present a challenge to theorists, as do the orbital eccentricities of the longer-period planets.

There are only two ways of forming gas giant planets: top-down or bottom-up. The latter mechanism is the conventional explanation for forming Jupiter and Saturn – a solid core forms first on a circular orbit by collisional accumulation of planetesimals, and then a gaseous envelope is accreted from the protoplanetary disk. Alternatively, the disk might break-up directly into clumps that could form gas giant planets, if the disk's gas is cold enough. This mechanism naturally leads to planets in eccentric orbits (see diagram). However, neither of these mechanisms can explain the formation of hot Jupiters at ≈0.05 AU without invoking *ad hoc* physics or parameters. Instead the hot Jupiters have taught us that at least some gas giant planets experience significant orbital migration following their formation at distances of several AU from their stars. Two mechanisms are favoured: interactions with the disk's gas, and close encounters with other planets leading to gravitational slingshots. The latter mechanism is unlikely to be able to explain orbital periods as short as three days, whereas disk interactions are so inevitable and robust that leaving any planets behind at all after the disk disappears is a major problem for theorists.

Ice giant planets such as Uranus and Neptune must be made by collisional accumulation of ice and rocky planetesimals, but models of the formation of Uranus at ~20 AU require such long periods of time (billions of years) that theorists have begun to suggest making the ice giant planets in the Jupiter-Saturn region, and then migrating them outward to their current locations.

However, since formation times for gas giant planets at ~5 AU already require several million years or more (comparable to or longer than inferred protoplanetary disk lifetimes), it is unclear if moving the problem of the formation of the ice giant planets elsewhere will really help. Nevertheless, the surprising discoveries of extrasolar planets to date have already revolutionized theoretical ideas about planet formation, and will undoubtedly continue to do so as the discoveries push down toward Earth-mass planets.

**Alan Boss**
*Carnegie Institution of Washington, USA*

# Precision cosmology!

At the opening session of Symposium 201 (New Cosmological Data and the Values of the Fundamental Parameters), Malcolm Longair (University of Cambridge), who gave the introductory review, heralded the dawn of a "new realm of precision cosmology". In particular, he emphasized the importance of the interplay between the various fields and that of astrophysics. "It is no longer acceptable to use standard candles unless we can explain to three orders of magnitudes why they are standards," he commented. Many of the recent observational results, showing a degree of agreement unheard of in the not too distant past, were discussed. Particular importance was being given to the results of the BOOMERANG and MAXIMA experiments, which will feature strongly in the days to come. These results agree with each other and with inflationary predictions, and are also within two standard deviations of values for $\Omega_o$ determined by studies of primordial nucleosynthesis. A possible note of caution is provided by comparisons with the limits implied by gravitational lensing at large redshifts. These are currently in agreement with the other data, but further studies may prove otherwise. The icing on the cosmologists' cake is being provided by the latest calculations of the age of the oldest stars which places them at approximately 11-12 thousand million years old. This figure follows the adjustments of the local distance scale after the Hipparcos mission and, when combined with the latest value of 13-14 thousand million years for the age of the Universe, seems to put an end to the problem of the oldest stars appearing older than the Universe. The stage was then set for the first of the more than fifty speakers who will take the stage over the next week, not all of whom may agree with the rosy picture presented above. Watch this space...

# The General Assembly: Well Under Way



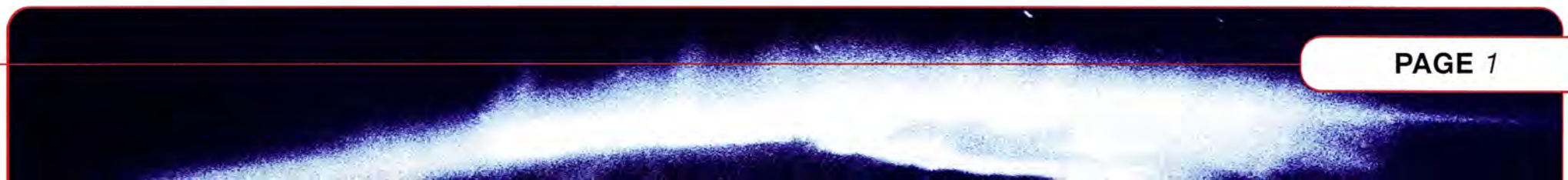

Based on past experience, the first day of registration for the 24th General Assembly was expected to be fast and furious. In fact, it was not. Around 300 delegates were anticipated on Saturday, in the Whitworth Hall, but in fact a mere 48 appeared, and the large registration area seemed to have a somewhat ghostly aspect!

We need not have worried. Sunday produced an avalanche of delegates from all over the world; to list just a few countries, there were arrivals from Denmark, the United States, Germany, Norway, Mexico, Russia, Australia, Taiwan, Switzerland, Iceland, India, Italy, Japan, Turkey, Finland, Holland, Iraq, Cyprus...No less than 277 delegates registered on Sunday, and another 298 by noon on Monday, so that by then well over 600 people were present. (The total number had risen to 850 by 5pm on Monday.) Of course, the list was by no means complete – for example, the numerous representatives from China are arriving later, and in addition there will be late registrations from delegates in Britain. It must be said that the registration affairs were handled expertly by the organizers; there was no confusion – as had happened sometimes in the past! – and all problems were sorted out with courtesy and smoothness.

So the Manchester General Assembly is now well under way, and we all look forward to a fascinating time during the next two weeks.

## The Brown Dwarf Desert

Is there a very definite distinction between planetary bodies and brown dwarfs? According to the latest results announced on August 7 at Symposium 202 the answer is 'yes'. Examine a histogram of the masses of bodies below a mass of about 10 times that of Jupiter (~$0.01M_o$) and there is a distinct gap, known as the 'brown dwarf desert'. More than fifty planetary bodies orbiting other stars are now known, but very few fall into the gap between the most massive known planetary body and the lowest-mass brown dwarf. The 'desert' is indeed almost unpopulated. It seems strange now to recall that not too many years ago no brown dwarfs had been identified, and their very existence was doubted.



# The Story of Jodrell Bank

Photo: University of Manchester

*Sir Bernard Lovell, the inspiration behind the establishment of the Jodrell Bank Observatory.*

On a cold, foggy day in December 1945, a young research scientist from the University of Manchester sat huddled over a coke stove in a gardener's shed in a muddy field in Cheshire. He was there to experiment with an ex-army radar system installed at a small botanical research station run by the University. Its location, about 30 km south of Manchester, was a little-known rural backwater called Jodrell Bank.

Fifty-five years later, that remote site is home to Jodrell Bank Observatory and the surrounding countryside is dominated by the world's second-largest, fully-steerable radio telescope. That scientist, Sir Bernard Lovell, remains one of Britain's most accomplished astronomers and the history of Jodrell Bank, with which he is synonymous, is a fascinating story of post-war determination.

Prior to the war, Bernard Lovell had been studying cosmic rays at the University of Manchester. During the war years he became involved in the development of the first military radar systems. On the very first day of the conflict, Lovell had witnessed sporadic, unexplained echoes on the coastal radar's cathode-ray tube at Staxton Wold, Yorkshire and had wondered if these might be caused by the passage of cosmic rays through the atmosphere. After the war, he returned to Manchester with the hope of investigating this possibility. He acquired some ex-army radar equipment which was set up in the quadrangle of the University's Physics Department.

Photo: University of Manchester

*The Lovell Telescope, after its refurbishment in the early 1970's.*

Lovell soon found that the equipment was of no use in the centre of Manchester. The radar's cathode-ray tube was awash with interference from the electric trams running past the Physics Department. Permission was given for Lovell to move his equipment, for a two-week period, to the University's small botanical research station south of the city. In early December 1945 the three trailers arrived at the remote spot, and were set up next to the botanists' huts.

It was not long before Lovell found that the sporadic echoes were not, in fact, from cosmic ray showers. They were from the plasma trails of meteors. Lovell had soon outstayed his two-week period at the botanical station at Jodrell Bank, but he remained, acquired some co-workers and moved more equipment into the surrounding fields. Over the next few years they studied the meteor echoes in some detail, and were able to show that many meteors originate in the dust-tails of comets.

In 1947 the scientists obtained a small grant to build a 218-ft (66.4-metre) parabolic reflecting aerial made of wire mesh, easily the largest radio antenna in the world at that time. With this transit instrument they tried, once again, to detect cosmic ray showers. But by this time the equipment was proving more useful in other areas of research, and Lovell soon gave up the idea of studying cosmic ray showers with radar techniques and turned his attention to radio astronomy.

The 218-ft radio antenna at Jodrell Bank was put to work studying astronomical sources and, amongst other discoveries, made the first detection of radio waves from another galaxy, M31. The success of this instrument led Lovell and his colleagues to conceive of a telescope of similar size that would be fully steerable. The astronomer's encroachment into the botanists' fields was about to become permanent.

Eventually, Lovell engaged a consulting engineer based in Sheffield, Charles Husband, to draw up plans for an ambitious radio telescope. It was originally designed to work at long wavelengths with a wire mesh surface, but the 1951 discovery of the 21-cm hydrogen line resulted in a redesigned solid steel surface. After extensive negotiations, the Department of Scientific and Industrial Research agreed to help fund the project. Construction of the telescope was begun in September 1952 and completed in 1957. With the telescope still not entirely operational, an event occurred which instantly propelled the project into the public eye. On 4th October 1957 the Soviet Union launched the first artificial satellite, Sputnik 1, into earth orbit. The advanced state of the Soviet space programme shocked the world. The rocket that carried Sputnik into orbit was a modified ballistic missile and military leaders were concerned that no radar had detected it. Hurriedly, Lovell and his colleagues equipped the giant telescope with a radar system and on 12th October saw the echo of the rocket, still orbiting the Earth, as it sped 160 km overhead at 8 km a second. Jodrell Bank was subsequently crucial in the accelerating space race, tracking US and Russian rockets and, in October 1959, receiving the first photograph of the far side of the Moon from Lunik 3.

In the early 1970s the telescope received a new reflecting surface. The modified telescope now weighs 3200 tonnes, and has a dish with a diameter of 76.2 metres, reaching a maximum height above the ground of 89 metres. On its thirtieth birthday, in 1987, the instrument was renamed the Lovell Telescope, in honour of its founder. It is still the world's second largest, fully-steerable radio telescope and has continued to participate in important astronomical breakthroughs, including the discovery of quasars, the confirmation of the existence of pulsars and the detection of maser emission from star-forming regions.

Jodrell Bank has also been a pioneer in radio interferometric techniques. In November 1969, transatlantic fringes were obtained on several continuum sources between the Lovell telescope and Arecibo. The first true VLBI image was obtained for 3C 147 in 1974, using telescopes in the UK and US. By the mid-70s, Jodrell Bank had plans for an entire network of UK antennæ. At the end of 1980 a system of six telescopes came into service and in 1990 a new 32-metre telescope at Cambridge was added to the array. The instrument was named MERLIN, the Multi-Element Radio Linked Interferometer Network and still represents Jodrell Bank's primary research instrument. MERLIN routinely matches the angular resolution of the HST, and Jodrell Bank astronomers are active researchers in many other wavebands. The observatory now operates a total of nine radio telescopes and includes an active optical astronomy group.

As Jodrell Bank approaches its half-century, it still remains at the forefront of astronomical research. Over the coming years several major developments are planned, including the provision of optical-fibre links for the MERLIN array and the replacement of the surface of the huge Lovell telescope. Visits to Jodrell Bank Observatory are available free to IAU delegates.

**Alastair G. Gunn**
*University of Manchester*
*Jodrell Bank Observatory*

# Dennis Sciama Remembered

With this meeting of the IAU taking place in Manchester, it seems appropriate to say here a few words to commemorate Dennis Sciama, who was born in Manchester in 1926 and who died at the end of 1999, having played a pivotal rôle in the development of modern cosmology and relativistic astrophysics both through his own work and through being the mentor of a large number of research students and colleagues who then went on to become leading figures in their own right. It is sad that he was not here with us at Symposium 201; undoubtedly, he would have made valuable contributions to it.

He was a research student of Paul Dirac in Cambridge just after the Second World War, working on Mach's principle - the idea that the nature of local physical laws is affected by the state of the whole Universe. He became passionately involved with developments in cosmology and relativity theory, interacting particularly with Hermann Bondi, Thomas Gold, Fred Hoyle and Felix Pirani and becoming, for a while, a committed advocate of the Steady-State theory of the Universe, until eventually abandoning it in the face of mounting contrary observational evidence and switching allegiance to the Big Bang picture which then became standard. He then became a pioneer of investigating astrophysical processes in the evolving and expanding universe, making full use of his extremely broad knowledge of basic physics to make fruitful links between different areas.

His interests spanned studies of anisotropies in the microwave background, the structure of radio sources and quasars, X-ray astronomy, the physics of the interstellar and intergalactic medium, astro-particle physics and the nature of dark matter. Perhaps most significant of all was his advocacy of relativistic astrophysics, the study of black holes and the interaction between quantum theory and general relativity. The group which he led in Cambridge in the 1960s (including George Ellis, Stephen Hawking, Martin Rees and Brandon Carter) and his links with Roger Penrose, were immensely influential in this. After Cambridge, he subsequently led groups in Oxford (1970s and early 1980s) and at SISSA in Trieste (1980s and 1990s), carrying on the earlier traditions and creating an ever-expanding 'family' of students and collaborators. Well-known students from these later years include John Barrow, James Binney, Philip Candelas and David Deutsch.

He will be remembered particularly for the warm friendship and excitement in doing physics which he communicated to those around him, for his charismatic lecturing and for his books (*The Unity of the Universe, The Physical Foundations of General Relativity, Modern Cosmology* and *Modern Cosmology and the Dark Matter Problem*) which have been of great importance for introducing many people to these subjects. He leaves a legacy of a large group of physicists and astronomers who share the privilege of having known him, and who will continue to carry on something of the style and enthusiasm which he brought to our subject.

**John Miller**
*University of Oxford, UK*

## Planet of Tau Boötis: Reflection Spectrum Not Confirmed

Tau Boötis is one of the stars definitely known to be attended by a planet. It had been reported that the reflection spectrum of the planet had been observed – and this would have been the first optical confirmation of a planet orbiting another star. However, at Symposium 202 (Planetary Systems in the Universe), held on August 7, it was announced that new observations had not been confirmatory.

Andrew Collier-Cameron (University of St. Andrews, UK) and his colleagues observed for six nights with the William Herschel Telescope, under excellent conditions, and found that by sheer bad luck they had been misled by 'random noise'. However, the investigations have still been useful. They mean that the Tau Boötis planet has the expected size and albedo. Had the reflection spectrum been observed, the planet would have been exceptional. The new investigations were to a much greater depth, and a great deal has been learned from them. Despite the initial disappointment, it may well be that reflection spectra will be detected before long using present day ultra-sensitive equipment.

# The Origin of Planets

At the end of the 20th century, theories of planetary origin have centred around two main concepts. The first of these, the planetesimal model, is dominant in that it has the greatest number of adherents, generates the greatest number of published papers and, presumably, project funding. This idea has been around for thirty years and still no clear-cut, generally accepted mechanism has emerged that will produce giant planets on a suitable timescale. In a recent BBC television series *The Planets*, one solar nebula theorist admitted that, "...according to our theories, Uranus and Neptune do not exist". We have a number of papers on this theme at the present meeting and even one that considers the pros and cons of the planetesimal model against direct accretion in a disk.

The second concept involves the idea that planets are produced by interactions between stars and protostars within a forming stellar cluster. This was first suggested in 1964 when it was shown that a compact star could capture material from a tidal filament drawn out of a diffuse protostar. More recently (e.g. Poster S202.051P) it has been convincingly shown by detailed SPH modelling that the captured material could be in the form of giant protoplanets. Other types of interaction have been extensively studied by A Whitworth and his co-workers. These involve either dynamical interactions between disks around stars, or the tidal interaction of one star on the disk of another. In both cases SPH modelling, beautifully illustrated on p.13 of the booklet *Astronomy in the UK* included in your conference bag, reveals the formation of planetary companions to stars.

The choice is between two concepts. The first has struggled for thirty years, is replete with complex mechanisms and still generates more questions than answers. The second produces planets without fuss or difficulty in various ways and calls on no more theoretical aids than tidal effects, collisions of streams of matter and gravitational instability.

I wonder what William of Occam would have chosen?

**Michael Woolfson**
*University of York, UK*

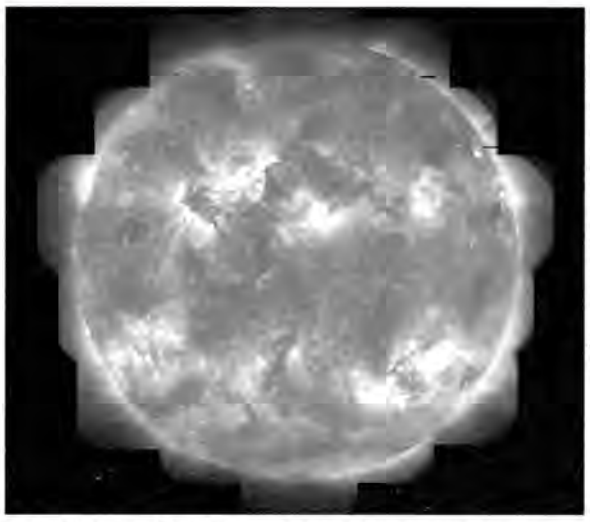


*Photo: NASA and Lockheed Martin Missiles and Space.*

*Full disk image of the Sun consisting of three separate images from the TRACE Satellite.*

# Networking the Solar Network

The increasing reliance of global telecommunications on satellite technology means that the vagaries of the space environment are no longer of interest only to a few astronomers worrying about the health of their space-based instruments. Instead, understanding the fluctuations in radiation and magnetic fields around the Earth has become a matter of international concern.

This is why the European Solar Magnetometry Network (ESMN) has been established to develop in a Europe-wide partnership, tools for studying the Sun's magnetic field, which we know to be the dominant cause of these fluctuations.

An astronomical readership will also not need to be reminded that a proper understanding of the magnetic field of our one, nearby, highly-resolved star is central to understanding the larger problem of stellar magnetic activity.

The ESMN works on several lines of research, operating in parallel. At optical wavelengths, the highest resolution instruments are ground-based, and we are using the Vacuum Tower Telescope and the Swedish Vacuum Telescope with the latest image deconvolution techniques to obtain unprecedented resolution of solar granulation and sunspots. At shorter wavelengths – in the hot chromosphere and even hotter transition region and corona – we are using space-based data from SOHO and TRACE (The Transition Region and Coronal Explorer).

On the theoretical track, we are developing numerical techniques to model the propagation of waves through magnetic structures in the solar atmosphere, in the hope that we can learn how to use observations of such waves to determine the configuration and strength of solar magnetic fields. Already we have made some progress with the realization that non-vertical fields inhibit the growth of wave amplitude into the non-linear régime, so that the presence or absence of high-amplitude waves and shocks may be useful diagnostics of the orientation and strength of the underlying field.

**Colin Rosenthal**
*University of Oslo, Norway*

# Kyoto Model Lives ... at least until 2000?

*Carole Jordan and Virginia Trimble.*

Astronomers trying to tell the world how exciting their work is, tread a precarious, narrow path between seeming to be unable to make up their minds about the age of the Universe, how stars form or whatever, and seeming to claim, as new and fundamental, ideas almost as old as some of your Vice-Presidents. Our current understanding of the basic cosmological parameters either avoids both sins or commits them both simultaneously, depending upon your point of view.

A symposium at the 1997 General Assembly in Kyoto, addressing many of the same issues as IAU Symposium 201 this week, ended with a panel discussion in which several of us put up slides with our 'best bet' values of the cosmic baryon density and sc forth. Admittedly, some of the other panelists went on record as doubting the correctness of the entire hot Big Bang story. And indeed representatives of both camps are with us here in Manchester.

In the intervening years, new results have been announced from studies of Type Ia supernovae at moderate redshift, and more recently from the mapping of fluctuations within the cosmic microwave background on scales of about 1°. I have been amazed and on the whole pleased, to see that the 'new' numbers come very close to the 'Kyoto model'; that is a density parameter of gravitating matter $\Omega_m \approx 0.3$ (divided among baryons with $\Omega_b \approx 0.03$, non-zero rest mass neutrinos with $\Omega_\nu \approx 0.02$, and cold dark matter with $\Omega_{cdm} \approx 0.25$), and a density parameter of vacuum energy $\Omega_\Lambda \approx 0.7$, for $H \approx 65$km/sec/Mpc. All of these come with small error bars that do not include the systematic errors we haven't thought of. I predict that we will come to the end of S201 with rather similar numbers. Just remember the old sailors adage: *constant bearing means collision.*

**Virginia Trimble**
*University of California, USA*

# Let the presses roll...

With the first issue of *Northern Lights* ready for printing, Associate Editor, Patrick Moore, pressed the button to start the presses rolling, and Patrick and Editor, John Mason, inspected the first copy as it came hot off the press.

Don't forget to pick up your copy of the newspaper each day from one of the many collection points. These are located in Whitworth Hall beside the mailboxes, and by the coffee serving points in all of the meeting venues. If you happen to miss an issue then back issues can be collected from the newspaper office located in the Crawford Building, Seminar Rooms A and B.

Come in and see us if you have an item for the paper. Our editorial team has been augmented by Julie Semmence, who has joined us as Administrative Assistant.

# IAU Press Office

The IAU Press Office will be open throughout the General Assembly. In charge of the Press Office is Jacqueline Mitton.

The office is located in Seminar Rooms D and E of Crawford House, next to the *Northern Lights* office. The Press Office is available to all delegates for contacts with the news media (journalists, TV, radio, etc.). Delegates who need any assistance in this respect should contact the Press Office direct.

The Press Office telephone numbers are 0161 275 9449 and 0161 275 9458. The fax number is 0161 273 6380.

## Public Understanding of Science Lecture

The IAU General Assemblies always include several public lectures, given by distinguished astronomers. The first of these is being delivered this evening by Professor David Hughes in the Renold Theatre of UMIST (University of Manchester Institute of Science and Technology) at 7pm. His title is 'Deep Impact: Asteroids and Comets', a subject very much in the public mind. Patrick Moore will be in the Chair.

# Welcoming Reception

A welcoming reception for all delegates and guests was held at the Staff House, University of Manchester, on the evening of August 7. These gatherings are always enjoyable, particularly when there is no set agenda; it provides a splendid opportunity to make new friends and to renew old acquaintances.

Predictably, there were guests from all countries; some of who had been to many IAU General Assemblies, and those who are arriving for the first time. These included Presidents, Vice-Presidents and IAU officials, both past and present. Staff House, where the event was held, is ideal for this type of function; it is spacious and well equipped, without sacrificing any of its informality.

All in all, this was a most pleasant and memorable reception, so typical of the excellent atmosphere which has so far marked the 24th General Assembly – and will no doubt continue to do so until we part in just under two weeks' time.

# Encyclopædia launched at start of GA24

A major new Encyclopædia of Astronomy was launched on August 7, at a drinks reception in the Staff House, to which all IAU General Assembly participants were invited. The publishers are the Nature Publishing Group and Institute of Physics Publishing.

Astronomy and astrophysics encompass virtually everything more than 100 kilometres above the surface of the Earth, as well as aspects of geophysics. The fields are both vast and interdisciplinary, and as the Editor-in-Chief of the *Encyclopædia of Astronomy & Astrophysics* I was keen to push out the boundaries.

If nothing else, this explains why the Encyclopædia is such a large work!

Astronomy is as universal as its subject matter. I also wanted to reflect its international character through the membership of the Encyclopædia's Board of Editors and its hundreds of authors, from many of the astronomically active countries in the world.

The 2500 articles show the unity of astronomy, and celebrate its diversity. They pay tribute to astronomy's heroes and the technology that they created to advance our science.

Our next challenge is to publish the Encyclopædia as an electronic version on the WWW, taking advantage of the new information technology to refresh the material continuously, like a self-organizing quarterly volume of review articles. It may be a never-ending job!

**Paul Murdin**
*British National Space Centre*

## Have you got your Concert ticket yet?

In our announcement about the Free Concert on the back page of the first issue, we stated that the ticket was included in the conference bag. In fact, although you will find a buff-coloured slip about the concert in your bag, you must pick up a ticket from the Registration Desk, if you wish to attend.

Don't miss the cultural highlight of the 24th General Assembly.

## 1 How to set up a data table

Astronomical Data Centres like CDS and NASA/ADC have agreed on certain standards for the preparation of tabular data which they prepare for public accessibility through their centres. You, as an author, could facilitate their work and increase the ease of use of your data tables if you stick to these conventions. See http://vizier.u-strasbg.fr/doc/catstd.htx

Documentation also has a standard format allowing simultaneous searches through hundreds of such tables using web tools. If, for your research, you'd like to see more of these tables available on the WWW, why not send your data tables to these centres in the appropriate form and together with standard documentation?

**Heinz Andernach**
*ESA, IUE Observatory*
*Villafranca, Spain*
*for Commission 5 WG on Astronomical Data*

# Want to Keep Fit?

If you're becoming a couch potato, sitting in GA meetings all day, then get in shape.

The Armitage Centre close to the Fallowfield Halls of Residence can offer sports and keep fit facilities to delegates attending the IAU conference upon production of their card or badge as follows:

| | |
|---|---|
| Tennis: | £4 per court per hour |
| Squash: | £2.80 per court per 45 min |
| Badminton: | £4.20 per court per hour |
| Five-a-side football (indoor): | £24 per court per hour |
| Five-a-side football (outdoor): | £12 per court per hour |
| Netball: | as per five-a-side |
| Basketball: | as per five-a-side |
| Hire of synthetic pitch: | £21 per hour |
| Jogging: | free of charge |

*All above subject to availability.*

For delegates wishing use the fitness suite it is essential that they undergo a 45-minute induction session. These will be FREE OF CHARGE and will take place on the following days:
Tuesday, August 8: 4-5 pm and 9-10 pm - TODAY
Thursday, August 10: 4-5 pm and 9-10 pm

Only up to six people per session can be accommodated, and this will be done on a first-come, first-served basis. They will then pay £3 each time they use the facility.

The Armitage Centre is open Monday to Friday from 9.15 am - 11 pm, and on Saturday and Sunday from 10am - 8pm.

Please wear loose clothing, i.e. track suit/shorts and trainers.

## 1 The Naming Game

Did you know that the mission of IAU Commission 5 Task Group on Astronomical Designations is to promote clear and unambiguous designations of astronomical sources?

See http://ulda.inasan.rssi.ru/IAU/SUBDIVISION/TG_D for details.

Look out for future news items from the TG on Designations each day under "The Naming Game" heading.

**Helene R. Dickel**
*University of Illinois, USA & Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# Locating Mailboxes

To locate anyone's mailbox in the Whitworth Hall, you do not necessarily have to look up their name on one of the two computers provided. If the name appears in the Participants List booklet (included in the conference bag), where they are printed in alphabetical order, then the four digit Registration number to the left of the name is also the mailbox number.

Don't forget that it is the mailbox **BELOW** the number which is the correct one.

## Owens Park Bar

**For the benefit of all those people staying at the Halls of Residence, there will be a bar open at Owens Park from 7pm until 11pm Monday to Saturday, and from 7pm to 10.30pm on Sundays.**

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.3:** *Wednesday 9th AUGUST*

# New Programme for the Oschin Telescope

The Palomar 48-inch (1.2-metre Oschin telescope has had a long and profitable career. Now it is about to begin a new phase of activity – the electronic detection of comets and Near-Earth Asteroids (NEAs).

Recent decades have witnessed a dramatic increase in the discoveries of NEAs, normal asteroids and comets. The number of known NEAs exceeds 1000, and of these over 400 have diameters greater than 1km. Over 250 are classed as Potentially Hazardous Asteroids (PHAs). Only twelve of these PHAs were known when the first dedicated search for NEAs – the pioneering Palomar Planet-Crossing Asteroid Survey (PCAS) – started in the early 1970s. After a few years of discovery, more attention was given to these small Solar System bodies.

The NEAT programme, an offshoot of the PCAS programme, is in the process of upgrading (NASA funded) the 48-inch (1.2m) Oschin Telescope at Palomar Observatory. This telescope has conducted the two Palomar sky surveys (1949-1956 and 1985-2000) and numerous other limited programmes including asteroid surveys by the author and Tom Gehrels of the University of Arizona, using its wide field of view. The Palomar-Leiden Survey of Faint Asteroids was carried out in the early 1960s and provided a statistical base for asteroid studies. Notable discoveries from this time period were 1979 VA(4015) Wilson-Harrington, the first evidence of an asteroid evolving from a comet to an asteroid over a thirty year period (1949-1979), and the stunning discovery of 1982 DB (4660 Nereus), most accessible asteroid for low-cost spacecraft missions (current and future target object). Impressive detailed images of Comet Halley were taken in the spring of 1986 using the Schmidt. Other important work carried out on the Schmidt included Halton Arp's *Atlas of Peculiar Galaxies*, and Charles Kowal's Solar System Search which led to the discovery of Chiron.

The new programme will, it is hoped, contribute at least 50% to the NASA goal of discovering 90% of the near Earth asteroids (NEAs) larger than 1 km by 2009. These are NEATs primary targets.

With the addition of a computer-control pointing and sequencing system, and a large format multi-CCD camera, NEAT will begin a large-scale asteroid survey in late 2000.

An enhanced and enlarged version will be the result of a large CCD array to be added to the 48-inch by Charles Boltay of Yale University, David Rabinowitz, Yale University and co-investigator of NEAT by 2001. This augmentation (112 CCDs) will increase sky coverage to over 9 sq° in excess of other search telescopes' field of view.

**Eleanor Helin**
*NASA Jet Propulsion Laboratory, USA*

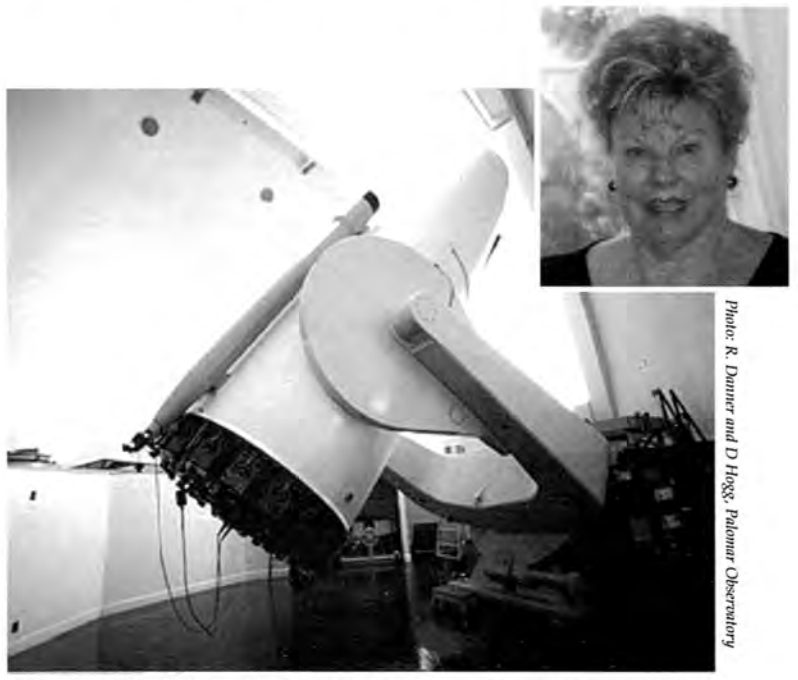


*Photo: R. Danner and D Hogg, Palomar Observatory*

*The 48-inch Oschin Schmidt Telescope at the Palomar Observatory, which is about to join the hunt for NEAs, with Eleanor Helin (inset).*

# S Marks the Spot

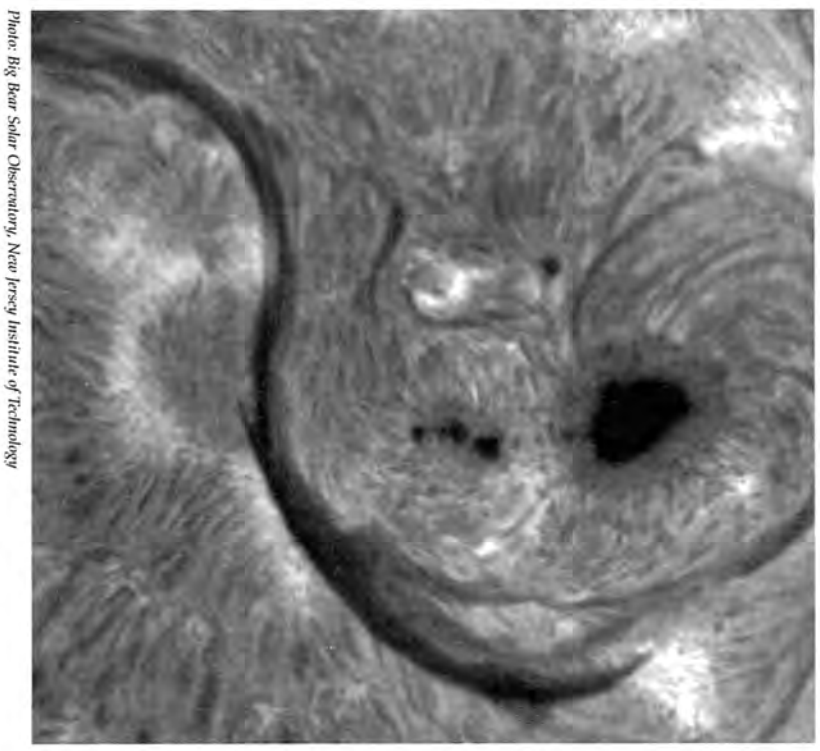


*Photo: Big Bear Solar Observatory, New Jersey Institute of Technology*

*High resolution H-alpha image of a sigmoidal structure acquired on 19 August 1999 at the Big Bear Solar Observatory during the third Whole Solar Month campaign.*



*Photos: Yohkoh, NASA and ISAS*

*Sigmoidal structure observed in X-rays by the Yohkoh satellite on 7 April 1997. **Above**: before eruption. **Right**: cusp shape seen during eruption.*

At Symposium 203 (Recent Insights into the Physics of the Sun and Heliosphere) Sarah Gibson (Catholic University of America) yesterday presented the most recent results from studies of active regions of the Sun known as 'sigmoids.' These S-shaped disturbances are "good for sitting and staring at", for they are believed to kick off many of the other, more familiar features of solar activity. Best seen in the X-ray region of the spectrum, and well within the grasp of instrumentation on the Yohkoh satellite, the studies presented were part of the outpouring of data from the third Whole Solar Month campaign. A representative sequence of images was shown, with the S-shape altering to a cusp during eruption before returning to the standard formation as the disk was crossed. Work has also been done on modelling the conditions around the sigmoid, and support is found for a view in which high altitudes are hotter than lower ones. This results in an upflow of material at the ends of the S, and when combined with the large scale of these features – covering a significant fraction of the solar disk – this may result in their high levels of activity. Whatever the final outcome of this work – and much more detail can be found on the relevant poster (S203.105) – it seems certain that sigmoids are features to watch out for in forthcoming SOHO, TRACE and Yohkoh observing campaigns.

## Data from Balloons

The first talks on the second day of Symposium 201 focussed on both ongoing and future missions to map the cosmic microwave background (CMB). Much of the excitement was centred around the two balloon-borne experiments; BOOMERANG and MAXIMA. Both teams have announced and published data in recent months which seem to support the idea of a geometrically flat Universe. In other words, the total amount of mass in the Universe appears to be exactly on the critical value, as predicted by inflation. Confidence has been further bolstered with the electronic publication of a jointly authored paper confirming that both groups' results are consistent. This was highlighted by Paul Richards (University of California), who did comment that in order to obtain the fit it was necessary to reduce the values found by MAXIMA by one standard deviation (8%) and increase those from BOOMERANG by one standard deviation (20%). The mood of the meeting was that the necessity for this small adjustment would be removed by the addition of future data, for example from the second full flight of BOOMERANG, which are now being analysed. The paper can be located via the preprints service at http://xxx.lanl.gov/abs/astro-ph/0007333.

# The IAU Inaugural Ceremony

The Inaugural Ceremony, which takes place today at 2 pm sharp in Manchester's historic Bridgewater Hall, is one of the main highlights of the 24th General Assembly. There are distinguished speakers, as one would expect, and there are also two musical items. First, to initiate the whole proceedings, an organ recital by Paul Walton, and then, before the First Session of the General Assembly, an interlude by the Zeneka Brass Quintet. These musical items are described separately on this page by Sir Bernard Lovell, himself a skilled organist.

*Nigel Weiss, RAS President*

The first of the main speakers is Professor Nigel Weiss, President of the Royal Astronomical Society. He grew up in South Africa, but has spent most of his life in Cambridge. After reading physics as an undergraduate he began research in geophysics, and started thinking about the origin of the Earth's magnetic field, but soon decided that solar magnetism was more interesting.

After spells at MIT and at Culham, developing computational magneto-hydrodynamics, he returned to Cambridge as a Lecturer in the Department of Applied Mathematics and Theoretical Physics (and a Fellow of Clare College), and has been there ever since, apart from sabbaticals in the United States, Munich and, most recently, in Japan. In due course he became a Reader and Professor of Mathematical Astrophysics, and for five years held a SERC Senior Fellowship. He comments that after sitting on many Committees, being President of the RAS is not just an honour, but a pleasure.

His research extends into many fields. At present its central aim is to explain the structure and origin of magnetic fields in the Sun and other stars. He is also engaged in modelling stellar dynamos and explaining the origin of episodes of reduced solar activity such as the Maunder Minimum, as well as in exploring the relationship between solar activity and climatic change. Since the IAU is holding its General Assembly in England for the first time in thirty years, it is surely appropriate for the first speaker to be the President of the RAS.

*Councillor Hugh Barrett, Lord Mayor of Manchester*

Professor Weiss is followed by Manchester's leading citizen – the Lord Mayor, Councillor Hugh Barrett. He is Manchester born and bred; he was educated at St. Michael's RC School, Ancoats, and his career has included electrical engineering and a retail outlet business. He was elected as Labour Councillor for Ardwick in 1968, where he served until 1994, when he was elected to the Sharston ward. He is a senior member of the many Committees, and continues to play a leading rôle in Manchester's affairs.

*Katharine Perera, Pro-Vice-Chancellor, University of Manchester*

We are the guests of the University of Manchester, and we are delighted that the next speaker will be Professor Katharine Perera, Pro-Vice-Chancellor of the University. Katharine Perera grew up in Cheshire. She read for a degree in English Language and Literature at Bedford College, London University; after graduating she went to Malaysia as an English teacher with Voluntary Service Overseas. On return to the UK she taught English in Merseyside schools, and after gaining an MA in Linguistics at Manchester University spent three years engaged in teacher training. From 1977 she lectured in Linguistics at Manchester University, obtaining her PhD in 1989. Her academic interests have always concerned children's language development, and in addition to writing books and papers she was for fourteen years editor of the *International Journal of Child Language*. In 1991 she was appointed to the new Chair of Educational Linguistics at Manchester University. In 1994 she was made a Pro-Vice-Chancellor with responsibility for teaching and learning across the University, and in 1997 became a senior Pro-Vice-Chancellor, with responsibility for academic development.

*Sir Robert May, Head of UK Office of Science and Technology*

Our Inaugural Ceremony would not be complete without welcoming the Chief Scientific Advisor to the UK Government and Head of the UK Office of Science and Technology. Professor Sir Robert May, Fellow of the Royal Society, holds this position on leave from his Royal Society Research Professorship in the Department of Zoology, Oxford University, and at Imperial College London. Previously he was Class of 1977 Professor of Zoology at Princeton University (1973-1988) and Professor of Physics at Sydney University (1969-1973). Trained as a theoretical physicist and applied mathematician, for the past twenty years or so he has studied various aspects of the ways in which populations and communities are structured. It is indeed appropriate to hear from him at our Inaugural Ceremony, particularly in view of the presence here of Jodrell Bank – undoubtedly the most famous radio astronomy observatory in the world.

*Robert Kraft, IAU President*

To complete our panel of distinguished speakers, we have Professor Robert Kraft, President of the International Astronomical Union. He is Professor Emeritus of Astronomy and Astrophysics and Astronomer Emeritus, University of California Observatories and Lick Observatory. His current research interest is the chemical composition, kinematics, and spatial distribution of stars in the halo of our Galaxy in those of other galaxies. He and his research associates have also been studying characteristics of RR Lyræ stars and evolved blue stars in the far halo, and also the chemical compositions of evolved blue stars in globular clusters. In addition, of course, his research extends over many other fields of astrophysics and cosmology.

The Inaugural Ceremony is always a great occasion. It is marked today by outstanding speakers, and it sets the scene for what we all expect to be a particularly significant General Assembly.

# Musical Interludes

The organ recital, which precedes the official opening of the 24th General Assembly will be of special interest to astronomers because it includes music by William Herschel. In March 1781, Herschel discovered the planet Uranus; he was appointed King's astronomer (not Astronomer Royal) by King George III, received the highest honour of the Royal Society, constructed his great telescopes and devoted the rest of his life to the study of the Milky Way and the nebulæ.

It is as an astronomer that Herschel is best known, but, in his earlier life he was a professional musician. At the age of 14 he was engaged as a musician in the Hanoverian Guards. In 1757, when 19 years old, Herschel came to England. He earned his living as a music-copyist, but his musical ability was soon recognised. He journeyed north, and became head of the band for the Earl of Darlington's regiment of Militia. In 1761 he resigned and after various freelance activities he was appointed director of public concerts in Leeds. Five years later he became organist in the parish church of Halifax, and in December 1766 he was appointed organist at the Octagon Chapel in the city of Bath. Herschel occupied that post as his astronomical interests developed, eventually resigning in 1782 to become one of the world's great observational astronomers. As a musician Herschel was an oboeist, organist, conductor and composer. In his year in Leeds he composed over 20 symphonies, and during the Bath period most of his organ music was composed – mainly short preludes and fugues for the services at the Octagon Chapel.

It is one of these pieces, *Andante and Allegro*, which we will have as the second item in Paul Walton's recital on the Bridgewater Hall organ (now recognised as one of the finest organs in Europe). It will be played from a manuscript score given to the present writer in 1967 by Susi Jeans (wife of the astronomer Sir James Jeans).

Paul Walton is one of the brilliant young musicians to emerge from the Royal Northern School of Music. Now in his twenty-fourth year, he began studying the organ at the age of 12, and entered the Royal Northern School of Music as an undergraduate in 1995. In 1999 he graduated with an honours degree, and in that year he gained the Fellowship of the Royal College of Organists and won the Dixon Prize for improvisation. He is now a postgraduate in the Royal Northern College of Music, and he has been an organ scholar at Manchester Cathedral since September 1999.

Paul Walton will include in his recital one of the Rhapsodies for organ by the 20th century English composer Herbert Howells.

The second musical interlude during the Inaugural Ceremony will be the Zeneka Brass Quintet and we are grateful to the Royal Northern College of Music for the following information about the performances.

The musicians of the Zeneca Brass Quintet are Richard Cowen and Mark Allen (trumpets), Liam Duffy (horn), Jonathan Parkes (trombone) and James Pickering (tuba).

The Zeneka Brass Quintet was formed in 1996 whilst the members were in the first year at the Royal Northern College of Music. The players, all aged twenty-one years, have had strong musical upbringings, playing in both the National Youth Orchestra and the National Brass Band of Britain, and are all very successful as individual performers. Richard Cowen works regularly with Manchester Camerata, the Mahler Chamber Orchestra of Europe and the Northern Chamber Orchestra; Mark Allen is a regular extra-work player with the Hallé Orchestra and recently has performed with the BBC Philharmonic and the London Symphony Orchestras. Liam Duffy is in great demand throughout the region including the BBC Philharmonic, Royal Liverpool Philharmonic and Hallé Orchestras. Jonathan Parkes and James Pickering have performed with some of the country's leading brass bands as well as with the Hallé and Manchester Concert Orchestras. The ensemble performs regularly throughout the country, and also gives many recitals, some of which have been performed at the Bridgewater Hall. The Quintet has a wide and varied repertoire.

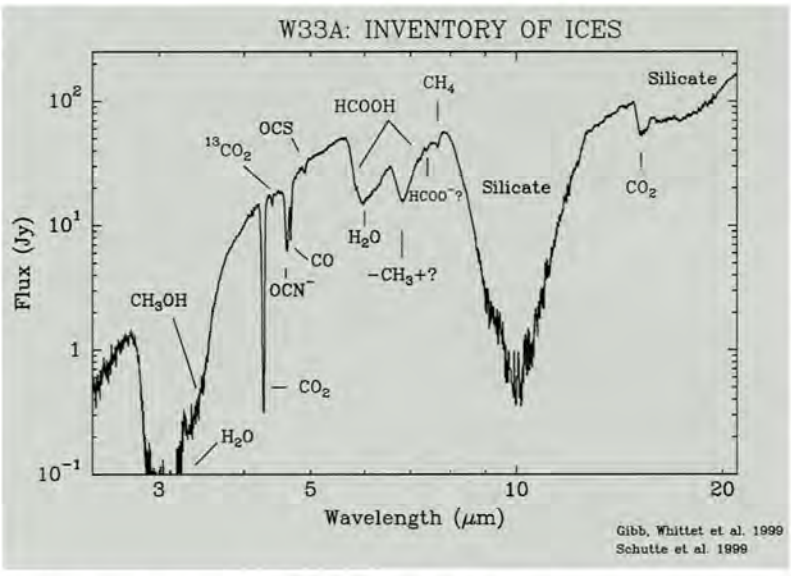
The Zeneka Brass Quintet appears by kind permission of the Principal, Royal Northern College of Music.

**Bernard Lovell**
*Jodrell Bank Observatory*

1

# Joint Discussion

## Atomic and Molecular Data Needs in Astronomy




*ISO Spectrum of ice bands in the young stellar object W33A.*

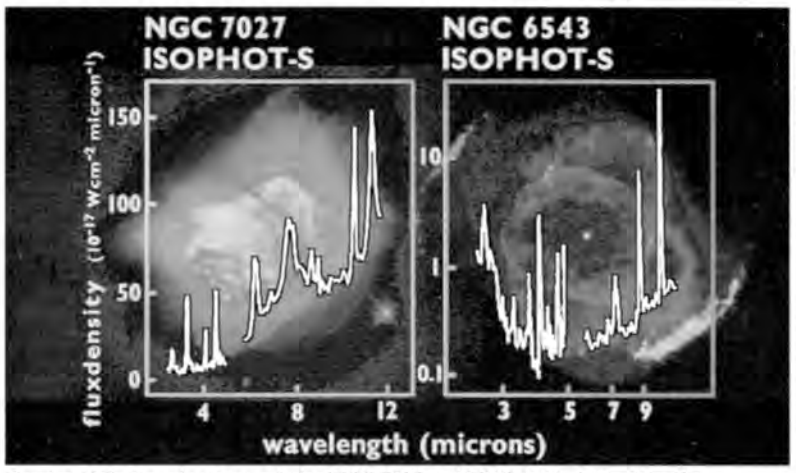
Advances in astronomy depend on the detection of photons to observe new phenomena and to test and refine theoretical models. Over the last thirty years, techniques for the detection of these elusive particles have enabled us to explore the Universe from gamma-ray to radio wavelengths. At the same time, the development of computing power has enabled us to make complex models of astrophysics and to make subsequent predictions. As a result, we have powerful probes of many environments which allow for substantial advances in our understanding of the Universe.

The interpretation of astronomical observations relies to a great extent on the availability of accurate atomic and molecular data. At a time when funding becomes tight, there is a danger that the science of data provision will be viewed as something of a luxury and given lower priority, so that scientific advances may be missed through the lack of accurate models. The aim of Joint Discussion 1, which has been organized by Commission 14 under the chairmanship of François Rostas (Observatoire de Paris-Meudon) and which begins today, is to discuss the data needs of recent or forthcoming space missions and to encourage consistent and comprehensive approaches to data provision for these missions.

Historically, the early development of astrophysics relied on the provision of atomic data at visible wavelengths. Stellar atmosphere calculations require, for example, accurate transition wavelengths and oscillator strengths for several millions of transitions. The development of X-ray spectroscopy using satellite observatories such as XMM-Newton, Chandra and Cluster requires data for a range of ionization stages and for many heavy elements. Since accurate abundances often depend on the observation of lines having very small oscillator strengths, the provision of data usually requires significant computational effort. More recently, models of cool stars and brown dwarfs has required similar amounts of molecular line data, in particular for water. The determination of the necessary information is a major computational and intellectual challenge to the molecular physicist.

Finally, it is important to realise that theory cannot provide all of the data required in modern astronomy. In addition to atomic and molecular data, one of the more unusual aspects of the subject to be covered in the discussion meeting concerns the need to provide dust properties. Traditionally, this has meant the provision of optical constants, but more recently incorporates the need for accurate absorbances for pure and mixed ices, and the response of infrared ice absorption bands to the effects of thermal heating and particle and photon processing. The ice absorption bands contain in their profiles significant information about the history of cold interstellar material, a history which is difficult to uncover. For the most part we need to rely on laboratory experiments which seek to recreate the processing of ices under conditions of density, temperature and photon fluxes, though not the time scales, appropriate to interstellar clouds. This laboratory work is essential in the interpretation of ISO observations, and will continue to be important for new missions such as SOFIA, SIRTF and FIRST.

**Tom Millar**
*University of Manchester Institute of Science Technology (UMIST), UK*




*Spectra of the two planetary nebulae NGC 7027 and NGC 6543 obtained by the ISOPHOT-S instrument aboard ISO.*

*Photo: ESA/ISO, MPIA Heidelberg and ISOPHOT Consortium*

# Solar System debate hots up

"When we discovered extrasolar planets we lost understanding of our own Solar System" said Pawal Artymowicz (Stockholm Observatory) in Tuesday morning's lively session of Symposium 202. The main emphasis of the standard theory of planet formation was Jupiter and used the melting of ice in the solar nebula to define Jupiter's position. The theory predicted a gap which opened up in the solar nebula to forecast the mass of Jupiter and assumed the planet's orbital eccentricity was zero – it was "obvious."

Now we have exoplanets and that theory is in disarray. Jupiters are everywhere - not just at 5 AU. They are usually much bigger than Jupiter itself and they have high orbital eccentricities at large distances from their parent stars. Revisiting the solar nebula theory has shown theorists just how sensitive the outcome is to the assumptions and the physical treatments, particularly the thermodynamics.

According to Alan Boss (Carnegie Institution, Washington), "...theory says it is easier not to make giant planets, and that's the wrong answer." In fact according to a vehement intervention from Michael Woolfson (University of York), "after 30 years of work we are no nearer to understanding how planets form." Woolfson and Boss exchanged their competing views of planetary formation (see *Northern Lights No 2*, Tuesday) in what turned out to be the most heated exchange of GA24 so far.

In the following session, Shigeru Ida (Tokyo Institute of Technology) gave a presentation entitled 'Terrestrial Planet Formation: the Solar System and Other Systems'. Various theories of planet formation were summarized. In our Solar System there are two 'gas-giants' (Jupiter and Saturn), two 'ice-giants' (Uranus and Neptune) and a number of terrestrial-type planets. When planets were formed from the original disk, large bodies formed first; this is why Jupiter and Saturn accumulated so much gas, while the slower forming Uranus and Neptune did not. In the region of terrestrial planet formation, other factors have to be considered notably orbital crossings and giant impacts.

The speaker considered that the initial thickness of the planet-producing disk was of paramount importance. The disks could be either massive, medium or light. Calculations indicated that a massive disk would produce many gas-giants; a medium disk would result in a Solar System similar to ours, while a light (i.e. less massive) disk would produce a large number of terrestrial planets and probably no gas-giants at all. In this case our own Solar System would be completely typical for a solar-type star associated with a 'medium' disk, and systems of this kind are likely to be very common in the Galaxy.

# Silicon Nanoparticles in Interstellar Space

Many astronomical environments containing both dust and ultraviolet photons, e.g. reflection nebulae, HII regions, planetary nebulae, the diffuse galactic ISM, and the ISM of starburst galaxies, exhibit a broad red emission feature, commonly referred to as Extended Red Emission (ERE). The ERE has been interpreted as resulting from UV-excited photoluminescence by small interstellar grains, but the unique identification of a single spectroscopic feature is inherently uncertain. Over the past decade and a half, various proposals have been advanced, including PAH molecules, hydrogenated amorphous carbon, quenched carbonaceous composite, aromatic hydrocarbon clusters, and silicon nanoparticles, to explain the origin of the ERE.

Recently, a new observation in the near-IR has led to a possible breakthrough on the identification issue. Spectroscopy in the 0.8 - 2.5μ region of the spectrum of one of the brightest ERE filaments in the reflection nebula NGC 7023 has revealed evidence for a new emission feature at 1.15 μ, which closely matches the wavelength and profile of a second silicon nanoparticle emission feature, which had previously been seen in low-temperature laboratory samples of silicon nanoparticles. This match provides additional strength to the proposal that the ERE in dusty astronomical environments is caused by oxygen-passivated silicon nanoparticles in the 1 - 5 nm size range.

A second, quite unexpected discovery made during the same observation of NGC 7023 involves a new broad emission feature centered at 1.50μ. This feature, which is comparable in strength to the visible ERE band, has been tentatively identified with a photoluminescence band in small iron-disilicide (beta FeSi2) grains.

These results will appear in the *Astrophysical Journal* later this year and are currently available in preprint form: Gordon et al. (2000), http://xxx.lanl.gov/abs/ astro-ph/0007143

**Adolf N. Witt**
*University of Toledo, USA*

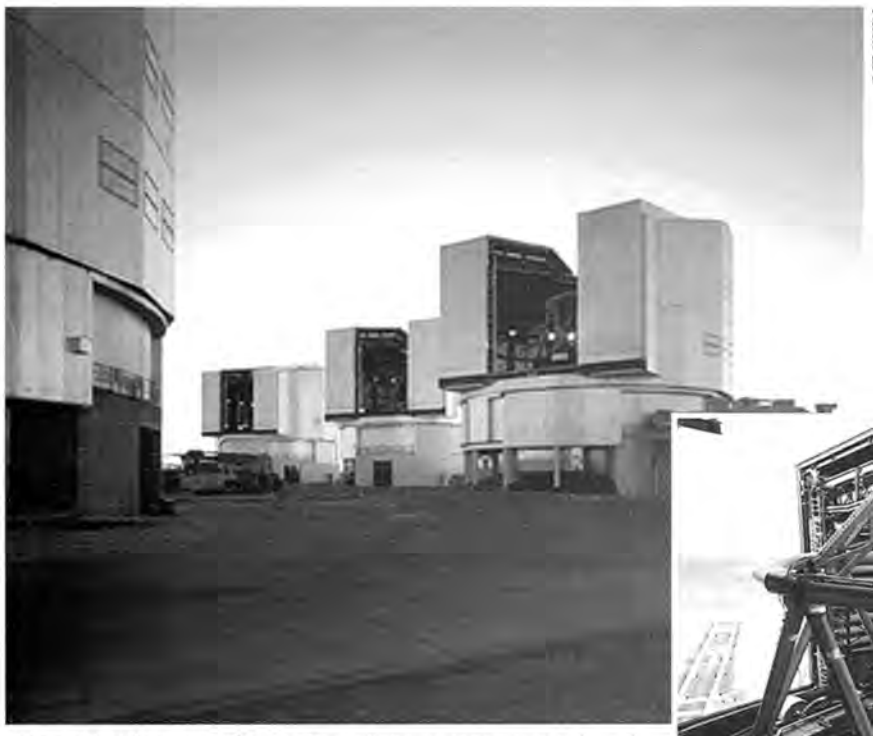


Photo: ESO

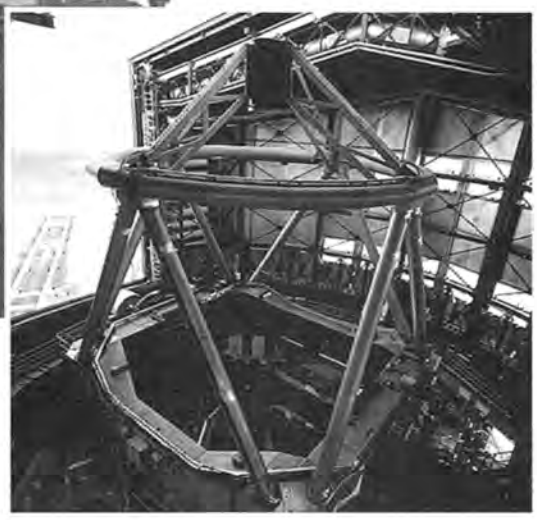


Photo: ESO

***Above**: The telescope platform on Paranal at sunset, showing all four of the VLT unit telescope. Yepun is in the foreground, with Antu, Kueyan and Melipal behind. **Right**: Antu during the evening start-up sequence.*

# VLT, VLTI, ALMA, OWL

These acronyms, which hold great promise for 21st century astronomical research, are also the headlines under which the European Southern Observatory (ESO) presents itself at a 50 square metre exhibition in the entrance foyer of the Royal Northern College of Music.

The exhibition contains large information panels, videos and a model of the Very Large Telescope Array on Paranal. Three of the 8.2-metre VLT unit telescopes – called Antu, Kueyen and Melipal (Mapoche names for celestial objects) – are now in operation, while the fourth telescope, Yepun, will see 'first light' soon.

High on the ESO agenda is the implementation of the VLT Interferometer (VLTI), with its 1.8-metre auxiliary telescopes and optical delay lines currently under construction.

Documentation about ESO and its projects is available at the exhibition, including the most recent issue of the *Messenger* – published only a few days ago – with a 10-page presentation of the 100-metre OWL telescope project. Information about the ALMA project can be obtained at the joint ALMA Information Stand, located at the ground floor of the Royal Northern College of Music

**Claus Madsen**
*European Southern Observatory*

# Astrophysics Data System

The Astrophysics Data System (ADS) is a NASA-funded project which provides a number of FREE World Wide Web data services. The main feature is an Abstract Service containing over two million references included in four databases 1) Astronomy and Astrophysics; 2) Space Instrumentation; 3) Physics and Geophysics; and 4) Preprints. The eight mirror site in France, Germany, Japan, Chile, Britain, India and China help to provide better access from all countries. They welcome requests and suggestions for additional mirror sites.

Each dataset contains abstracts from hundreds of journals, publications, colloquia, symposia, proceedings, PhD Theses, and internal NASA reports. All abstracts can be searched by author, object name (astrophysics only), title, or abstract text words. Included in the Abstract Service are links to scanned images of articles appearing in all major and many minor astronomy journals. They have scanned many of these journals from their first volume and provide these scans for free to all users. Recent volumes of journals which are online at the publishers' websites are also linked into the system, usually available to anyone with an institutional subscription.

The ADS also provides links to data catalogues and archives, as well as browsing and printing capabilities of certain reference and historical books on astronomy. All of these services are available from the following websites – Abstract Services http://adsabs.harvard.edu/ads_abstracts.html and ADS Home Page http://adswww.harvard.edu/

Demonstrations of the ADS will be given by Guenther Eichhorn (Smithsonian Astrophysical Observatory) from 0900-1200hrs each morning on Wednesday, August 9 through to Friday, August 11, in the e-mail room on the third floor of the Schuster Building.

## The Session in the IAU General Assembly Final Programme (pp 90/91) announced as WG FLSF/DXI – Future Large Facilities

**TITLE: Future Observational Multi-Wavelength capabilities in Astrophysics**
Joint Session: Division XI/WG FLSF
Date: August 10, Sessions 2,3,4
Location: Bragg Theatre (in the Schuster Laboratory)
Time 11:00 - 18:15

**Programme:**

**11:00 -12:30**
Introduction 10 min
*W. Wamsteker*
Gamma-ray domain 20 min
*P.M.Chadwick*
X-ray domain 20 min
*R. Blandford*
UV domain 20 min
*W.Wamsteker*
High energy discussion 20 min
*Chair: Hasan*

**14:00 - 15:30**
Optical domain 20 min
*R. Gilmozzi*
Infrared domain 20 min
*M.Fridlund*
Mm domain 20 min
*K.Menten*
Radio domain 20 min
*K. Kellermann*
Low energy discussion 20 min
*Chair: H. Butcher*

**16:00 - 17:30**
*The Reality and the Future of Coordination:*
Observing in a Multi-wave Universe 30 min
*B.M.Peterson*
Concluding round table 60 min
*Y. Kondo, M. Smith, R.Ekers*

**17:30 – 18:15**
*International Project:*
Memorandum of Understanding signing ceremony by ten countries formalizing the International Steering Committee for Square Kilometre Array (SKA).

# 'Who's Who': Astronomers of Romanian Origin

In spite of the difficulties that our country faces today, Romanian astronomy continues to exist, thanks to both the efforts of the scientists in Romania and the contributions of those who are working all over the world. It is sufficient to mention the advances in the knowledge of the Universe due to the remarkable contributions of personalities born in Romania or with Romanian ascendancy, e.g., Hermann Oberth, Nicholas Sanduleak, or Daniel Goldin. We can add to these other personalities, such as the ones we present in the 'Who's Who' on the web site of the Astronomical Institute of the Romanian Academy (http://roastro.astro.ro). They are: Alexandre Humberto Andrei, Cristiano Batalli Cosmovici, Florin Diacu, Jean Dragesco, Morris S. Davis, Eugeniu Grebenicov, Zadig Mouradian, Dan Pascu, Michel Rapaport, today living in Brazil, Canada, France, Italy, Russia or the USA. Of course, the list is very far from complete. We have also drawn up a Directory of the young Romanian astronomers who are working abroad.

To support Romanian astronomy, to maintain the links between all Romanians, wherever they are, and to prove to the young people in our country that Romanian astronomy goes on, we invite all astronomers of Romanian origin to join the ones in our 'Who's Who'.

**Magda Stavinschi**
*Astronomical Institute of the Romanian Academy*

## 2 The Naming Game

Did you know that over 30 survey acronyms have been pre-registered since the Registry was approved at the last IAU General Assembly? These include a number of surveys made with the Chandra X-ray Observatory (acronyms beginning with CXO).

See http://cdsweb.u-strasbg.fr/viz-bin/DicForm for details on why YOU SHOULD pre-register an acronym for your large survey prior to publication - to avoid confusion with other sources, clashing of acronyms, etc.

**Helene R. Dickel**
*University of Illinois, USA*
*& Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

## Noticeboards

Please note that there is now a Division Noticeboard in the Whitworth Hall beside the Registrations Desk. There is also a Presidents of Commissions Noticeboard on the reverse side of the Sydney 25th General Assembly display in the Whitworth Hall. You will need to go up onto the stage by the mailboxes to read these notices!

## Access to e-mail

**Please note that access to the Internet and e-mail is available on the third floor of the Schuster Building (Department of Physics). The opening times are 0900-1700hrs weekdays only.**

## Walking the Planck with Acronyms – A *Northern Lights* Competition

The talk by Paul Lubin from the group developing the BEAST (Background Emission Anistropy Scanning Telescope) experiment in the first session of Symposium 201 was introduced with the comment that "this group appears to have won the acronym contest". Admittedly their entry is extremely strong; they have another experiment called BOOST, and the speaker commented that they "come up with the acronym first, and then decide on the experiment".

However, we at *Northern Lights* believe that improvement is still possible, and are challenging the rest of the General Assembly – from whichever discipline – to invent acronyms to be used for the next generation of cosmological satellites.

Suggestions to the office or the mailboxes (1655 or 1656) please, and we'll print the best.

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.4:** *THURSDAY 10th AUGUST*


# Cluster II: A Successful Launch

## Rumba and Tango join the cosmic dance troupe

*Photos: ESA*

I had to take time off from the General Assembly yesterday to attend a competing attraction in London – the European Space Agency's reception to witness the launch of the second pair of the Cluster satellites. Hundreds of Cluster scientists, science journalists, ESA, PPARC and BNSC officials crowded into the historic splendour of the Royal Society to view the video link from the Baikonur Cosmodrome. The Soyuz-Fregat launch vehicle stood on the launch pad, and the launch preparation crews scuttled away to a safe distance when their part in the process was finished. It was a scorching hot summer afternoon in Kazakhstan, with temperatures well over 40° C.

As the rocket motors ignited, a worrying cloud of smoke rose up from the base of the rocket, and disturbing memories passed across my mind. But the launcher lifted off its supports, they swung away, and at 12:13hrs British Summer Time the rocket rose gracefully above the Cosmodrome.

We all applauded and popped open the champagne. For the bureaucrats, the industrialists and the rocket scientists, Cluster was now all safely launched and their part was ended. Over the next two weeks the orbits of the four Cluster spacecraft – Rumba and Tango launched yesterday, and the first pair, Salsa and Samba, launched on July 16 – will be slowly brought together. There will then be a three-month period during which all four spacecraft will be thoroughly checked out, before beginning their two-year investigation of solar-terrestrial interactions. For the scientists their real work was just beginning as their investigations got under way. We are likely to hear the results at the 25th General Assembly in Sydney.

**Paul Murdin**
*British National Space Centre*



# Inaugural Ceremony

As was to be expected, the Inaugural Ceremony, at the Bridgewater Hall, was enjoyed by all those who were fortunate enough to be present. It was preceded by an organ recital by one of Britain's leading young musicians, Paul Walton, whose programme included compositions by Sir William Herschel and what could be more appropriate than a contribution by the very first true President of the Royal Astronomical Society? Paul Walton's performance showed why he is so rapidly gaining a great musical reputation.

Professor Carole Jordan, in the Chair, formally opened the proceedings, and introduced the first speaker, Professor Nigel Weiss, President of the Royal Astronomical Society, who said that it was a great pleasure to be meeting in Manchester; astronomy had changed so much since the last British General Assembly, thirty years ago. Manchester had a great scientific tradition, quite apart from being the home of the Jodrell Bank Observatory with its great Lovell Telescope. He paid tribute to the members of the National Organizing Committee, the Local Organizing Committee and all those who had worked so hard to ensure that the Assembly ran smoothly; preparations had been started four years ago.

Professor Weiss was followed by The Lord Mayor of Manchester, Councillor Hugh Barrett, who welcomed the IAU to a city which was renowned for both its science and its artistic traditions; he hoped that the delegates would have enough time to 'look round', because there was certainly plenty to see. He commented that whenever a photograph of Manchester was taken, for whatever purpose, it was certain to include a view of the huge Jodrell Bank 'dish'.

***Left to right:*** *Sir Bernard Lovell, Carole Jordan, Sir Robert May, Robert Kraft, Councillor Hugh Barrett, Katharine Perera and Nigel Weiss at the Inaugural Ceremony*

Professor Katharine Perera, Pro-Vice Chancellor of The University of Manchester, also referred to the Lovell Telescope and said that she was glad that funds had been made available to refurbish the 'dish' and upgrade the steering mechanism. She recalled that in 1957 Jodrell Bank alone was capable of tracking Sputnik 1, the first artificial satellite, launched by the Russians and which marked the beginning of the Space Age. Manchester was indeed glad to welcome members of the IAU. "I hope that you will enjoy your time in our University, and that you will find here warm hospitality, congenial company and scintillating science."

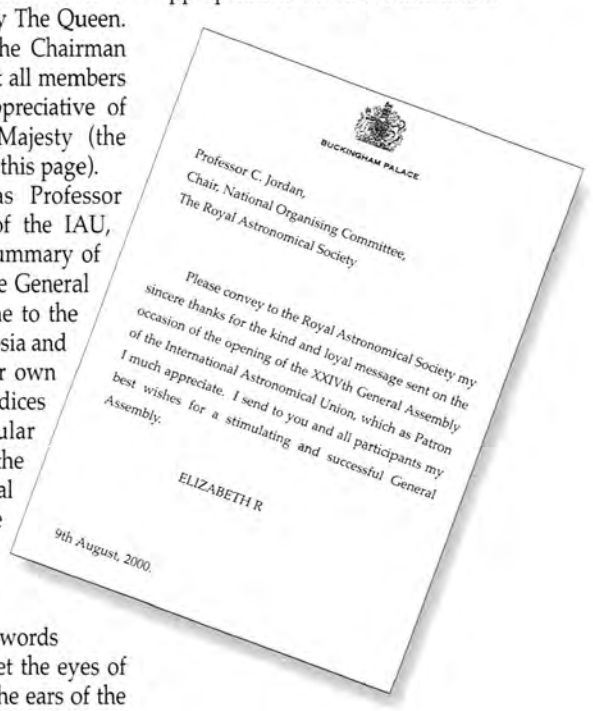
The next speaker was Professor Sir Robert May, Chief Scientific Adviser to the UK Government and Head of the UK Office of Science and Technology; he hoped that while delegates from other countries were in Britain they would have time to look at some of the many fascinating places – such as Stonehenge, which might well be regarded as the Jodrell Bank of its day! It was interesting to remember that less than 100 years ago the largest telescope in the world was the 72-inch reflector built by the Earl of Rosse. This was made and funded by one man, but the situation today was very different, and problems of cost had always to be borne in mind, but astronomy was of paramount importance and was also of special interest to members of the public.

At this stage Professor Jordan announced that there had been a message from Her Majesty The Queen. This was read out, and the Chairman said that she was sure that all members would be particularly appreciative of this gesture from Her Majesty (the message is reproduced on this page).

The last speaker was Professor Robert Kraft, President of the IAU, who gave an admirable summary of the aims and objects of the General Assembly. "We each come to the Invited Discourses, Symposia and Joint Discussions with our own personal ideas and prejudices about our own particular areas of astronomy. But the purpose of the IAU General Assemblies is to provide an arena for the exchange of facts and opinions from around the world. So we take seriously these words from Handel's *Messiah*: "let the eyes of the blind be opened and the ears of the deaf unstopped."

Following the speeches, there was a recital by the Zeneka Brass Quintet, whose skilled playing was appreciated and admired by all. We must not omit to add that the musical items were organized by Sir Bernard Lovell, who is, like Herschel, a first class organist.

An excellent Inaugural Ceremony was over. Now we proceed to what we all are sure will be a General Assembly appropriate to the new Millennium



BUCKINGHAM PALACE

Professor C. Jordan,
Chair, National Organising Committee,
The Royal Astronomical Society

Please convey to the Royal Astronomical Society my sincere thanks for the kind and loyal message sent on the occasion of the opening of the XXIVth General Assembly of the International Astronomical Union, which as Patron I much appreciate. I send to you and all participants my best wishes for a stimulating and successful General Assembly.

ELIZABETH R

9th August, 2000.

# Astronomers Sign International Agreement to Plan Square Kilometre Array

*Options for the stations of the SKA, from the top:*
*A set of large (>300m) spherical reflectors;*
*A large (>200m) reflector with the receiver supported by an aerostat;*
*An array of small (<10m) parabolic dishes;*
*A fixed planar (electronically phased) array;*
*An array of spherical (>10m) refracting lenses.*

Leading astronomers from Europe, North America, Asia and Australia will today sign an agreement jointly to plan a huge new radio telescope, the Square Kilometre Array (SKA), which will come into operation in the middle of the next decade. The General Assembly is an ideal opportunity to inaugurate the next stage of development of this truly global project.

The signing ceremony will take place at 17:30hrs in the Bragg Lecture Theatre in the Schuster Building at the end of the joint session on 'Future Observational Multi-Wavelength capabilities in Astrophysics' organized by the Working Group on Future Large Scale Facilities (WGFLSF) and IAU Division XI (Space and High Energy Astrophysics). The last part of the programme is a round-table discussion about the process of international co-operation and coordination.

Radio astronomers regard the SKA as a paradigm for the organization of future global astronomy projects. The SKA was the first radio astronomy project to have been 'born global' following the guidelines for successful international collaboration discussed at the 1994 IAU General Assembly in The Hague. The current concept has grown out of discussions over the past six years within the URSI/IAU Large Telescope Working Group and the OECD Global Science Forum. An International SKA Steering Committee (ISSC) has now been constituted to promote and to oversee the planning of the project. The signing of a formal Memorandum of Understanding will establish the ISSC for a period of five years. The signatories will be:

**Prof. Ron Ekers**: Australian SKA consortium
**Dr. Don Morton:** Herzberg Institute of Astrophysics, Canada
**Prof. Ai Guoxiang:** National Astronomical Observatory, PR China
**Prof. Rajaram Nityananda:** National Centre for Radioastrophysics, TIFR, India
**Prof. Harvey Butcher:** European SKA Consortium
**Dr. Jill Tarter:** United States SKA Consortium

At present 24 leading institutions in ten countries have agreed to pool their research and development efforts, with each individual institution concentrating on only a part of the overall design. Their shared aim is to reach agreement on the fundamental design of the SKA by 2005 and to begin construction in 2010.

In order to achieve its ambitious astronomical goals, the design of the SKA will integrate computing hardware and software on a massive scale in a revolutionary break from current radio telescope designs. The SKA is a challenging project, and as Ron Ekers of the Australia Telescope National Facility says:

"Designing, let alone building, such an enormous technologically-advanced instrument is beyond the scope of individual nations, or even small groups of nations. The SKA is therefore being planned from the outset as a truly-global telescope project."

The SKA will be a uniquely sensitive instrument. Its collecting area will be 50 to 100 times larger than today's biggest radio imaging telescopes, the VLA and the GMRT, and 200 times larger than the pioneering Lovell Telescope at Manchester University's Jodrell Bank Observatory (which can be visited during the General Assembly).

The idea of the SKA sprang from radio astronomers' desire to detect the faint 21-cm emission from atomic hydrogen in structures formed soon after the Big Bang, and in the galaxies which developed from these structures. As ISSC member Peter Wilkinson (University of Manchester) says:

"One square kilometre is not just a convenient round number—it arises naturally from a desire to image the hydrogen gas in distant galaxies with 0.1 arcsecond resolution".

Radio astronomy has been crucial in discovering phenomena such as quasars, pulsars, gravitational lenses, superluminal motion and the cosmic microwave background. It has led to three of the five Nobel prizes awarded for work in astrophysics, including all those awarded for observational work. Major advances in knowledge can be expected from a new radio telescope with the sensitivity of the SKA.

*Members of the SKA ISSC at last week's SKA Technical Workshop held at Jodrell Bank Observatory.*

Radio telescopes have a big advantage over those operating at most other wavelengths, because they can see through cosmic dust. This dust often prevents optical telescopes seeing into star-forming regions and the centres of galaxies. The latest sub-millimetre results from SCUBA on the James Clerk Maxwell Telescope show that dust can even obscure entire galaxies at visible wavelengths. Radio telescopes have another advantage in that they can be combined in arrays to produce images with the highest resolution in all branches of astronomy. On completion the SKA will, therefore, be the world's premier instrument for astronomical imaging.

The SKA's superb resolving power-which could extend to one milliarcsecond- and exceptional image quality will also provide crucial new information on the formation and early history of stars, galaxies and quasars unaffected by obscuring dust. Its enormously high sensitivity will mean that, for the first time, objects in the early Universe can be studied in detail in the radio range. The SKA is thus the perfect scientific complement to the large optical (e.g. CELT, ELT, OWL), infrared (NGST) and millimetre wave (ALMA) telescopes currently being planned.

A 6-page explanatory brochure about the SKA, written by the ISSC, has been widely distributed during the General Assembly. The full current science case for the SKA, and an electronic version of the brochure can be obtained from the SKA Web site at http://www.ras.ucalgary.ca/SKA

**Peter N. Wilkinson**
*University of Manchester*
*Jodrell Bank Observatory*

## New People Needed In Spectrum Management

The success that radio astronomy had at the recent WRC was due largely to the hard work of many individuals and the careful coordination of the proposal from all countries with radio astronomy programmes. Unfortunately, the community of people active in spectrum protection issues is greying rapidly. John Whiteoak, probably the most experienced radio astronomer in spectrum issues, will retire later this year. Dick Thompson, Dave Morris, Anders Winberg and Boris Dubinsky have recently retired or are about to retire. If our field is to prosper, these people must be replaced from the younger generation. Every observatory should have a person involved in spectrum management.

**Jim Moran**
*Chairman, Division X*

## Two more Joint Discussions take place today...

## 2 Joint Discussion

### Models and Constants for Sub-Microarcsecond Astronomy

All the discussions of JD2 will take place on Thursday August 10 in The Rutherford Theatre of the Schuster Laboratory. Chairman of the SOC, Kenneth Johnston (USNO) will present the various Resolutions and make a closing summary, at the start and end of the morning session. During the remainder of the morning sessions a variety of topics will be discussed.

Francois Mignard (OCA/CERGA, France) will present a report from the Working Group on the International Celestial Reference System (ICRS), summarizing the activities of its various sub-groups, looking at future work and the likely impact of space astrometry missions. Michael Soffel (Lohrmann Observatory, Dresden) will present proposals for IAU recommendations concerning relativity in astronomical reference frames. Gerard Petit (BIPM, France) will describe the work of the BIPM/IAU Joint Committee on Relativity. In particular, the report will concentrate on the application of a post-Newtonian reference framework to the measurements of time and frequency in the Solar System.

Toshio Fukushima (National Astronomical Observatory of Japan) will review recent progress in the determination of astronomical constants. Patrick Wallace (Rutherford Appleton Laboratory, UK) will deal with the SOFA initiative, set up at the last General Assembly to promulgate a set of fundamental constants and algorithms: since then the time has been spent in developing the specifications for a basic collection of fundamental astronomy algorithms. Erwin Gröten (Darmstadt) will review the present (2000) set of primary 'constants' and current 'best estimates' in the context of fundamental geodetic parameters.

Veronique Dehant (Royal Observatory of Belgium) deals with the latest precession-nutation model for a non-rigid Earth; the comparison of this model with VLBI observations has shown that the theoretical series must be improved to meet the observational precision now attained. Nicole Capitaine (Observatoire de Paris) will discuss proposals for a definition of the celestial pole within the ICRS, and the choice of a new origin on the celestial equator in place of the equinox. Dennis McCarthy (USNO) will discuss problems of Coordinated Universal Time (UTC) - which is created by adjusting International Atomic Time - and its relationship to Universal Time (UT1), the time determined by the rotation of the Earth. Since even with accurate estimates of the deceleration of the Earth's rotation there remain variations significant enough to prevent the prediction of leap seconds beyond a few months in advance, it is important to examine the future definition of UTC.

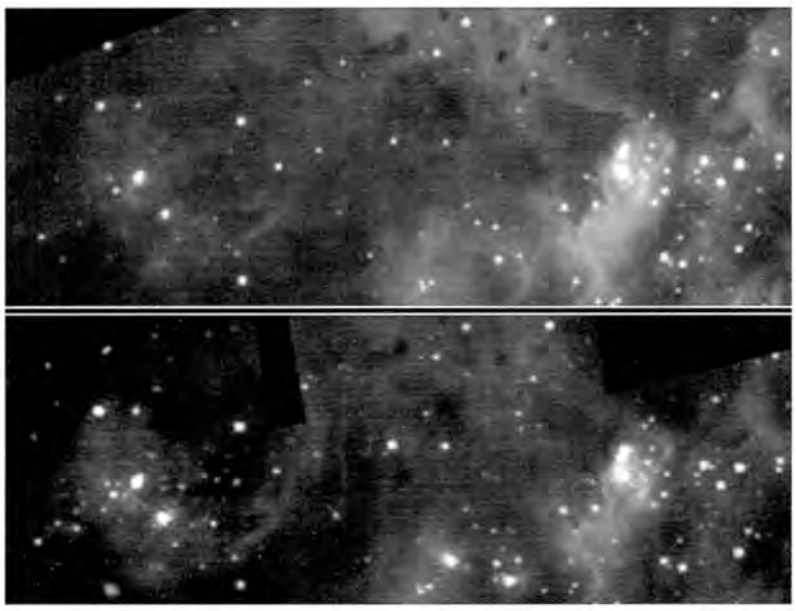
The afternoon sessions of JD2 will be devoted to a review of the Resolutions and comments before their adoption. All in all this will be a most fruitful Joint Discussion, and will provide valuable data to form the basis of future work.

# 3 Joint Discussion

## Massive Star Birth

Joint Discussion 3 will consider the birth processes of massive stars, those with initial masses greater than ten solar masses. While similar phenomena are found in low mass star formation (accretion disks, outflows, etc.) additional physics must be considered given the ionization of the interstellar environment by Lyman continuum photons, stellar winds from the hot star(s), and their deeper gravitational potentials. JD3 will bring together experts from several disparate astronomical communities.

The birth places of massive stars are in molecular cloud cores, but stars newly born within these regions are initially optically shrouded by the dust in the natal cloud. Massive stars, those of types O and B, are typically formed together in loose, or tight, groupings of associations or clusters. These hot and luminous stars have a profound effect on their local environments from their extensive Lyman continuum luminosity and strong stellar winds. Due to the large gravitational potentials of the central stars, all dynamical processes occur on shorter time scales than those near low mass protostars. Consequently, the neighbourhood of massive protostars is a very dynamic place in which gas velocities, densities and temperatures are expected to change by orders of magnitude within a radius less than $10^{11}$km.



Photos: Nolan Walborn and Rodolfo Barba', and John Trauger and James Westphal, and NASA/STScI

*Images taken in infrared (top) and visible light by the Hubble Space Telescope of the 30 Doradus Nebula revealing details of the birth and development of massive stars.*

In an oversimplified early evolution scenario one would imagine that the photons dissociate, excite, and ionize the local material and the stellar winds will blow this away from the formation sites. Thus the initial birth processes are highly time dependent, and dynamical effects from the ensemble of hot stars probably play a major rôle in the overall formation processes.

Observations of the earliest, most deeply embedded stages of massive star formation are only just becoming feasible with (sub)millimetre and mid-infrared telescopes. These objects are still so young that little or no radio continuum is detected. They are characterized by strong water masers and a rich, time-dependent chemistry in their surrounding envelopes. The formation of these 'hot cores' and their evolution to the HII region stage is still poorly understood; for molecular core clouds one would like to evaluate the importance of oblateness and discover if the distribution of water and methanol masers, which are often observed to have linear distributions on the sky, are indicative of "edge-on" geometry.

Ultra-compact (UC) HII regions represent a well known early phase in the evolution of massive stars. Statistically, there are far too many of them to be consistent with the expectations from classical Strømgren theory, thus this phase lasts on average about 100 times longer than expected from the sound crossing times. Numerous postulates for the lifetime of UCHII regions have been proposed but no general consensus has yet emerged.

A very general issue to be considered is the similarities and differences between massive and low mass star formation. So far, the evidence for the presence of disks around massive young stars has been controversial. Also, the rôle of the ionizing photons from massive hot stars is poorly understood in terms of star formation. For example on what time scale would they photo-evaporate stellar disks? How do they affect the surrounding envelopes, and how many photons are "leaking out"? During the UCHII region phase there are still many unresolved issues.

While many of the overall properties of the dust and gas in giant HII regions are well known from radio and IR observations, it is only recently that individual exciting stars have been identified and classified through near-IR photometry and spectroscopy. There is strong evidence from observations of M17 that the earliest type O stars are free of their natal dust clouds, while somewhat less luminous objects still have disc geometry. It is expected that more extensive near-IR photometry and spectroscopy of additional Galactic HII regions will become available shortly.

We feel the time is now ripe to consider the specific topic of massive star birth. By bringing together experts in various subdisciplines for a one day Joint Discussion, we believe that: 1) a better understanding of the problems of massive star formation can be achieved; 2) an assessment of where we are in solving those problems will result; and 3) ideas for future programmes to attach remaining problems will follow.

**Peter Conti,**
*JILA, University of Colorado, USA*
**Edward Churchwell,**
*University of Wisconsin, USA*
*Co-Chairmen of SOC*

## Spectra of Extrasolar Planets

On August 8, in S202, Mark Marley (New Mexico State University) discussed the reflection spectra of extrasolar giant planets. There are obvious difficulties – the spectra have first to be detected – but much could be learned from studies of this kind. Albedo values are of special importance; it must be borne in mind that the reflection spectrum of an extrasolar giant planet is controlled by the flux of incident radiation, the atmospheric composition and thermal profile of the planet, and the presence or absence of clouds. For example, a cool and cloud-free giant planet would look blue. Much also depends upon the type of the parent star; early-type and late-type stars will produce different spectral effects. Moreover, trace species in planetary atmospheres are important. ("Why is Jupiter yellow?")

Photometric monitoring studies will be most promising for planets orbiting nearby stars; Tau Boötis and Upsilon Andromedæ being good examples of this, even though the observations of the reflection spectrum of the Tau Boötis planet proved to be spurious. However, a great deal was learned from this episode. We need new and better observations, but with modern-type equipment the prospects are bright, and we should be able to obtain data concerning the composition and temperatures of the atmospheres. However, as the speaker very wisely stressed, major modelling will be required to interpret extrasolar planetary reflection spectra.

## 3 The Naming Game

Did you know that the Commission 5 Task Group on Designations, together with Commission 26 Binary/Multiple Stars, is sponsoring an all-day Multi-Commission Meeting tomorrow, Friday, August 11, in the Blackett Theatre, on Designations of Stellar Companions, which will include all types of companions from planets to stars?

The panel discussion during the early afternoon session will focus on a proposed IAU Resolution, three possible designation schemes, and questions regarding implementation. A summary of the programme appears below.

**Helene R. Dickel**
*University of Illinois, USA*
*& Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

**Summary of programme of the Multi-Commission Meeting on Designations of Stellar Companions, involving Commissions 4, 5, 8, 24, 26, 30, 40, 42 And 45.**

**Tomorrow**, Friday, August 11 in the Blackett Theatre.
Four sessions each of 90 min duration.

**Sessions 1 and 2: Moderator** - H. Dickel
Presentations in the morning (about 10 min each)
Introduction to the problem (~20 min), then WDS, multiple star systems, astrometry, radial velocities, X-ray binaries, photometric/eclipsing binaries, extrasolar planets, pulsar companions, current and future space missions, databases and search capabilities

**Sessions 3 and 4: Moderator** - T. Corbin
Panel Discussion in the afternoon (with audience participation) on:
Designation Schemes - 90 min
IAU Resolution and future plans - 30 min
Further deliberations by SOC - 60 min

## 2 How to set up a data table

My decade-long experience in collecting published tabular data in electronic form continues to show that some basic facts are forgotten frequently when formatting tables of observational data for publication. Did you know that when you list both the RA and DEC of an object with the same number of fractional digits in RA (time) seconds and DEC arcseconds, then the implied accuracy for the Right Ascension is at least 15 times more than that for Declination? Thus if the errors in RA and DEC are similar (in arcsec), you had better quote one digit less for RA than for DEC. Also, don't forget to quote the equinox for your coordinates (B1950 or J2000). Note that the term 'epoch' refers to a different thing: it is either the date when your observations were taken or, e.g. for moving objects, the date for which you calculated the object to be at the quoted position (and in this case you had better specify BOTH equinox AND epoch!).

**Heinz Andernach**
*ESA, IUE Observatory*
*Villafranca, Spain*
*for Commission 5 WG on Astronomical Data*

## Division X: Change of schedule (from Thursday)

**Friday, August 11 in the Moseley Theatre, Ground Floor, Schuster Building**

| | |
|---|---|
| (1) 0900-1030hrs | Div X Observatory Reports |
| (2) 1100-1230hrs | Div X Observatory Reports |
| (3) 1400-1530hrs | Div X Business Meeting |

**James Moran**
*President, Division X*

## Radial Velocity: A Meeting

A meeting to discuss the stringent definition of the concept of radial velocity will be held on August 10, at 4pm, in Roscoe 3.4.

The meeting will consider two important resolutions, formulated by Dainis Dravins and Lennart Lindegren (Sweden).

## Commission 33

The Business Meeting scheduled for Friday, August 11 in Roscoe 3.2 at 1100hrs has been cancelled.

Please come to the Division VII Science Session (Star clusters and the Galaxy) on Friday, August 11 at 1400hrs (Bragg Theatre). A very short Business Meeting will be held at the start of this session.

**Ken Freeman**
*President, Commission 33 and Division VII*

# Great Success for Radio Astronomy

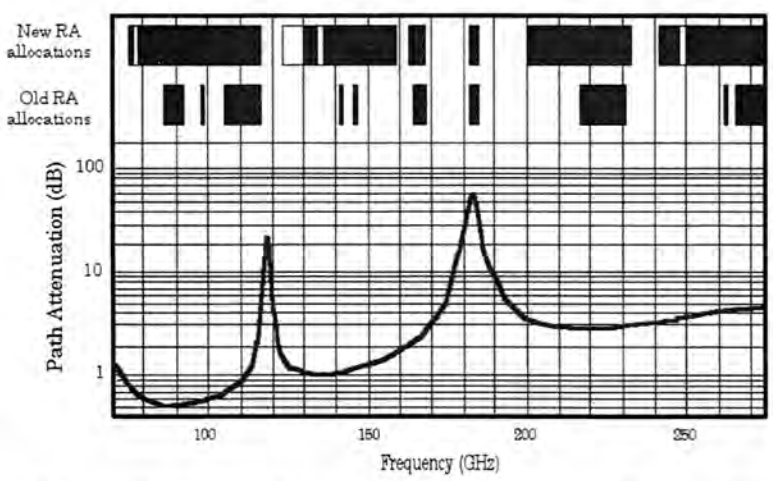
Today the IAU Working Group on important radio lines meets to plan its strategy for the coming six years. Radio astronomers have just succeeded in winning protection for crucial parts of the millimetre wave spectrum up to frequencies of 275 GHz. Many members of the winning team for astronomy are retiring soon, so it is vital that new people come forward to help in the next stage of the battle, to protect the submillimetre bands above 275 GHz for radio astronomy.

The radio spectrum is a unique precious resource that has to be shared amongst many users. The International Telecommuncation Union (ITU), a specialized agency of the United Nations Organization, regulates the planned usage of this spectrum through its Radio Regulations. The Regulations are revised every few years at World Radio Conferences (WRCs). Radio services, including radio astronomy, are `allocated' frequency bands in the Regulations, within which they can in principle operate without suffering interference.

Radio astronomy received its first frequency allocations in 1959, but has had no new allocations since 1979. Over the years the allocated bands to our service have provided only limited effectiveness. They have offered little protection for the wide frequency ranges needed to answer the current most important radio astronomy questions. For instance, for frequencies below 20 GHz radio astronomy is allocated only 1.4% of the spectrum. There has been little protection for frequencies of important molecular spectral lines detected since 1979, nor of redshifted frequencies of lines being detected in objects in the far reaches of the Universe.

So much for the background. A month-long meeting of WRC-2000 was held last May in Istanbul, with about 2,500 participants, which gave radio astronomy its first opportunity since 1979 to improve its allocations at high frequencies (from 71 to 275 GHz). Radio astronomy presented a set of internationally co-ordinated proposals developed over several years. About a dozen radio astronomers representing almost as many countries participated in WRC-2000, and carefully nursed the proposals through the various committees that had to approve them. The result was total success: ALL the proposals for improved allocations (almost one hundred were needed to cover the 71-275 GHz band) were adopted by WRC-2000.

So what have we gained? The results are shown in the accompanying figure. The line profile shows the schematic variation of vertical atmospheric absorption with frequency. Atmospheric `windows' containing attenuation minima occur in the ranges 70-115 GHz, 125-175 GHz, and 195-275 GHz. The new radio astronomy allocations now extend across most of the windows, and for the central window in particular, the improved protection is enormous. Many hundreds of molecular lines have been detected within the entire band, and most of these, even if redshifted, are now covered by allocations.




*New frequency allocations to radio astronomy in the frequency range 71 to 275 GHz, compared to previous allocations. The solid curve below shows how atmospheric attenuation varies with frequency.*

As a consequence of the bargaining to increase the allocations, some of the allocated frequencies will have to be shared with other services, which are not yet operational. However, it is commonly believed that sharing will not be a problem at these high frequencies where ground-level atmospheric attenuation is high.

We believe that WRC-2000 has provided a great legacy for the future of high-frequency radio astronomy.

(The results of WARC-2000 were also reported in *Science* (2000), **288**, 2107-2018, and in an article by Tomas Gergley in the current *NRAO Newsletter*.)

**John Whiteoak,**
*Australia Telsecope National Facility*
**Jim Cohen,**
*Jodrell Bank Observatory*

## Direct observations of Planetary Systems

A 'nearby' extrasolar Earth-like planet reflects light and glows in the infrared like a 100$\mu$ diameter dust particle in our atmosphere from a range of 4000 km. If we could see an extrasolar planetary system, either in the visible or the infrared, after we had managed to cut out the glare of the star, we would next see the glow of the Zodiacal dust cloud. Finally we would notice that embedded in this dust cloud were some faint points of light - the planets.

Nearby planets will typically be 1/10th arcsecond from their star. At visible wavelengths, the planets will be about as bright as Hubble Deep Field galaxies, and their images will be swamped by scattered starlight. To see them we would have to devise a coronagraph/adaptive optics system 10,000 times better than the best we currently use at telescopes.

If we look in the mid-infrared, then relative to the star the dust and planets will become 1000 times brighter - say 22nd magnitude at 10$\mu$. But then we will have difficulty with diffraction, since even an 8-metre telescope has a diffraction core 0.6 arcseconds in diameter. We start by getting rid of starlight, and can then measure the dust glow. We can only hope to see planets where the photon noise of the dust permits and the dust brightness variations are small, as in the Solar System. Progress is being made in reducing the starlight and diffraction rings by making the starlight interfere with itself. We expect next year to be able to observe ordinary star Zodiacal dust glow by ground-based observations, and begin to select the more dust-free systems for examination. For all planets except a few nearby bright gas giants, our further observations must wait for equipment in space, where we can operate very large, very cold telescope systems.

**Neville Woolf**
*University of Arizona*
*Steward Observatory*

# Welcomed at the Town Hall

The Town Hall in Manchester is a magnificent building; from an astronomical point of view it is notable for the very fine mural depicting the observation of the transit of Venus by Crabtree in 1639. It was here that a reception was held for IAU delegates and guests yesterday evening. The Lord Mayor of Manchester, Councillor Hugh Barrett, opened the proceedings, and extended the IAU delegates a warm welcome. He said: "We are delighted that Manchester has been chosen for this conference. We are a European city of excellence. We believe in partnership between science, business and the community, and your conference applies to all these. We send you all our best wishes."

Following the Lord Mayor's welcoming remarks, the delegates continued to enjoy the excellent wine served in the delightful, although very crowded surroundings of the Town Hall. It was a splendid opportunity to mingle with old acquaintances and forge new friendships - a very large pleasant interlude in a very busy fortnight.

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.5:** *FRIDAY 11th AUGUST*

# New Roads into Space: WSO/UV

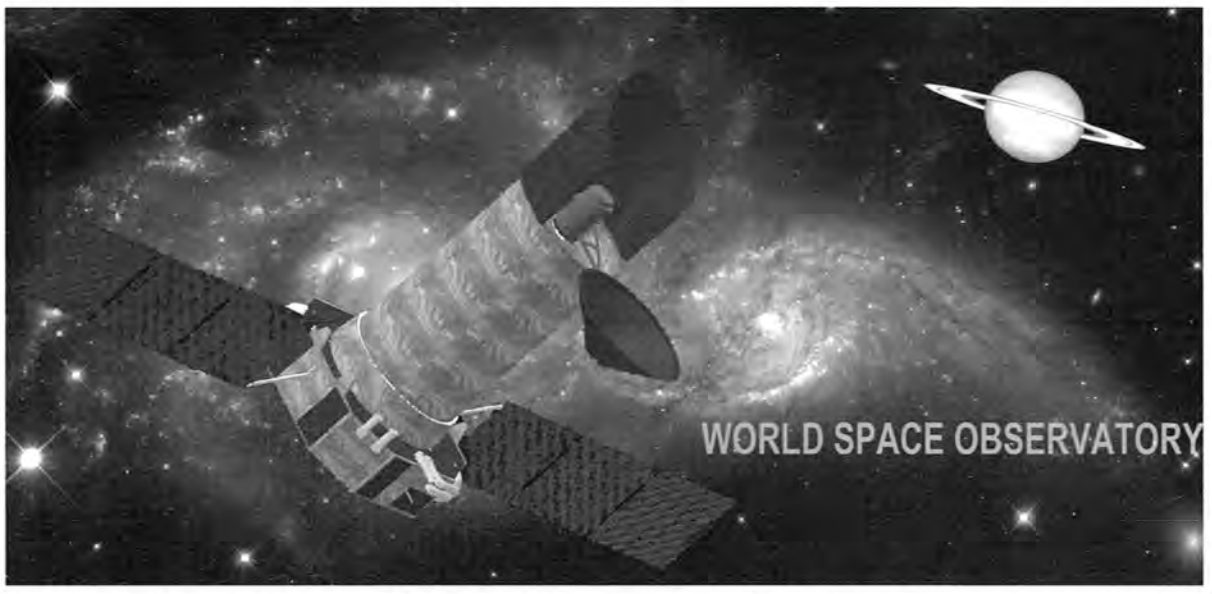



Photo: ESA

*Engineering model of the WSO/UV at its orbital location in L2 (1.8 million km from Earth) against a background of its science goals.*

Space astrophysics was born under the auspices of the Cold War. The new world order of the 21st century might require some revision of the ways in which astronomers retain access to those windows of the electromagnetic spectrum which can only be accessed through space missions. To evaluate the consequences of this, the concept of a World Space Observatory (WSO) has been developed during the nine UN/ESA Workshops for Basic Space Science for the developing countries. This was discussed yesterday in the Joint Session of Division XI with the WG on Future Large Scale Facilities.

Over the years during which such ideas have evolved and matured, some seven space agencies have expressed their interest in the concept of a WSO. As such lofty concepts can be discussed easily but are more difficult to implement, a small international group of scientists met last year to clarify a mission concept for a WSO. They came to the conclusion that a WSO/UV would represent an excellent study model. This would represent a mission with very broad scientific impact and would, at the same time, allow early and open participation of all countries in the mission.

Apart from the obvious scientific interest in a WSO/UV as defined with a 1.7-metre telescope, a spectroscopic resolution of $5 \times 10^4$, and an image quality of 0.1 arcsecond in the UV, the open nature of the project would allow an unprecedented sharing in the study of the Universe by a broader public on a worldwide scale. No capabilities of similar nature are foreseen for the next decade, so that the contributions of WSO/UV to the results of our current major missions and ground-based telescopes will be very important. An assessment study of the WSO/UV has been made in the long-term planning of the European Space Agency. This has shown that a WSO/UV mission is both practicable and feasible, and could be launched in 2006. The fully integrated approach to the mission development, including hardware, software, mission operations, science operation and user activity simultaneously, presents a realistic challenge.

Further information on WSO/UV may be obtained from the author.

**Willem Wamsteker**
*ESA/VILSPA*

# Death of a Comet

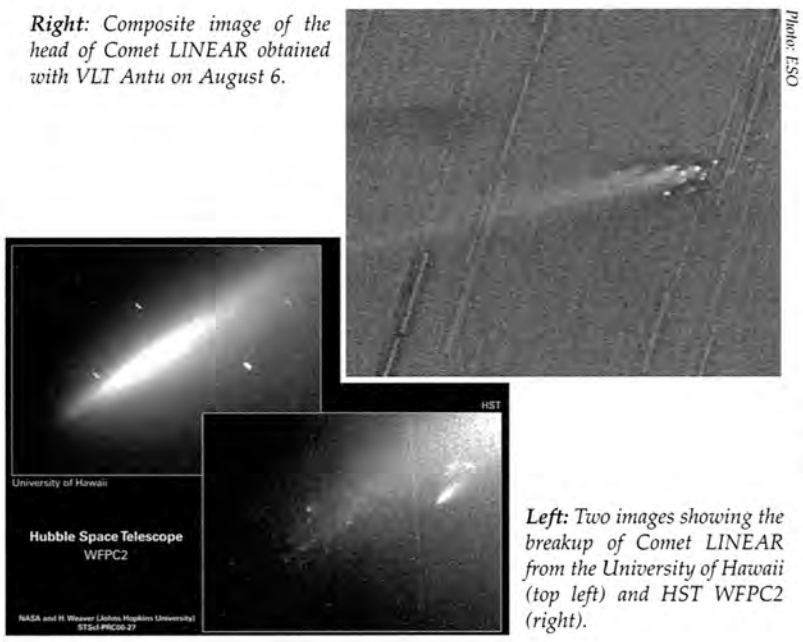



Photo: ESO

***Right:*** *Composite image of the head of Comet LINEAR obtained with VLT Antu on August 6.*

***Left:*** *Two images showing the breakup of Comet LINEAR from the University of Hawaii (top left) and HST WFPC2 (right).*

Comets are known to be short-lived members of the Solar System, but few die as suddenly and spectacularly as Comet LINEAR is doing. At one stage, in mid-July, it was on the fringe of naked-eye visibility, but then broke up, and by July 27 the bright core was no longer to be seen. The disintegration of the comet, first reported by Mark Kidger and his colleagues at the Roque de los Muchachos Observatory on La Palma, was at first thought to be complete, but Comet LINEAR had many more tricks up its sleeve!

Astronomers at the Space Telescope Science Institute in Baltimore hastily re-programmed Hubble to begin a search, and at once a small 'armada' of mini-comets came into view, left behind by the dying comet. Hal Weaver (Johns Hopkins University) commented that he was 'stunned' when half a dozen of these mini-comets, with tails, appeared on his screen. They were clustered in the tip of an elongated stream of dust; an isolated bright object in front of the main cluster was taken to be the parent nucleus for the smaller fragments. Yet how could an object the size of a mountain disintegrate in only two weeks? Carey Lisse, of STScI, commented: "I would have been more amazed if Hubble had seen no pieces. The comet's break-up was too violent and too fast for it to vaporize completely. How do you pulverize something as large as this?"

Hubble could follow the comet for a while, and there was a second 'window' of availability in early August, but after about the 13th of the month the comet will no longer be accessible from Hubble. However, observations with large ground-based telescopes are being energetically carried out. Time was obtained on the VLT (Very Large Telescope) at Cerro Paranal in Chile, and on the early evening of August 6, three short-exposure photographs were taken with the multi-mode FORS instrument on Antu, one of the VLT's eight-metre telescope units. More than a dozen mini-comets were recorded; image processing suppressed the bright part of the comet's tail in order to give a better view of the faint condensations.

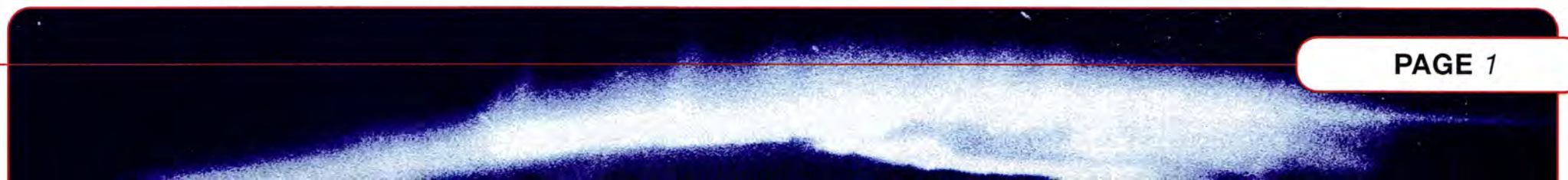
Studies of the behaviour of these condensations will give a unique insight into the structure and composition of the cometary dust and ices. As pieces of the original nucleus lose their material they will fade and vanish, and may well disintegrate completely, so that observations with the VLT are being planned while the fragments are still bright enough to be observed. It is generally assumed that the comet will not survive. It may well have come from the Oort Cloud, and was making its initial return to perihelion. If so, its first visit to the inner Solar System will also be its last!

## Tonight's Concert

### Alice Neary plays the Elgar Cello Concerto

This evening's concert by the Royal Liverpool Philharmonic Orchestra in the Bridgewater Hall, at 8pm, is free to all delegates. Vernon Handley will conduct a programme of all British music. The main item will be the Elgar cello concerto, with Alice Neary as the soloist. Regarded as one of Britain's most brilliant young soloists, the music critic of the London *Times* wrote that she was "astonishingly mature in her musicianship and a player of rare gifts". Alice was educated in Manchester at Chetham's School of Music and the Royal Northern College of Music and then studied at Stony Brook, USA as a Fulbright Scholar. She has won many prizes in this country and abroad, including the 1998 Pierre Fournier award, and in 1997 was placed second in the Adam International Cello Competition in New Zealand. In the cello concerto this evening, Alice will be playing a Gagliano cello of 1720. This concerto, composed in 1919, belongs to the brilliant period when Elgar composed his two symphonies (1908 and 1911) and the violin concerto (1910).

**Sir Bernard Lovell**



# To be discussed today...

# Light Pollution Issues

Photo: P. Cinzano, F. Falchi, C.D. Elvidge and K. Baugh.

*The artificial night sky brightness at the zenith in Europe in 1998/99 based on the upward flux measured by the U.S. Air Force DMSP satellite and on the modelling of the propagation of light pollution in the atmosphere.*

Environmental impacts on astronomy have become increasingly severe at the radio and optical wavelengths. As outlined by General Secretary Johannes Andersen at the First Session of the General Assembly on Wednesday, the IAU in recent years has been taking an increasingly active rôle in protecting astronomers' ability to observe the Universe. A major step was a meeting held in 1999 in Vienna, IAU Symposium 196 on 'Preserving the Astronomical Sky' (the proceedings will appear within the next six months). Besides the usual technical sessions, this meeting was successful in its political goal of persuading the United Nations to adopt policies favourable to astronomy's needs. Eventually we hope that these policies can be part of a new United Nations Treaty for Outer Space. Until then, the United Nations policy (not yet in a treaty) includes references to: (1) developing international radio quiet zones, (2) the need for environmental impacts (on astronomy as well as on other sciences) to be assessed before major space projects are approved, and (3) nations "acting to control pollution of the sky by light and other causes, for the benefit of energy conservation, the natural environment, night time safety and comfort, and national economy as well as science".

Commission 50 (Protection of Existing and Potential Observatory Sites) has recently established a Working Group on Light Pollution under the chairmanship of Malcolm Smith, Director of the Cerro Tololo Inter-American Observatory (CTIO) in Chile. Smith is ideally situated because over the past decade, Chile has become a key astronomical nation, site of numerous major present and future facilities, such as CTIO, Gemini, ESO, VLT, Las Campanas, etc. In addition, European and American radio observatories are developing the ALMA array of 64-millimetre wavelength radio telescopes, which will provide maps of unprecedented sensitivity and detail (to within 0.01 arcseconds).

The Working Group on Light Pollution will meet today and next Monday (see back page) to discuss the many issues relating to protection of the night sky – measurements, trends, laws, international coordination, strategies, etc. Please join us. Further information is available via the website of the International Dark-Sky Association (www.darksky.org).

**Woodruff Sullivan**
*University of Washington, USA*
*President, Commission 50*

## Four more Joint Discussions take place today...

## 4 Joint Discussion

### The Trans-Neptunian Population

When Edgeworth and Kuiper first conjectured the existence of a belt of small bodies beyond Neptune, they were certainly imagining a disk of planetesimals preserving the pristine conditions of the proto-planetary disk. But, since the first discoveries of Kuiper Belt objects in 1992, astronomers have realized that the orbital distribution of the bodies discovered so far is not trivial: the Kuiper Belt is not a disk of particles on quasi-circular and coplanar orbits, as was generally expected.

As of the present day more than about 300 bodies have been discovered. In *the inner belt* (semi-major axis smaller than 40 AU) all the known objects have large eccentricities and are associated with first order mean motion resonances with Neptune (mainly the *Plutinos*, in the 2/3 resonance). Beyond 42 AU the *classical belt* begins, where the discovered objects are not specifically related to any mean motion resonance. In addition to these two belts, theoretical considerations and the discovery of the object 1996 $TL_{66}$ argue for the existence of a third population of bodies, which evolve under the effects of sporadic close encounters with Neptune, forming a sort of *scattered disk*.

The peculiar orbital distribution of the Trans-Neptunian objects may provide decisive clues for an improved understanding of the formation and primordial evolution of the outer Solar System. The overabundance of objects in the 2/3 resonance and the large eccentricities and inclinations of the bodies in the classical belt must be the result of some process which occurred during the primordial era. Three main scenarios have been proposed. They include the sweeping of the Belt by mean motion resonances due to the radial migration of Neptune; the displacement of the secular resonances due to a gradual mass loss of the Trans-Neptunian regions, and the primordial existence of 'Large Scattered Planetesimals' in orbits crossing the Kuiper Belt.

The observed structure of the Kuiper Belt also provides new hints on the origin and the evolution of circumstellar dust disks. According to the statistics of discoveries per unit area of searched sky, about 70,000 objects bigger than 100 km should exist in the Kuiper Belt up to 48 AU. The total mass of the Belt up to 48 AU seems to be ~0.3 Earth masses ($M_E$). This is much lower than its estimated primordial mass of about 30 $M_E$ which seems to imply that collisions among Kuiper Belt objects are not rare. The analogy between Kuiper and extrasolar dust belts seems close. The study of these objects provides complementary information on the large vs. small-size end of the distribution of bodies in disks.

This science is still young and rapidly evolving, but it is evidently a very interdisciplinary one. The goal of Joint Discussion 4 (the first one proposed on this topic) is to summarize the state of the art and prompt a debate among the communities of dynamicists, observers, experts of cometary physics, Solar System formation and circumstellar disks.

**Anne Lemaître**
*FUNDP, Belgium*

## 5 Joint Discussion

### Mixing and Diffusion in Stars:
#### Theoretical Predictions and Observational Constraints

Our understanding of transport processes in stars is still in its infancy. First, consider overshooting. There is now ample evidence, e.g. from the best-observed binary stars and fits of models to observed colour-magnitude (C-M) diagrams, that some amount of mixing must occur beyond the classical boundary of the convective core set by the Schwarzschild criterion. Such mixing can be achieved by convective penetration; however, despite impressive progress on the theoretical front, a rigorous prediction of the extent of overshooting has not yet been achieved. As a result, most stellar evolutionary calculations have simply opted to extend convective core sizes by an amount (usually measured as a fraction of a pressure scale height) that produces reasonable consistency with observations. But how realistic are such models? To what extent does the overshooting depend on mass and/or evolutionary state? What is the rôle of rotation in determining the size of convective cores? How much does rotation-induced meridional circulation contribute to such mixing?

In the Sun, helioseismology reveals the presence of a sharp transition in the rotation rate which changes abruptly from differential (i.e. latitude-dependent) in the convection zone, to almost uniform in the radiative interior. What is the structure of this tachocline, what is the efficiency of particle transport through it, and what rôle does it play in the Li depletion? Is this depletion correlated with the loss of angular momentum from solar-type stars? In that case would one expect tidally-locked binaries to be less depleted than single stars; is this property confirmed by the observations? Why do current models of rotational mixing fail to predict the almost uniform rotation of the radiative interior of the Sun? Further, what link does this tachocline have to the magnetic field? Is it the seat of the solar dynamo?

Convective transport in the giant phase is at least as problematical. The evidence is compelling that giants are able to dredge matter up to their surface layers from the vicinity of their H-burning shells. Even in subsolar mass stars, there is apparently sufficient internal rotation to set up the circulation currents which are presumably responsible for the observed abundance "anomalies". However, what is particularly disconcerting is that there appears to be some nucleosynthesis of such elements as aluminium and magnesium in bright, first-ascent red giants (in several metal-deficient globular clusters). This should not occur, even if matter is mixed into the H-burning shell, because such shells are too cool for significant processing to occur via the Ne-Na and Mg-Al cycles. There are also indications that the mixing commences in some systems when stars are just beginning to ascend the red-giant branch. According to theory, circulation currents should be able to reach down to the vicinity of the H-burning shell only along the upper giant branch, when there is no longer a steep gradient of chemical composition above the shell. How are we to explain such observations? Similarly, the Li-rich giants appear to require a fine tuning of convective transport which is not yet understood.

The surface chemistry of stars is also apparently modified by turbulent, diffusive, and radiative acceleration processes. In the Sun, helioseismology has confirmed the importance of the gravitational settling of helium. In AmFm, Ap, and HgMn stars, most anomalies appear to be caused by radiation-driven diffusion. However the anomalies are rarely as large as the atomic diffusion processes alone would lead to, so that competing hydrodynamical processes must also (apparently) play a rôle in those objects. We are forced to the same conclusion regarding the halo dwarfs which comprise the so-called 'Spite plateau'. The latter have such exceedingly uniform Li abundances that it seems impossible to reconcile the observations with either diffusive or rotationally-mixed models. Moreover, isochrones that do not include diffusion are able to mimic observed C-M diagrams much better than those that do. What are the competing hydrodynamical processes that are serving to reduce the effects of diffusion in Population II stars?

The recent availability of large atomic data bases (OPAL, Opacity Project) has made it feasible to calculate evolutionary models in which the transport of up to 28 chemical elements can be explicitly included. The same 28 elements can then be used, in principle, as observational constraints to test stellar models by, for instance, comparing the predicted surface abundances with those measured in galactic cluster stars. Abundance anomalies have therefore become believable tests of internal stellar hydrodynamics.

Given the considerable importance of these processes for the modelling of stellar populations, thus for determining their ages, and for assessing the primordial abundance of Li, Be and B, Commission 35 took the initiative of organizing this Joint Discussion on 'Mixing and Diffusion in Stars'. We expect the discussion of both the theoretical and observational aspects of all these issues to be very illuminating and to initiate further progress.

**Don VandenBerg**
*University of Victoria, Canada*
**Jean-Paul Zahn**
*Observatoire de Paris*
*Co-Chairmen SOC*

# 6 Joint Discussion

## Applied Historical Astronomy

It is a truism that astronomy is the oldest of the sciences. But less appreciated is the fact that historical data can be of service to modern astronomy. Joint Discussion 6 which takes place today in the Computer Science Building will survey the whole range of these data, including eclipses, occultations, comets, meteors, planetary and lunar observations, sunspots, auroræ, and supernovæ.

During this one-day meeting you will learn:

- why very few datable cuneiform astronomical records survive from Mesopotamia prior to the mid eighth century B.C.
- where the earliest surviving series of solar eclipse observations were taken.
- the sources of Arab and Indo-Persian observations.
- the lessons learned from Galileo's and Lalande's observations of Neptune.
- how information in historical sunspot records may be of great importance in determining the long-term behaviour of the solar magnetic cycle.
- what historical auroral records tell us about the long-term variation of solar activity and the Earth's magnetic field.
- What 449 ancient and mediæval eclipse observations tell us about changes in the Earth's rotation over the past 2,500 years.
- How ancient observations are the only sources for modelling the long-term behaviour of periodic comets.
- The frequency of injection of giant comets into the inner Solar System, and whether such a body could have been present within the last ten to one hundred thousand years.
- How historical observations of supernovæ are useful for the modern astrophysical interpretation of their remnants.

Applied historical astronomy is a vibrant field, with the majority of historical observations undoubtedly remaining to be discovered.

JD6 has been organized by Commission 41 (History of Astronomy), with support from Divisions I, II and III, and Commissions 4, 19 and 20.

If you wish to hear more about the work of Commission 41, please attend our Business Meeting on August 15, at 1100hrs in the Blackett Theatre, Schuster Laboratory. We welcome new members.

**Steven J Dick**
*U.S. Naval Observatory*
*President, Commission 41*

# 7 Joint Discussion

## The Sun and Space Weather

The safe operation of the International Space Station will depend upon timely warnings of eruptions on the Sun. This will be discussed during the afternoon session of JD7 today by Paal Brekke (ESA), who is Deputy Project Scientist for SOHO.

Dr Brekke comments: "For thousands of years my ancestors in Norway marvelled at the space weather seen in the Northern Lights. But auroræ never hurt a sailor or a farmer. It is only with our modern electrical, electronic and space technologies that the Sun's effects have become damaging, and potentially hazardous for astronauts. The more we do in space, the more serious and costly the problems of space weather will become."

The Sun is now near the peak of its eleven-year cycle of activity, and a major solar outburst last month demonstrated the value of SOHO. On July 14 there was a brilliant solar flare near the centre of the Sun's disk, and this was followed by the detection of a mass of gas racing outward - a Coronal Mass Ejection (CME). A burst of energetic particles hit SOHO, the most intense storm of such particles seen during the present solar cycle. Travelling more slowly, the interplanetary shock wave driven by the gas of the CME arrived at SOHO a day later, on July 15. The solar wind instrument CELIAS on SOHO registered a jump in the windspeed from 500 to 800 km per second, increasing to 900 km per second an hour later. As SOHO is stationed 1.5 million km out, on the sunward side of the Earth, the CME slammed into the Earth's magnetic field half an hour later than at SOHO, provoking auroral displays which peaked early on July 16.

Several satellites experienced problems, and some permanent damage has been reported. The storm left the Advanced Satellite for Cosmology and Astrophysics (ASCA) spinning out of control and there is little hope of saving it. Power companies reported many disturbances in their systems and one transformer appears to have been damaged. There were severe blackouts of radio communications as well as degraded navigational signals.

*Photo: SOHO, ESA and NASA.*

*Artist's impression of the SOHO spacecraft in the 'line of fire' between the Sun and the Earth's magnetosphere.*

With a view to predicting CMEs before they occur, research is being undertaken by another instrument on SOHO, the Coronal Diagnostic Spectrometer (CDS). Several CME onsets have already been identified with these new techniques, as on 1999 July 25, when CDS saw a magnetic loop rising through the solar atmosphere at 10 km/sec for two hours before a CME. A magnetic explosion then occurred, releasing the CME and also causing a flare. Richard Harrison (Rutherford Appleton Laboratory, UK) has commented: "At least we begin to see tell-tale events which precede eruptions on the Sun. Yet the link between CMEs, flares and dangerous outbursts of particles is still very vague."


*Photo: SOHO, ESA and NASA.*

***Left**: A sequence of three images showing the development of the Coronal Mass Ejection of July 14.*

# Precision Cosmology? Not Yet!

Malcolm Longair began Symposium 201 on Monday by saying that we were entering an era of precision cosmology. However, ideally we would like to measure cosmological parameters not only to high *precision*, but also to control systematic effects; i.e. measure them to high *accuracy* as well as precision. The results being presented at this Symposium provide clear and very encouraging evidence that new experiments and observations are being carried out with higher precision than previously possible, and are, moreover, being designed from the outset to minimize, test and correct for systematic effects. This is welcome progress, since historically systematic errors have dominated all measurements of cosmological parameters.

Several recent measurements of the Hubble Constant ($H_0$) were reported at the meeting on Wednesday. Two talks were given presenting results from the HST key project. This group has used HST to measure Cepheid distances to galaxies, and has determined $H_0$ using five different methods. The combined value for these different methods, based on a new calibration of the Cepheid period–luminosity relation, is $74 \pm 3 \pm 7$ km/sec/Mpc. The error bars refer to statistical and systematic uncertainties respectively.

New results were also reported by Alan Dressler (Carnegie Observatories) on surface brightness (also one of the methods used by the key project group). A Cepheid calibration of this method gives $H_0 = 77 \pm 4 \pm 7$. Paul Schechter (MIT) presented results on $H_0$ from time delays of gravitational lenses. For three well-modelled lens systems, correcting for internal galaxy motions and cosmology, he reported a value of $H_0 = 62$, but cautioned against believing statistics for three objects.

Two talks summarized the status of rapid progress in using the Sunyaev-Zel'dovich effect in clusters of galaxies to measure $H_0$. For a lambda cosmology, values of $H_0 = 75$ and 65 were reported, with uncertainties of about 15%. There is considerable promise that the accuracy for this technique will steadily improve as the resolution of both the radio and X-ray measurements continues to increase.

My own definition of precision would be restricted to measurements at the few percent level, and we are not there yet. However, I believe that we have entered the realm where 10% measurements are now possible, and factors of two are behind us. And with upcoming next generation interferometers and large telescopes both on the ground and in space, the prospects for the future are bright.

**Wendy Freedman**
*Carnegie Observatories, USA*

# Rotational Braking, Angular Momentum Transport and Light Element Abundances

The observed depletion of lithium in the Sun has puzzled astronomers for many decades. As the base of the solar convective zone (CZ) is not hot enough to deplete lithium, this requires mixing below the CZ which is not predicted by the standard solar model. In the last decade, non-standard, turbulence-based models have linked this mixing process to another fundamental, ubiquitous and yet poorly understood process: the transport and dissipation of angular momentum.

Rapid rotation is a remnant of the star formation process, but older solar-type stars are typically slow rotators. To explain this, the models predict that after the surface of a rapidly rotating zero-age-main-sequence star is spun-down by surface winds, the star is left in a state of differential rotation with the interior spinning more rapidly than the surface. Angular momentum is transported via turbulence resulting from the shear forces between the layers, and dissipated from the surface. Simultaneously, the turbulence results in a slow mixing current which leads to the depletion of surface lithium. These models offered an attractive explanation for the observations.

However, three pieces of observational evidence strongly contradict the predictions of the model. Firstly, while the models predict that the present-day Sun has a rapidly-rotating core, inter-pretation of helioseismological data reveal that the solar interior is rotating slowly as a rigid body down to 0.2 $R_{Sun}$. Secondly, the models predict that the slow, deep mixing results in the simultaneous depletion of lithium and, the more robust but yet fragile, beryllium. A re-analysis of the Be II lines in the UV have shown that the solar beryllium abundance equals the meteoritic value, indicating that mixing down to beryllium-depletion depths has not occurred over the entire history of the Sun. Finally, the models predict that short-period, tidally-locked binaries with a different rotational history from their single-star counterparts, will have far higher lithium abundances than single stars. Evidence that contradicts this point will be presented during Joint Discussion 5 this morning.

It appears therefore that the transport of angular momentum proceeds far more efficiently than predicted by turbulence-based transport, perhaps via magnetic fields or internal gravity waves which are currently being investigated theoretically. In the Sun, the depletion of lithium may possibly result from localized turbulence at the base of the CZ. An understanding of the complete pattern of lithium observations remains elusive.

**Suchitra C. Balachandran**
*University of Maryland, USA*

# An Accelerating Universe?

Photo: NASA/STScI

*Supernova 1994D in the galaxy NGC4526.*

The first Invited Discourse of the General Assembly was held last night in Bridgewater Hall. The speaker was Robert Kirshner of the Harvard Smithsonian Centre for Astrophysics who took as his title 'An Accelerating Universe? Evidence from Supernovæ'.

It was a visit by Einstein to Manchester in 1921, he said, that gave the first opportunity for scientists to properly examine General Relativity, which then included the cosmological constant ($\Lambda$). It was fitting, therefore, that the latest results on $\Lambda$ should be discussed here. The goal of the project at inception was simply to detect supernovæ like the one seen in the accompanying HST image, but at distances one hundred times greater. The work by the team is in parallel with that obtained by the Supernova Cosmology Project, but has both a smaller data set and smaller error. The results of this work led to an unexpected conclusion; that the Universe was still accelerating. This obviously places a large burden of proof on the data and Prof. Kirshner detailed the work being done to eliminate sources of error. The emphasis here is on utilizing the vast data set that has been accumulated through studying low redshift supernovæ. In particular, features such as the second maximum visible at higher wavelengths can be used as a check on the effects of dust.

Other ideas to be pursued as supernovæ are detected at ever greater redshifts include looking for indications in the data of the 'change over', when the Universe switched from initial deceleration to its current accelerating state. As a vital part of this study HST is being used to follow up new discoveries, although this part of the programme has not been without mishaps, Prof. Kirshner recalled. The team had been scheduled to observe on the very day that a gyroscope stopped working last November, sending the instrument into safe mode! All in all, the crowded auditorium was treated to a *tour de force* of one of the most exciting and most debated areas of our subject, in a talk that was as entertaining as it was stimulating and informative.

# Catch a Shooting Star Tonight

Missed the Leonids again? Never mind, after the concert this evening, and in the early hours of Saturday and Sunday, why not look skywards and watch the Perseids. Of course, there is a minor problem, a nearly full moon. Not noticed that? That's the other problem; the fairly predictable presence of cloud cover. We can be much more certain that the Perseids will be there, over the coming weekend. The shower has been amazingly regular throughout the last Millennium, producing several meteors per minute over many hours. It was one of the first streams to have its associated comet, 109P Swift-Tuttle identified, back in the 1860s.

You might think that observing such a regular stream with an undisputed parentage was scientifically not very exciting, but this is not the case. Based on the 1862 apparition of comet Swift-Tuttle, its period was thought to be about 120 years, making its return in about 1982. It did not appear despite intensive searches. Indeed after a few years, some were beginning to think that we had missed it. However, the Perseid stream reassured us by producing a second peak in activity in the late 1980s, about the same strength as the main peak and slightly displaced in time. This grew in strength during the early '90s, and the parent comet itself returned to perihelion in December 1992.

Thus in the Perseids, we have exactly the same phenomenon as with the Leonids; a strong display of new meteors when the comet is nearby, except that in the Perseid case, this is not regarded as spectacular because the main stream is usually rather strong. Scientifically it is just as significant because it allows us to study a set of very young meteoroids, probably so young that gravitational perturbations and Poynting-Robertson drag have had no time to really affect their orbits, and so giving a good measure of the ejection process.

So stay up this weekend and you may see a good Perseid shower with both young and old meteoroids together.

**Iwan Williams**
*Queen Mary & Westfield College*
*London, UK*

## A Note on Security

It is strongly recommended that IAU delegates do not wear their identification badges when walking around Manchester. This indicates that they are visitors to the city, and are potentially more vulnerable. Attacks are rare, but they can happen, and it is only sensible to take due precautions.

## Commission 50 WG on Light Pollution

**Friday, August 11**
1600-1730hrs
Roscoe 3.5

**Monday, August 14**
0900-1030hrs and 1100-1230hrs
Moseley Theatre

**Posters**: In the hallway on the 2nd floor of the Roscoe Building (including large versions of the night-time Earth views, similar to that on p2 of this issue).

# MHD Seismology of the Solar Corona

During Symposium 203, Valery Nakariakov (University of Warwick, UK) discussed recent developments in studies of MHD wave motion in the solar corona, and introduced a new method for the determination of one of the previously uncertain physical parameters of the corona – the field strength – based upon analyses of coronal loop oscillations observed with EUV imaging telescopes on board the SOHO and TRACE spacecraft. The structure, dynamics and evolution of the corona have long been known to be controlled by the solar magnetic field, which is generated by dynamo processes in the Sun's interior; when it breaks through to the surface it becomes measurable in sunspots, and extends out into the corona and the solar wind.

Spectacular images of the corona were shown during the presentation. It was found that the field strength in the loop analyzed was from 20-30 G, very close to the value expected from extrapolation of the surface value. The technique is based upon a delicate combination of high-precision EUV observations and a refined theory of MHD waves. It opens up new perspectives in studies of the physics of the solar corona.

## Scientific Programme for Symposium 201

**Friday, August 11:**
**Concert Hall, Royal Northern College of Music**
Revised schedule (after 1120hrs all times are the same as before )

| | |
|---|---|
| **0900-0925hrs** | CMB analysis and cosmological parameters: Dick Bond (Canada) |
| **0925-0945hrs** | Joint constraints using CMB, LSS, supernovæ, lensing, etc: Charley Lineweaver (Australia) |
| **0945-1000hrs** | Cosmic Data Fusion: Sarah Bridle (UK) |
| **1000-1015hrs** | Cosmological Parameters and Hyper-Parameters: Ofer Lahav (UK) |
| **1015-1030hrs** | A new perspective on structure formation: Chung-Pei Ma (USA) |
| **1100-1110hrs** | The large scale structure peak as a comoving standard ruler: Boud Roukema (France) |
| **1110-1120hrs** | Update on the status of the TOPHAT balloon experiment: Robert Silverberg (USA) |
| **1120-1140hrs** | Beyond Planck and FIRST: Matt Griffin (UK) |
| **1140-1200hrs** | The X-ray background: Xavier Barcons (Spain) |
| **1200-1220hrs** | SNAP: Saul Perlmutter (USA) |
| **1220-1230hrs** | The Sky Polarization Observatory (SPOrt) Programme: Ettore Carretti (Italy) |
| **1400-1430hrs** | New theoretical insights and outstanding problems: Martin Rees (UK) |
| **1430-1500hrs** | Poster reportage: Virginia Trimble (USA) |
| **1500-1530hrs** | Concluding remarks: Jim Peebles (USA) |

## 4 The Naming Game

Have you read the simplified "How to refer to a source or designate a new one"?
See http://cdsweb.u strasbg.fr/ic/how.htx for details.

**Helene R. Dickel**
*University of Illinois, USA*
*& Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# Public Lectures at GA24

UMIST are running a series of lectures for the public during GA24. These lectures have been advertised widely to schools, amateur astronomical societies and on local radio. Entrance IS BY TICKET ONLY and all available tickets have been allocated to the general public. Attendance by participants at GA24 is welcome, but comes with a health warning! Ticket holders will be admitted to the lecture theatre as a priority. Only if seats are still available, just before the start of the lecture, will those without tickets be admitted.

We hope that you will appreciate our desire to give the genuine public some feeling for the excitement of astronomy during GA24.

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY — MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.6:** *SATURDAY 12th AUGUST*

# Coronal Heating and Solar Wind Acceleration

The exact origins of the solar corona and wind remain controversial following a lively session of Symposium 203 on Thursday. The hot corona exists because the outer solar atmosphere is thermally unstable to 'mechanical' (most likely magnetic) energy inputs originating deep in the Sun. Expansion of this hot gas into the near vacuum of interplanetary space produces the solar wind and governs cometary gas tails. That much is clear. What remains obscure is the nature of the energy inputs and particularly whether they occur locally and spasmodically rather than smoothly and steadily. The former scenario has gained favour over the last decade, the idea being that 'micro'-versions of the magnetic energy released in flares occur throughout the plethora of loops constituting the corona.

Such 'microflares' seen directly in SOHO images were discussed by Arnold Benz (ETH, Zurich) while possibly related rapid fluctuations in white light coronal data from last August's total eclipse were reported by Ken Phillips (Rutherford Appleton Laboratory, UK). These microflares of themselves do not have enough power to heat the corona, but if their size distribution is extrapolated downward, 'nanoflares' there would do the trick. (The problem here is akin to the low-mass cut-off in the stellar mass distribution.) The lively nanoflare debate was set against a broad-brush backdrop of review talks on the solar wind (Eckart Marsch - MPIA), the corona (Francesco Malara – Universita della Calabria) and on stellar analogues of solar phenomena.

**John Brown**
*University of Glasgow*
*Astronomer Royal for Scotland*

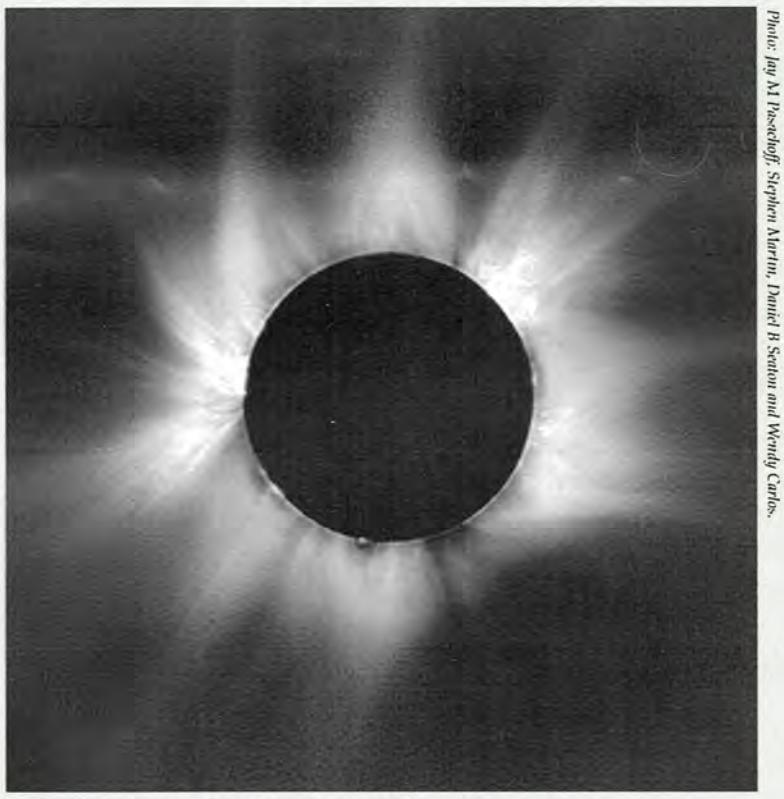


Photo: Jay M Pasachoff, Stephen Martin, Daniel B Seaton and Wendy Carlos.

*A composite image bringing out the fine structure of the solar corona over a wide range of intensity at the total solar eclipse of 1999 August 11.*

# The Man who Missed the Eclipse

Did you miss the total solar eclipse of last August? So did an American astronomer, the Rev. Samuel Williams, in 1780, but for a rather different reason, as recalled by Myles Standish (NASA JPL) at Joint Discussion 5 (Applied Historical Astronomy) yesterday.

At that stage the fledgling United States was at war with Britain, and it was clear that an American eclipse expedition would have difficulty in reaching the chosen observing site, Penobscot Bay. Representations were made to the British authorities. 'Please will you stop your war and let us through?' Amazingly, permission was granted, and Williams, with around a dozen colleagues, reached Penobscot, where they set up their equipment. For some days there was thick fog, and no observations could be made. Williams' diary records that on one occasion he adjusted the clock and 'lengthened the pendulum', which admittedly does not inspire a feeling of great confidence.

However, eclipse day was brilliantly clear, and the clocks and other instruments seemed to be working well. The Moon began to creep on to the Sun; still no problems. A tiny sliver of the photosphere was left, and then came Baily's Beads. Totality was imminent – or was it? To the consternation of Williams and his team, the Sun started to reappear. The observers were outside the zone of totality…

How had this happened? Presumably because of an error in the calculations. But it is all very strange, and it is worth adding that some years later Williams was driven out of Harvard for falsifying some documents relating to personal debts. Altogether it is a decidedly murky episode, and the full story may never be told.

# Adaptive Optics meets Infrared Spectroscopy

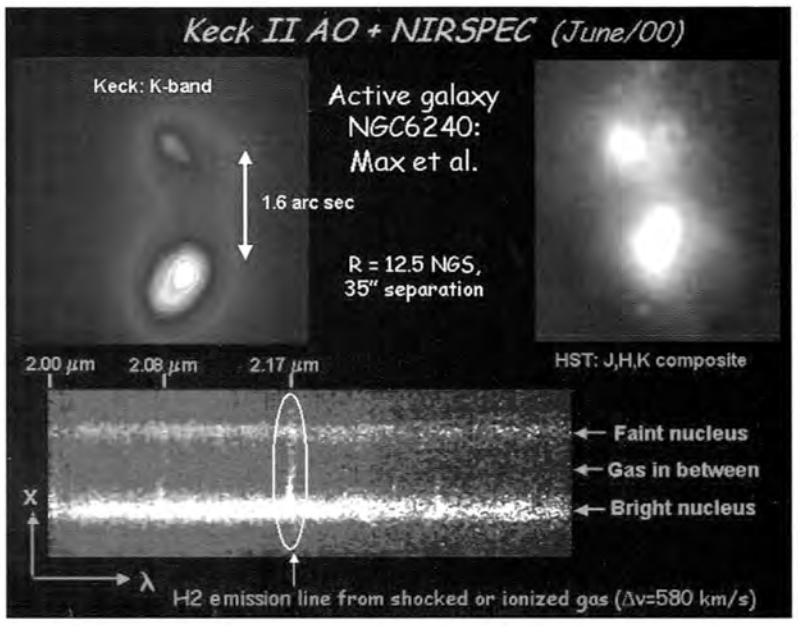



Photo: Claire Max (LLNL)

***Upper left:*** *an image of the core of NGC6240 at 2.2 μm (K band) using the Keck AO system.* ***Upper right:*** *the same field observed with the NICMOS instrument on the Hubble Space Telescope.* ***Lower panel:*** *a section of a spectrum obtained with NIRSPEC + AO showing redshifted emission from shocked molecular hydrogen gas, in both nuclei and between them.*

In June 2000, the very first mating of the recently-commissioned high-resolution Near Infrared Spectrometer (NIRSPEC) on the Keck II 10-metre telescope and the Keck Adaptive Optics (AO) system was achieved. So successful was this combination that it was released to the general community the following month.

With pixels of only 17 milliarcseconds (mas), and typical final image diameter of 50 mas or better in the near infrared (from 1-2 μm), spectacular images and spectra were obtained for objects ranging from the outer objects of our Solar System to the centre of the Milky Way, and beyond.

NIRSPEC's infrared slit-viewing camera provides the near-diffraction-limited pictures while its spectroscopic mode operates to yield spectra with resolving powers of 2,500-25,000 – more than enough for numerous applications ranging from spectral typing to abundance analysis and Doppler velocity studies.

The only limitation of the technique is the need for a 'natural guide star' brighter than about 14th magnitude within 20-30 arcseconds.

Many new opportunities have been enabled by this advance. For example, detailed studies of the atmosphere of the outer planets, Uranus and Neptune, are possible, because infrared spectroscopy probes different levels in the atmosphere due to methane absorption, and moons such as Io and Titan are actually resolved! Similarly, the ring structure around Uranus is easily detected, and the spectrum of Pluto and Charon (~0.7 arcseconds apart) can be obtained separately without contamination.

Regions such as the Galactic Centre are inaccessible to study except in the infrared because of extinction due to dust. The NIRSPEC + AO combination enables one to resolve numerous sources within the central 0.6 arcseconds, and obtain the spectra of these objects.

As illustrated in the accompanying figure from Claire Max (LLNL), observations with NIRSPEC + AO even extend to ultra-luminous infrared galaxies. The Keck AO images of NGC6240 are better than Hubble Telescope images, but more importantly, the detailed velocity structure of the shocked or ionized gas can be readily traced between the double nuclei of this dust-enshrouded active galaxy.

Further information about these instruments and facilities, together with the latest images, can be obtained from the W M Keck web site.

**Ian McLean**
*University of California Los Angeles, USA*

# The Future of Jodrell Bank Observatory


Graphic: University of Manchester

*Jodrell Bank is at the heart of the MERLIN array of radio telescopes. First operational in 1980 and extended in 1991, the array now stretches 217km across, from the Welsh borders in the west to Cambridge in the east.*

The University of Manchester has a proud tradition of astronomy, centred around the Jodrell Bank Observatory (JBO) which Sir Bernard Lovell founded in 1945 and which is part of the Department of Physics and Astronomy. With the IAU General Assembly being held in Manchester it is appropriate to describe the ambitious plans that JBO and the MERLIN/VLBI National Facility have for the future.

Recent articles in the British press have speculated about the future of JBO. The origin of the uncertainty lies in the desire of UK astronomers to join the European Southern Observatory (ESO). To find the money, there will have to be cuts in budgets, and possibly even closure, of some of the current British observatories. A statement on July 25th by Lord Sainsbury, the Science Minister was most helpful. He was quoted as saying that "The Particle Physics and Astronomy Research Council (PPARC) has reassured me that it has no plans to close Jodrell Bank. No decision has been taken by the Research Council about joining the ESO. However, if we did join then Jodrell Bank's radio frequency capability would complement the ESO's optical and infrared telescopes. PPARC has confirmed that it has no plans to change Jodrell Bank's funding."

The first of JBO's development plans is a comprehensive upgrade of the Lovell Telescope (LT) for which the University of Manchester was recently awarded £2M from the Joint Infrastructure Fund (JIF). The upgrade will be complete towards the end of 2002; its primary aim is to enable the telescope to work well in the frequency range 5-8 GHz and possibly higher. Once upgraded, the LT will play a key rôle in many different areas of astronomy. Added to MERLIN it will more than double sensitivity at a key operating frequency; it will enhance the capabilities of the world's most sensitive VLBI array, the European VLBI Network; it will also continue to provide superb single-dish spectral-line and continuum capabilities.

MERLIN is a world-class imaging telescope, funded by PPARC, that is unique in providing routine imaging capabilities at 0.1 arcsecond resolution complementary to those of the Hubble Space Telescope, Gemini, Subaru and other new generation optical and mm-wave telescopes (see figure at right). MERLIN consists of six radio telescopes distributed over central England, connected via narrow-band (28 MHz) microwave links and controlled from JBO. A proposal will be submitted to PPARC later this year to transform MERLIN by vastly increasing its sensitivity. The e-MERLIN project involves replacing the microwave links with optical fibres capable of supporting bandwidths of up to 4 GHz, replacing the existing correlator with a new much more capable broad-band system, and adding new receiver bands. When linked with the upgraded LT e-MERLIN will be 30 times more sensitive than the present array and will provide an enormous increase in capability to the astronomical community, especially in such areas as cosmology, star-formation across the Universe, active galactic nuclei and stellar evolution.

JBO is also contributing to the ALMA project. Building on expertise being developed in the astronomical use of optical fibres and the establishment of an optical fibre laboratory at Jodrell Bank, staff are currently engaged in developing concepts for the fibre systems for ALMA. Other ALMA-related developments are planned.

Many of JBO's current developments and future technological plans are centred around an international reputation for the quality of its low-noise, cryogenically-cooled receiver systems and the expertise that has been developed in the construction of multi-beam receivers. Projects with which JBO has been involved, often in collaboration with other institutes, include the Very Small Array, an aperture synthesis array for CMB studies recently installed on Mount Teide, Tenerife; the Low Frequency Instrument (LFI) for the Planck Surveyor satellite; and a 4-beam HI system, now in routine use on the Lovell Telescope.

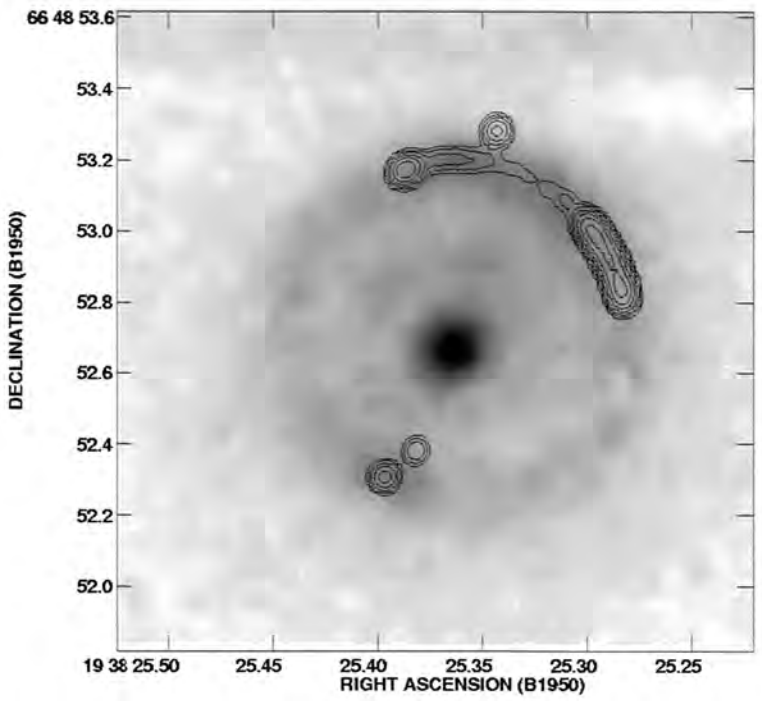
Other multi-beam focal-plane arrays are planned. In order to exploit the capabilities of the upgraded LT a seven beam system to cover the band 4-8 GHz will be built. This will be used, among other projects, to perform fast and deep surveys of the Milky Way to study and locate regions of star-formation through the detection of molecular masers and thermal emission. In addition, an ambitious 100-element wide-field detector called the One Centimetre Receiver Array (OCRA) is being planned. OCRA is designed to make deep all-sky surveys at 30 GHz; its main purpose will be a 'blind' survey for Sunyaev-Zel'dovich decrements. It is expected that OCRA will advance astronomy at 1-cm wavelength as much as the SCUBA bolometer array on the James Clerk Maxwell Telescope has advanced sub-mm wavelength astronomy.

Looking to the long-term, JBO hopes to play a pivotal rôle in the development of the next-generation radio telescope, the Square Kilometre Array (SKA). SKA will be a global project from the start; its organization is being set up now and technology workshops are defining the systems required; the most recent - 'Technological Pathways to the Square Kilometre Array' - was held at JBO on 3-5 August, 2000. JBO plans to contribute to SKA through its proven expertise in fibre and receiver technology, digital processing, software and the burgeoning techniques of astronomical survival in frequency bands contaminated by Radio Frequency Interference.

University of Manchester staff at JBO also run a cottage industry building small, cost-effective instruments for use on optical telescopes. The two Manchester Echelle Spectrometers are currently being upgraded, and will be used on telescopes around the world. Other instruments are also under development. The academic staff at JBO are also fully involved in the teaching of undergraduates. A new development starting in October is a distance learning course whereby students can enroll in an internet-based programme entitled 'Life in the Universe'. An active postgraduate training scheme also exists with, on average, 15-20 Masters or PhD level students enrolling each year.

Although technological developments underpin the science that astronomers can do, the exploitation of the technology requires vigorous and active research groups. JBO has a large group of world-class astronomers using techniques across the electromagnetic spectrum and telescopes around the world and in space. Strong research groups are active in the study of pulsars, masers, stellar outflows, interacting binary stars, starburst galaxies, active galaxies and their nuclei, gravitational lenses and the cosmic microwave background. There is no doubt that, given the ambitious plans that the observatory has for its future, and considering the strength of its research staff, the Jodrell Bank Observatory has a long and productive future ahead.

**Philip Diamond**
*Director, MERLIN/VLBI National Facility, University of Manchester*




*An image of the Einstein Ring gravitational lens B1938+666. The greyscale is a NICMOS image from the Hubble Space Telescope with the lensing galaxy visible at the centre. The contours show the 5GHz radio emission observed with MERLIN. MERLIN does not detect the radio-quiet lensing galaxy. The angular resolution of each image is very similar.*

# 'Heavy Metal' to Ruin Supernovæ Party?

A word of warning was sounded in Symposium 201 (New Cosmological Data and the Values of Fundamental Parameters) by Tom Shanks (University of Durham) on Thursday morning. Speaking on 'The Cepheid P-L relation metallicity dependence, Hubble's Constant and Type Ia Supernovæ', Dr Shanks followed three talks on the use of Type Ia Supernovæ as standard candles. His own research centered on Cepheids, but he said he believed that any factors affecting these more well known standards could also affect the Type Ia supernovæ used by other groups. The talk began with an investigation of the Tully-Fisher relationship (a well established link between the luminosities of spiral galaxies and the width of their hydrogen lines) and distances obtained by means of Cepheids and Type Ia Supernovæ.

The lecture then turned to Cepheids themselves and specifically the possible effects of metallicity on their use as standard candles. NGC 7790 in particular was used as an example; an important cluster since it contains no fewer than three visible Cepheid variables. This cluster has a well established distance and so provides a useful reference for studies of this type. Dr Shanks detailed some of the differences that have been found and highlighted the cluster's high metallicity as an explanation. The thrust of his argument was that the effects of metallicity could be substantial and that, as a result, the currently quoted HST Cepheid distances could be in error by as much as 25±5%.

Supernovæ are also used to estimate the matter and energy densities of the Universe. The results of this do not rely on being able to measure exact distances, but on how their brightness appear to vary with distance.

If Dr Shanks' findings are applied to supernovæ the agreement we have seen and reported in recent days will be damaged. Dr Shanks commented; "It is not even possible to rule out a Hubble Constant of less than fifty".

# Subaru Telescope

Photos: Subaru Telescope, NAOJ

*Above: The summit of Mauna Kea on the Big Island of Hawaii showing the many observatory domes and enclosures.*
*Left: The enclosure and control building of Subaru Telescope.*

Subaru Telescope is currently the world's largest monolithic mirrored optical-IR telescope, with a primary mirror 8.3 meters (27 feet) in diameter. The telescope saw 'first light' in January 1999 and is preparing for its first semester of Open Use beginning in December of this year. It will initially be offering its wide-field CCD camera (Suprime-Cam) located at the prime focus, and its versatile InfraRed Camera/Spectrograph (IRCS) located at the Cassegrain focus. Suprime-Cam currently uses an array of 8 individual 2048 x 4096 pixel CCD detectors to achieve a 24' x 24' field-of-view (FOV) with 0.2 arcsec per pixel. IRCS uses an ALADDIN II (1024 x 1024 pixel) InSb array in several imaging modes (23 and 58 milliarcseconds per pixel, FOV 23" and 60") and for low resolution (R~100-2000) grism spectroscopy, and a second identical array for high resolution (R ≤ 20,000) echelle spectroscopy with wavelength coverage from 0.9 to 5.4 μm.

All seven of the first phase instruments have now arrived in Hawaii and all have seen their respective 'first lights'. The adaptive optics unit has also arrived on the Big Island of Hawaii and is currently undergoing commissioning. The imaging performance of the telescope is excellent, having achieved 0.3 arcseconds on several occasions in visible light, and 0.2 arcseconds in the near IR (even before the use of the telescope's active secondary mirror).

It's been a very busy 19 months since the telescope produced its first images and expectations are high for a very productive future. Information about Subaru Telescope, including regular reports about the commissioning phase, scientific results and applying for telescope time can be obtained from the Subaru Telescope website at http://SubaruTelescope.org.

Subaru Telescope is operated by the National Astronomical Observatory of Japan (NAOJ), founded in 1988 under the jurisdiction of the Japanese Ministry of Education, Science, Sports and Culture. The NAOJ functions as an inter-university research institute for astronomy and related science fields, promoting collaborations and hosting international programs at various levels. The current activities of the NAOJ range from geodesy to radio astronomy, including ground and space-based VLBI projects (VERA, VSOP), research and development of a gravitational-wave detector (TAMA300), the Large Millimeter and Submillimeter Array (LMSA) and the Subaru Telescope.

**Ian Shelton**
*Subaru Telescope, NAOJ*

# Oh Be A Fine Girl Kiss Me (Right Now Sweetheart) ... *Lovingly Tender*

**This rather antiquated mnemonic has served to teach stellar spectral types for nearly a century, but now we have brown dwarfs and the spectral types L and T we could do with something new and perhaps a little racier. We invite you to submit suggestions to *Northern Lights*, and next week we will publish the best entries.**

In the meantime if you want to find out what L and T dwarfs are all about there is a meeting devoted to their theory, properties and issues of spectral classification. The joint session of Commissions 45 and 29 on Ultra Cool Dwarfs is being held today in Roscoe 3.2 from 9am; see pages 84-85 of your Final Programme.

Although astronomers have been searching the skies for brown dwarfs for decades, it is only in the last few years, with more sensitive detectors and new near-infrared all-sky surveys, that these cool objects have popped out from the background. The first detections came in 1995, with the identification of lithium.

Lithium, a light alkali element, is depleted in objects more massive than 65 Jupiter masses ($M_J$), so identification of this line pegs the object as a brown dwarf. There has been some debate over this method of identification, but for objects less massive than 60-65 $M_J$ and warmer than spectral type L6-7, it appears to be an accurate substellar test. Nonetheless, it should be stressed that the L spectral class does not define an object as being a brown dwarf nor as a 'lithium object'. The L spectral class arises because of the discovery of a large number of cool faint objects with spectroscopic features fundamentally different from M dwarfs, in particular the emergence of strong neutral atomic lines of alkali metals together with the replacement of metallic oxides TiO and VO with the metallic hydrides CrH and FeH. L is chosen because of available letters for new spectral classes and its alphabetical proximity to M.

At roughly the same time, a search around young nearby stars came across a companion object to the M1V star Gl 229. This object was truly bizarre, showing strong absorption bands of $CH_4$ in the near-infrared, the same features seen in the planets Jupiter and Saturn and even the moon Titan. Clearly this was a very cool object, and further investigation pinned down a temperature of around 1000K, far cooler than any star or brown dwarf identified at that time. This object, Gl 229B, continues to be a benchmark for brown dwarf research, and is the prototype object of the class called T dwarfs, or methane brown dwarfs. For four years no objects similar to Gl 229B were identified, until May 1999, when Sloan, 2MASS, and the NTT Deep Field announced discoveries of field methane dwarfs in sky surveys. These all turned out to be very similar to Gl 229B. A breakthrough in understanding these objects came with the discovery of a field T dwarf that turned out to be a distant fourth member of the Gl 570ABC system. At 5.9 pc, Gl 570D is about a 2.5 times intrinsically fainter than Gl 229B, which translates into a $T_{eff}$ = 750±50 K. This provides a second point in the temperature scale; however, like many of the other T dwarf discoveries, this object's near-infrared spectrum is nearly identical to Gl 229B's. There are some slight variations, but they are subtle.

On the warm end, the link to the L dwarfs has effectively been closed, by the detection of objects that show both $CH_4$ and CO at K and L bands. However, the near-infrared colours are similar to main sequence giant stars, and it appears that such objects will be hard to tease from survey data. It is as yet unclear how rapidly the transition occurs, which will depend greatly on the rapidity of $CH_4$ formation and, perhaps more importantly, the degree of mixing in the upper atmosphere, which will tend to delay $CH_4$ saturation.

Work on the observational and theoretical properties of L and T dwarfs is progressing rapidly. The session today will try to address most of existing problem areas together with developing new areas, for example, variability, the deuterium test, the multiplicity of brown dwarfs and identification of cooler objects. Although the current work is advancing well to reveal the properties of brown dwarfs, how large their population is, and the physics of their thick atmospheres ... we could do with a new mnemonic.

**Hugh Jones**
*Liverpool JMU*
**Adam Burgasser**
*Caltech*

# WG on Solar Eclipses of the Solar Commissions

## (Division II: Sun and Heliosphere)

This Working Group coordinates professional observations of solar eclipses, assists expeditions with technical matters, and provides a source of advice to astronomers and education in the countries involved. Particularly important in the last category is the information they provide about the distinctions for the general public between total and partial phases, and how to observe the partial phases safely. Jay Pasachoff (USA) summarized the WGs activities to the Business Meeting of Division II on Thursday. Long-term members of the WG include members from the USA, Russia, Belgium, Japan, India, Slovakia, and Canada. For the 1997-2000 triennium, it included Magda Stavinschi from Romania. For the 2000-2003 triennium, it includes Francis Podmore from Zimbabwe, Case Rijsdijk from South Africa, and Peter Kalebwe from Zambia.

Scientific work at eclipses includes studies of the chromosphere and corona, and overlaps with the important observations from such satellites as SOHO, Yohkoh, and TRACE. Some spatial regions of the lower corona, some spectral domains, and some time domains can still be studied uniquely at eclipses. Examples include the spatial region below the height at which the LASCO coronagraphs on SOHO cut off, yet above the disk coronal UV images from EIT, the infrared, and waves with periods of a few seconds or less.

The WG's website at www.williams.edu/astronomy/IAU_eclipses contains links to all types of eclipse activities. Scientific expeditions are asked to register there.

The path of totality at the next total solar eclipse will cross Angola, Zambia, Zimbabwe, Mozambique, and Madagascar on 2000 June 21. It is expected that scientific expeditions will go to Zambia and Zimbabwe. The path of totality at the following total solar eclipse, on 2002 December 4, will cross parts of Angola, Botswana, Zimbabwe, South Africa, Mozambique, and, at sunset, in Australia. A partial solar eclipse will be visible from the United States, Canada, and Mexico on Christmas Day, 2000 December 25.

**Jay M Pasachoff**
*Williams College – Hopkins University, USA*

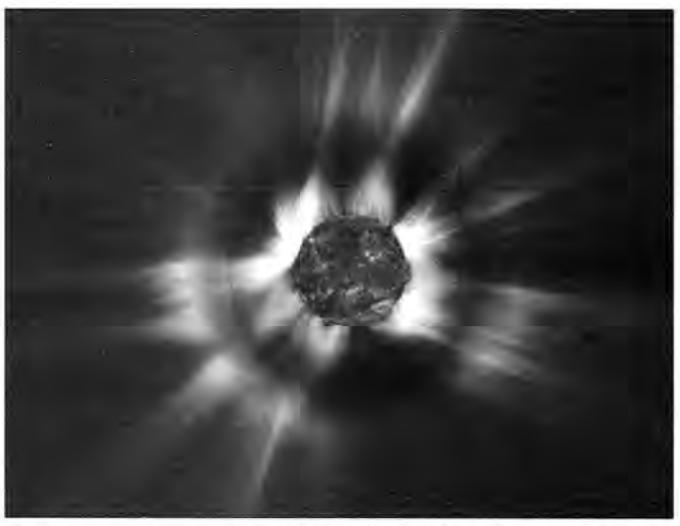


Photo: Jay M Pasachoff and colloquies (eclipse), NASA/GSFC (EIT) and Naval Research Lab (LASCO).

*The solar corona imaged during the 1999 August 11 total eclipse in Romania by the Williams College expedition fills the gap between the solar disk coronal image from SOHO's EIT instrument and the SOHO LASCO coronagraph.*

# Trans-Neptunian Objects: A Hot Topic

With the population of trans-Neptunian objects (TNOs) having more than tripled since the last General Assembly, any statement more than five years old in this subject is classical, said Brett Gladman (Observatoire de Nice, France) in JD4. But the beginnings of the realization that there was something odd about the outer Solar System started with the discovery of Pluto, pointed out Alan Stern (Southwest Research Institute, USA). Its eccentricity and its high inclination are characteristic of the TNOs and mark them as dynamically 'hot,' even though in temperature they are cold, so far from the Sun.

Pluto and its satellite Charon are a binary planet and the only viable model for Charon's formation is a giant impact, similar to the formation of Earth's Moon. If this is so there must have been a large number of possible impactors for one to find Pluto and collide with it in such a big region. Given the population of TNOs, the Kuiper Belt (30-50 AU) is even now as collisional as the asteroid belt once was – there is a greater volume but more objects.

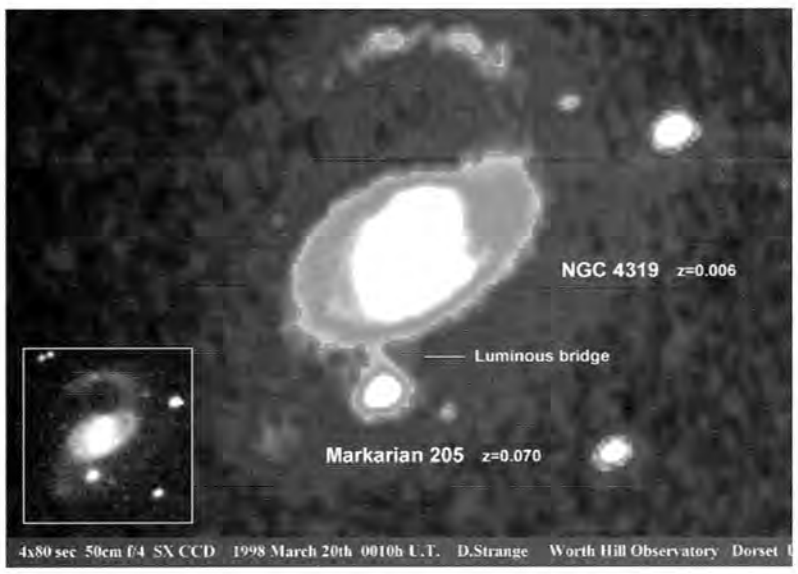
The accretion process that generated the TNOs in the early history of the Solar System would have gone on to build up fewer but larger objects but the number of planets was stopped at nine when the population of TNOs became hot. The trans-Neptunian zone out to 50 AU is currently dynamically evolving by the influence of the gas giant planets - concentrated into resonances like the Plutinos or pushed into planet-crossing orbits like the Centaurs or the short period comets.

What lies beyond 50 AU? Alan Stern speculated that it is a zone which is collisionally evolving, maybe still accreting, and there could be a small number of largish bodies – even Earth-sized – still to find at distances of 100 AU – Planets X, Y and Z? Alternatively, there could be a large number of smaller bodies, forming a 'Kuiper disk' relating to the dust disks seen orbiting round extrasolar main sequence stars.

To spontaneous applause Robert Millis (Lowell Observatory) paid tribute to David Jewitt's persistence in searching for Kuiper Belt objects long after everyone else had given up, with the reward of finding the first, 1992 QB1. This discovery, said Stern, formed a context for the oddities of Pluto. It is not a rogue planet, and with its fellow TNOs, it makes a natural connection between our home Solar System and the evolution of planetary disks in other stars.

**Paul Murdin**
*British National Space Centre*

# NGC 4319/Markarian 205




The assumption that redshifts measure distances is crucial to cosmology. Many observations, however, have reported the association of high-redshift quasars with low-redshift galaxies. Cases of actual connection are rare, but one of the best is shown here. This famous example was discovered over twenty years ago with the 200-inch Palomar telescope, and confirmed with the KPNO 4-metre telescope. But the connection has been denied by various astronomers using other large telescopes.

Now an observation by an amateur, David Strange, using a 50-cm telescope from the English countryside shows the connection as well as or better than any previous picture. It is shown here in grey tones (the colour picture is on the web page of the Worth Hill Observatory.) Image processing of previous observations by Jack Sulentic has shown the effect of the filament leading directly into the nucleus of the very distorted NGC 4319 galaxy.

The galaxy has about 2000 km/s redshift, and the quasar AGN has 21,000 km/s. Another recently discovered case links a quasar of redshift z=2.15 with a galaxy of very low redshift. That galaxy, NGC 3628, also shows signs of explosive activity; it is emitting long hydrogen plumes, and is agreed by observers to be ejecting X-ray material along its minor axis. Amazingly, the z=2.15 quasar is located exactly on the end of an X-ray filament emerging from the active nucleus of the galaxy.

Of course the location of very high and very low redshift objects together in space violates the cosmological assumption of extragalactic astronomy that redshift always means recessional velocity, and can be used to measure distances and luminosities. Nevertheless, the pictures represent primary observational data, and have been independently confirmed. In view of the vital importance for cosmological theory, it is surprising to many people that professional astronomers do not investigate these cases. These and numerous other cases are not scheduled to be discussed in any talks at the current IAU General Assembly.

**Halton Arp**
*Max-Planck Institut für Astrophysik, Germany*

## The Universe: Larger Than We Thought?

Stars burn brightly; while planets are cool. They are also infinitely distant.

From the London *Times*, August 8

## Saturday Refreshments

Unfortunately, morning coffee and afternoon tea will NOT be available in the Schuster Laboratory today. So, would all participants attending meetings in the Schuster Laboratory please go to the neighbouring Roscoe Building for their refreshments.

## You (may) Have Mail!

Some delegates have complained that messages left in mailboxes in the Whitworth Hall earlier in the week are still there. PLEASE remember to check your mailbox every day. The mailboxes are located on the stage to the right as you go through the doors into the main Registration area.

## 3 How to set up a data table

Astronomical Data Centres like CDS and NASA/ADC have agreed on certain standards for the preparation of tabular data

See http://vizier.u-strasbg.fr/doc/catstd.htx

You, as an author, could help and stick to these conventions. E.g., if a value in a certain column is unknown, better leave it blank, and do not use "dummy" values like "0.0", "-999", etc., as these may occasionally be mistaken for real data. To quote an equatorial position (RA and DEC) it is a good idea to write e.g. "00 01 03.4 +03 04 05" rather than "0 1 3.4 3 4 5" (for example, see Table 1 of AJ 119, 2092 to get an idea what can happen otherwise). When quoting radial velocities (of stars or galaxies) make sure you mention the reference frame your data correspond to (e.g. LSR, geocentric, heliocentric...), and whether you are using the radio or relativistic velocity convention rather than the standard optical convention.

**Heinz Andernach**
*ESA, IUE Observatory*
*Villafranca, Spain*
*for Commission 5 WG on Astronomical Data*

## Division XI: New X-Ray Missions

**Saturday, August 12: Bragg Theatre**

| | |
|---|---|
| **09:00 - 10:30hrs** | **CHANDRA** |
| **09:00 - 09:30hrs** | The Chandra Observatory and Observations of Young Clusters J. Linsky |
| **09:30 - 10:00hrs** | CHANDRA High Resolution Spectroscopy of the Supernova Remnant E0102-72 K.Flanagan |
| **10:00 - 10:30hrs** | The X-Ray Background and the CHANDRA Deep Field South G. Hasinger |
| **11:00 - 12:30hrs** | **XMM-NEWTON** |
| **11:00 - 11:30hrs** | The XMM-Newton Observatory F.Jansen |
| **11:30 - 12:00hrs** | Galactic Sources with EPIC F Haberl |
| **12:00 -12:30hrs** | X-ray Astrophysical Spectroscopy of Cosmic Sources with XMM-Newton RGS F. Paerels |

**Willem Wamsteker**
*President, Division XI*

# About those old plates...

*What old plates? Oh – the ones in our plate vault? Been there for years. We were thinking of tossing them out because no-one works on them nowadays, and some people want the space for computers.*

Wait... don't toss them yet. They've been accumulating value for upwards of fifty years. They contain a wealth of information about long-term variability that no amount of modern equipment can repeat or recover in the short term.

There are projects afoot to digitize the photographic observations. Technically that is perfectly feasible, but it faces two important problems: (a) obsolescent equipment and (b) superannuating expertise. Fortunately, sufficient of both still remain to get the projects under way.

Photographic archives are an enormous, rich and invaluable heritage. We would like to have that information on-line, ready to use for our research and teaching – Wouldn't you? Come to our meeting on Monday afternoon, August 14 in the Bragg Theatre, Schuster Building, and join us as we debate the future of this unique resource.

**Elizabeth Griffin**
*Working Group for Spectroscopic Data Archives, Division IV*

## 5 The Naming Game

Did you know that the new FITS "object" keyword now supports 68 characters (instead of only 8 characters)? The new revised FITS standard, 100-2.0, (dated 29 March 1999) is available at http://fits.gsfc.nasa.gov

**Helene R. Dickel**
*University of Illinois, USA*
*& Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

## Did you miss the 1999 Leonids?

On 1999 November 18 a brilliant display of Leonid meteors was seen over Europe and the Middle East; the hourly rate reached one meteor per second for a brief period. Unfortunately many people missed the meteor storm, because of bad weather. However, you will have a chance to see it during the present General Assembly.

The National Astronomical Observatory of Japan has set up its Exhibition in the Royal Northern College of Music, and is pleased to show GA delegates a video of the 1999 Leonids as recorded from an aircraft by the NHK high-sensitivity HDTV camera. The video also includes general scenes; the whole presentation lasts for about 20 minutes. Details can be checked at the Royal Northern College of Music. Contacts: Jun-ichi Watanabe or Tashio Fukushima of the Public Relations Centre at the National Astronomical Observatory of Japan.

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY

MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.7:** *MONDAY 14th AUGUST*

## Pluto: Planet, TNO, Asteroid – or What?

In Joint Discussion 4 (Trans-Neptunian Objects) on Friday, there was a lively discussion about the status of Pluto. Ever since its discovery, by Clyde Tombaugh in 1930, it has presented astronomers with a great number of problems. It has long been classed as a planet, but the discoveries first of Chiron and then of other trans-Neptunian objects (TNOs) have somewhat muddled the situation.

Opening the discussions, Michael A'Hearn (University of Maryland) pointed out that there was an analogy with the case of the archæopteryx, which has the characteristics of both a bird and a dinosaur. It has feathers, a wishbone and bird-like hind limbs, but also a pelvis, teeth, and vertebræ, which are decidedly un-avian.

So with Pluto. Planet-like, it has a bound atmosphere and is far larger than any other object in the far reaches of the Solar System, but as a potential TNO it has orbital resonance with Neptune, and has an orbit which is both eccentric and inclined.

After all, what really defines a planet – in particular, does it dominate its part of the system? And remember that there are several satellites (Titan, the Galileans and our own Moon) which are of 'planetary' size. Summing up, A'Hearn said that Pluto "has properties of both planets and TNOs, and its bearing on the evaluation of planetesimals is unchanged by the present verbal question."

The Chairman of the Discussion, Brain Marsden, then called for a vote. The results were interesting.

Those who believed Pluto to be only a planet: 8 votes

Those who believed it to be only a TNO: 14 votes

Those who believed it to be a 'mixture', with 'dual nationality': 37 votes

Perhaps the final word was left to a questioner who called for a vote to see how many people regarded Pluto as only a dog. This had no support at all, and the Discussion closed.

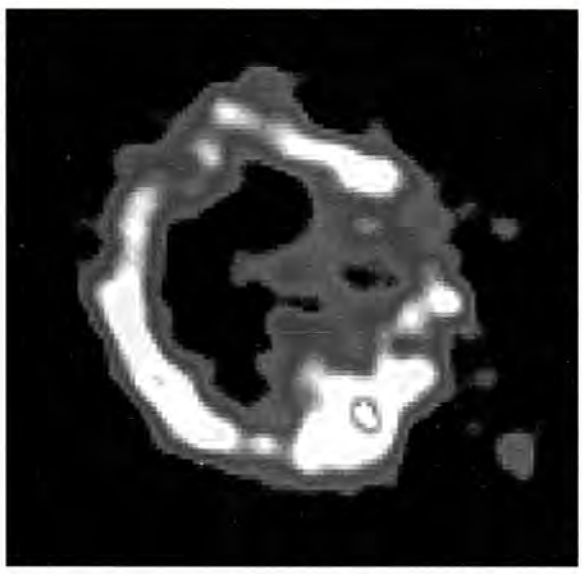


Photo: NASA/MIT

## Chandra Explores Ashes of Exploded Star

*The oxygen in supernova remnant E0102-72 is seen here shining brightly with X-rays of a single energy. Image from the Chandra High Energy Transmission Grating/Advanced CCD Imaging Spectrometer.*

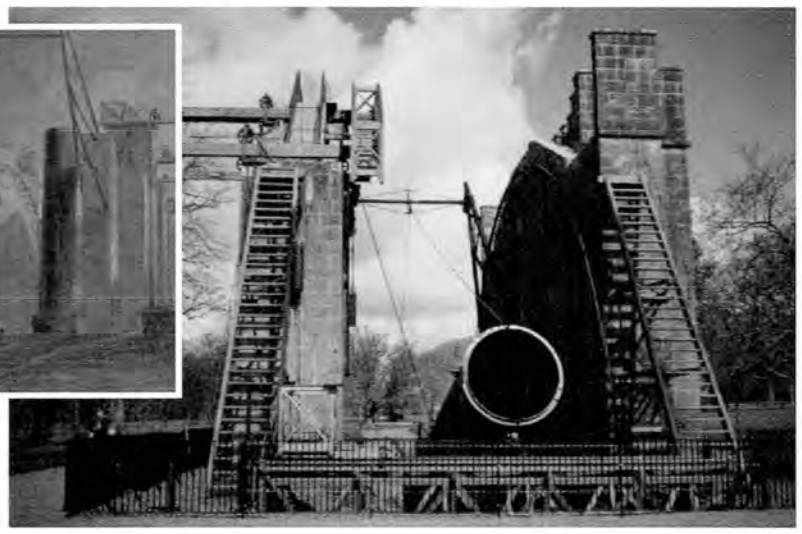
On Saturday, August 12, Division XI hosted a meeting dealing with results from the X-ray observatories XMM-Newton and Chandra. XMM is an ESA Cornerstone Mission, while Chandra is NASA's third Great Observatory.

Among the many interesting topics presented were two data sets obtained with the diffraction grating spectrometers on both observatories. The accompanying figure shows a monochromatic image obtained with the High Energy Transmission Grating (HETG) on Chandra, at an X-ray line of highly ionized oxygen from the young supernova remnant E0102-72 in the Small Magellanic Cloud. The observation shows bulk velocities at 1000 km/s, and an inward-moving shock front. The XMM observations of E0102-72 with the Reflection Grating Spectrometer have led to the very first detection of the X-ray lines of highly ionized carbon and nitrogen in any supernova remnant. They also provide direct and complementary evidence with regard to the process of an inward-moving shock. Both of these missions were launched during the past year.

On another front, based on early results, high resolution spectroscopic observations of cooling flows in clusters of galaxies are expected to contribute enormously to our understanding of these phenomena.

**Frits Paerels**
*Columbia University, USA*
***Kathryn Flanagan***
*MIT*

## The Irish 'Leviathan'



Illustrations: Birr Castle Archive

*Two views of the 72-inch reflector at Birr Castle. **Above**: during its construction. **Right**: as it is today, following complete restoration.*

Those IAU delegates and guests who took part in this weekend's trip to Ireland will have seen what is certainly the most unconventional telescope in the world – and also one of the most significant. This is the 72-inch reflector built by the third Earl of Rosse at Birr Castle in County Offaly, some way from Athlone, and completed in 1845.

Lord Rosse became interested in astronomy at an early age, and after graduating from Trinity College Dublin he decided to construct a large telescope. His first major success came with a 36-inch reflector, conventionally mounted and set up in the Castle grounds. The mirror was of speculum metal, an alloy of copper and tin; at that period it would have been well nigh impossible to cast a glass disk of such a size. Lord Rosse's first task was to build a forge, into which the metal was poured; when cooled, the 'mirror' was figured. During this process Lord Rosse developed what may be regarded as the first mechanical grinding device.

Next came an even greater experiment: the construction of a 72-inch mirror, far larger than any mirror previously made - but how to mount it? Engineering techniques of the day were simply unequal to the task of making a mounting for the huge tube which could reach the whole of the sky. So the tube was mounted between two massive stone walls, and pivoted at the bottom, so that it could swing in altitude but for only a limited distance to either side of the meridian. The observer had to wait for the Earth's rotation to bring the target object into the required position. The optical system was Newtonian, so that the observer had to ascend a ladder to reach the viewing cage; there was no drive, so that the position of the telescope had to be moved by hand and required a team of assistants; and there was no finder. Yet at once it became clear that the telescope was a success. It had an immense light-grasp, and could 'see' objects which no other contemporary instrument could hope to do.

Lord Rosse looked at the nebulæ which had been catalogued by Charles Messier. Some of them were spiral, resembling huge Catherine wheels. One of the first to be examined was M51, in Canes Venatici – the 'Whirlpool', as Lord Rosse called it. His drawing of it compares well with modern photographs, and other spirals were soon found, though other 'nebulæ' showed no structure and were clearly gaseous.

Astronomers from all over the world came to use the great telescope, known popularly as the 'Leviathan', and all were warmly greeted; it was said that nobody ever came to Lord Rosse for help or advice and went away unsatisfied. Undoubtedly the first thirty years of the telescope's existence were the most fruitful, and in the course of time it was overtaken by glass-mirrored, more conveniently mounted telescopes. The telescope was dismantled in 1909; the mirror was sent to the Science Museum in London, and the tube was left lying between its stone walls.

Today it is good to report that the telescope has been completely restored, and will be in full operation again before the end of 2000. The story of the Birr Castle telescope is unique, and nothing comparable can ever happen again. It will be good to turn the telescope to the sky, and see the Whirlpool Galaxy just as Lord Rosse saw it for the first time, more than 150 years ago.

# Identity Crises in the Solar System

*Illustration: David Jewitt, University of Hawaii*

*Artist's impression of icy bodies in the Kuiper Belt.*

The news item last week about the discovery of a planet orbiting Epsilon Eridani contained the statement that this was the closest planet to the Sun – after the nine planets of the Solar System. This last annoying remark, while presaging the suggestion that other planetary systems also contain extensive collections of smaller bodies, sells our planetary system short. Those who continue to think of the Solar System as consisting of the Sun and nine planets do it a disservice. The 100,000 or so rocky objects so far recognized in the cisjovian belt represent a substantial fraction of the 0.03% of an Earth mass believed to reside there. And although we have our work cut out if we are to catalogue a similar fraction of the icy objects providing 3 to 30% of an Earth mass in the trans-Neptunian belt, some small progress has been made in that direction.

" Is it not likely that in Pluto there has come to light the first of a series of ultra-Neptunian bodies, the remaining members of which still await discovery but which are destined eventually to be detected?" In considering the Solar System to be "composed successively of the families of the terrestrial planets, the minor planets and the giant planets, with further small bodies beyond the giant planets", Frederick C Leonard was way ahead of his time when he published these statements in the August 1930 *Leaflet of the Astronomical Society of the Pacific*. Long before Edgeworth and Kuiper, Leonard was clearly describing something surprising similar to what we have seen to be the case since the discovery of (15760) 1992 QB1.

If we include also the Centaurs, objects very probably dynamically evolved from Leonard's "ultra-Neptunian bodies", and of which the first, (2060) Chiron, was discovered in 1977, into orbits which interact with the giant planets, the number of known 'distant objects' is currently 336, some 40% of which have been observed at two or more oppositions and have tolerably reliable orbit determinations.

Examination of the reliable orbits has yielded patterns which could pretty much have been deduced beforehand if enough thought had been applied to the matter beforehand. The dominant population, variously called the 'classical Kuiper Belt' or 'Cubewanos', range up to several hundred km in diameter and have rather low-eccentricity orbits with semi-major axes in the range 41-47 AU and no current possibility of approaching Neptune within 9-10 AU. Pluto is itself the largest of a population characterized by orbits generally of somewhat higher eccentricity at 39-40 AU. With their orbital periods half as long again as that of Neptune, the 'Plutinos' exist in a limited set of configurations with Neptune and the Sun and are also prevented from approaching Neptune within 9-10 AU. Smaller populations of resonant objects exist with periods of twice, five-thirds and four-thirds that of Neptune. Another group of regular members of the belt is now starting to become apparent in low-eccentricity orbits at 38 AU from the Sun.

Perhaps the most complex part of the trans-Neptunaian population refers to the so-called scattered disk objects (SDOs), which, like the Centaurs have eccentric orbits and interact with at least one of the giant planets, Neptune, over a relatively short interval of time. The first of these, 1996 $TL_{66}$, orbits between 35 and 135 AU from the Sun. Some of these have orbits taking them 200 AU from the Sun at aphelion. Is there a significant difference between the scattered population and the Centaurs? Not a great deal, I think, and for many purposes they can be combined. What is the distinction, when one has an object like 1999 $TD_{10}$ in a low-inclination orbit ranging from 12 to 200 AU from the Sun? Possibly a working distinction is to grant that the SDOs have perihelion distances in the range 30-38 AU (whereas the Centaurs are currently at 22 AU and smaller), but that could change.

Allowing for the fact that the closer objects are apparently brighter than those at greater distances, we can estimate that perhaps two-thirds of the total population of distant objects are Cubewanos. Although Plutinos seem to be quite populous, they may account for only 12% of the population with the SDOs then weighing in at 9%. The orbital inclination of these bodies to the ecliptic range up to more than 30 degrees, which in practice means that we could find them not just near the ecliptic, but over half of the sky. Several of the highest-inclination objects are among the Cubewanos, giving rise to the appearance of two distinct sub-populations there.

Perhaps the trans-Neptunian belt differs from what Leonard envisaged in 1930. But it also differs from what Edgeworth and Kuiper were talking about around 1950. And while Fred Whipple, writing in 1964, was also understandably short on the details, he did draw the trans-Neptunian belt in just about the right place, included Pluto as a member, and estimated that many of the others awaiting our detection would be 100-km objects at apparent magnitude 22.

**Brian G Marsden**
*Harvard-Smithsonian Centre for Astrophysics, USA*

# Special Session:

## Astronomy for Developing Countries

In a new departure at General Assemblies, the IAU Executive Committee has approved the holding of a Special Session – something more than a Joint Discussion but less than a Symposium – on the topic 'Astronomy for Developing Countries'. This meeting arose from a joint proposal by the Working Group for the Worldwide Development of Astronomy and Commissions 5, 38 and 46; it is the longest meeting on this topic that the Executive Committee has yet approved, although many of the same sponsoring Commissions have helped to organize shorter sessions at the three immediately previous General Assemblies.

We have already attracted much interest, and hope to see a good crowd at our meeting in the Cordingley Theatre, Architecture Building (PLEASE NOTE the change of venue from that given in the Final Programme), which begins today and continues tomorrow and Wednesday.

As well as a summary in Highlights of Astronomy, we intend to publish our proceedings in a separate volume of the ASP Conference Series (which you may order on the same terms as the symposia volumes from this Assembly which will also be published by ASP). Our hope is that the volume of proceedings will serve as a manual both for those who are trying to revitalize astronomy in their own countries and for those from other countries who are trying to help them. To do this, we will try to examine what is going on in developing countries now and what we can do to strengthen those local initiatives. We have speakers from every continent (except Antarctica!) and from countries in a wide range of economic and astronomical development.

We will learn at first hand what it is like to try to study astronomy without a telescope, possibly without even a computer, and without easy access to journals and books. Can distance learning help? Can access to modern databases substitute for the ability to travel and to obtain one's own observations? What is it like to be one of only a few (perhaps less than half-a-dozen) astronomers in a country? Should people in such circumstances even attempt to study astronomy at all? How much money should any country spend on its astronomers? We will grapple with all these questions and perhaps more as well, and we expect to hear a large variety of answers to them.

The latter part of Wednesday morning will be devoted to a panel discussion moderated by Rajesh Kochhar. We solicit written questions in advance, and they may be given either to him or to the undersigned. Of course, all General Assemblies offer many interesting sessions in parallel, and few of us have yet learned how to be in two or more places at once. Our Special Session, like all events at the General Assembly, has to compete for attention with several other important meetings, but we hope that many of you will be able to come to at least parts of this ground-breaking event. Perhaps you have some special insight to contribute, or you may learn from us some way in which you can help colleagues who are less fortunately placed in their studies than you are yourself.

**Alan H Batten**
*National Research Council, Canada*

# Maori Astronomy

Interesting notes on some Maori observations were given during Joint Discussion 5 (Applied Historical Astronomy) last Friday by Wayne Orchiston (Australia, formerly Director of the Carter Observatory at Wellington, New Zealand).

New Zealand was first settled by the Polynesians, and there are no records of any kind before a thousand years ago at most. Early information depends upon myths, rock art, decorated artifacts and astronomically oriented structures, often by no means easy to interpret.

One Macri record refers to a *mahutonga* – 'a star of the south which remains invisible'. Could this by any chance indicate a nova or a supernova? There is no clue as to the date, but we can make a guess at the location. In the Maori language the Southern Cross is *kahui o mahtonga*, and the Coal Sack is *te rua o mahu*. If the record is founded on fact, it seems logical to assume that the object appeared in the region of Crux. However, it is all very vague, and there are no other references to it from Polynesia. All we can say is that there is a chance that a supernova flared up, so far south in the sky that it was not seen by any European observers; and there are four or five known supernova remnants in the same general area, so that it is just possible that one of these refers to the star seen by the Maori.

Much more recently – in 1830 – a Maori record states that a *rongomai* (fireball) appeared near Owhiro, in the region of Wellington; it was 'seen in broad daylight, a fiery ball rushing through space, which struck the ground and threw up a cloud of dust.' This sounds very like a meteorite impact, in which case a crater may have been formed, but so far nothing of the sort has been identified in the area.

# 8 Joint Discussion

## Oxygen Abundances in Old Stars and Implications to Nucleosynthesis and Cosmology

In Joint Discussion 8, to be held in the Concert Hall of the Royal Northern College of Music today, attention will be paid to the problem of oxygen abundance in metal-poor stars. This is a controversial issue; some investigators find an over-abundance relative to iron of a factor of more than 10, whereas others find a factor of 3 to 5 at most.

These varying results are derived from different lines in different stars (e.g. giants and dwarfs). In cases in which it is possible to derive oxygen abundances from different sets of lines for the same star, discrepancies are often found. This demonstrates the need for a detailed analysis of each set of lines in terms of atomic and molecular constants, model atmospheres in 1D, 2D and 3D calculations, non-local thermo-dynamic effects and continuum opacity. The derivation of oxygen abundances, using high signal-to-noise spectra obtained with large telescopes, based on the forbidden [OI] lines, permitted OI lines, ultraviolet OH lines and infrared OH lines, will all be discussed.

The implications of the oxygen overabundance in metal-poor stars are very important. There are several reasons for this. (1) The estimated ages of globular clusters can change by several gigayears (and this would affect the derived age of the Universe, since globular clusters are the oldest extant objects). (2) Models of the early enrichment of the light elements Li, Be and B formed by spallation of CNO atoms are strongly affected by the amount of oxygen over-abundance. (3) The constraints to be imposed on chemical evolution at early times can be refined; these in turn affect the higher mass supernovæ. All these points will be discussed during the meeting today.

**Beatriz Barbuy**
*University of Sao Paulo, Brazil*

# 9 Joint Discussion

## Cold Gas and Dust at High Redshift

After opening remarks by Chairman David Wilner (CfA), the first presentation of Joint Discussion 14, which deals with matters relating to gas and dust in high-redshift galaxies, will be given by M Fall (STScI, Baltimore), who will address issues relating to gas inflow and outflow during star formation and metal and dust production in galaxies as functions of redshift.

Paola Andreani (Osservatorio di Padova) reviews the observational status of dust at different cosmological epochs, from the local Universe, to z=1 and up to z=5, and shows how it will soon be possible to disclose the entire history of evolving dusty objects and, therefore, of star formation. She is followed by Frank Briggs (Kapteyn Institute, Groningen) who will discuss the importance of atomic hydrogen (HI) and the radio telescopes such as those at Westerbork, GMRT, and the Extended VLA, which will measure the HI content and general deployment of gas-rich galaxies since the period when they began to assume their present form. Amy Barger (University of Hawaii), deals with star formation and AGN activity in dust-enshrounded distant galaxies, and presents new results obtained with SCUBA, the bolometer array on the James Clerk Maxwell Telescope at Mauna Kea. Frank Bertoldi (Max-Planck Institut für Radioastronomie, Bonn) summarizes the results from deep imaging and pointed observations made with MAMBO (Max-Planck Millimetre Bolometer), at the IRAM 30-metre telescope.

Millimetre and submillimetre results relating to molecular gas and dust in ultra-luminous IR merger galaxies will be reviewed by Dennis Downes (Institut de Radio Astronomie, Grenoble). These data may be relevant for interpreting observations of high-z sources. Chris Carilli (NRAO) will show how centimetre (cm) observations can be used to study cold gas at high-redshift, through observations of HI 21-cm absorption and molecular lines in absorption and emission. Observations of such emission using the VLA at cm wavelengths will be presented. David Elbaz (CEA Saclay) will present results of the ISO mid- and far-infrared surveys performed with ISOCAM and ISOPHOT which have revealed a population of faint luminous infrared galaxies more numerous than expected. Ryohei Kawabe (Nobeyama Radio Observatory, Japan) gives news about the Japanese Large Millimetre and Submillimetre Array (LMSA) and the US/Europe Atacama Large Millimetre Array (ALMA), which are to be set up at a very high, dry site in the north of Chile. Finally, Andrew Blain (IOA, Cambridge) will show that, although based on observations made with COBE, SCUBA and ISO, we now have a reasonable working knowledge of the submillimetre wave and far infrared background radiation intensity and of the source counts of luminous high-redshift dusty galaxies, important details remain unclear. He will review the prospects for the new, more capable ground-based submillimetre-wave cameras (BOLOCAM, SHARC-II and SCUBA-II), and wide-band spectro-graphs. In the afternoon there will be a concluding open discussion by all JD participants.

*Photo: Joint Astronomy Centre (Hawaii), PPARC (UK), National Research Council of Canada and The Netherlands Organization for Scientific Research.*

*Photo: ESA, ISAS and NASA*

*The James Clerk Maxwell Telescope (above) and Infrared Space Observatory (right) - two of the instruments which have been used to make some of the observations which will be presented during Joint Discussion 9.*

# 10 Joint Discussion

## Cluster Mergers and Their Connection to Radio Sources

Our understanding of the dynamical second evolutionary state of clusters of galaxies is undergoing major changes. Clusters are no longer believed to be simple, relaxed structures but are interpreted within the framework of the hierarchical growth of rich clusters via mergers of poor groups. This merger activity appears to be continuing at the present time, and would explain the relative abundance of substructure in Abell clusters. It is also supported by the temperature gradients detected in the cluster intergalactic medium by X-ray observations.

During Joint Discussion 10, a one-day meeting, which takes place today in Theatre 1 at Crawford House, the radio, optical and X-ray properties of clusters will be reviewed, and new results from the Chandra and XMM satellites will be presented.

It is well established that an important component of the intergalactic medium in clusters and groups of galaxies is the hot gas, detected in X-rays. In addition, magnetic fields are widespread in clusters, and play an important rôle in the dynamics of the intracluster plasma. The data suggest that the magnetic field is strong enough to be dynamically significant on large scales, and may be close to thermal equipartition in the cores of some clusters. Moreover, clusters can contain large quantities of relativistic particles, whose presence can be directly revealed in some cases by diffuse radio emission. A goal of JD10 is to gain new insight into the interaction between thermal and relativistic plasma in clusters, and their connection with the dynamical processes.

The properties of large-scale cluster radio halos and relics will be discussed. They are extended, diffuse radio sources with no optical counterpart, typical sizes of 1 Mpc and a steep radio spectrum. Halos permeate the cluster centre, with no polarized emission detected; relics, on the other hand, are found at the peripheries of clusters with relatively strong polarization.

Many questions remain un-answered about the origin and evolution of these strongly magnetized regions. It has been suggested that they are related to the presence of ongoing merger processes, but the details of this model are still unclear: the connection between halo formation and the timescale and energies of the merger process needs to be quantified.

The supply of relativistic electrons is an important topic for discussion. The proposed theoretical models are: (1) in situ acceleration by turbulent gas motion; (2) diffusion of relativistic electrons out of the present head-tail radio galaxies; (3) secondary particle production. The rôle played by the environment on the formation and structure of radio galaxies will also be discussed. Cluster radio galaxies show typical morphologies very different from those of isolated radio galaxies. The dominant structures of cluster radio galaxies are the wide-angle-tailed and narrow-angle-tailed, which result from the interaction between radio sources and the outer gas.

A possibility is that these sources, which are associated with dynamically complex clusters, are shaped by merger-induced gas bulk motions. This science is rapidly evolving, owing to the amount of new information which is becoming available with the new generation X-ray satellites, optical telescopes and deep radio surveys.

JD10 has been organized by Division X (Radio Astronomy) with support from Divisions VIII and XI. It will summarize the state of the art and stimulate debate among the communities of radio, optical and X-ray specialists for a fruitful exchange. The JD includes both talks and posters. An oral review of the posters in also planned.

**Luigina Feretti**
*Istituto di Radioastronomia CNR, Italy.*

*... for Joint Discussion 11 see page 4*

## Resolutions Committee

For technical reasons, it has not proved possible, as planned, to publish the three General Assembly B Resolutions in French. Copies of the full French text of the Resolutions are available from the IAU Secretariat (Committee Room D, Whitworth Building) and copies will also be available at the Bridgewater Hall on Wednesday August 16. The Resolutions, in English, will be available on Monday, August 14 (pm) on the Notice Boards, and will be included with *Northern Lights* on Tuesday, August 15. Please bring a copy of the Resolutions with you to the Second Session of the General Assembly.

***Derek McNally***
*Chairman, Resolutions Committee*

11

# Joint Discussion

## First Results from the FUSE Mission

*Photo: Johns Hopkins University and NASA*

*The Far Ultraviolet Spectroscopic Explorer satellite before launch.*

The Far Ultraviolet Spectroscopic Explorer (FUSE) satellite was launched on 1999 June 24 on a three-year mission to answer questions about the origin of the light elements and the physical processes controlling the structure and evolution of galaxies.

The far ultraviolet spectral interval between the photoionization limit of atomic hydrogen (911 Å) and 1200Å is one of the few regions of the electromagnetic spectrum between X-rays and optical light that is essentially unexplored by astronomers. High resolution spectroscopy at these wavelengths is technically challenging but holds great promise for shedding new light on age-old questions about the origins of the Universe and the chemical elements of which stars, planets, and life form. The last major instrument to explore this spectral region was the Copernicus mission in the 1970s, and this was limited to stars within 1 kpc of the Sun.

The first scientific results from the FUSE mission are being described today in Joint Discussion 11. Many of the results presented were just recently published in 22 papers in a special issue of the *Astrophysical Journal Letters* (2000 July 20).

FUSE covers the wavelength range 905 Å to 1187 Å with high spectral resolving power (~20,000, or a velocity resolution of ~15 km/sec). The sensitivity of the FUSE instrument is over 10,000 times greater than that of the Copernicus mission and is sufficient to perform absorption line studies using distant quasars as background light sources.

The far ultraviolet spectral region is extremely rich in important spectral diagnostics that are not accessible elsewhere. These include the Lyman series of atomic hydrogen and deuterium, the electronic ground-state absorption bands of molecular hydrogen ($H_2$) and the HD molecule, the transitions of highly ionized atoms O VI (1032, 1038 Å) and S VI (933, 945 Å) which are formed at higher temperatures (T ~ 300,000 K) than any resonance lines observable at longer ultraviolet or optical wavelengths, and resonance lines of lower ionization stages of many abundant elements (C I-III, N I-III, P II – V, S III-IV).

The scientific highlights to date include the following:-

FUSE has found that hot gases traced through O VI absorption is detected in many different environments, including the disk of the Milky Way, the Milky Way halo, high velocity clouds, the Magellanic Clouds, and the low-redshift intergalactic medium. The FUSE data for the Galactic halo strongly supports the picture that supernova-powered fountains vent hot gas from the disk into the halo, resolving a major uncertainty in the origin of the Milky Way's hot corona.

An initial attempt to observe the He II absorption at moderate redshifts (z ~ 2.7) has been successful. FUSE is also refining estimates of the amount of baryonic material in the low-z Universe through measurements of the HI Lyman series in Lyman-alpha forest clouds. The detection of O VI absorbers at low z argues for a substantial reservoir of hot, metal-enriched gas in the intergalactic medium.

FUSE detects molecular hydrogen in previously unexplored low-density environments of the Galactic halo, high velocity clouds, planetary nebulae, and the Magellanic Clouds. The ubiquity of $H_2$ suggests that molecules survive in relatively harsh environments. FUSE has also detected $H_2$ and HD in translucent clouds and on denser sightlines through diffuse interstellar gas.

The FUSE results for the interstellar gas of the Milky Way and the Magellanic Clouds were obtained from observations of massive OB stars. These spectra also reveal important new findings about the stars themselves. Comparison of two similar O stars in the SMC and LMC shows that the star in the higher metallicity galaxy (LMC) has a higher terminal velocity and much stronger O VI absorption from its stellar wind. The presence of strong O VI in the LMC star is puzzling and indicates that the time-dependent structures in the wind produce much of the O VI. The absence of comparable structures in the SMC star is probably due to either the reduced oxygen abundance or to the lower wind speeds resulting from a reduced metallicity.

The FUSE observatory is operated for NASA by the Johns Hopkins University, which was responsible for its design and construction. FUSE is a joint project of the US, Canada, and France.

**George Sonneborn**
*NASA Goddard Space Flight Centre*

# New Cosmology Prize

The Cosmology Prize of the Peter Gruber Foundation has been created to honour scientific advances in our perception and understanding of the Universe. The Prize carries a cash award of US$ 150,000 and is the first major international award dedicated to any branch of astronomy. It is given annually to an outstanding astronomer, physicist, or mathematician, selected internationally by a Board of distinguished peers in the field.

To inaugurate the Cosmology Prize, the Peter Gruber Foundation will today, Monday August 14, announce award of the Prize for the year 2000 to two outstanding recipients. The announcement will be made at 12.30 pm in the Council Chamber, Whitworth Hall, in the presence of representatives of the Foundation and the IAU. All interested IAU members and other participants at the General Assembly are invited to attend this event.

At the same time, the IAU and the Peter Gruber Foundation announce the conclusion of an Agreement by which the IAU will provide the expertise and personal contacts of professional astronomers worldwide for the nomination and selection of future Prize Winners. Under this agreement, calls for nominations will be made through the *IAU Information Bulletin* and Web site, and members of the selection Board will be nominated by the IAU and other relevant international scientific Unions.

The inaugural Prizes for the year 2000 will be officially conferred at the Pontifical Academy of Sciences at the Vatican later this year. Future Prizes will be conferred at the IAU General Assemblies or, in non-GA years, in places of historical importance in the development of our understanding of the Universe.

In addition to honouring accomplished achievements, the Agreement also has a forward-looking aspect. With the aim to promote the continued recruitment of young talent into the field, the Peter Gruber Foundation will also fund a new fellowship programme for promising young astronomers, operated by the IAU. Within a total envelope of US$ 75,000 per triennium, 2-3 such fellowships will be awarded at each future General Assembly, following announcements in the *IAU Information Bulletin* and on the Web. The first fellowships will be awarded in 2001.

Unlike many other national and international organisations, the IAU has never been associated with any award programme. The Executive Committee therefore reviewed the proposed Agreement and its implications very carefully. It was found that the nature and magnitude of the Prize, the procedures for awarding it, and the associated support for the next generation of scientists - high on the list of the Union's priorities – were indeed such that this association would be appropriate. Accordingly, the EC approved the proposal at its 73rd meeting on Monday, August 7. I trust that participants will join me in saluting the vision and good will of the Foundation in offering this significant support of our science.

The Peter Gruber Foundation, founded in 1993, funds social service organisations, scholarship programmes, and community foundations, so far principally in the U.S. Virgin Islands. It also supports other programmes focusing on young people and their education.

**Johannes Anderson**
*General Secretary*

# Neptune - Before 1846

Several observations of Neptune have been recorded, well before the identification of the planet by Galle and D'Arrest in 1846. In 1613 Galileo, using his primitive 'optick tube', was making observations of the four satellites of Jupiter which we now call the Galileans. He often added nearby stars, and one of these is now known to have been Neptune; Galileo even noted that the separation between it and an adjacent star changed from one night to the next. The positions as given by Galileo are self-consistent, though there are slight discrepancies with modern ephemerides.

Views of Neptune by J J de Lalande in 1795 are also genuine and are self-consistent, as described during Joint Discussion 5 on Friday by Myles Standish (NASA JPL). The speaker added that on one occasion Lalande was explaining to some of his colleagues that spiders were quite harmless; to drive this point home, he picked up some spiders and ate several.

The same consistency cannot be said of observations made in 1811 by A M Robertson, at one time Radcliffe Observer at Oxford (UK). The description of the equipment used, and the impossibly accurate results given, demonstrate that the observations were deliberately falsified, though the reasons for this deception will never be known.

# 6 The Naming Game

Did you know that the revised IAU Recommendations on Nomenclature now has "Helpful Hints" which includes current practices re subcomponents? See http://cdsweb.u-strasbg.fr/Dic/iau-spec.htx#3.6 for details.

**Helene R. Dickel**
*University of Illinois, USA & Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

Buses to Invited Discourses in the Bridgewater Hall leave from the Royal Northern College of Music and Whitworth Hall from 1700hrs to 1815hrs.

The lectures commence at 1830hrs.
**Monday, August 14th Michel Mayor**
**Tuesday, August 15th Michael Perryman**

Buses and Trains are also available to Manchester Airport – Please note that you can use your Megarider passes for buses to the Airport. Further information and timetables are available from the Information Desk situated in Whitworth Hall.

# Opera at Tatton Park

On Wednesday, August 16, at Tatton Park, Opera Europe will present Rossini's sparkling comic opera, The Silken Ladder. Tatton Park is one of the finest historical houses in England, set in the heart of the Cheshire countryside, just 30 minutes away from Manchester city centre. This is an excellent opportunity to hear young operatic stars from across Europe. The offer is exclusive to GA24 delegates. A £16 ticket includes coach transport; the coach will depart from Brunswick Street (opposite the Roscoe Building) at 1730hrs and arrive back in Manchester at 2200hrs. Contact Lisa Hill at the European Opera Centre on 0161 273 8111.

# A Memorable Concert

Music is always a part of IAU General Assemblies, and as an Invited Guest I was delighted to attend the concert at the Bridgewater Hall on Friday evening, given by the Royal Liverpool Philharmonic Orchestra. The venue was ideal; the Hall has a large capacity, an impressive interior, excellent acoustics and a beautiful backdrop of the huge organ, which is truly magnificent; its silver pipes reflected the golden lights.

The orchestra itself was superb, and the chosen programme was excellent, catering for all musical tastes, ranging from Walton's 'Crown Imperial' to much lighter items. The Elgar Cello Concerto in E Minor, played by Alice Neary, was very warmly received; I enjoyed it immensely – Elgar has always been one of my favourite composers and this particular piece of music has a personal meaning for me. All in all it was a wonderful evening and the warmth of the applause showed that it was enjoyed by all those who were fortunate enough to be present.

**Anne Hurst**
*Invited guest*

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.8:** *TUESDAY 15th AUGUST*

# New Planetary Names

*Photo: Clementine Lunar Image Browser, Naval Research Laboratory.*

*The ruined ring Bliss occupies the space between the dark floor of Plato and the bright mountain Pico, directly below Plato in this Clementine spacecraft image.*

At a meeting of the Working Group for Planetary System Nomenclature yesterday, new names were introduced. On the asteroid Eros, following the pass by the spacecraft NEAR (Shoemaker) 37 craters, one regio and one dorsum were named. The names are fairly predictable; they include Cupid, Don Juan and Don Quixote. The satellite of Asteroid 45 Eugenia was named Petit-Prince commemorating the son of the Empress Eugenie.

There are three new names for satellites of Uranus. Satellite 1999 U3 becomes XVIII Prospero; 1990 U1 becomes XIX Setebos, and 1999 U2 becomes XX Stephano. (The numbers are given in order of confirmation dates.) The new satellite of Jupiter (XVII) will be given the name of one of Jupiter's numerous lovers, but the name must end in e, because the satellite belongs to the retrograde group and all these have names ending in e (Ananke, Carme, Pasiphaë and Sinope).

Several names for lunar craters were added, subject to the approval of the Committee Chairman, who was unable to be present. For example, the large ruined ring between Plato and Pico was named Bliss, after the second English Astronomer Royal; Bliss has not previously been commemorated anywhere. On 31 July 1999 the Prospector probe landed inside a 50.9 km crater at 87.7° South, 42.8° East; the name recommended here is Shoemaker, after the great lunar geologist whose ashes have been scattered on the Moon.

It was suggested that a 'data bank' of names be set up for features on Pluto. Certain features shown by the Hubble Space Telescope seem to be fairly definite, although any maps are as yet extremely rough.

In total, 216 new names on planetary bodies were approved.

**Patrick Moore**
*WG Planetary System Nomenclature*

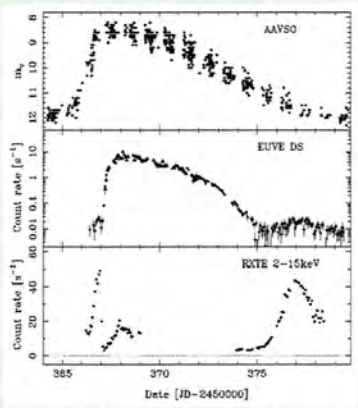


## Amateurs, Professionals and A White Dwarf

Amateur and professional astronomers have combined in a useful study of a flaring white dwarf star – the fainter component of the famous cataclysmic variable SS Cygni. Outbursts occur on average every 49 days; the outburst concerned was detected in its very earliest stages by amateur observers of the American Association of Variable Star Observers (AAVSO) in Kansas, California and Hawaii. They alerted AAVSO Director, Janet Mattei, and she called Christopher Mauche (Lawrence Livermore National Laboratory) and Peter Wheatley (University of Leicester, UK) who head, respectively, the teams dealing with EUVE (the Extreme Ultraviolet Explorer) and RXTE (the Rossi X-ray Timing Explorer). Within twelve hours of the initial amateur optical observations, EUVE and RXTE were turned toward SS Cygni. The results were presented during the Commission 42 (Close Binaries) Science Session on Saturday.

The observations show that the white dwarf outburst starts in the optical band in the outer part of the accretion disk, moves to X-ray wavelengths about a day later, and then becomes detectable in the extreme ultraviolet (EUV) as the gas flow reaches the white dwarf. The dramatic switch at the beginning of the outburst from X-ray to extreme ultraviolet emission is a result of the sudden drop in temperature of the boundary layer between the accretion disk and the star, from 100 million degrees to 100 thousand degrees. The increased density round the boundary allows the region to cool.

"This transition has never been observed before, and was only detected due to the superb response by the staff of the EUVE and RXTE to the triggering observations by amateur astronomers," commented Mattei. The full outburst of SS Cygni was followed by 150 amateur observers around the world, including many in the UK.




*Light curve in three wavelengths of the outburst of SS Cygni.*

## Cosmology Prize Winners Announced

*Left:* *Allan Sandage.*
***Above right:*** *Vera Rubin and Peter Gruber.*

***Left to right:*** *Vera Rubin, Peter Gruber, Johannes Andersen and Jim Peebles after yesterday's Cosmology Prize announcement.*

The inaugural winner of the Cosmology Prize of the Peter Gruber Foundation, the first award ever dedicated to cosmology, was announced yesterday in the IAU Council Chambers by Peter Gruber, founder of the award. In a surprise move, two awards were announced, each a prize of US$150,000. The recipients are Dr Phillip J.E. (Jim) Peebles, Albert Einstein Professor of Science, Princeton University, and Dr Allan R. Sandage, Staff Astronomer Emeritus, Observatories of the Carnegie Institution of Washington.

Jim Peebles has devoted his career to the study of the physical processes which have shaped the structure of our Universe, ranging from the creation of the lightest chemical elements to the formation of galaxies and the cosmic distribution of matter. His remarkable text books have instructed several generations of students and astronomers.

Allan Sandage has been in the forefront of the observational quest to understand stars, galaxies, and the Universe during the past half century. With relentless energy, he has pursued the value of the Hubble constant and the geometry and age of the Universe. He has compiled several extensive atlases of galaxies. Both the photographs and his discussion of each galaxy reveal his wisdom and understanding and are required reading for serious students of galaxies.

The Peter Gruber Foundation and the IAU will continue to collaborate on the yearly award of the international Peter Gruber Foundation's Cosmology Prize and a Fellowship programme. The Advisory Board for the inaugural prize consisted of Dr John Barrow and Sir Martin Rees, Cambridge University; Dr George Coyne, S.J. Vatican Observatory; Dr Owen Gingerich, Harvard University; and the author.

**Vera Rubin**
*Carnegie Institute of Washington, USA*

# IAU Symposium 204 The Extragalactic Infrared Background and its Cosmological Implications

Observations carried out with the Cosmic Background Explorer (COBE), in the early 1990s, are currently yielding the first reliable measurements of the strength and spectrum of the ubiquitous diffuse cosmic infrared background. This radiation reaching us from the cosmos reflects the history of the Universe since the first stars and galaxies began to shine. The origin of this background is being vigorously debated, making Symposium 204, which begins today in the Concert Hall of the Royal Northern College of Music, both timely and instructive.

To launch the Symposium, P. James E. Peebles (Princeton University) - one of the two inaugural winners of the Cosmology Prize of the Peter Gruber Foundation - will present a talk entitled 'Keeping Book on the Universe', which will summarize our current knowledge of the Universe. In the three-and-a-half days which follow, contributors hope to advance our understanding of the background through presentations of new results and lively debate of clashing perspectives.

Powerful optical telescopes on the ground and in space now permit us to count individual galaxies out to great distances and to measure their brightness. Does the sum of the inferred infrared emissions add up to the background observed by COBE? Or is there an even more diffuse component we have not yet identified? To resolve such questions, galaxies ranging out to the greatest distances, highest redshifts, and earliest stages in the evolution of the Cosmos are being inventoried. The latest available results will be presented starting today. Those who are doubtful about such approaches, are beginning to pursue another course: The highest energy photons observed in the Cosmos carry an energy ten trillion ($10^{13}$) times greater than that of visible light. Yet such 'monster' photons seem incapable of traversing distances greater than a few hundred million light years. The most distant galaxy observed at these energies to date, Markarian 501, lies only 400 million light years away - a mere stones-throw in our Universe. Along their way, the gamma-ray photons collide with infrared background photons to annihilate spectacularly with the production of electron-positron pairs. In principle, the entire spectrum of the infrared background might be independently determined by measuring the distance to which gamma-rays at different energies penetrate the background. This afternoon's discussions will highlight the emerging debate between gamma-ray and infrared astronomers.

The Wednesday and Thursday morning sessions will be devoted to surveys conducted at many wavelengths ranging from the near-infrared to the thousand-times-longer submillimetre régime. Together these yield a picture in which the most prominent sources, perhaps the most powerful contributors to the background, appear to be galaxies in collision. But what produces the observed energy outpour? Is it the formation of supermassive, highly luminous stars or could it be the accretion of giant black holes in the nuclei of these active galaxies? A spirited debate is in progress.

Massive stars cannot shine without producing and explosively ejecting heavy elements. If the bulk of the background is produced by distant, luminous stars, then the star formation rate observed at each epoch, should be precisely commensurate with an enrichment of the elements helium, carbon, oxygen and iron, as the Universe evolves. But if the background is largely produced by the earliest active galactic nuclei, we should find little chemical enrichment; rather, a growing population of massive black holes should appear as we sweep back from high redshifts and early times, to low red shifts and the present day. The Thursday afternoon and Friday morning sessions will host this discussion to which recent observations from the Chandra X-ray observatory are contributing.

Later on Friday, participants will look ahead to future space missions planned to yield greater clarity on the background and its origins. In a final session that afternoon, Malcolm Longair (Cavendish Astrophysics, University of Cambridge) will conclude with a summary of the Symposium's findings and questions remaining to be resolved.

This should be an exciting symposium for astronomers with a wide range of interests.

**Martin Harwit**
*Cornell University, USA*

# IAU Symposium 205 Galaxies and their constituents at the highest angular resolutions

*Illustration: NASA and Smithsonian Astrophysical Observatory.*

*Artist's impression of the CHANDRA X-ray observatory in orbit.*

Throughout astronomical history, five principal instrumental themes have played a decisive rôle in expanding our knowledge of the Universe: increased access to the electromagnetic spectrum, increased sensitivity, increased spectral resolution, increased time resolution, and increased angular resolution. Symposium 205 (which begins today in Theatre A, Roscoe Building, and continues through Friday), will highlight the contribution of the last of these themes to our understanding of galaxies as the most prominent constituents of the Universe.

Centimetre wavelength radio astronomy has long been the front-runner in high angular resolution in astronomy, with very long baseline interferometry in the vanguard. But, with the advent of the Hubble Space Telescope, the optical interferometers at Cambridge, Flagstaff and Narrabri and the IR interferometers under construction at the VLT and Keck sites, the millimetre arrays and their long baseline extensions planned or under construction on Plateau de Bure, Owens Valley, Hat Creek, and Nobeyama, the sub-millimetre array on Mauna Kea, and the recent launch of CHANDRA, angular resolution in other wavelength regimes is sub-arcsecond as well. In some cases the resolution approaches or exceeds 100 milliarcseconds, overlapping that of the radio interferometric arrays. At X- and gamma-ray wavelengths, measurements in the time domain can also supply additional spatial information, as do radio scintillation observations.

With comparable sub-arcsecond angular resolution across most of the electromagnetic spectrum, astronomers now have access to complementary data on a broad range of astronomical targets including young stars, jets, and protoplanetary disks; stellar winds from evolved stars and their effects on the surrounding ISM; planetary nebulae; colliding winds in binary systems; micro-quasars; novae; supernovae; starbursts; extragalactic megamasers; Seyfert galaxies; radio quiet quasars; optical and radio jets in active galactic nuclei; radio galaxies; distant forming galaxies in the Hubble Deep Field; and gravitational lenses. The smallest physical scales probed range from sub-stellar diameter in nearby stars to sub-solar system at the centre of our Galaxy, and from a fraction of a parsec in the nuclei of galaxies at low redshift to a few parsec at high redshift.

With sub-arcsecond data from the new observing facilities now becoming standard for the first time, it is timely to hold a Symposium to explore the relationships amongst the various constituents and physical processes in galaxies throughout the observable Universe. The 24th General Assembly's location at the University of Manchester is most appropriate for this Symposium, since it is home to the Jodrell Bank Observatory, which is at the heart of the MERLIN array of radio telescopes, and a pioneering institution in radio interferometric and optical intensity interferometric techniques.

The scientific programme will cover six broad areas: the central parsec of galaxies including our own Galaxy, the central kiloparsec of galaxies, star formation and outflow processes in our Galaxy, supernova remnants and the ISM, molecules in external galaxies, and stars and stellar atmospheres. Invited review talks will set the scene for the latest results in the radio, mm, optical, and X-ray to be presented in the oral contributions and posters. Beautiful Chandra images of galaxies and galactic supernovæ will be a highlight.

Looking to the future, presentations on plans for new instrumentation for high angular resolution will be made, including VLBI arrays on the ground and in space, ALMA, Square Kilometre Array, IR and optical interferometers, NGST, large diameter optical telescopes, X-ray interferometry, gamma-ray instrumentation, and optical astrometry in space.

**Richard Schilizzi**
*Joint Institute for VLBI in Europe, Netherlands*

# A Visual Treat

The third Invited Discourse of GA24 will be given this evening by Michael Perryman (European Space Agency). His topic is 'The Three-Dimensional Structure of our Galaxy'. It is a big subject, rich in history, to which the HIPPARCOS results have added a lot of new details. What promises to make this an evening lecture not to be missed is the way that Dr Perryman has chosen to illustrate his talk. HIPPARCOS has done something which is, fundamentally, pretty spectacular; it has measured how stars are distributed, and how they are moving, through space. So why not show just this – why not illustrate their 3-d distributions and their space motions?

The problem, of course, is how to conjure up the 3-d effects in front of a large audience. Michael did exactly that in his George Darwin lecture to the Royal Astronomical Society last year. Dual polarized light beans were projected on to a reflecting screen, and everyone in the audience was equipped with the necessary polarizing glasses. Those who were present said that the visual effect was stunning, and that it really brought home to them what was meant by measuring the distance to the stars. We asked Dr Perryman which fields look most dramatic; "seeing how the stars in the Hyades will move in three dimensions over the next 60,000 years is probably my favourite," he said. And he set this as an exercise for members of this evening's audience: "try to visualize how stellar images move as a gravitating mass (e.g. the Sun) moves across a star field." It promises to be an unusual and entertaining lecture.

Don't forget to arrive in good time to collect your polarizing glasses, and check the suggested seating instructions as you enter the auditorium.

# Planets Aplenty

"But an infinite number of worlds exist, some similar to ours, others different." So wrote Epicurus to Herodotus, 2000 years ago. Those were also the words used by Michel Mayor to open his Invited Discourse about extrasolar planets, at the Bridgewater Hall yesterday evening. By now 49 such planets are known (as of August 13), and more are being discovered almost each day.

The speaker dealt first with the history of extrasolar planet discovery; several teams were involved – we have come a long way since that first detection of the planet of 51 Pegasi in 1995. Up to now all the detected planets are giants, but some are less massive than Saturn; there are two multi-planet systems, and also 'free floaters', which have been found in the Sigma Orionis cluster. There are of course several methods of detection; radial velocity measurements, astrometry, microlensing and transits, while in the future we hope for major advances from the Darwin space mission.

It is interesting to compare the words of Epicurus with those of Giordano Bruno, little more than 300 years ago: "The stars are similar to the Sun. They are also floating in an infinite Universe, surrounded by planets similar to the Earth. Some of these are inhabited." When will we have real proof that Bruno was right?

# IAU Resolutions

There are three Resolutions of Type B to be voted on under Agenda Items 10.2 at the Second Session of the General Assembly on Wednesday, August 16, 2000 at 14.00hrs in the Bridgewater Hall. The Resolutions are set out in full in English below.

**D McNally**
*Chairman: Resolutions Committee*

## B1.1 Maintenance and Establishment of Reference Frames and Systems

The International Astronomical Union

**Noting**

1. that Resolution B2 of the XXIIIrd General Assembly (1997) specifies that "the fundamental reference frame shall be the International Celestial Reference Frame (ICRF) constructed by the IAU Working Group on Reference Frames,"

2. that Resolution B2 of the XXIIIrd General Assembly (1997) specifies "That the Hipparcos Catalogue shall be the primary realisation of the International Celestial Reference System (ICRS) at optical wavelengths", and

3. the need for accurate definition of reference systems brought about by unprecedented precision, and

**Recognising**

1. the importance of continuing operational observations made with Very Long Baseline Interferometry (VLBI) to maintain the ICRF,

2. the importance of VLBI observations to the operational determination of the parameters needed to specify the time-variable transformation between the International Celestial and Terrestrial Reference Frames,

3. the progressive shift between the Hipparcos frame and the ICRF, and

4. the need to maintain the optical realisation as close as is possible to the ICRF

**Recommends**

1. that IAU Division I maintain the Working Group on Celestial Reference Systems formed from Division I members to consult with the International Earth Rotation Service (IERS) regarding the maintenance of the ICRS,

2. that the IAU recognise the International VLBI Service (IVS) for Geodesy and Astrometry as an IAU Service Organization,

3. that an official representative of the IVS be invited to participate in the IAU Working Group on Celestial Reference Systems,

4. that the IAU continue to provide an official representative to the IVS Directing Board,

5. that the astrometric and geodetic VLBI observing programs consider the requirements for maintenance of the ICRF and linking to the Hipparcos optical frame in the selection of sources to be observed (with emphasis on the Southern Hemisphere), design of observing networks, and the distribution of data, and

6. that the scientific community continue with high priority ground- and space-based observations (a) for the maintenance of the optical Hipparcos frames and frames at other wavelengths and (b) for links of the frames to the ICRF.

## B1.2 Hipparcos Celestial Reference Frame

The International Astronomical Union

**Noting**

1. that Resolution B2 of the XXIIIrd General Assembly (1997) specifies, "That the Hipparcos Catalogue shall be the primary realisation of the International Celestial Reference System (ICRS) at optical wavelengths",

2. the need for this realisation to be of the highest precision,

3. that the proper motions of many of the Hipparcos stars known, or suspected, to be multiple are adversely affected by uncorrected orbital motion,

4. the extensive use of the Hipparcos Catalogue as reference for the ICRS in extension to fainter stars,

5. the need to avoid confusion between the International Celestial Reference Frame (ICRF) and the Hipparcos frame, and

6. the progressive shift between the Hipparcos frame and the ICRF,

**Recommends**

1. that Resolution B2 of the XXIIIrd General Assembly (1997) be amended by excluding from the optical realisation of the ICRS all stars flagged C, G, O, V and X in the Hipparcos Catalogue, and

2. that this modified Hipparcos frame be labelled the Hipparcos Celestial Reference Frame (HCRF).

## B1.3 Definition of Barycentric Celestial Reference System and Geocentric Celestial Reference System

The International Astronomical Union

**Considering**

1. that the Resolution A4 of the XXIst General Assembly (1991) has defined a system of space-time coordinates for (a) the solar system (now called the Barycentric Celestial Reference System (BCRS)) and (b) the Earth (now called the Geocentric Celestial Reference System (GCRS)), within the framework of General Relativity,

2. the desire to write the metric tensors both in the BCRS and in the GCRS in a compact and self-consistent form,

3. the fact that considerable work in General Relativity has been done using the harmonic gauge that was found to be a useful and simplifying gauge for many kinds of applications,

**Recommends**

1. the choice of harmonic coordinates both for the barycentric and for the geocentric reference systems,

2. writing the time-time component and the space-space component of the barycentric metric $g_{\mu\nu}$ with barycentric coordinates $(t, \mathbf{x})$ ($t$ = Barycentric Coordinate Time (TCB)) with a single scalar potential $w(t, \mathbf{x})$ that generalises the Newtonian potential, and the space-time component with a vector potential $w^i(t, \mathbf{x})$; as a boundary condition it is assumed that these two potentials vanish far from the solar system,

   explicitly,

$$g_{00} = -1 + \frac{2w}{c^2} - \frac{2w^2}{c^4},$$

$$g_{0i} = -\frac{4}{c^3} w^i,$$

$$g_{ij} = \delta_{ij}\left(1 + \frac{2}{c^2} w\right),$$

   with

$$w(t,\mathbf{x}) = G\int d^3x' \frac{\sigma(t,\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|} + \frac{1}{2c^2} G \frac{\partial^2}{\partial t^2} \int d^3x' \sigma(t,\mathbf{x}')|\mathbf{x}-\mathbf{x}'|,$$

$$w^i(t,\mathbf{x}) = G\int d^3x' \frac{\sigma^i(t,\mathbf{x}')}{|\mathbf{x}-\mathbf{x}'|},$$

   here, $\sigma$ and $\sigma^i$ are the gravitational mass and current densities respectively,

3. writing the geocentric metric tensor $G_{ab}$ with geocentric coordinates $(T, \mathbf{X})$ ($T$=Geocentric Coordinate Time (TCG)) in the same form as the barycentric one but with potentials $W(T, \mathbf{X})$ and $W^a(T, \mathbf{X})$; these geocentric potentials should be split into two parts - potentials $W_E$ and $W_E^a$ arising from the gravitational action of the Earth and external parts $W_{ext}$ and $W_{ext}^a$ due to tidal and inertial effects; the external parts of the metric potentials are assumed to vanish at the geocenter and admit an expansion in positive powers of $\mathbf{X}$,

   explicitly,

$$G_{00} = -1 + \frac{2W}{c^2} - \frac{2W^2}{c^4},$$

$$G_{0a} = -\frac{4}{c^3} W^a,$$

$$G_{ab} = \delta_{ab}\left(1 + \frac{2}{c^2} W\right),$$

the potentials W and $W^a$ should be split according to

$$W\ (T,\mathbf{X}) = W_E(T,\mathbf{X}) + W_{ext}(T,\mathbf{X}),$$

$$W^a(T,\mathbf{X}) = W^a_E(T,\mathbf{X}) + W^a_{ext}(T,\mathbf{X}),$$

The Earth's potentials $W_E$ and $W^a_E$ are defined in the same way as w and $w^i$ but with quantities calculated in the GCRS, with integrals taken over the whole Earth,

4. using, if accuracy requires, the full post-Newtonian coordinate transformation between the BCRS and the GCRS as induced by the form of the corresponding metric tensors,

   explicitly, for the kinematically non-rotating GCRS (T=TCG, t=TCB, $r^i_E \equiv x^i - x^i_E(t)$, and a summation from 1 to 3 over equal indices is implied),

$$T = t - \frac{1}{c^2}\left[A(t) + v^i_E r^i_E\right] + \frac{1}{c^4}\left[B(t) + B^i(t) r^i_E + B^{ij}(t) r^i_E r^j_E + C(t,\mathbf{x})\right] + O(c^{-5}),$$

$$X^a = \delta_{ai}\left[r^i_E + \frac{1}{c^2}\left(\frac{1}{2}v^i_E v^j_E r^j_E + w_{ext}(\mathbf{x}_E) r^i_E + r^i_E a^j_E r^j_E - \frac{1}{2}a^i_E r^2_E\right)\right] + O(c^{-4}),$$

where

$$\frac{d}{dt}A(t) = \frac{1}{2}v^2_E + w_{ext}(\mathbf{x}_E),$$

$$\frac{d}{dt}B(t) = -\frac{1}{8}v^4_E - \frac{3}{2}v^2_E w_{ext}(\mathbf{x}_E) + 4v^i_E w^i_{ext}(\mathbf{x}_E) + \frac{1}{2}w^2_{ext}(\mathbf{x}_E),$$

$$B^i(t) = -\frac{1}{2}v^2_E v^i_E + 4w^i_{ext}(\mathbf{x}_E) - 3v^i_E w_{ext}(\mathbf{x}_E),$$

$$B^{ij}(t) = -v^i_E \delta_{aj} Q^a + 2\frac{\partial}{\partial x^j}w^i_{ext}(\mathbf{x}_E) - v^i_E \frac{\partial}{\partial x^j}w_{ext}(\mathbf{x}_E) + \frac{1}{2}\delta^{ij}\ddot{w}_{ext}(\mathbf{x}_E),$$

$$C(t,\mathbf{x}) = -\frac{1}{10}r^2_E\left(\dot{a}^i_E r^i_E\right),$$

here $x^i_E$, $v^i_E$, and $a^i_E$ are the barycentric position, velocity and acceleration vectors of the Earth, the dot stands for the total derivative with respect to t, and

$$Q^a = \delta_{ai}\left[\frac{\partial}{\partial x_i}w_{ext}(\mathbf{x}_E) - a^i_E\right],$$

the external potentials, $w_{ext}$ and $w^i_{ext}$ , are given by

$$w_{ext} = \sum_{A\neq E} w_A, \quad w^i_{ext} = \sum_{A\neq E} w^i_A,$$

where E stands for the Earth and $w_A$ and $w^i_A$ are determined by the expressions for w and $w^i$ with integrals taken over body A only.

**Notes**

*It is to be understood that these expressions for w and $w^i$ give $g_{00}$ correct up to $O(c^{-5})$, $g_{0i}$ up to $O(c^{-5})$, and $g_{ij}$ up to $O(c^{-4})$. The densities $\sigma$ and $\sigma^i$ are determined by the components of the energy momentum tensor of the matter composing the solar system bodies as given in the references. Accuracies for $G_{ab}$ in terms of $c^{-n}$ correspond to those of $g_{\mu\nu}$ .*

*The external potentials $W_{ext}$ and $W^a_{ext}$ can be written in the form*

$$W_{ext} = W_{tidal} + W_{iner},$$

$$W^a_{ext} = W^a_{tidal} + W^a_{iner}.$$

$W_{tidal}$ generalises the Newtonian expression for the tidal potential. Post-Newtonian expressions for $W_{tidal}$ and $W^a_{tidal}$ can be found in the references. The potentials $W_{iner}$ and $W^a_{iner}$ are inertial contributions that are linear in $X^a$. The former is determined mainly by the coupling of the Earth's nonsphericity to the external potential. In the kinematically non-rotating Geocentric Celestial Reference System, $W^a_{iner}$ describes the Coriolis force induced mainly by geodetic precession.

Finally, the local gravitational potentials $W_E$ and $W^a_E$ of the Earth are related to the barycentric gravitational potentials $w_E$ and $w^i_E$ by

$$W_E(T,\mathbf{X}) = w_E(t,\mathbf{x})\left(1 + \frac{2}{c^2}v^2_E\right) - \frac{4}{c^2}v^i_E w^i_E(t,\mathbf{x}) + O(c^{-4}),$$

$$W^a_E(T,\mathbf{X}) = \delta_{ai}\left(w^i_E(t,\mathbf{x}) - v^i_E w_E(t,\mathbf{x})\right) + O(c^{-2}).$$

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Kopeikin, S.M., 1989, *Celest. Mech.*, **44**, 87.


## B1.4 Post-Newtonian Potential Coefficients

The International Astronomical Union

**Considering**

1. that for many applications in the fields of celestial mechanics and astrometry a suitable parametrization of the metric potentials (or multipole moments) outside the massive solar system bodies in the form of expansions in terms of potential coefficients are extremely useful, and
2. that physically meaningful post-Newtonian potential coefficients can be derived from the literature,

**Recommends**

1. expansion of the post-Newtonian potential of the Earth in the Geocentric Celestial Reference System (GCRS) outside the Earth in the form

$$W_E(T,\mathbf{X}) = \frac{GM_E}{R}\left[1 + \sum_{l=2}^{\infty}\sum_{m=0}^{+l}\left(\frac{R_E}{R}\right)^l P_{lm}(\cos\theta)\left(C^E_{lm}(T)\cos m\phi + S^E_{lm}(T)\sin m\phi\right)\right],$$

   here $C^E_{lm}$ and $S^E_{lm}$ are, to sufficient accuracy, equivalent to the post-Newtonian multipole moments introduced by Damour et al; (Damour et al., 1991, Phys. Rev. D, **43**, 3273) $\theta$ and $\phi$ are the polar angles corresponding to the spatial coordinates $X^a$ of the GCRS and R=|X|, and

2. expression of the vector potential outside the Earth, leading to the well-known Lense-Thirring effect, in terms of the Earth's total angular momentum vector $\mathbf{S}_E$ in the form

$$W^a_E(T,\mathbf{X}) = -\frac{G}{2}\frac{(\mathbf{X}\times\mathbf{S}_E)^a}{R^3}$$

## B1.5 Extended relativistic framework for time transformations and realisation of coordinate times in the solar system

The International Astronomical Union

**Considering**

1. that the Resolution A4 of the XXIst General Assembly (1991) has defined systems of space-time coordinates for the solar system (Barycentric Reference System) and for the Earth (Geocentric Reference System), within the framework of General Relativity,

2. that the Resolution B1.3 entitled 'Definition of Barycentric Celestial Reference System and Geocentric Celestial Reference System' has renamed these systems the Barycentric Celestial Reference System (BCRS) and the Geocentric Celestial Reference System (GCRS), respectively, and has specified a general framework for expressing their metric tensor and defining coordinate transformations at the first post-Newtonian level,

3. that, based on the anticipated performance of atomic clocks, future time and frequency measurements will require practical application of this framework in the BCRS,

4. that theoretical work requiring such expansions has already been performed,

**Recommends**

that for applications that concern time transformations and realisation of coordinate times within the solar system, Resolution B1.3 be applied as follows:

1. the metric tensor be expressed as

$$g_{00} = -\left(1 - \frac{2}{c^2}\left(w_0(t,\mathbf{x}) + w_L(t,\mathbf{x})\right) + \frac{2}{c^4}\left(w_0^2(t,\mathbf{x}) + \Delta(t,\mathbf{x})\right)\right),$$

$$g_{0i} = -\frac{4}{c^3} w^i(t,\mathbf{x}),$$

$$g_{ij} = \left(1 + \frac{2w_0(t,\mathbf{x})}{c^2}\right)\delta_{ij},$$

where ($t \equiv$ Barycentric Coordinate Time (TCB), $\mathbf{x}$) are the barycentric coordinates, $w_0 = G\sum_A M_A / r_A$, with the summation carried out over all solar system bodies A, $\mathbf{r}_A = \mathbf{x} - \mathbf{x}_A$, $\mathbf{x}_A$ are the coordinates of the center of mass of body A, $r_A = |\mathbf{r}_A|$, and where $w_L$ contains the expansion in terms of multipole moments [see their definition in the Resolution B1.4 entitled 'Post-Newtonian Potential Coefficients'] required for each body. The vector potential $w^i(t,\mathbf{x}) = \sum_A w^i_A(t,\mathbf{x})$, and the function $\Delta(t,\mathbf{x}) = \sum_A \Delta_A(t,\mathbf{x})$ are given in note 2,

2. the relation between TCB and Geocentric Coordinate Time (TCG) can be expressed to sufficient accuracy by

$$TCB - TCG = c^{-2}\left[\int_{t_0}^{t}\left(\frac{v_E^2}{2} + w_{0ext}(x_E)\right)dt + v_E^i r_E^i\right]$$

$$- c^{-4}\left[\int_{t_0}^{t}\left(-\frac{1}{8}v_E^4 - \frac{3}{2}v_E^2 w_{0ext}(x_E) + 4v_E^i w^i_{ext}(x_E) + \frac{1}{2}w^2_{0ext}(x_E)\right)dt - \left(3w_{0ext}(x_E) + \frac{v_E^2}{2}\right)v_E^i r_E^i\right],$$

where $v_E$ is the barycentric velocity of the Earth and where the index ext refers to summation over all bodies except the Earth.

**Notes**

1. *This formulation will provide an uncertainty not larger than $5 \times 10^{-18}$ in rate and, for quasi-periodic terms, not larger than $5 \times 10^{-18}$ in rate amplitude and 0.2 ps in phase amplitude, for locations farther than a few solar radii from the Sun. The same uncertainty also applies to the transformation between TCB and TCG for locations within 50000 km of the Earth. Uncertainties in the values of astronomical quantities may induce larger errors in the formulae.*

2. *Within the above mentioned uncertainties, it is sufficient to express the vector potential $w^i_A(t,\mathbf{x})$ of body A as*

$$w^i_A(t,x) = G\left[\frac{-(r_A \times S_A)^i}{2r_A^3} + \frac{M_A v^i_A}{r_A}\right],$$

*where $\mathbf{S}_A$ is the total angular momentum of body A and $v^i_A$ is the barycentric coordinate velocity of body A. As for the function $\Delta_A(t,\mathbf{x})$ it is sufficient to express it as*

$$\Delta_A(t,x) = \frac{GM_A}{r_A}\left[-2v_A^2 + \sum_{B\neq A}\frac{GM_B}{r_{BA}} + \frac{1}{2}\left(\frac{(r_A^k v_A^k)^2}{r_A^2} + r_A^k a_A^k\right)\right] + \frac{2Gv_A^k(r_A \times S_A)^k}{r_A^3},$$

*where $r_{BA} = |\mathbf{x}_B - \mathbf{x}_A|$ and $a^k_A$ is the barycentric coordinate acceleration of body A. In these formulae, the terms in $\mathbf{S}_A$ are needed only for Jupiter ($S \approx 6.9 \times 10^{38}\ m^2 s^{-1} kg$) and Saturn ($S \approx 1.4 \times 10^{38}\ m^2 s^{-1} kg$), in the immediate vicinity of these planets.*

3. *Because the present Recommendation provides an extension of the IAU 1991 recommendations valid at the full first post-Newtonian level, the constants $L_C$ and $L_B$ that were introduced in the IAU 1991 recommendations should be defined as <TCG/TCB> = 1 - $L_C$ and <TT/TCB> = 1 - $L_B$, where TT refers to Terrestrial Time and <> refers to a sufficiently long average taken at the geocentre. The most recent estimate of $L_C$ is (Irwin, A. and Fukushima,T., 1999,* Astron. Astrophys, *348, 642-652.)*

   $L_C = 1.48082686741 \times 10^{-8} \pm 2 \times 10^{-17}$,

   *From the Resolution B1.9 on 'Redefinition of Terrestrial Time TT' one infers $L_B = 1.55051976772 \times 10^{-8} \pm 2 \times 10^{-17}$ by using the relation $1-L_B = (1-L_C)(1-L_G)$. $L_G$ is defined in Resolution B1.9.*

   *Because no unambiguous definition may be provided for $L_B$ and $L_C$, these constants should not be used in formulating time transformations when it would require knowing their value with an uncertainty of order $1 \times 10^{-16}$ or less.*

4. *If TCB-TCG is computed using planetary ephemerides which are expressed in terms of a time argument (noted $T_{eph}$) which is close to Barycentric Dynamical Time (TDB), rather than in terms of TCB, the first integral in Recommendation 2 above may be computed as*

$$\int_{t_0}^{t}\left(\frac{v_E^2}{2} + w_{0ext}(x_E)\right)dt = \left[\int_{T_{eph_0}}^{T_{eph}}\left(\frac{v_E^2}{2} + w_{0ext}(x_E)\right)dt\right] \Big/ (1 - L_B)$$

# B1.6 IAU 2000 Precession-Nutation Model

The International Astronomical Union

**Recognising**

1. that the International Astronomical Union and the International Union of Geodesy and Geophysics Working Group (IAU-IUGG WG) on 'Non-rigid Earth Nutation Theory' has met its goals by

   a. establishing new high precision rigid Earth nutation series, such as (1) SMART97 of Bretagnon *et al.*, 1998, *Astron. Astrophys*, **329**, 329-338; (2) REN2000 of Souchay *et al.*, 1999, *Astron. Astrophys. A Supl. Ser* **135**, 111-131; (3) RDAN97 of Rcosbeek and Dehant 1999, *Celest. Mech.* **70**, 215-253;

   b. completing the comparison of new non-rigid Earth transfer functions for an Earth initially in non-hydrostatic equilibrium, incorporating mantle anelasticity and a Free Core Nutation period in agreement with observations,

   c. noting that numerical integration models are not yet ready to incorporate dissipation in the core, and

   d. noting of the effects of other geophysical and astronomical phenomena that must be modelled, such as ocean and atmospheric tides, that need further development;

2. that, as instructed by IAU Recommendation C1 in 1994, the International Earth Rotation Service (IERS) will publish in the IERS Conventions (2000), a precession-nutation model that matches the observations with a weighted rms of 0.2 milliarcsecond (mas);

3. that semi-analytical geophysical theories of forced nutation are available which incorporate some or all of the following – anelasticity and electromagnetic couplings at the core-mantle and inner core-outer core boundaries, annual atmospheric tide, geodesic nutation, and ocean tide effects;

4. that ocean tide corrections are necessary at all nutation frequencies; and

5. that empirical models based on a resonance formula without further corrections also exist;

**Accepts**

the conclusions of the IAU-IUGG WG on Non-rigid Earth Nutation Theory published by Dehant *et al.*, 1999, *Celest. Mech.* **72(4)**, 245-310 and the recent comparisons between the various possibilities, and

**Recommends**

that, beginning on 1 January 2003, the IAU 1976 Precession Model and IAU 1980 Theory of Nutation, be replaced by the precession-nutation model IAU 2000A (MHB2000, based on the transfer functions of Mathews, Herring and Boffett, 2000 - submitted to the *Journal of Geophysical Research*) for those who need a model at the 0.2 mas level, or its shorter version IAU 2000B for those who need a model only at the 1 mas level, together with their associated precession and obliquity rates, and their associated celestial pole offsets, to be published in the IERS Conventions 2000, and

**Encourages**

1. the continuation of theoretical developments of non-rigid Earth nutation series,

2. the continuation of VLBI observations to increase the accuracy of the nutation series and the nutation model, and to monitor the unpredictable free core nutation, and

3. the development of new expressions for precession consistent with the IAU 2000A model.

# B1.7 Definition of Celestial Intermediate Pole

The International Astronomical Union

**Noting**

the need for accurate definition of reference systems brought about by unprecedented observational precision, and

**Recognising**

1. the need to specify an axis with respect to which the Earth's angle of rotation is defined,

2. that the Celestial Ephemeris Pole (CEP) does not take account of diurnal and higher frequency variations in the Earth's orientation,

**Recommends**

1. that the Celestial Intermediate Pole (CIP) be the pole, the motion of which is specified in the Geocentric Celestial Reference System (GCRS) (see Resolution B1.3) by motion of the Tisserand mean axis of the Earth with periods greater than two days,

2. that the direction of the CIP at J2000.0 be offset from the direction of the pole of the GCRS in a manner consistent with the IAU 2000A (see Resolution B1.6) precession-nutation model,

3. that the motion of the CIP in the GCRS be realized by the IAU 2000A model for precession and forced nutation for periods greater than two days plus additional time-dependent corrections provided by the International Earth Rotation Service (IERS) through appropriate astro-geodetic observations,

4. that the motion of the CIP in the International Terrestrial Reference System (ITRS) be provided by the IERS through appropriate astro-geodetic observations and models including high-frequency variations,

5. that for highest precision, corrections to the models for the motion of the CIP in the ITRS may be estimated using procedures specified by the IERS, and

6. that implementation of the CIP be on 1 January 2003.

**Notes**

*The forced nutations with periods less than two days are included in the model for the motion of the CIP in the ITRS.*

*The Tisserand mean axis of the Earth corresponds to the mean surface geographic axis, quoted B axis, in Seidelmann, 1982* (Celest. Mech.)

*As a consequence of this Resolution, the Celestial Ephemeris Pole is no longer necessary.*

## B1.8 Definition and use of Celestial and Terrestrial Ephemeris Origin

The International Astronomical Union

**Recognising**

1. the need for reference system definitions suitable for modern realisations of the conventional reference systems and consistent with observational precision,

2. the need for a rigorous definition of sidereal rotation of the Earth,

3. the desirability of describing the rotation of the Earth independently from its orbital motion, and

**Noting**

that the use of the "non-rotating origin" (Guinot, 1979) on the moving equator fulfills the above conditions and allows for a definition of UT1 which is insensitive to changes in models for precession and nutation at the microarcsecond level,

**Recommends**

1. the use of the "non-rotating origin" in the Geocentric Celestial Reference System (GCRS) and that this point be designated as the Celestial Ephemeris Origin (CEO) on the equator of the Celestial Intermediate Pole (CIP),

2. the use of the "non-rotating origin" in the International Terrestrial Reference System (ITRS) and that this point be designated as the Terrestrial Ephemeris Origin (TEO) on the equator of the CIP,

3. that UT1 be linearly proportional to the Earth Rotation Angle defined as the angle measured along the equator of the CIP between the unit vectors directed toward the CEO and the TEO,

4. that the transformation between the ITRS and GCRS be specified by the position of the CIP in the GCRS, the position of the CIP in the ITRS, and the Earth Rotation Angle,

5. that the International Earth Rotation Service (IERS) take steps to implement this by 1 January 2003, and

6. that the IERS will continue to provide users with data and algorithms for the conventional transformations.

**Note**

*The position of the CEO can be computed from the IAU 2000A model for precession and nutation of the CIP and from the current values of the offset of the CIP from the pole of the ICRF at J2000.0 using the development provided by Capitaine* et al. *(2000).*

*The position of the TEO is only slightly dependent on polar motion and can be extrapolated as done by Capitaine* et al. *(2000) using the IERS data.*

*The linear relationship between the Earth's rotation angle $\theta$ and UT1 should ensure the continuity in phase and rate of UT1 with the value obtained by the conventional relationship between Greenwich Mean Sidereal Time (GMST) and UT1. This is accomplished by the following relationship:*

$$\theta(UT1) = 2\pi\,(0.7790572732640 + 1.00273781191135448 \times (\text{Julian UT1date} - 2451545.0))$$

**References**

Guinot, B., 1979 in D. D. McCarthy, and J. D. Pilkington (eds), Time and the Earth's Rotation, D. Reidel Pub. Co., 7.

Capitaine, N., Guinot, B., McCarthy, D. D., 2000, "Definition of the Celestial Ephemeris Origin and of UT1 in the International Celestial Reference Frame," *Astron. Astrophys.*, **355**, 398-405.

## B1.9 Re-definition of Terrestrial Time TT

The International Astronomical Union

**Considering**

1. that IAU Resolution A4 (1991) has defined Terrestrial Time (TT) in its Recommendation 4,

2. that the intricacy and temporal changes inherent in the definition and realisation of the geoid are sources of uncertainty in the definition and realisation of TT, which may become, in the near future, the dominant source of uncertainty in realising TT from atomic clocks,

**Recommends**

1. that TT be a time scale differing from TCG by a constant rate: $dTT/dTCG = 1-L_G$, where $L_G = 6.969290134 \times 10^{-10}$ is a defining constant.

**Note**

*$L_G$ was defined by the IAU Resolution A4 (1991) in its Recommendation 4 as equal to $U_G/c^2$ where $U_G$ is the geopotential at the geoid. $L_G$ is now used as a defining constant.*

## B2 Coordinated Universal Time

The International Astronomical Union

**Recognising**

1. that the definition of Coordinated Universal Time (UTC) relies on the astronomical observation of the UT1 time scale in order to introduce leap seconds,

2. that the unpredictablity of leap seconds affects modern communication and navigation systems,

3. that astronomical observations provide an accurate estimate of the secular deceleration of the Earth's rate of rotation,

**Recommends**

1. that the IAU establish a Working Group reporting to Division I at the General Assembly in 2003 to consider the redefinition of UTC,

2. that this study discuss whether there is a requirement for leap seconds, the possibility of inserting leap seconds at pre-determined intervals, and the tolerance limits for UT1-UTC, and

3. that this study be undertaken in cooperation with the appropriate groups of the International Union of Radio Science (URSI), the International Telecommunications Union (ITU-R), the International Bureau for Weights and Measures (BIPM), and relevant navigational agencies.

## B3 Safeguarding the information in photographic observations

The International Astronomical Union

**Consequent upon**

its Recommendation C13 (1991) of the XXIst General Assembley to create accessible archives of the large quantities of observational material collected during the 20th Century and currently stored on photographic plates,

**Recognising**

that unless action is taken this unique historical record of astronomical phenomena will be lost to future generations of astronomers,

**Considering**

the important efforts made by the Working Groups on (i) Sky Surveys, (ii) Carte du Ciel plates and (iii) Spectroscopic Data Archives, as well as by the Centre for European Plates recently launched at the Royal Observatory of Belgium, in locating and cataloguing plates, in defining the tools needed to safeguard them, and in negotiating the means to preserve their recorded information in digital form in the public domain,

**Realising**

that the cataloguing, storage and safeguarding of the photographic plates is an important aspect for the implementation of the possible future digitisation processes needed for selective media transfer of high quality data,

**Recommends**

the transfer of the historic observations onto modern media by digital techniques, which will provide worldwide access to the data so as to benefit astronomical research in a way that is well matched to the tools of the researcher in the future.

## 12 Joint Discussion

### Highlights of Planetary Exploration from Space and from Earth

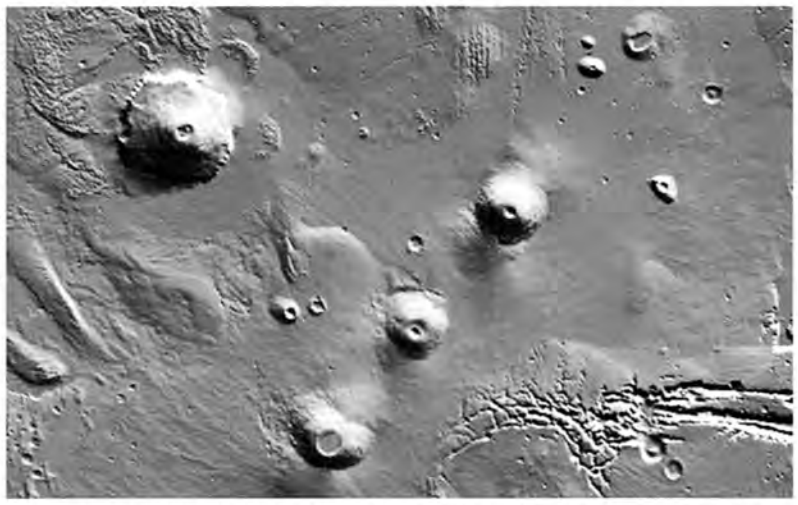

Photo: NASA/Goddard Space Flight Centre

*Topography of the Tharsis/Valles Marineris region of Mars from the Mars Observer Laser Altimeter on-board the Mars Global Surveyor (MGS) spacecraft.*

The last few years have seen great strides in our understanding of the Solar System, resulting from ever more sophisticated instrumentation on the ground and in space. JD14, which takes place today and tomorrow in Theatre 1, Crawford House, will summarize some of the most exciting new discoveries, with an emphasis on the Jovian system, Titan, and Mars.

The Galileo mission has resulted in huge increases in our understanding of Jupiter and its satellites. The Galileo probe accomplished the first direct sampling of a Jovian planet atmosphere, with implications for the formation of Jupiter and Jovian planets both in this Solar System and elsewhere. Meanwhile, images and near-IR spectra from the Galileo orbiter have provided a context for the probe results, and Earth-based studies of Jovian auroræ have provided a new window on processes in Jupiter's upper atmosphere and magnetosphere. Images and spectra of the four planet-sized Galilean satellites have provided a hundred-fold increase in resolution over earlier data, revealing many surprises, including ultra-high-temperature volcanism on Io, bizarre geology on Europa that provides evidence for a subsurface ocean, and a mysterious blanket of deep dust on Callisto.

Saturn's large moon Titan, whose dense nitrogen envelope is in some ways the most Earth-like known extraterrestrial atmosphere, is soon to receive intense scrutiny from the Cassini/Hugyens mission, which will probe its atmosphere directly in 2004. However, we are already learning much about Titan from Earth, as we begin to penetrate the dense atmospheric haze with high-resolution infrared imaging and spectroscopy. We now have near-infrared maps of its surface, revealing surprising diversity, and evidence for highly variable clouds in the lower atmosphere. These results provide a tantalizing glimpse of the Cassini/Hugyens discoveries to come.

Mars has also come under intense recent scrutiny from the Mars Global Surveyor (MGS) spacecraft, which has been in orbit since 1997. MGS has provided a spectacular global topographic map, the first reliable one for Mars, and the best-yet orbital images of the surface. Surprises have included evidence for running water on the surface in the geologically recent past, new evidence for a former ocean in the northern plains, and evidence for widespread rocks of andesitic (relatively silicon-rich) composition in the northern hemisphere.

These results and others will be presented and discussed during JD12.

**John Spencer**
*Lowell Observatory*

## 13 Joint Discussion

### HIPPARCOS and the Luminosity Calibration of the Nearer Stars

Trigonometric parallaxes of stars have been determined through photographic astrometry at many observatories during the last century, following the first successful visual measurements by Henderson, Bessel and Struve in the 1830s. The quantity and precision of these data are not adequate to meet many current needs, despite the great effort involved, but the ESA astrometric satellite HIPPARCOS has transformed the situation by providing a large and relatively complete set of parallax measurements of a quality comparable to the best ground-based measurements.

Any large new data set requires study by many astronomers before it can be fully assimilated by the community. Techniques to handle the data must be devised, and the properties of the data set, such as random and systematic errors and any selection effects, need to be understood. The first morning session of JD13, which takes place today in the Rutherford Theatre, Schuster Building, is devoted to this aspect of the HIPPARCOS material.

The bulk of the stars for which data are available are necessarily those which are relatively common, that is the ordinary stars of the main sequence and the giant branch. Much of our data on stellar classification – spectral types and multicolour photometry – have been obtained for these same stars. The second and third sessions are devoted to the assessment of luminosity calibration in the light of the new parallaxes which, for the first time, are sufficient to show some of the finer detail in the Hertzsprung-Russell diagram for field stars.

The final session tackles the question of the use of stars of the red giant clump as distance indicators – the technique has given results at variance with those of more traditional methods – and the application of the HIPPARCOS-based luminosity estimates to the asteroseismology of several types of variable stars.

**Tom Lloyd Evans**
*South African Astronomical Observatory*

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# Joint Discussion

## The Origins of Galactic Magnetic Fields

The origin of the magnetic fields found in spiral galaxies has been a matter of controversy since their discovery fifty years ago. The observed magnetic fields can be represented by a regular (mean) component and a turbulent (random) part, each of which plays an important rôle in the dynamics of the interstellar medium. The origin of both is still controversial. The two main competing theories are the primordial field scenario and dynamo theory. Our present understanding of the origin of cosmological magnetic fields, MHD turbulence, dynamics of the interstellar medium and dynamo theory seem to promise that the controversy may soon be resolved (and the dynamo theory seems to be winning the competition). JD14, which takes place today in the Computer Science Theatre, may contribute importantly to this resolution.

The aim of JD14 is to present a multifaceted view of galactic magnetic fields, combining insights from observational, theoretical and numerical studies. The participants represent most of the groups active worldwide in the field. There is emphasis on 30 min open discussions, to follow each of the four parts of the meeting, and the programme of invited talks has been planned to catalyse and direct active debate.

The meeting will start with a discussion of the extragalactic and pregalactic magnetic fields which must provide an initial condition in any picture.

The observational status of galactic magnetic fields is the subject of the second part of JD14, when both the Milky Way and external galaxies will be discussed. This will be followed by presentations on the theory of galactic magnetic fields.

The last part of the meeting is devoted to the most controversial issue in the modern theory of turbulent dynamos: the non-linear behaviour of mean-field dynamos and their possible suppression by turbulent magnetic fields. Both the pros and cons of mean-field turbulent dynamos will be presented by their proponents, and confronted with the numerical and observational evidence.

**David Moss**
*University of Manchester, UK*

# Results from Joint Discussion 2

## Models and Constants for Sub-Microarcsecond Astrometry

The accuracy of astrometric measurements has increased substantially over the last twenty years. VLBI observations at radio wavelengths and the HIPPARCOS space mission have resulted in improvements in position of several orders of magnitude. This has led to the establishment of the International Celestial Reference Frame (ICRF) based on the positions of extragalactic radio sourced and the adoption of the International Celestial Reference System (ICRS).

The unprecedented accuracy (~300 μas for the positions of the individual radio sources making up the ICRF) requires refinements for the ICRS. Several IAU Working Groups in the area of 1) the International Celestial Reference System, 2) Relativity for Celestial Mechanics and Astronomy, 3) a BIPM/IAU Joint Committee on General Relativity for Space-Time Reference Systems and Metrology, 4) Astronomical Standards and 5) Non-Rigid Earth Nutation Theory were formed three years ago to address the needs for achieving computational accuracies of sub-mircoarcseconds

An IAU Colloquium 'Towards Models and Constants for Sub-microarcsecond Astronomy' was held in Washington DC in March 2000. This Colloquium drafted resolutions which were the results of the efforts of the working groups. These ten resolutions were presented at JD2 and were approved, with minor revisions by the attendees. These resolutions appear in the pull-out centre supplement in today's issue of *Northern Lights*.

The future for the improvements in astronomical accuracies appears very promising with the future founded and proposed space missions, FAME, SIM and GAIA.

**Kenneth J Johnston**
*US Naval Observatory*

## Commission 41: Special Session

Inventory and Preservation of Astronomical Archives, Records and Artifacts

**Wednesday, August 16: Roscoe 3.2**
Chair: Steven Dick

| | |
|---|---|
| **0900hrs** | The Inventory of IAU Archives, and the ESO Archives<br>Adriaan Blaauw (Netherlands) |
| **0915hrs** | Royal Astronomical Society Library and Archives<br>Peter Hingley (UK) |
| **0930hrs** | Norman Lockyer Observatory Archives<br>George Wilkins (UK) |
| **0945hrs** | "Alidade" and the iconographic base for the astronomical archives preserved in France<br>Suzanne Debarbat (France),<br>Jean-Pierre Cressent (France) |
| **1000hrs** | German Archives<br>Wolfgang Dick (Germany) |
| **1015hrs** | Specola 2000: A Programme for the Preservation and Inventory of the Archives of the Italian Astronomical Observatories<br>Giorgia Foderà (Italy) |
| **1030hrs** | Status of the Euler Edition and Archives<br>Andreas Verdun (Switzerland) |
| **1045hrs** | Russian Archives<br>Alexander Gurshtein (Russia) |
| **1100hrs** | Preservation and Digitization of Observatory Publications<br>Brenda Corbin (USA),<br>Donna Coletti (USA) |
| **1115hrs** | Preserving the Material Heritage of Astronomy. The International Catalog of Sources of the American Institute of Physics<br>David DeVorkin (USA) |
| **1135hrs** | Inventory and Preservation of Archives in Australia and New Zealand<br>W. Orchiston (Australia) |
| **1150hrs** | The Nha Il-Seong Museum of Astronomy<br>Il-Seong Nha (Korea) |
| **1205hrs** | Archives in India<br>S M R Ansari (China) |
| **1220hrs** | Astronomical Records from China<br>Li CiYuan (China) |
| **1235hrs** | Astronomical Archives in Japan<br>T. Nakamura (Japan) |

## 7 The Naming Game

Did you know that you may suggest designation topics for the Commission 5 Task Group on Designations to consider? All you have to do is attend their Business Meeting during the afternoon session today in room Roscoe 3.4.

**Helene R. Dickel**
*University of Illinois, USA & Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# Philip C Keenan (1908-2000)

*Photo: Ohio State University archives.*

*Philip C Keenan, who died this April, in a portrait made in 1978.*

A familiar figure at IAU meetings will be missed this year. Philip C Keenan, Professor Emeritus of Astronomy at Ohio State University and a leading authority on the spectra of late-type stars, died in April this year at the age of 92.

Keenan was best known for his work on spectral classification. *The Atlas of Stellar Spectra*, published in 1943 in collaboration with W W Morgan and E Kellman, established the MK system as the universally adopted system for the classification of stellar spectra. In it they introduced the Roman-numeral notation for luminosity classes which is still used today, and argued strongly for a system which is defined on the basis of standard stars, not measurements.

As soon as the HIPPARCOS Catalogue was published, Keenan used the improved absolute magnitudes resulting from its parallaxes to test his own luminosity subdivisions for late-type giants. The results were announced in his last published paper, which appeared in the *Astrophysical Journal* in 1999 with the collaboration of Cecilia Barnbaum: this appeared 68 years after his first *ApJ* paper.

Joint Discussion 13, which takes place today, will consider 'HIPPARCOS and the Luminosity Calibration of the Nearer Stars'. To a large extent it was Keenan's recent work with Cecilia Barnbaum which inspired this choice of topic.

Keenan was a member of IAU Commissions 29 and 45, and played an active rôle in their activities. His papers are known for the remarkable quality of their illustrations of stellar spectra. His *Atlas of Spectra of the Cooler Stars Types G, K, M, S and C* (with R McNeil, 1976) is a marvellous example of this attention to detail.

Philip Keenan's interests were extremely broad; in his early years at the Yerkes Observatory he wrote both observational and theoretical papers on a variety of topics, including an early series of papers on the photometry of 'extra-galactic nebulæ'. During his later years he developed a serious interest in the history of Latin-American astronomy and published a number of historical papers as well as a book *The Chilean National Astronomical Observatory, 1852-1965,* in collaboration with S Pinto and H Alvarez.

Despite his loss of hearing, his visual acuity never suffered. At the age of 90 he convinced himself that he could make finer and more consistent luminosity distinctions than in his earlier work and he decided therefore to re-examine the luminosity classifications of several hundred G and K stars. He was on track to complete the project in time to present the results at this General Assembly. The work, however, was stopped abruptly when he slipped and fell getting on a city bus ("the stupidest thing I've ever done," he said). Following surgery to repair a broken pelvis, he was forced to spend winter in a nursing home, mostly in good spirits but becoming increasingly impatient to get back to his microscope and his spectra. Unfortunately he never recovered from the accident; his bones healed, but his strength did not return.

Philip Keenan will be remembered as a small, quiet, elderly man with a pleasant but often self-deprecating sense of humour. Indeed, he seemed elderly for at least the last forty years of his life, and so frail that his longevity surprised everyone, even himself. He never married, and he had no living relatives at the time of his death. His family was instead made up of his astronomical colleagues, his devoted former students, his flowers, his rare books and his stars.

**Robert T Wing**
*Ohio State University*
**Tom Lloyd Evans**
*South African Astronomical Observatory*

GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY

MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.9:** *WEDNESDAY 16th AUGUST*

# Io's Super-Hot Volcanoes

Io, Jupiter's innermost large satellite, is like nowhere else in the Solar System. Highlights of our new view of Io were summarized in talks by Ashley Davies, Melissa McGrath and the author during Joint Discussion 12 (Highlights of Planetary Exploration from Space and from Earth) yesterday.

Intense tidal heating, resulting from Io's proximity to Jupiter and its orbital resonance with the other Jovian satellites, which forces its orbit to be eccentric, produces a surface heat flux forty times that of the Earth. The result is volcanic activity on a massive scale. Because the volcanism continually supplies volatiles (dominantly sulphur dioxide - $SO_2$) to Io's surface, and supports a tenuous nanobar atmosphere, about a tonne of material per second escapes Io altogether, producing a dense plasma which fills the Jovian magnetosphere.

The past few years have seen rapid progress in our understanding of Io, due to discoveries by the Jupiter-orbiting Galileo mission, and improvements in ground-based and Earth-orbiting instrumentation, particularly HST. This progress has culminated in three close flybys of Io by Galileo since October 1999. The flybys have increased the resolution of our best Io images fifty-fold, and have provided unprecedented infrared maps of volcanic thermal emission and surface composition, in addition to providing new details of Io's interaction with the Jovian magnetosphere.

Perhaps the most remarkable discovery from Galileo has been that many of Io's volcanoes produce magmas hotter than any seen at terrestrial volcanoes. This probably indicates unusual magma compositions, perhaps silicate magmas poor in silicon and rich in iron and magnesium, similar to the 'komatiite' lavas which were common on the early Earth but are almost unknown today. Io may thus give us a window into the Earth's early history. Galileo has caught several of these high-temperature eruptions in the act, including dramatic high-resolution images of fire-fountaining activity and spreading, glowing lava flows at the volcano Tvashtar. Galileo observations of a lower-temperature but more powerful volcano, Loki, indicate that its caldera is covered with fresh, hot, lava at the astonishing rate of 150 square kilometres per day, though it's not yet clear how this is achieved.

Galileo has also provided insights into the generation of Io's remarkable volcanic plumes, in which gas and dust is thrown up to several hundred kilometres above the surface. Some of the plumes appear to result from the vapourization of surface materials, such as $SO_2$ frost, by advancing lava flows, rather than being ejected directly from volcanic vents. HST has also contributed to our understanding of Io's plumes: Hubble spectra of one of the largest plumes, Pele, reveal abundant $S_2$ gas in addition to the expected $SO_2$ gas. Colourful red deposits seen around many Ionian volcanoes may result from breakdown of the unstable $S_2$ gas into red $S_3$ and $S_4$ molecules after condensation on to Io's surface.

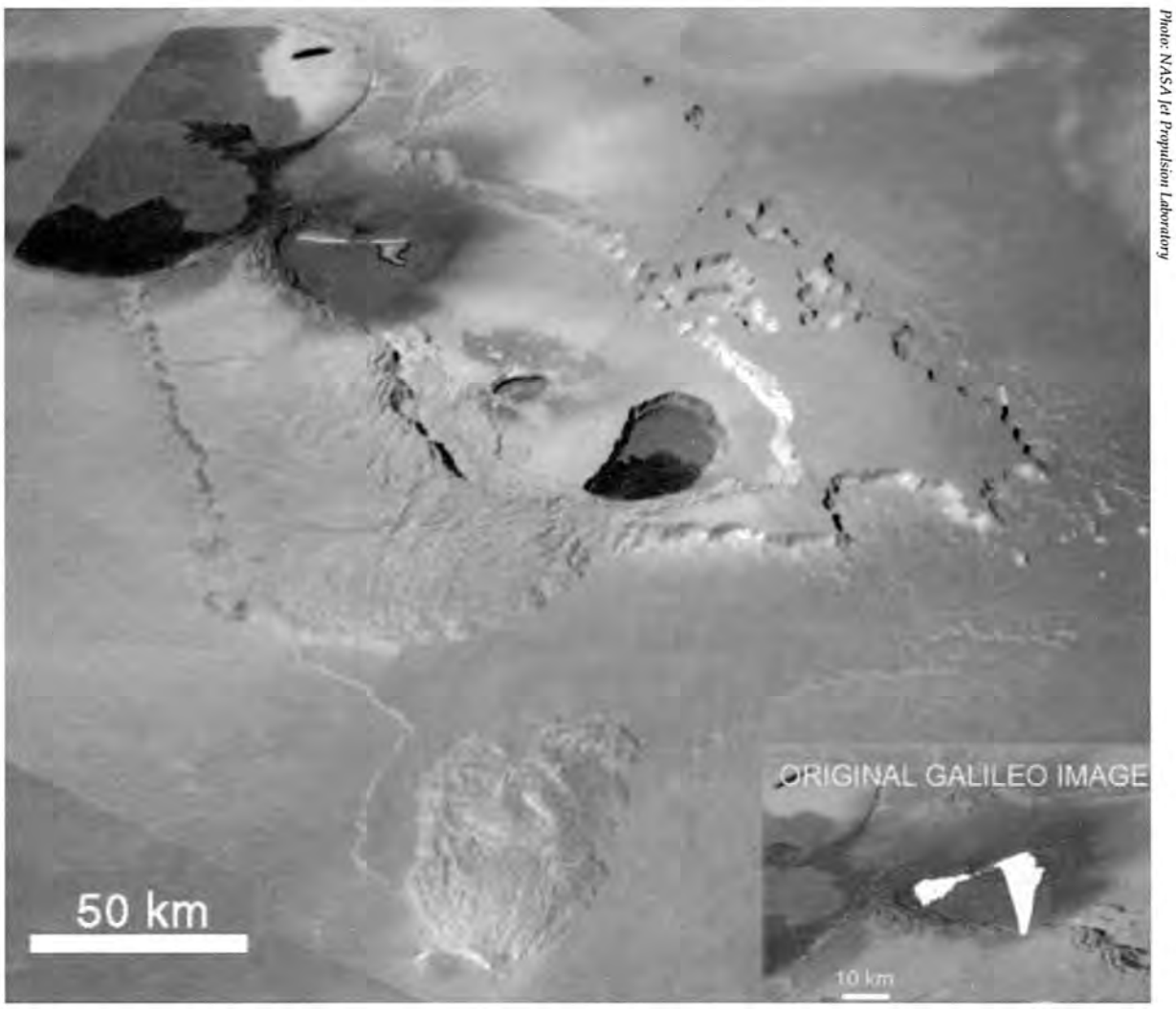



*Photo: NASA Jet Propulsion Laboratory*

*Galileo spacecraft image of a 25km long 'curtain of fire' at Io's volcano Tvashtar, taken in November 1999. The intense thermal emission from the magma has saturated the CCD, causing downward bleeding.*

**John Spencer**
*Lowell Observatory, USA*

# Black Holes: A Closer Look

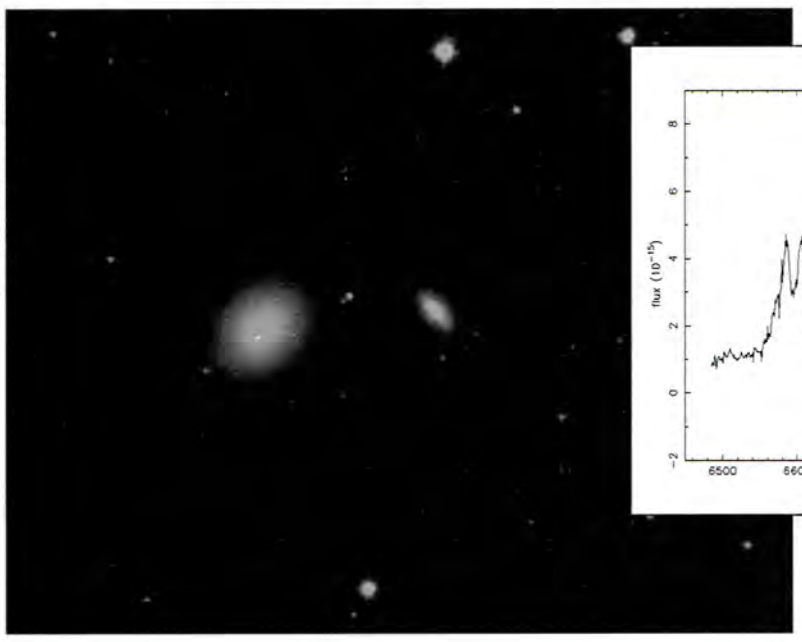
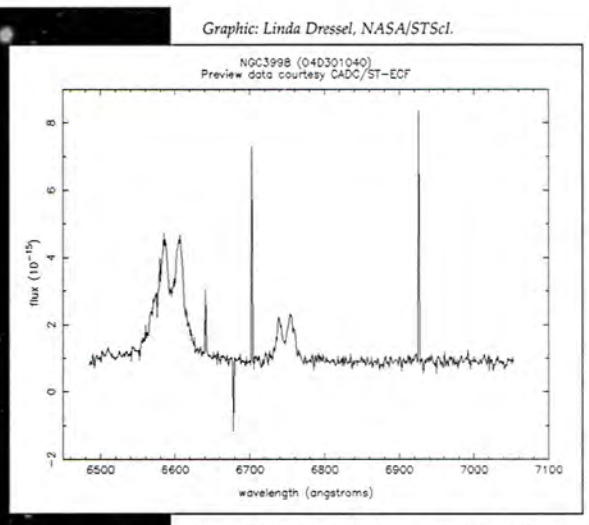


*Photo: NOAA/Kitt Peak National Observatory.*

*Graphic: Linda Dressel, NASA/STScI.*

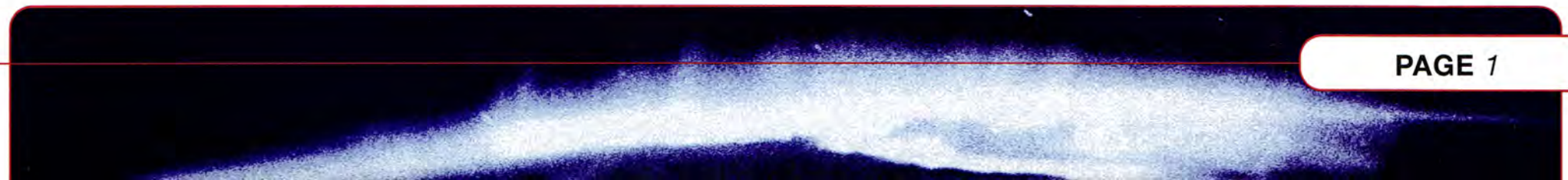



***Above**: High-resolution spectral data for the disk of NGC 3998 obtained by STIS.*
***Left:** Ground-based image of the radio-bright galaxy NGC 3998.*

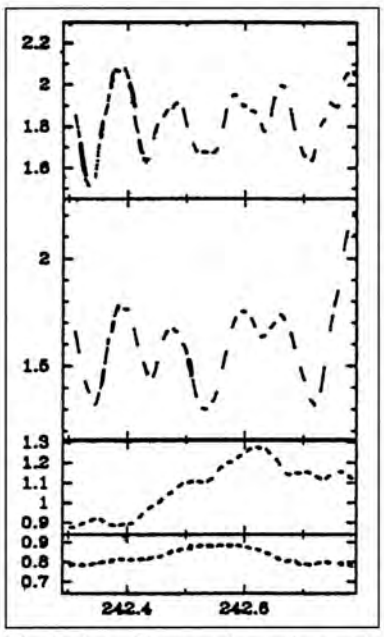
At Symposium 205 (Galaxies and their Constituents at the Highest Angular Resolutions) yesterday, Linda Dressel (Space Telescope Science Institute) presented the most direct and complete high-resolution measurements ever made of a supermassive black hole and the density of its surrounding nuclear matter. The target was the nucleus of the radio-bright Liner galaxy NGC 3998, which lies at the same distance as the Virgo cluster.

Dr Dressel first observed the nucleus of the galaxy in Hα + [NII] emission and two adjacent continuum bands with the HST's WFPC2, locating a sub-arcsecond oval emission line region, and then observed this apparent disk with the Space Telescope Imaging Spectrograph (STIS) at Hα + [NII] and SII. She then fitted theoretical rotation curves (which are sensitive to both the black hole mass and the density of surrounding material) to the velocity measurements obtained. This revealed a 1.5-2 x $10^8$ solar mass black hole in the inner part of the disk, and a density of about 1500 solar masses per cubic parsec in the outer part. Further observations of other relatively nearby galaxies should follow soon. Obtaining a large sample of central engine mass determinations is a crucial first step toward understanding the physics of AGN central engines, including the puzzling difference between radio-loud and radio-quiet AGNs.





# The Smallest Radio Sources




*The 12 hour discovery observations made on 1996 June 8 of the variations in PKS 0405-385, observed with the ATCA at 8.6, 4.8, 2.4 and 1.4 GHz, from top to bottom.*

The old children's nursery rhyme "twinkle, twinkle, little star," applies not just to the optical twinkling of stars in the Earth's atmosphere, but also to the scintillation of the smallest, most distant radio quasars in the ionized interstellar medium of our Galaxy.

Intra-day variability (IDV) at radio wavelengths was first discovered a decade and a half ago. This IDV was initially thought to be intrinsic to the sources themselves, as with IDV at X– and gamma-ray wavelengths. However, the implied brightness temperatures were far too hot, up to $10^{21}$K, so alternative mechanisms not intrinsic to the sources, were sought. Of these, interstellar scintillation, ISS, proved the most promising, but there seemed no easy way to determine conclusively if the mechanism was intrinsic or extrinsic.

The dichotomy has now been settled in favour of scintillation, primarily through two sets of observations. The first sought and measured a highly significant time delay of ~2 min in the appearance of the variability pattern at 5GHz in the extremely variable source PKS0405-385 between two widely spaced radio telescopes, the Australia Telescope Compact Array (ATCA) and the VLA. The second followed the change in the character of the pattern of variability at Westerbork over the course of a full year of the source J1819+3845 as the Earth moved around the Sun. The variability pattern was seen to slow-down then speed up, just as expected for scintillation.

Interstellar scintillation leads to far less extreme source conditions than if the variations were intrinsic. However, there remain several serious problems:

- the sources are still too hot, with brightness temperatures of $\geq 5 \times 10^{14}$K, not easily explained by relativistic beaming;
- there are far too many IDV sources being found, and there is good evidence to indicate that most, if not all AGN contain weak microarcsecond cores;
- these IDV sources also show exceptionally high levels of circular polarization, and both the circularly polarized and linearly polarized flux also show IDV!

The measurement of radio source IDV means that sensitive flux density measurements with single radio telescopes, yields a probe of radio source structures on an angular scale that cannot presently be reached by VLBI from the Earth or from space.

**David Jauncey**
*Australian Telescope National Facility/CSIRO*

*Photo: Netherlands Foundation for Research in Astronomy.*

*The dishes of the Westerbork Synthesis Radio Telescope (left), and the Australia Telescope Compact Array (below), where these extremely rapidly variable sources were discovered.*

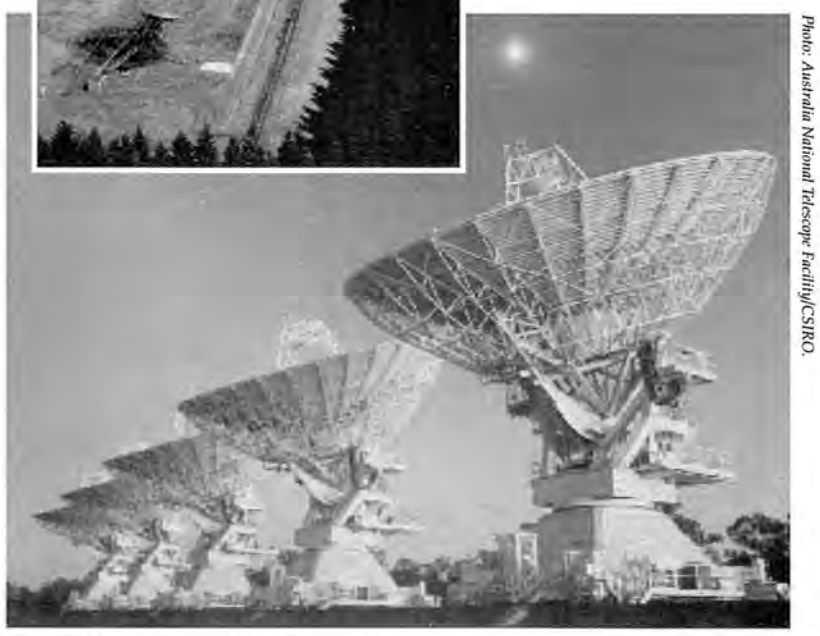
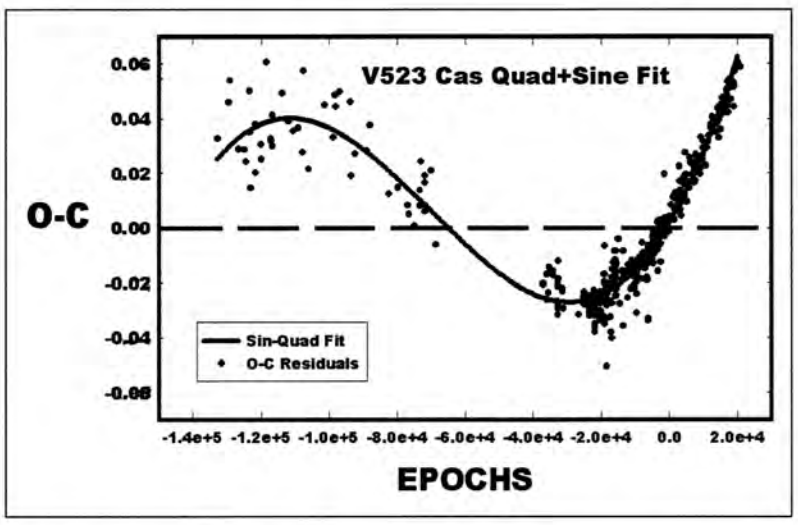


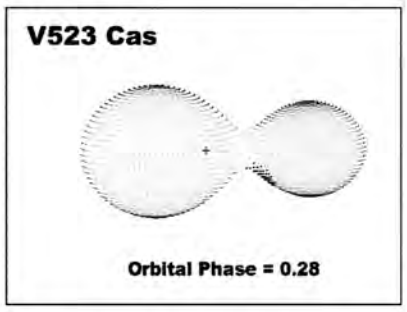
*Photo: Australia National Telescope Facility/CSIRO.*

# Surprising Results from Archival Research




*Left: Plot showing the sinusoidal variation overlaying the continuous increase in the period of V523 Cas.*

*Below: Vizualization of the close pair of stars in the V523 Cas system.*




V523 Cassiopeiae [WR16, CSV 5867, GSC 3257-167] has figured prominently in studies of very short period K-type non-degenerate eclipsing binaries over the past 15 years. Both amateur and professional observers have heavily observed it over the past 37 years. These timings suggest that the orbital period of the system is continuously increasing, which is not unusual for W UMa binaries of this type. Recently, David B. Williams of the AAVSO obtained 50 timings of 'low light' by examining archived photographic plates from Harvard/SAO. While it is not possible to measure times of minimum light from the plates, these times of low light correspond well with eclipses. The timings cover the interval from 1901 to 1942 and greatly extend the baseline over which the period behavior of V523 Cas may be studied. Combined with the already available 403 epochs of minimum light and seven timings from our 1998 observations, some 460 eclipse timings, spanning 152,000 orbits and 99 years were accumulated! A least-squares linear fit to all available timings (see accompanying figure), revealed an unexpected result; a sinusoidal variation overlaying the continuous period increase. The quadratic term, $1.03 \times 10^{-11}$ d/E$^2$, is due to mass accretion onto the primary component or some as yet unexplained physical process causing the components to continuously separate. However, the sinusoidal behavior with an amplitude of $0.037 \pm 0.06$d (light time: 6.39 AU) is seen only in systems that have a third star present in the system. Assuming that this is the case, and that the inclination from our orbital solution for the close pair is the same as for the larger orbit, the mass of the third star was found to be 0.36 $M_\odot$. Its orbital period is $103 \pm 16$ years. The distance modulus yields a distance of 77 pc. The third member, at magnitude 15 compared to the contact binary's magnitude 11, should be near greatest separation now, ~0.3 arcseconds. With adaptive optics on a large telescope and good seeing it should be possible to resolve the companion, if it exists! This result underlines the importance of preserving plate archives.

**Ronald Samec**
*Bob Jones University, USA*

# With Thanks...

By this stage of the General Assembly it should be clear to everybody that the planning and preparations for the meeting have required an enormous amount of detailed work. From the time of the initial site visit four years ago, the bulk of this work has fallen on Rod Davies and Dennis Walsh, the Co-Chairs of the Local Organizing Committee. They have worked tirelessly with their colleagues at the University of Manchester to produce a well-organized and smoothly running meeting. In particular, Christine Bolton and her staff in the University of Manchester Conference Office have provided invaluable experience. On behalf of the National Organizing Committee, I would like to thank Rod and Dennis and all their colleagues who have ensured that we have had such an enjoyable time in Manchester.

I would also like to thank the members of the NOC who have helped in all manner of ways. In particular, our thanks are due to Sir Bernard Lovell for organizing the excellent concert and to Patrick Moore (and members of UMIST) for his work on the popular public lectures. The Executive Secretary of the RAS, John Lane, has given me practical support and advice on a variety of issues

Each General Secretary of the IAU has to be responsible for one General Assembly. On this occasion we are grateful to Johannes Andersen who, with the IAU Secretariat, has worked hard to ensure that the high standards of the IAU were met.

You will have all met the friendly and helpful staff of World Event Management who have dealt efficiently with the registration process.

I would like to thank our three major sponsors, the Royal Astronomical Society, the Particle Physics and Astronomy Research Council and the Royal Society, for their financial support. Also, the University of Manchester has borne many costs and has provided lecture theatres and rooms free of charge; we have enjoyed the scientific sessions in comfortable, often recently refurbished surroundings.

Finally, thank you, the participants, for attending and contributing to the scientific success of the Symposia and the Joint Discussions.

**Carole Jordan**
*Chair, NOC*

# Closing Dinner

Will delegates attending the Closing Dinner in the Jarvis Piccadilly Hotel this evening, please note that they should arrive at 1915hrs for 1945hrs and NOT at 1800hrs as stated in the Final Programme.

# Winter and Spring
## at the Pulkovo Observatory

*Photos: Oleg Bykov, Pulkovo Observatory*

*Views of the Pulkovo Observatory in winter and spring.*

The Pulkovo Observatory in St. Petersburg, Russian's oldest astronomical observatory, was known during the 19th century as 'the astronomical capital of the world'. Sadly, the Observatory has been passing through a difficult period in its history, due to financial constraints. However, observational work is continuing, - mainly astrometry - notably double star measurements and studies of the satellites of the giant planets with the 26-inch refractor, now equipped with an ST6 CCD matrix. The astrograph is also in regular use, carrying out its traditional programme of making photographic observations of asteroids and galaxies, as well as determinations of stellar proper motions. We are regularly given observing time on the Russian 6-metre telescope, with emphasis upon observations of Edgeworth-Kuiper Belt objects.

We have welcomed twenty scientists from the former Institute of Theoretical Astronomy, and we also collaborate successfully with astronomers all over the world. If it has recently been 'winter' at the Pulkovo Observatory, we hope that 'spring' is now on its way.

**Oleg P Bykov**
*Pulkovo Observatory*

# Lunar Astronomy

In the meeting of the Division X WG on 'Astronomy from the Moon', considerations relating to the selection of suitable sites for manned bases were outlined by Shigemi Kaifu (National Astronomical Observatory of Japan). He stressed that everything depended upon the choice of site. A polar crater, with its floor in permanent shadow, would be ideal for some branches of research, because of the stable thermal conditions and the lack of background 'noise'. There would be an excellent energy supply via a nearby high peak which would be in permanent sunlight; communications with Earth would also be good, since the Earth would always be in view from the top of the peak. From latitudes $80^{o}$ to $90^{o}$ there would also be easy communications, though there would, of course, be great diurnal temperature variations. From the Moon's far side there would be no radio interference – and care would have to be taken to ensure that the radio-quiet conditions were retained in the long-term.

Japan has a very keen interest in astronomy from the Moon. The orbiting Selene satellite is due for launch in 2003 or 2004. There are also plans for a lander on Selene-2. One experiment will land a zenith telescope in a near-polar zone, with a liquid-mercury mirror; this will measure the librations very accurately leading on to improved studies of lunar structure and dynamics. It is also hoped to land equipment to search for NEOs – a pair of twin 35-cm telescopes, and then two 1-metre telescopes. Dr Kaifu commented that only a limited amount of human activity on the Moon would soon surpass the results obtained by robots, and in the long run would cost less.

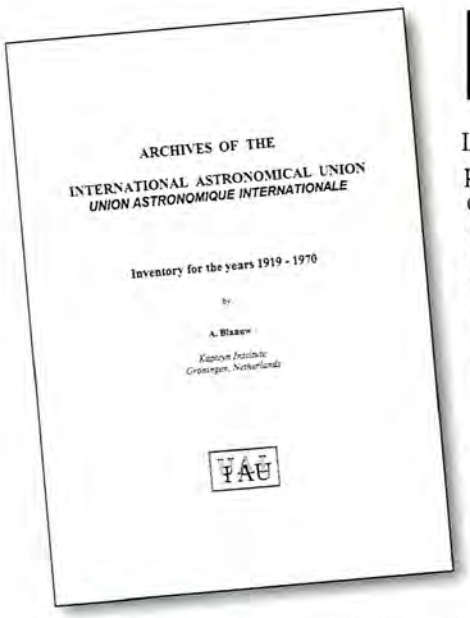
# Changing of the Guard

After serving for almost one-third of a century as Director of the IAU Central Bureau for Astronomical Telegrams, Brain Marsden is stepping down at the end of this General Assembly.

The new Director of the CBAT is Daniel Green, who has been on the CBAT staff since 1980, for most of that time as Associate Director.

Since Green has in fact prepared most of the *IAU Circulars* in recent years, it is not anticipated that the change will be other than transparent. Marsden will in any case continue to be associated with the CBAT as Director Emeritus and as President of Commission 6. He will also continue as Director of the Minor Planet Center.

# IAU Archives


ARCHIVES OF THE

INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE

Inventory for the years 1919 - 1970

by

A. Blaauw

Kapteyn Institute
Groningen, Netherlands

IAU

IAU Historical Archives for the period 1919-1970 were compiled by Adriaan Blaauw (Kapteyn Institute, Groningen) in preparation for his book *History of the IAU* (Kluwer, 1994), and supplemented afterwards. Through an agreement between the IAU and the Academie des Sciences in Paris, the IAU has donated these Archives to the Academie where they will be accessible under supervision to qualified astronomers and historians. Access requires prior written authorization of the IAU General Secretary. A 42-page detailed Inventory of these Archives has now been published. It was described by Prof. Blaauw at the Special Session of Commission 41 (Inventory and Preservation of Astronomical Archives) yesterday. Pending arrangements to be finalized after this General Assembly, members interested in acquiring copies of the Inventory are advised to contact the author, either during the Assembly, or by e-mail to blaauw@astro.rug.nl.

# Another Dimension

Yesterday evening's Invited Discourse on the 'Three-Dimensional Structure of our Galaxy' by Michael Perryman (European Space Agency) was a visual treat. The lecture set out to explain the main features of our Galaxy's 3-d structure as we understand them today, and did so with remarkable success. The speaker described how the HIPPARCOS results have strengthened our ideas, and set it all into an historical context which neatly showed how the latest distance measurements have built upon the pioneering positional measurements of the past 300-400 years. It also set the scene for how microarcsecond positional measurements – which, with planned missions like SIM, FAME and GAIA, seem to be almost upon us – will carry the quantitative exploration of our Galaxy's structure onwards in the future.

Sitting in the darkened auditorium of the Bridgewater Hall, the visual effects were truly spectacular. Even the simple reconstruction of the 2-d stellar motions in various fields on the sky brought the subject immediately to life. Seeing the motions of stars in the solar neighbourhood, the reconstructed motions of stars moving through the galactic disk, stars moving up and down in the disk's potential, simulated motions of planetary systems, and the effects of the Sun's gravitational light bending on background stellar images, really brought home what an astonishing range of topics HIPPARCOS has been able to influence.

This Invited Discourse demonstrated, in spectacular fashion, what modern space astronomy – referred to by the speaker far more vividly as "stereoscopy" – is all about. For all those present, it will probably change how they think about the structure of our Galaxy in the future.

# The Plate Debate

Astronomy possesses a major resource of astronomical data recorded during the first three-quarters of the last century. These observations map the histories of comets, novæ and supernovæ, trace the orbits of asteroids, describe long-term variations in apparently constant objects, and reveal the modulations of evolution. The resource is a distributed archive of photographic plates – and it is going to waste. Photographic observations are non-digital; nowadays not many groups rely on them for research, and fewer have the equipment or expertise to measure them. What should be done with them?

Surely we can't just throw them away. That would be scientific mutilation. They are not needed as historic artefacts; a few tens would suffice not a few million. Their value is their recorded information. To repeat the observations with

digital detectors would take 50-100 years, and would not sample the same events. The cost-effective, scientific solution is to digitize the archives – as is already happening in oceanography and meteorology.

Currently there are some residual scanning activities (in photographic astronomy), but these are not funded as open-ended commitments. The proposal is therefore to establish a small number of international plate-digitizing laboratories specializing in spectrograms, objective-prism plates, or direct-image plates.

Will our Working Group's initiative to digitize selections of the world's spectrograms (the Spectroscopic Virtual Observatory, http://herbie.ucolick.org/techdocs/vo) win cooperation and support? Can UDAPAC (http://udapac.oma.be), launched recently in Brussels to scan Europe's direct plates within five years, trigger parallel efforts in other continents? Will we be able to report in 2006 that astronomy's observational heritage is largely available digitally for our contemporaries and our successors?

The debate continues...

**Elizabeth Griffin**
*WG for Spectroscopic Data Archives, Division IV*

# Women's Lunch

A very successful lunch was held during the first week of the General Assembly to discuss the issues affecting women astronomers. About sixty GA participants (including some men) attended and a wide range of facts and figures, viewpoints and opinions were aired. Wendy Freedman presented some of the latest statistical findings from the USA which show that proportionately more men than women are advancing at almost every stage of the careers ladder, particularly at the very highest levels. Sawako Maeda presented similar statistics from Japan which reveal, amongst other things, that about half of all married Japanese women astronomers endure years of separation from their husbands due to the problem of finding two jobs in the same locality. This is one of many well known problems which affect female astronomers worldwide.

There then followed a lively discussion. On the bright side, we heard that in both Italy and India things look relatively good for female astronomers. However, in France, a country widely believed to have a good culture for women astronomers, we heard that the number of young women entering the profession is declining. This trend was predicted some years ago.

There was strong support for a more formal meeting to address many of the issues discussed at the next GA in Sydney. These issues are not new, and they affect women from many cultures and nationalities. The challenge for such a meeting will be to find new ways forward, enabling more women to contribute fully to the pursuit of scientific knowledge.

I would like to thank the Royal Astronomical Society, who generously sponsored the lunch, co-organisers, Althea Wilkinson and Phillipa Browning, and everyone who attended for making this an interesting and enjoyable occasion.

**Myfanwy Bryce**
*Jodrell Bank Observatory*

## 4 How to set up a data table

You should have read this in your basics books on statistics and error analysis, but just in case you (or your referee...) didn't: Did you know that quoting a value to n "significant" digits, the implied error, if not quoted explicitly, is about half a unit in the last digit? Thus, make sure to list all values of your table with adequate precision. E.g., it is a waste to quote "1.2345 +/- .234" which is simply and correctly "1.2 +/- 0.2". Sometimes flux values of objects are quoted as "1.2 +/- 1.5" or even "-1.5 +/- 2.0". These should actually be listed as upper limits, quoting the number of standard deviations one has used to compute this limit.

**Heinz Andernach**
*ESA, IUE Observatory*
*Villafranca, Spain*
*for Commission 5 WG on Astronomical Data*

# WORKING GROUP
## Future Large Facilities

The IAU Executive Committee approved the formation of the WGFLS in August 1995, and Harvey Butcher was chair until the 23rd General Assembly in Kyoto in 1997. At Kyoto the following membership was adopted: Prof R D Ekers (Chairman), Dr I Appenzeller, Prof Dr H R Butcher, Dr N S Kardashev, Dr J Lequeux, Dr J L Linsky, Dr F Pacini, Dr F Praderie, Prof G Swarup, Dr Massimo Tarenghi, Prof Okuda.

The Working Group's tasks are:

i. to promote the early discussion and dissemination of information on potential large scale astronomical projects;
ii. to make and maintain an inventory of planned large scale projects in astronomy;
iii. to further contacts and cooperation between different projects;
iv. to identify areas of duplication and areas where clearly desirable efforts are lacking.

There will be an open Business Meeting of the WGFLS in Roscoe 3.3 today, commencing at 1100hrs. Anyone interested in contributing to the better coordination of the development of large facilities, is encouraged to attend.

**Ron Ekers**
*Chair WGFLS*

## 8 The Naming Game

Did you know that several journals allow celestial objects to be marked by the author to facilitate integration of objects and their associated data into public astronomical databases (NED, SIMBAD, etc)?

For example:

\object{catalog ID} - {for A&A journal - section 5.5 (p. 13) of aadoc.

See

ftp.springer.de/pub/tex/latex/aa }

or

\objectname[<catalog ID>]{<text>} where catalog ID specifies the particular catalog for the "identifier" or name given in "<text>" - {for AAS journals - section 2.15.3 (p.10) of comprehensive author guide.

See

http://www.journals.uchicago.edu/AAS/AASTeX/ }

**Helene R. Dickel**
*University of Illinois, USA &*
*Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# Bargain Basement

Please note that additional GA24 conference bags and abstract books are available for sale to delegates as follows:

**Conference Bags** **£5**
(suitable for carrying a lap-top computer)

**Abstract Books** **£3**

Available from World Event Management (WEM), Committee Room 'A', Ground Floor, Whitworth Building.

**Hurry while stocks last!**



GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.10:** *THURSDAY 17th AUGUST*

# MAXIM's Goal:
## To Image a Black Hole

X-ray astronomers should be enjoying the highest resolution images of all in astronomy, but they aren't. Because X-ray wavelengths are so short, the diffraction limit is not encountered so quickly. X-ray wavelengths are one thousand times shorter than visible light and 10 million times shorter than radio waves, indicating huge potential improvements in resolution at any given aperture. Because the surface brightness of blackbodies rises as the fourth power of temperature, compact X-ray sources have many millions of times the surface brightness of compact visible light sources.

The VLBA, reduced in scale to the X-ray domain, would be about the size of a dinner plate, and an X-ray telescope with the collecting area of a dinner plate (e.g. Chandra) can easily detect thermal sources as small as 10 km across at many kiloparsecs. If X-ray astronomers could build interferometers of modest scale, images of unprecedented resolution would result.

Recently, at the University of Colorado, we have shown that synthetic aperture telescopes with good efficiency are possible using grazing incidence optics. It turns out that X-ray observatories using grazing optics in an analogue of Michelson's stellar interferometer are achievable with today's technology.

The potential for X-ray interferometry is being developed within the context of MAXIM, the Micro-Arcsecond X-ray Imaging Mission (see http://maxim.gsfc.nasa.gov). The MAXIM scientists have unanimously agreed that the goal of X-ray interferometry should be to image a black hole. The event horizons in nearby AGNs are about a micro-arcsecond across, so MAXIM will need to be an X-ray interferometer with a baseline on the order of 100 metres. Surprisingly, all the technology needed to build and stabilize such an observatory exists today.

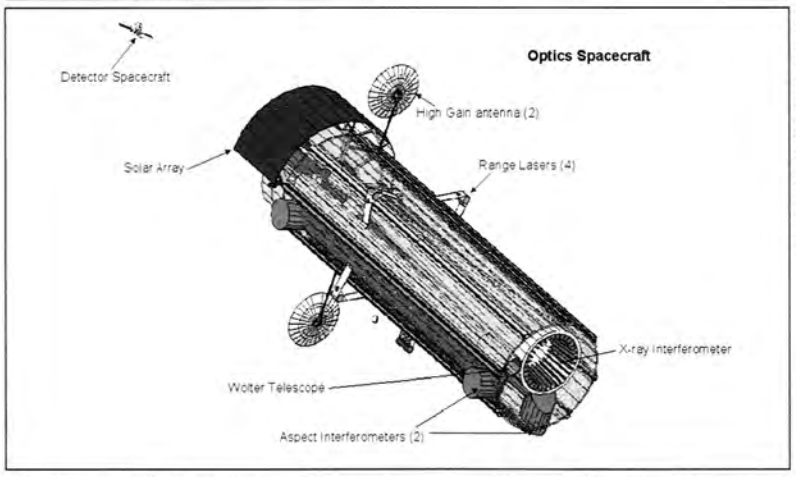
MAXIM Pathfinder, a smaller X-ray interferometer of diameter 1.4 metres, is also being defined. Technically, the Pathfinder is a stepping-stone mission with a resolution of 100 micro-arcseconds, which is being designed to help us learn the realities of X-ray interferometry before moving on to the more ambitious black hole mission. MAXIM Pathfinder is very exciting in its own right; it will be able to capture pictures of the coronæ of the nearby stars and the broad line regions of AGNs.

MAXIM is now part of NASA's strategic planning, and will be described today at Symposium 205 (Galaxies and Their Constituents at the Highest Angular Resolutions). With luck, X-ray interferometry will become a powerful new tool of the astronomical community during the second decade of the 21st Century.

**Webster Cash**
*University of Colorado*

*Computer simulation of a black hole.*

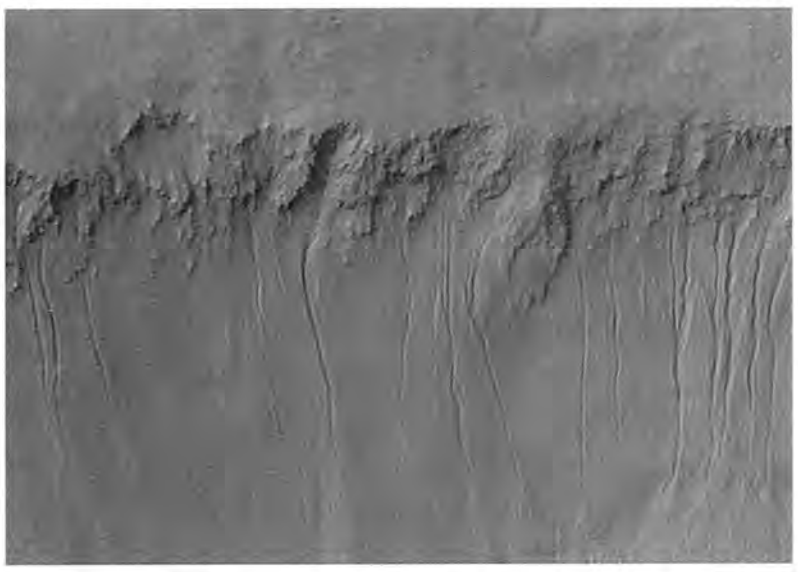
*Illustration: Kevin Rauch, ITP and University of Maryland.*




*The MAXIM Pathfinder Mission will feature two spacecraft flying in formation. The front craft carries the X-ray interferometer. The rear craft, many kilometres away, carries the detector.*

*Graphic: N White (HEASARC), W Cash (University of Colorado), and LHEA, NASA GSFC.*

# Mars Surveyed



*Photos: NASA/JPL/Malin Space Science Systems.*

***Above:*** *Small gullies on the walls of the Nirgal Vallis valley system where water may once have ran down the hill forming the channels.*

***Right:*** *A series of troughs and layered mesas in the Gorgonum Chaos region of Mars' southern hemisphere.*

*Both images are from the Mars Global Surveyor Mars Orbiter Camera.*

Space missions to Mars have met with mixed fortunes. Some have failed because of unavoidable technical problems, others because of human error. On the other hand, some have been very successful indeed, and one of these is NASA's Mars Global Surveyor (MGS) launched towards Mars on 7 November 1996; it entered an elliptical orbit around the planet on 11 September 1997, and is still functioning excellently. Some of the most important results obtained to date were summarized by Arden Albee (California Institute of Technology) during yesterday's session of Joint Discussion 12.

The initial aim of the mission was to make a variety of observations, with global coverage, over a complete Martian year (687 Earth days or 668 Mars days or 'sols'). From its arrival at Mars until March 1999, MGS acquired scientific data from decreasing-sized orbits as it alternated between aerobraking and nadir-pointing modes. One early investigation concerned the presence of a Martian magnetic field. The field was known to be extremely weak, but significant remnant magnetization of the crust was confirmed, and this indicates that there was once a molten interior with a vigorous core dynamo. However, it seems that this dynamo was 'turned off' before the end of the Great Bombardment period. There is no measurable global magnetic field now, and in this respect Mars differs from Mercury.

Great attention was also paid to the gravity field and topography of Mars. Reliable global models indicate a relatively thick crust with near-isostatic compensation in the rough, older southern hemisphere, and a thinner crust with a range of uncompensated gravity anomalies in the smoother, younger north. MGS data has resulted in the best topographic model obtained for any planet. There is a 30-km range of topography, and a pole-to-pole slope which apparently controlled the transport of water in the early history of Mars. There is also a relatively flat, northern depression which, it has been suggested, may once have been water-filled – a large, ancient ocean. Certainly, there was extensive volcanism during early to mid-Martian history, as demonstrated by the presence of thick, layered sequences of strata in Valles Marineris and elsewhere.

The rocks in the southern hemisphere differ in general from those of the north – southern basalts and northern andesites. The widespread occurrence of plagioclase and pyroxene, coupled with the lack of weathered hydrated materials, indicates the absence of pervasive weathering. Several coarse-grained hæmatite deposits were found, possibly indicative of deposition in a surface hydrothermal environment. No identifiable areas of carbonates, sulphates or quartz have been detected.

It is known that the two Martian polar caps are not identical; the northern residual cap consists of water ice, while the southern cap contains more carbon dioxide ice. A reliable estimate of the total volume of water in the present caps indicates that there is not enough to fill a hypothetical ancient ocean to any appreciable depth. There is, however, clear evidence of a sapping origin of many channels from the probable melting of ground ice, and possible evidence for recent liquid water on the surface in various spatially-isolated regions.

Detailed and long-continued surveys have provided evidence for continuing aeolian processes; there are many dust-devils as well as dust-storms, streaks, dunes and sand sheets. There are also many tiny plateaux and associated minor features. Mars is undoubtedly an active world and changes are taking place all the time. Much has been learned from MGS, and it will, it is hoped, continue operating for some time yet – perhaps even until the time of our next General Assembly!

# 'Fast Train' to Pluto

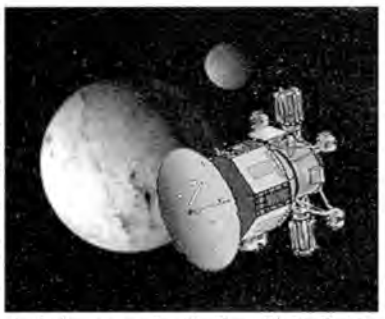


Illustration: NASA Jet Propulsion Laboratory

*Artist's concept of the Pluto-Kuiper Express spacecraft.*

Of all the main bodies in the Solar System, only Pluto has so far been left unvisited by spacecraft. This omission will, it is hoped, be remedied by the launch of the Pluto-Kuiper Express (PKE) mission. Alan Stern was Chairman of the Outer Planets Working Group which first planned the mission, some years ago; he is now Director of the Department of Space Studies at the Southwest Research Institute in Boulder, Colorado. He came into the Northern Lights office earlier this week, to give us the latest news about the mission.

**NL.** First, when is PKE due to be launched – and when will it arrive?

**AS.** It is due for launch in December 2004, and should arrive at its destination on Christmas Eve 2012 – if all goes well.

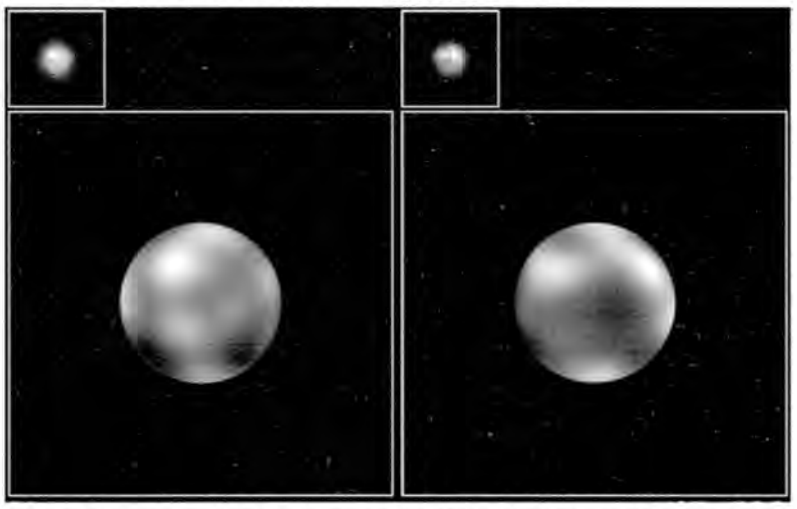
**NL.** Are sufficient funds available?

**AS.** Well, NASA has already spent US$40 million in developing the concept, and that is about 10% of the total cost, so more is needed. It is worth noting that I have so far spent 12 years working on funding problems, and this is longer than the eight years needed for the spacecraft to cross the entire Solar System!

**NL.** Presumably you are anxious to send PKE before Pluto's atmosphere freezes out, as the planet moves outward from the Sun? Perihelion was passed as long ago as 1989, and Pluto is now moving well beyond the orbit of Neptune.

**AS.** Yes, indeed. It is possible that Pluto's atmosphere will freeze out before the end of the present decade, though this is decidedly uncertain, and there are a few people who believe that the atmosphere will not freeze out entirely. Certainly one of PKE's main science goals will be to characterize the neutral atmosphere of Pluto, including composition, thermal structure and aerosol particles.

*Photos: Alan Stern (SWRI), Marc Buie (Lowell Observatory), NASA/STScI and ESA.*



*Light and dark areas on Pluto's surface are revealed in both hemispheres of the planet in these HST/FOC images. The smaller inset pictures at the top are the HST images; the larger images are from a global map constructed by computer processing of Hubble data.*

**NL.** Let us now turn to the other main objectives of the mission. Of course, maps will be made of the surfaces of both Pluto and Charon?

**AS.** Yes, that is another of the science goals. Maps will be made and detailed compositional measurements carried out. We intend to characterize the global geology and geomorphology of both Pluto and Charon, imaging both sides of each. The two bodies are decidedly different; Charon has a lower albedo, and has a surface covered with water ice, while Pluto is much brighter, with a surface coated with nitrogen, carbon monoxide and some water ice. The densities are also different. One interesting experiment will be to map the night side of Pluto in 'Charonlight', and this ought to be possible, though naturally with much lower resolution.

**NL.** What do you think are the chances of success?

**AS.** Without adequate funding, nil! But we are hoping to improve this situation by collaborating with Europe. If the European Space Agency joins the mission, things will become much easier in many ways. If funding is obtained, and we have a good launch, the chances of success are very high, because this is a relatively simple mission – a straightforward flyby. The results should be better than those obtained by Voyager 2 during its pass of Triton.

**NL.** What about the launch vehicle?

**AS.** We could use a Delta, launch from the Shuttle, or – with a slower trajectory – an Atlas-3. It is also very important to remember that exploration of the Kuiper Belt is a fundamental part of the mission; it is hoped to make flybys of one or more Kuiper Belt objects.

**NL.** It is indeed a most important and exciting project. Thank you very much.

We now look forward eagerly to December 2004. By our next General Assembly we will no doubt be able to say more; let us hope that the funding problems will be solved, and that there will be full support from Europe.

# SETI at Jodrell Bank

Photo: National Astronomy and Ionosphere Centre, Cornell University and NSF.

*The radio telescopes at Arecibo in Puerto Rico (above) and at Jodrell Bank (right), which have combined for Project PHOENIX.*

Photo: University of Manchester.

The Lovell Telescope at Jodrell Bank has joined with the 305-metre Arecibo Telescope in Puerto Rico to take part in what is the most sensitive search yet undertaken to search for radio signals from extraterrestrial civilizations. Called Project PHOENIX, led by the privately funded SETI Institute, this is a targeted search whose aim is to observe over 1000 of the nearest Sun-like star systems. Phoenix has scheduled time on the Arecibo Telescope for around 40 nights each year. The data analysis is carried out in real time and uses a second telescope to provide an immediate rejection of man-made signals. This second telescope does not need to be quite so large as Arecibo, but should not be significantly smaller, and at present the University of Manchester's 76-metre Lovell Telescope is being used.

The Arecibo Telescope uses a 56-million channel receiver to make initial signal detections. Information about those signals which are not in the data bank of known terrestrial signals are passed to two further sets of identical receivers at Arecibo and Jodrell Bank. Due to the rotation of the Earth, and the great distance separating the telescopes, a signal from outside the Solar System will have precisely calculable differences when observed at the two observatories. This allows an extra-terrestrial signal, should one be found, to be distinguished from those originating on, or near, the Earth. To prove that the complete system is operating as expected, each night a search is made for the signal from the Pioneer 10 space probe. Launched in 1972, this is now 10.5 billion kilometres from Earth, but still transmits with a power of a few watts so providing a superb test signal.

Observations, which began in September 1998, did not get off to a very auspicious start when, just 10 days into the observations, Hurricane George swept through the Caribbean and damaged the Arecibo Telescope, curtailing that observing session. Happily though, the damage was not too serious, and since then observations have run smoothly, but as yet there has been no call from ET. After 40 years, should we be disheartened? No. To be honest, it is only recently that we have been capable of having a realistic chance of detecting a signal, and even then from only from our near neighbourhood in the Galaxy. Advanced civilizations would have to be very common indeed, and deliberately wishing to make their presence known to us, for us to have had a high probability of detecting them so far. The search is only just beginning in earnest.

At the moment, searches like project PHOENIX are our only chance of detecting life outside our own Solar System. Let's hope that some day they might be successful, for it would surely be one of the most exciting discoveries ever made. But it may be that, after many years of listening, using even more advanced receivers and a new generation of large telescopes, no signals are found. If so, we may well come to the realization that our planet Earth and our human race are, if not unique (for we could never be sure of that), then at the very least rare and rather special. I think that this perhaps would be an even more valuable thing for us to know.

**Ian Morison**
*Jodrell Bank Observatory*

# The 26th IAU General Assembly, 2006

As the Union grows and conference venues need longer lead times for reservations and preparations, the IAU is moving into a system of deciding the venue of future General Assemblies six years before the event. At its meetings ending Tuesday, August 15, the Executive Committee considered the two proposals received to host the 26th General Assembly in 2006, following an invitation to all member states to submit such proposals.

The two proposed venues were both fully adequate to host a memorable General Assembly, both proposals had the strong and enthusiastic backing of the astronomical communities and research organizations in the host countries, and the choice was an exceedingly difficult one. An extended deliberation took place and a very wide range of factors that might be relevant for the choice of venue was considered.

In conclusion, the Executive Commitee decided to recommend to the Second Session of this General Assembly to accept the invitation by the Czech National Committee for Astronomy and the Astronomical Institute of the Czech Academy of Sciences, under the auspices of the Academy, to hold the 26th General Assembly of the IAU in Prague, Czech Republic, in the summer of 2006. The precise dates will be decided and communicated at a later time. See you in Prague in 2006!

**Johannes Andersen**
*General Secretary, IAU*

# Name a Minor Planet

Following a fairly routine adoption of revised terms of reference for the Committee on Small Body Nomenclature (CSNC – formerly Small Bodies Names Committee) of Division III, a lively discussion ensued over policy for naming minor planets. It was noted that minor planet names are traditionally chosen by the discoverers of the objects, and thus names chosen tend very strongly to concentrate within the cultural and geographic regions of the discoverers themselves rather than more broadly representing all regions and cultures of the world. From here, the discussion turned to considering whether the IAU should indulge in the practice of "selling names", a matter of recent notoriety with regard to companies selling "star names". It was generally agreed that while such a practice might raise needed funds for legitimate research purposes, it should be regarded as unethical to offer a minor planet name on a quid pro quo basis. It was however agreed that policy should remain flexible, to allow for recognition of benefactors of minor planet research, in the same way as can be seen in the names of many buildings on any university campus.

Brian Marsden, Director of the Minor Planet Centre and an ex officio member of the CSBN, raised an interesting point which could address several of the above matters. While the discoverer of a minor planet is accorded the opportunity to propose a name, the authority for adopting a name lies within the CSBN (subject to appeal of any controversial case to the full membership of Division III). Generally, the right of the discoverer to propose the name is held for ten years, but even this is a flexible policy. Thus some substantial pool of unnamed minor planets exists for which the CSBN could consider proposals from others beside the discoverer, and it is expected with the current massive surveys that more such bodies will become available. Thus the CSBN welcomes serious proposals from the outside community for names for minor planets, with special preference for under-represented geographical regions or cultures.

The general guidelines for acceptable names allow for naming after either living or deceased individuals, but political figures are excluded for at least a century after death. Fictitious persons or places (from literature, legends, etc.) are allowable, but names of pets are discouraged (hence Pluto should not be a minor planet name!). Commercial entities or product names could be considered, but subject to the above restriction on quid pro quo "selling" of names. For example, a minor planet was named Loral, to honour that company's pioneering work in developing astronomical CCDs. Citations are limited to a length of four lines in the published Minor Planet Circulars, which translates to about 300 characters including spaces. A citation should include the geographical location and dates relevant to the name proposed, and a brief explanation (justification) of the choice of the person, object or place named. A self-evident introductory phrase such as "named in honour of..." should be avoided for the sake of brevity. To help reduce the editorial workload, the CSBN requests proposers to review examples of past citations (http://cfa-www.harvard.edu/iau/info/Astrometry.html#newnames) and adhere closely to the content and format restrictions that must be imposed. Suggestions for names with a proposed citation may be submitted to the Minor Planet Centre directly at mpc@cfa.harvard.edu.

Contributed by **Alan W. Harris**, with assistance from **Julio Fernandez**, **Brian G. Marsden**, **Gareth V. Williams**, and **Daniel W. E. Green**.

# Goodbye Manchester Hello Sydney

*Scenic views of Sydney, Australia where the 25th IAU General Assembly will take place.*

*Photos: Australian Tourist Commission.*

Australia will host the 25th IAU General Assembly in 2003, with six associated Symposia, numerous Joint Discussions and a host of other meetings. It will be held from 13th-26th July 2003 at Darling Harbour, Sydney's harbourside cultural and international conference centre.

Sydney is Australia's largest city, and one of the most beautiful in the world. The people of Sydney are friendly, cosmopolitan and enthusiastic about their city and about Australia as a place to live, explore and enjoy. Sydney is, of course, hosting the 2000 Olympic Games.

Sydney's famous Opera House and beautiful harbour are within walking distance of the conference centre, while surrounding beaches and coastline, and the nearby countryside and mountains will entice visitors to explore further afield. The city is also the nation's airline hub for Alice Springs and the Outback, the Great Barrier Reef and the tropical north, at its best in July.

The National Organizing Committee is planning a scientific congress to address a broad range of current issues and lively topics in astronomy. A series of special interest tours throughout the conference period will enable delegates to visit many of the country's astronomical facilities. We are also planning a number of tours which will offer opportunities to enjoy Australian's unique environment and culture. These tours will be led by Australian experts to help you experience the desert environments of Central and Northern Australia, the Great Barrier Reef and the rainforest and wilderness regions of Tasmania.

Registration forms and many other details for planning your trip to Australia will be available by July 2002 on our www site. This site which outlines the details of the Sydney congress is at: http://www.iau-ga2003.org

Over the next two years the www site will be continually updated as the planning progresses. There will be information on accommodation facilities, congress plans, scientific programmes and details of the special interest tours available for you. You will also be able to pay all costs associated with your Australian visit at the www site.

To help the organizing committee plan the congress and the many and varied outings and tours take the time to visit the website, complete and submit the expression of interest form online to receive future notices about the 2003 General Assembly Down Under! See www.iau-ga2003.org

**Catherine Ross**
*ICMS, Australia*

# Below the Clouds of Jupiter

*Photo: NASA Jet Propulsion Laboratory.*

*Cloud features north of Jupiter's equator imaged by the Galileo spacecraft.*

The latest results from the Galileo entry probe were presented by Sushil Atreya (University of Michigan, USA) during Joint Discussion 12 (Highlights of Planetary Exploration from Space and from Earth). The results had not been what was expected, because by sheer chance the probe entered at the edge of an exceptional region - termed a '5-micron hot spot' (these features are dark patches which reflect relatively little sunlight, but emit infrared radiation coming from below). Most of the results came from Galileo's mass spectrometer. Thick clouds of ammonia, hydrogen sulphide and water and their compounds had been expected, but were not found. The local meteorology indicated that very dry downwelling air depleted the condensible volatiles in the region sampled by the probe.

The ratios (to hydrogen) of the heavy elements sulphur, nitrogen, carbon and the rare gases, argon, krypton and xenon were found to be 2-3 times the solar values, which has important implications for theories of the formation of Jupiter. Preliminary analysis has shown no heavy hydrocarbons in excess of 10 ppb, but the data are not complete; work is continuing, and the speaker stressed the importance of sending further atmospheric entry probes, both for Jupiter and (if practicable) also for the other giant planets.

# Telescopes in Education

C46 and RAS Teachers' Meeting
Friday, August 18: 0930 – 1100hrs
Bragg Theatre, Schuster Building

Come and see a live link up with the robotic 24-inch TiE telescope on Mount Wilson, California. Using the Internet and taking advantage of the 8 hour time difference – and weather and technology permitting – we will be able to observe some of your favourite objects while sitting in the comfort of a Manchester lecture room.

This demonstration by Paul Roche and David Smith (UK) will show what can be done for students in the classroom and forms an introduction to a day of discussion on 'Astronomical Research Projects for School and University Students". The full programme is given on the back page of this issue of *Northern Lights*.

*Photo: Mount Wilson Observatory.*

*The dome of the 24-inch TiE telescope on Mount Wilson, California.*

**Margaret Penston**
*RAS Secretary, UK*

# A Candle in the Dark

During the Inaugural Ceremony on Wednesday, August 9, Sir Robert May drew attention to the need to maintain public support for science. He joked about the confusion between astrology and astronomy in Whitehall. When it comes to media attention, astrology and pseudo-science win hands down. Bart Bok attempted to draw attention away from astrology, and later Carl Sagan, in his book The Demon-Haunted World followed on a broader scale. Two voices crying for public sanity. And now the Harry Potter phenomenon proves that the world of magic lures young minds away from the real world.

In Australia, a large regional newspaper has just scrapped an astronomy column, which it has carried for 33 years (as a counter to the daily astrology nonsense) in favour of increased space for a local psychic! Carl Sagan saw organized scepticism as one way to expose anti-science, whether it be creationism, crop-circles, psychics or horoscopes. The 'Skeptics' (spelled with a k) creed is to seek the evidence. Following this approach the Australian Skeptics have exposed psychic charlatans, useless pseudo-scientific devices and triggered successful prosecutions of 'quack' medical operators. At the same time, they positively encourage real science by sponsoring an annual AUS$10,000 'Eureka Prize' for critical thinking, and are one of the three major sponsors of the Exploratory Science Centre at the Mount Stromlo Observatory.

It is difficult for professional societies to attack pseudo-science, but individuals can follow Carl Sagan's lead and get behind the nearest of the hundred or so Skeptics Societies around the globe. Think about it...

**Colin Keay**
*University of Newcastle, Australia*

# Promoting Astronomy in Africa

The African continent is very poorly represented in the IAU. As of 1999, the total IAU membership among African countries amounted to 95 persons, or 1.1% of the total IAU membership. The African membership of the IAU is dominated by South Africa (48%) and Egypt (41%), followed by Nigeria, Algeria, Morocco and Mauritius, all with 4% or fewer members. Not surprisingly, these countries are among the more prosperous nations on the continent.

One should bear in mind that the above statistics reflect the presence of nationally organized astronomical communities. There are many individual scientists distributed throughout Africa who are involved in astronomy education, and in some cases also research, who are not IAU members.

The Working Group on Space Sciences in Africa is an organization which was founded by African participants at the 6th UN/ESA Workshop on Basic Space Science in Bonn in 1996. This Working Group aims to promote the development of the basic space sciences (including astronomy and astrophysics) in African countries through a variety of means. The Working Group works in collaboration with IAU Commission 46 (Astronomy Education and Development) and the UN Office of Outer Space Affairs.

The WGSSA publishes a newsletter called African Skies/ Cieux Africains, which is distributed by the UN Office of Outer Space Affairs to over 1000 addresses, mostly in Africa. At present, the Working Group has individual members in Algeria, Burundi, Central African Republic, Chad, Congo, Egypt, Ethiopia, Ghana, Kenya, Libya, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Morocco, Namibia, Nigeria, South Africa, Sudan, Togo, Tunisia, Uganda, Zambia and Zimbabwe.

A considerable number of these individuals are university physics lecturers with an interest (and in some cases formal training) in astronomy. The Working Group is particularly interested in assisting those among its members who wish to introduce astronomy courses into their physics curricula and to participate in astronomical research.

The Working Group's activities include: publication of the newsletter *African Skies/Cieux Africains*, facilitation of access by African students to summer/winter schools organized by various astronomical observatories, distribution of astronomy books/journals donated by astronomers, and seeking funding for fellowships to enable its members to visit astronomical institutions for extended periods. The Working Group is also currently attempting to coordinate efforts to assist governments in Africa to educate the public on safe methods of viewing the total solar eclipses in 2001 and 2002.

There is presently a dearth of large-scale facilities in Africa, which means that many African astronomers are forced to move elsewhere in order to pursue their careers in astronomy. However, this situation will change dramatically over the next 5-10 years because of a number of exciting projects currently in planning or under development. These include the Southern African Large Telescope (a 10-metre class optical/infrared telescope being built in Sutherland, South Africa), the High Energy Stereoscopic System (an array of gamma-ray telescopes being built near Gamsberg, Namibia), and the World Space Observatory (an ultraviolet space telescope project in the planning stage, designed to involve participation by the developing countries). These facilities are all complementary, and each has potential to stimulate (necessary) local infrastructural or technological developments.

There are 14 IAU members and 3 invited participants from African countries registered at this General Assembly. They come from Algeria (2), Egypt (3), South Africa (11) and Zimbabwe (1). The three major facilities mentioned above have great potential to stimulate astronomical development on the continent. Hopefully this will be reflected in increasing participation by African countries in future IAU General Assemblies.

For further information about the Working Group on Space Sciences in Africa, please contact Peter Martinez (Box 539) or send an email message to wgssa@saao.ac.za.

**Peter Martinez,**
*South African Astronomical Observatory*

# 9 The Naming Game

Did you know that even the simplest form of a designation requires an acronym in addition to a number (which may be a running number or be based on a position)? See http://cdsweb.u-strasbg.fr/how.html for details.

**Helene R. Dickel**
*University of Illinois, USA & Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# New Asteroid Names

Several new asteroid names, very recently approved by the IAU, have been announced specially to coincide with the General Assembly in Manchester. All these asteroids were discovered by Edward Bowell of the Lowell Observatory. They are as follows:

**8077** Hoyle (=1986 AW2). Discovered 1986 January 12. Sir Fred Hoyle, President of the Royal Astronomical Society (1971-73).

**8078** Carolejordan (=1986 RS2). Discovered 1986 September 6. Professor Carole Jordan, President of the Royal Astronomical Society (1994-96) and Chair of the National Organizing Committee for the present General Assembly.

**8079** Bernardlovell (=1986 XF1). Discovered 1985 December 4. Sir Bernard Lovell, founder of the Jodrell Bank Observatory: President of the Royal Astronomical Society (1969-71).

**8813** Leviathan (=1983 WF1). Discovered 1983 November 29. The 'Leviathan of Parsonstown', nickname for the Rosse 72-inch reflector at Birr Castle.

**8814** Rossevan (=1983 XG). Discovered 1983 December 1. A contraction of "Rosse seven" for the present Seventh Earl of Rosse, William Brendan Parsons, in recognition of the restoration of the great Birr telescope.

**9300** Johannes (=1985 PS). Discovered 1985 August 14. Johannes Andersen, of the Niels Bohr Institute for Astronomy, Denmark and General Secretary of the IAU (1997-2000).

# Astronomy Research Projects for Schools and University Students' Programme

## Commission 46 - RAS Education Committee

Friday, August 18: Bragg Theatre, Schuster Building

| | | |
|---|---|---|
| 0930-1100hrs | 'Telescopes in Education' – A demonstration of a robotic telescope available for school use | David Smith & Paul Roche |
| 1100hrs | The Liverpool Robotic Telescope | David Carter & Mike Bode |
| 1120hrs | A 2-metre telescope entirely for schools | Robin Catchpole |
| 1140hrs | Astronomy research projects for education | John Baruch |
| 1200hrs | Hands-on astrophysics | John Percy & Janet Mattei |
| 1220hrs | Using real telescope data in schools education | Paul Roche |
| 1240-1300hrs | Brief Discussion | |
| 1400hrs | Developing a global programme of astronomy education and science | Carl Pennypacker *et al* |
| 1420hrs | Global education programme using tera-byte data at the Bisei Spaceguard Centre of Japan | Syuzo Isobe |
| 1440hrs | Research projects in astronomy education | Mike Simcoe & Richard Hammond |
| 1500hrs | Radio astronomy in schools | Trevor Hill |
| 1520-1600hrs | Discussion | |

# The End?

The Second Session of the 24th General Assembly and the Closing Ceremony were held in Bridgewater Hall yesterday afternoon, two days before the final events actually take place. It was well attended, and there were as many delegates present as there had been at the previous night's Invited Discourse, though the sense of excitement and keen anticipation was perhaps rather less marked.

The IAU Resolutions were read and approved; only one required discussion (in fact, the time taken for this particular debate was about the same as the time taken for a photon to go from the Earth to the Sun and back again). There were excellent speeches, enjoyed by those who paid close attention to them, and there were various announcements; since the next General Assembly, in 2003, is to be held in Sydney, David Malin gave a brief preliminary welcome to Australia. There was a draw for an outsize and very attractive koala, and the announcement that the winner was Kenneth Johnston (USNO) was greeted with prolonged applause. It was also confirmed that the 26th General Assembly will be held in Prague, in the Czech Republic.

Votes of thanks were given; the final speeches made, and the retiring President, Robert Kraft, officially closed the 24th General Assembly, ending with the hope that he will see us all again in Sydney in three years' time.

# Reorganization of Italian Astronomy

Italian astronomy has developed very fast during the past decade. We recall here some major achievements: the construction of two 32-metre VLBI dedicated radio telescopes in Medicine and Noto, to be followed by another 64-metre radio telescope in Sandinia; the 3.6-metre Italian Galileo National Telescope on La Palma; the membership of ESO and the Germany-Italy-USA Large Binocular Telescope (both at a participation level of 20-25%); the success of the Beppo-Sax satellite in finding the X-ray afterglow of gamma-ray bursts, and the BOOMERANG experiments. These are all clear evidence of the major rôle which Italy plays today in astronomical research. In Italy, such research is presently carried out in university departments, in eight institutes of the National Research Council, and in 17 astronomical observatories, with a total number of around 700 researchers. To increase coordination in future planning, the Italian government has recently established the 'Istituto Nationale di Astrofisica' (INAF), appointing Giancarlo Setti as President. The new Institute will coordinate and support the existing observatories, with a special emphasis on large national and international projects. It will also have a close relationship with the university astronomical community.

A similar coordination effort is also underway inside the National Research Council, which is merging the astronomical institutes into three bodies dedicated to radio astronomy, space science, and Solar System research, respectively.

**Lucia Paolcielli**
*Italian National Representative*

It has been announced at a meeting of the Commission on the Teaching of Astronomy the creation of a new international union: the International Union for Science Communication. (IUCS.) The headquarters of this organization will be at Bombay in India. It is only in the preliminary stage and all information could be obtained from either Prof J Narlikar (e-mail: jayant@iucaa.ernet.in) or Prof J C Pecker (e-mail: j.c.pecker@wanadoo.fr)

# Public Lectures at GA24

UMIST are running a series of lectures for the public during GA24. These lectures have been advertised widely to schools, amateur astronomical societies and on local radio. Entrance IS BY TICKET ONLY and all available tickets have been allocated to the general public. Attendance by participants at GA24 is welcome, but comes with a health warning! Ticket holders will be admitted to the lecture theatre as a priority. Only if seats are still available, just before the start of the lecture, will those without tickets be admitted.

We hope that you will appreciate our desire to give the genuine public some feeling for the excitement of astronomy during GA24.



GENERAL IAU 24 UAI ASSEMBLY 2000

# Northern Lights

XXIVth IAU GENERAL ASSEMBLY • MANCHESTER 2000

**Editor:** *JOHN MASON* • **Associate Editor:** *PATRICK MOORE*

**NO.11:** *FRIDAY 18th AUGUST*

## Bubble-Blowing Galaxies

Fifty million light-years away, in the constellation of Corvus, lie the two colliding galaxies NGC 4038 and 4039, known as the Antennæ Galaxies because of the spectacular antennæ-like streamers issuing from them. They are also producing huge bubbles of expanding X-ray emitting gas, which come into contact with each other and merge, forming what may be called 'superbubbles'. These were described during Symposium 205, by Guiseppina Fabbiano (CfA) who, with Andreas Zezas and Stephen Murray, has used NASA's Chandra X-ray observatory to capture this phenomenon in unprecedented detail.

The observations provide a nearby example of the conditions when our Universe was young and galaxies were forming. "Galaxies were much closer then," explained Fabbiano. "Collisions like the ones which produced the Antennæ were more common, and played a major rôle in shaping the galaxies we see around us today."

Galaxies do collide, and indeed it is widely believed that our own Milky Way is the product of a merger between two once-separate galaxies. Generally speaking the stars in colliding galaxies do not hit each other, but of course there are violent effects in the interstellar material; a collision may last for at least a hundred million years, and the shock-wave compression of the massive clouds of gas and dust can produce a 'starburst' region, in which millions of new stars are born. The explosions of these stars several million years later create thousands of supernova remnants – bubbles of gas at many millions of degrees Celsius enriched with heavy elements. These expanding bubbles collide and coalesce to form the superbubbles, thousands of light years across.

The most impressive Chandra X-ray image, taken on 1999 December 1, shows the central regions of the two colliding Antennæ Galaxies. In addition to the superbubbles, which show up as bright patches, there are dozens of bright point-like sources - neutron stars and black holes – produced by the flurry of supernova activity. The X-rays from these sources are generated by gas which is heated to tens of millions of degrees Celsius as it streams from nearby companion stars on to the neutron stars and black holes.

"What we are witnessing with Chandra is galaxy ecology in action," commented Andreas Zezas. "Over tens of millions of years, the superbubbles gradually enrich the galaxy's supply of oxygen and other elements, and may provide the energy needed to trigger the collapse of more clouds to form more stars and more supernovæ in a continuing cycle of star birth, death and renewal."

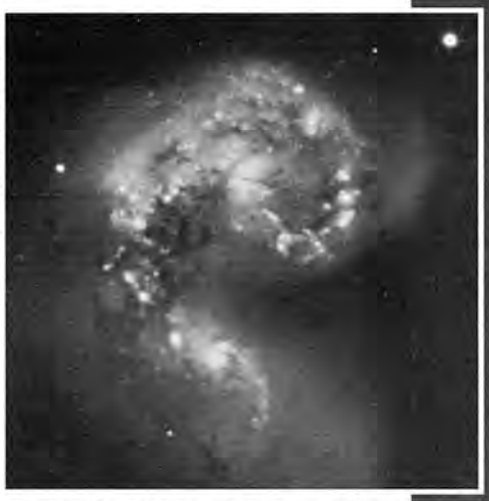


*Photo: Anglo-Australian Observatory.*

*Image: NASA/SAO/CXC/Giuseppina Fabbiano.*

***Above:*** *The Antennæ Galaxies in visible light from the Anglo-Australian Telescope.*

***Right:*** *Chandra X-ray image of the Antennæ obtained with the Advanced CCD Imaging Spectrometer (ACIS).*

## Optical/IT Interferometry: New Developments

*Illustration: Chris Haniff, University of Cambridge.*

*Artist's concept of the 15-element Large Optical Array (LOA).*

The next five years will see significant advances in high-resolution astronomy in the optical and infrared. With eight interferometers already producing results (five in the USA, and one each in Australia, France and the UK) and the Keck and VLT interferometers set to come on-line within the next two years, astronomers are looking forward to milliarcsecond angular resolution.

The scientific programmes will address a broad range of astrophysics. These include measuring fundamental stellar parameters, imaging the surfaces of stars and their environments, exploring stellar nurseries on AU scales, searching for extrasolar planets, and probing the nuclei of active galaxies. Crucial to these efforts will be the technique of phase referencing, which has now been demonstrated at the Palomar Testbed Interferometer, a precursor to the Keck Interferometer.

Hints of the potential of interferometry have come from the spectacular images of the spiral dust nebulæ of Wolf-Rayet 104 and the expanding dust cocoon around the nearby carbon star IRC+10216. These images were obtained by Peter Tuthill (University of California Berkeley) and colleagues by masking the aperture of a single Keck telescope, and illustrate the importance of having a large number of array elements. The next generation of ground-based arrays is being designed with this in mind, including the 15-element Large Optical Array (LOA) proposed by a consortium of UK universities.

Even more ambitious are plans for space interferometers such as SIM (Space Interferometry Mission), an approved NASA mission to detect Earth-like planets, using microarcsecond astrometry. A long-term goal is to launch an array of telescopes to image such planets, as well as the environments of black holes and accretion disks around protostars.

**Tim Bedding**
*University of Sydney, Australia*

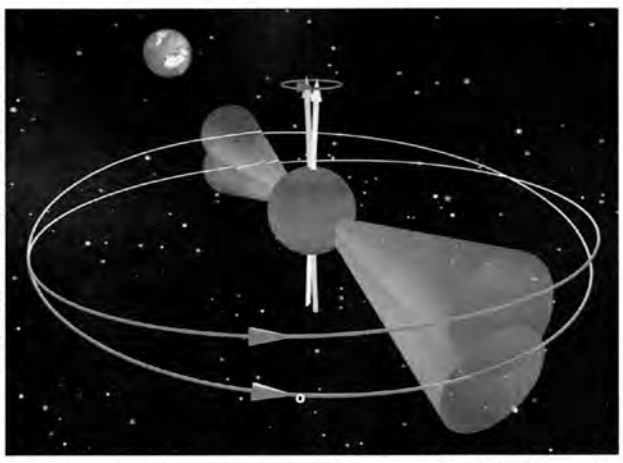


*Illustration: Michael Kramer, University of Manchester*

## Free Precession of a Neutron Star

*Precession causes the rotation axis of the pulsar PSR B1828-11 to follow a circle-like motion in time. As a result, we see the cone-like lighthouse beam of the radio pulsar from different angles, resulting in the observed changes in pulse shape and arrival time.*

A team at Jodrell Bank Observatory, University of Manchester, has used the 76-metre Lovell Telescope to determine that a young, isolated pulsar is undergoing free precession.

The Jodrell Bank scientists (Ingrid Stairs, Andrew Lyne and Setnam Shemar) have been studying 13 years' worth of data from the pulsar PSR B1828-11. This pulsar rotates 2.5 times per second, but, unlike any other, shows periodic variations in both its pulse times of arrival and its profile shapes. The variations have a fundamental period of about 1000 days. In particular, the changes in pulse profile shape and the pulse slow-down rate are highly correlated, demonstrating a clear link between the inclination of the pulsar to the line of sight and the torque on the pulsar.

The natural explanation for these phenomena is that the pulsar is precessing on a timescale of about 1000 days. Such a wobble may be expected to arise if the pulsar is slightly deformed, by about 0.1mm in the 10 km radius, so that its spin vector is misaligned with its angular momentum vector; its effects are illustrated in the diagram. Free, untorqued precession is, however, expected to be damped out on very short timescales by the interaction of the neutron superfluid vortices within the pulsar with the neutron star's sold crust. Further theoretical work on this interaction will be needed to explain the long-lived precession observed in PSR B1828-11.

This work appeared in a Letter to *Nature* on August 3, 2000 (*Nature* **406**, 484). A press release describing the work, along with an illustration and animation, can be found at http://www.jb.man.ac.uk/news/neutronstar/.

# SETI: Science Fact, Not Fiction

*Impression: SETI Research Institute.*

*Artist's concept of the Allen Telescope Array.*

It's a lot easier to find aliens in Hollywood than in the Milky Way Galaxy. We've been trying various search strategies for forty years now without success; is it time to give up? Absolutely not! We've hardly begun to search. Remember, it took over 20 years to find the first brown dwarf star, and yet it turns out that they're rather common. The right tools and the right strategy are the keys to success.

In SETI we have a good strategy (searching for manifestations of distant technologies), and after forty years, we are finally getting world class tools with which to pursue at least one type of search. The Allen Telescope Array is a joint project of the SETI Institute and the University of California Berkeley Radio Astronomy Laboratory. It will have a collecting area of 1 hectare (10,000 square metres, about the same as the VLA), provide continuous frequency coverage from 0.5 to 11 GHz, image a large field of view (a few square degrees at 1 GHz), and simultaneously synthesize multiple high resolution beams on the sky. To make it affordable (yes that's important, even with the generosity of Paul G. Allen and Nathan Myhrvold), it will be constructed using components from existing and emerging consumer-market technologies. It won't look like any other telescope. It will consist of 500 (or 1000), 5 (or 3) metre dishes spread over a few kilometres of northern California lava beds at Hat Creek Observatory. The size of the dishes, and their shapes, will be determined by how low we can drive the costs of the front-end electronics and fibre optic connectivity. Back-end processing capacity is being planned for deliberate growth and frequent replacement as Moore's Law delivers more capability for the same cost. The array will be able to carry out traditional radio astronomy research and a targeted SETI search of 100,000 stars at the same time, starting in 2004.

In the meantime, a targeted search will continue during jointly-scheduled sessions at Arecibo and Jodrell Bank (see article by Ian Morison in yesterday's *Northern Lights*), while commensal ('piggyback' for the non-biology crowd) sky surveys continue at Arecibo and Parkes, and start up at Medicina. Recently the world has been encouraged to join the effort via the hugely successful distributed computing experiment called SETI@home at UC Berkeley. Optical SETI - looking for nanosecond laser pulses - has now started on several small university telescopes at visible wavelengths (Harvard-SAO, UC Berkeley, Princeton). Expanding these searches into the infrared, devising ways to do sky surveys, and looking for opportunities to put such searches on to larger aperture telescopes will be the next set of challenges for scientists involved in this new field.

Guiseppi Cocconi and Phillip Morrison ended their seminal paper on SETI with the statement "The probability of success is difficult to estimate; but if we never search, the chance of success is zero." Our generation has embraced the challenges of searching for life as-we-don't-yet-know-it; from microbes to mathematicians. We cannot guarantee success, but we can do a good job of setting the stage for generations to follow.

**Jill Tarter**
*SETI Research Institute, USA*

# Africa's Giant Eye

The Southern African Large Telescope (SALT) is a 10-metre class telescope for optical/infrared astronomy based on the design of the Hobby-Eberly Telescope (HET) at McDonald Observatory, Texas. The design is a tilted-Arecibo concept with a segmented spherical primary mirror and a spherical aberration corrector on a tracker beam at the prime focus. The telescope will be located at the Sutherland observing station of the South African Astronomical Observatory (SAAO). Construction will start soon after the Ground Breaking Ceremony on 2000 September 1, and the telescope will be commissioned by December 2004.

SALT will benefit from the experience of the HET, and there are a number of design changes. The telescope will be tilted at 37 degrees to the vertical to enable access to the Small Magellanic Cloud. Edge sensors will be placed on the segmented spherical primary mirror to maintain mirror alignment. An improved design of spherical aberration corrector will enable better image quality, an increased 8 arcmin field, and with an image pupil covering the whole primary mirror array. The initial instrumentation suite is planned to include a prime focus imaging spectrograph constructed by University of Wisconsin and a fibre-fed high-dispersion echelle spectrograph constructed by University of Canterbury, New Zealand.

The present partnership in SALT includes South Africa, HET Board, Poland, University of Wisconsin-Madison, Rutgers University, Carnegie Mellon University, Goettingen University, University of Canterbury New Zealand and most recently a consortium of five UK institutions.

SALT is a highly cost-effective design of 10-metre class telescope. The total cost of SALT over a 15-year period, including a 10-year operations phase, is estimated at $30 million. The contributions of all partners presently total $25 million. Thus there is still an opportunity for additional partners to participate in this project. Please contact Bob Stobie (rss@saao.ac.za) if you are interested in SALT or in participating in SALT. Further information on SALT can be found at the web sites www.salt.ac.za and www.saao.ac.za.

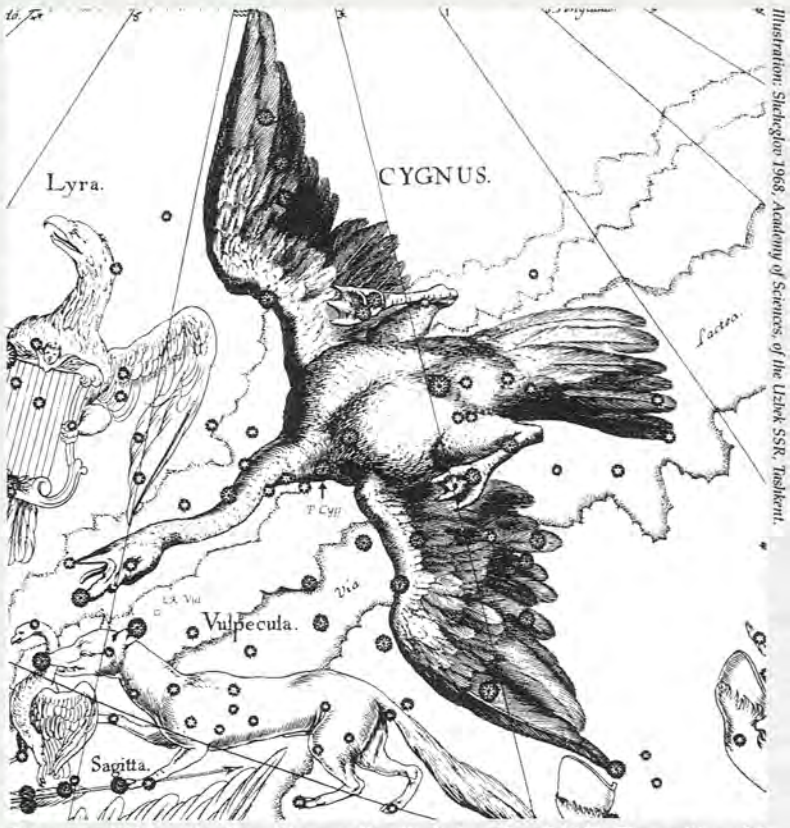
**Bob Stobie**
*South African Astronomical Observatory*

# Strange Hypergiant

Exactly 400 years ago, on 1600 August 18, the Dutch globe- and map-maker Willem Jansz. Blaeu (1571-1638) discovered a 'new' third magnitude star in the constellation Cygnus, the Swan. This was the first 'nova' to be reported since Tycho's Star of 1572. It is now of about the fifth magnitude, but its brightness, combined with the invention of the telescope soon after discovery, has ensured that there is a long series of observations of it, beginning in 1600 and still continuing today. It received the variable-star designation, P Cygni.

P Cygni is a B-type hypergiant, belonging to the group of massive stars in the upper left-hand corner of the Hertzsprung-Russell diagram. These exhibit a range of photometric variability, ranging from true outbursts over a long timescale to semi-regular variations of intermediate amplitude on a characteristic timescale of years or tens of years, and also short timescale semi-periodical variations (known as S Doradûs variations) which indicate pulsation.

The 400th anniversary of the discovery of P Cygni as a variable, together with the rounding-off of the 24th General Assembly, has motivated us to organize a three-day workshop 'P Cygni – 2000: 400 Years of Progress'. This Workshop will be held from August 21 to 23 at the Armagh Observatory in Northern Ireland, and will be directed by Mart de Groot, a specialist on the subject of P Cygni and other stars of this class.




*Cygnus and Vulpecula, from Johannes Hevelius' star atlas of 1687. The position of P Cygni has been indicated.*

The 400th anniversary of the discovery of P Cygni is certainly an appropriate time to discuss the progress made towards understanding this peculiar hypergiant, to ensure that the lessons learned from its study are not lost, and that these results can be applied to the study and understanding of similar objects, together with the nature and evolution of massive stars in general.

**Chris Sterken**
*University of Brussels, Belgium*

# From the New IAU President

Astronomers of my generation have been lucky. Scientific progress during my lifetime has been so rapid that the twentieth century has even been compared with the time when Galileo and others first turned telescopes to the sky. We have lived through the discoveries of exotic objects such as quasars, pulsars and black holes; radio astronomy has been developed; X-ray studies have become possible; and of course we have watched the first men walking on the Moon. We have sent automatic probes out to all the planets in the Solar System apart from Pluto, and we have now proved the existence of planets orbiting other stars. My generation was also fortunate in another way; the rapid progress meant that there were good opportunities for those people who were anxious to become astronomers.

It is also notable that public interest in astronomy is now greater than ever before. Against this, we have the problem of light pollution; the skies are becoming so brightly lit than many people are deprived of the joy of observing the stars. Let us hope that this situation will improve; the sky is part of our heritage – just as is a sunlit mountain or a green forest.

I am convinced that astronomy has another important rôle, too. Its popularity among members of the public means that it leads on to a better understanding of science in general, and this is clearly very desirable.

Before we meet again, in Sydney, in three years' time, there will certainly be more rapid progress, with spectacular and unforeseen discoveries. We will draw results from new equipment and new space missions; will we solve some of the problems of dark matter, neutrinos, high-energy cosmic rays, and gravitational waves?

During the past eighty years or so, the astronomical community has been represented by the International Astronomical Union. The scientific and organizational discussions held in Manchester have stressed the importance of the IAU, and, when necessary, its ability to change the ways in which it operates. It will be the duty of the Officers, the Executive Committee, the Divisions, Commissions, and Working Groups, and the entire membership, to make sure that the IAU continues to maintain its important rôle in the development of our science.

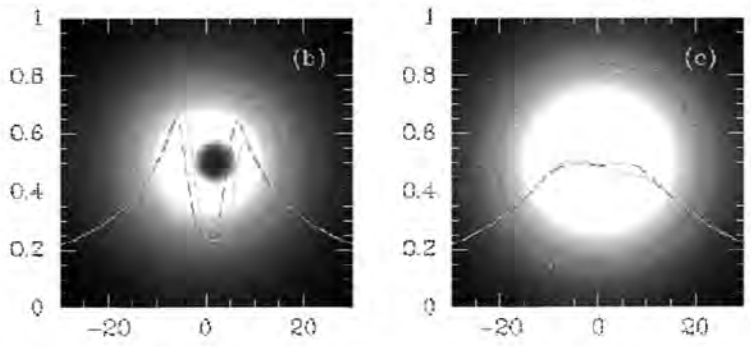
**Franco Pacini**
*Arcetri Astrophysical Observatory, Italy*

# The Black Hole at the Galactic Centre...

## Radio Studies of Sagittarius A*

Observations of the curvature in stellar orbits near Sagittarius A* (Sgr A*) by Andrea Ghez *et al*, and those by Andreas Eckart *et al* reported during Symposium 205 this week, have provided new evidence for the existence of a massive black hole at the Galactic Centre. To the relief of everyone, the orbits do indeed curve towards the black hole!

Other surprises come from the detection of strong circular polarization up to 43 GHz (Geoffrey Bower *et al.*) and the detection of a very low X-ray emission in Sgr A* by Chandra (Frederick Baganoff *et al.*). The latter result poses a serious problem for accretion flows as discussed by Robert Coker, and may indicate a non-thermal origin (Roger Blandford, Sera Markoff and the author).




*The appearance of the shadow of the black hole for Sgr A* (left) as the observing wavelength is decreased from 1.3mm (right) to 0.6mm (left).*

To zoom in on Sgr A* further, higher resolution observations are required. Observations with VLBI by Thomas Krichbaum *et al.* at 3 and 1.4 mm wavelengths confirm that the radio source is smaller than 15 Schwarzschild radii. This extremely sharp vision opens up exciting possibilities for investigating the event horizon of the black hole. General relativistic calculations of the appearance of a radio source engulfing Sgr A* (see accompanying figure), reveal a 'shadow' - the imprint of the event horizon of the black hole – with a diameter of 30 microarcseconds (5 Schwarzschild radii). Given that the best currently achieved resolution with mm-VLBI is 50 microarcseconds, it does not appear unreasonable to assume that we will soon be able to image the event horizon, the defining feature of a black hole.

This will require developing radio and (especially) VLBI techniques further towards shorter and shorter wavelengths. Given the broad move to higher and higher radio frequencies (e.g. as indicated by the ALMA project or the move of the VLBA to 86 GHz), we can expect further stunning results during the coming decade.

**Heino Falcke**
*Max-Planck-Institut fur Radioastronomie, Bonn*

## Curvature in Stellar Orbits near Sagittarius A*

Measurements of the proper motions and radial velocities of stars in the central cluster of the Milky Way have revealed the presence of a 2-3 million solar mass black hole at the position of the compact radio source Sagittarius A* (Sgr A*). The overall stellar motions do not deviate strongly from isotropy, and are consistent with a spherical isothermal stellar cluster. However, a small deviation from isotropy is found for the sky-projected velocity components of the young, early type stars.

Most of the bright HeI emission line stars are in tangential orbits. This overall rotation could be a remnant of the original angular momentum pattern in the interstellar cloud from which these stars were formed. The fainter, fast moving stars within one arcsecond of Sgr A* ('the Sgr A* cluster') appear to be largely moving on more radial orbits. Speckle spectroscopy with SHARP on the NTT and slit spectroscopy with ISAAC at the VLT suggest that several of them are early-type stars. This is consistent with the idea that these stars are members of an early type cluster with small angular momentum, and therefore are now in the immediate vicinity of Sgr A*. Explicitly including velocity anisotropy, one obtains a mass of the central black hole in the range of 2.9 - 3.1 x $10^6$ M for R = 8.0 kpc.

The most recent data now allow us to measure the curvatures of stellar orbits for a few of the stars which are closest to the centre and have the largest proper motions of up to 1400 km/s. The curvature indicates that the stars do indeed orbit the central compact object, and this will lead to further determinations of its mass and compactness.

**Andreas Eckart**
*University of Cologne*

# Tantalizing Titan

No spacecraft has visited Saturn's largest satellite, Titan, since Voyager 2, but major advances have been made by using HST and large telescopes, such as Keck. Peter Smith (University of Arizona, USA) summarized some of the results. The surface features which have been detected have shown major changes over periods of years; there is marked north-south asymmetry, and there are definite seasonal changes in intensity. There is a bright, continent-sized feature on the leading face (the speaker suggested that it might even be given a provisional name). It is definite that there is no global ocean, but on the surface there must be aquifers sufficient to maintain the amount of $CH_4$ in the atmosphere, and rain was likely above an altitude of about 80 km. Careful consideration had been given to the selection of a landing site for the Huygens probe in November 2004; we were not likely to learn a great deal more about the nature of the surface before them.

Athena Coustenis (Paris-Meudon Observatory, France) discussed images of Titan obtained at infrared wavelengths with the Canada-France-Hawaii Telescope. The brightly reflecting area in the equatorial area was found over 50° of longitude. It was considered that frozen methane might account for this bright region, and it could well be an ice-covered mountainous plateau; she and her colleagues were investigating theoretically whether methane ice could exist at high altitudes in the equatorial zone, or at higher latitudes, where the temperatures are lower. A peak would have to be around 7 km high to allow ice to exist at its summit. Caitlin Griffith (Northern Arizona University, USA) pointed out that we still do not know the abundance of methane in Titan's lower atmosphere, but slight albedo variations suggest the presence of small clouds, and it was possible to say a little about Titan's weather: cloud cover 1% or less, duration of each cloud around two hours, cloud type cumulus. If clouds were present, rain was likely.

More detailed information must await the arrival of Cassini-Huygens soon after the next General Assembly.

# Cosmology at the IAU

Cosmology has played an important rôle in the 24th General Assembly. Not only were there two Symposia (S201 and S204) devoted to it, and several Joint Discussions involving it, but also an Invited Discourse entitled 'An Accelerating Universe?'.

The unfortunate aspect of all of these presentations is that the community is expected to accept only one basic premise – that we live in a Universe which started in a Big Bang, and much of what we see around us is a result of conditions (not understood, but assumed) in a completely hypothetical Universe.

The reasons for this state of affairs are more sociological than scientific. In more than forty years I have got to know a large number of leading cosmologists, and only one I have ever met, the late lamented Dennis Sciama, ever changed his mind. Dennis was unique in being a very strong advocate of the Steady-State cosmology, but swung around to the Big Bang in the 1960's.

Probably the greatest cosmological discovery of the last century was that the Universe is expanding. Beyond that, the only claimed direct observational evidence for a Big Bang is that the measured abundances of D, $^3$He, and $^4$He agree with those calculated in an early Universe, and the existence of blackbody radiation with T=2.728K. If alternative ways of producing the lightest isotopes and the blackbody radiation can be found, as they have been, the case for the Big Bang theory is much weakened. What is not stated when the Big Bang claims are made, is that the correct abundances are only obtained if the correct initial ratio of photons to baryons is chosen. The further fudge factor needed in this theory to make the model work, and also to make galaxies, is called high-falutingly 'non-baryonic' matter.

Also, the microwave background radiation was discovered by McKellar in 1941 (he said that the temperature was between 1.8K and 3.4K). This was long before Gamow and his colleagues studied the physics of a hot fireball, and 24 years before Penzias and Wilson detected it. Thus the blackbody radiation is not a prediction of the Big Bang theory.

There are good alternatives to the Big Bang cosmology: related cosmologies which have been developed by Hoyle, Narlikar, Arp, the late IAU President Viktor Ambartsumian, myself and others; but you will find nothing of them here. Why? Because those who have master-minded the Symposia and who are prominent as speakers have excluded any discussion of Big Bang alternatives, except for one paper in S204.

Finally, a word about the 'accelerating universe'. It has been known since the 1960s that the redshift-apparent magnitude relation, if measured out to high enough redshifts, could allow us to distinguish between cosmological models. If the deceleration parameter $q_o$ is positive, this would indicate some type of Friedmann (Big Bang) model, while the classical Steady-State predicts $q_o$ = -1, and a quasi Steady-State model a value between –1 and 0.

It has been found from observations of Type Ia supernovæ that $q_o$ is negative. This is observational support for some kind of Steady-State model. But the observers who have found this result never even mention this point. Instead, they have achieved major publicity by talking about some new form of energy – always still believing in a Big Bang.

Why am I so angry about this general state of affairs in cosmology? Partly because I have worked for the last ten years on an alternative hypothesis. But largely because I strongly believe in fair play, meaning that in scientific discussion all legitimate views should be heard; and this has not been happening in cosmology for many decades

**Geoffrey Burbidge**
*University of California, San Diego*

# The New Liverpool Telescope


*The 2-metre Liverpool Robotic Telescope as it will appear in its enclosure on La Palma later this year. Three similar telescopes are currently being built by TTL on Merseyside.*

The IAU Commission 46 and RAS Education Committee Meeting on 'Astronomical Research Projects for School and University Students' takes place today in the Bragg Theatre, Schuster Building. At this meeting several significant new initiatives and facilities will be described. Among these is the public understanding of science programme of the new Liverpool Telescope (LT).

The LT is a fully robotic 2-metre aperture optical telescope nearing completion at Telescope Technologies Ltd. in Birkenhead UK. Around 100 delegates at the 24th General Assembly have actually been over to see it and two other similar telescopes under construction during the past two weeks. Later this year, the LT will be installed on La Palma in the Canary Islands. It will be operated from the Astrophysics Research Institute of Liverpool John Moores University, which leads the project. The LT's primary function will be as a research tool for the UK professional community, optimized for observations exploring the temporal domain. These include systematic monitoring of variable objects and rapid response to targets of opportunity of many kinds. The first light instrument will be a CCD camera, but a low-resolution spectrograph and infrared camera are now under development.

As an important adjunct to the telescope's primary rôle in front-line research, 5% of observing time is reserved for public access. Since 1997, EU-funded projects at Liverpool JMU have been bringing together professional and amateur astronomers, school teachers and public understanding of science professionals to maximize the public outreach impact of the telescope as it becomes operational. In the meeting today, the unique opportunities which are being provided for schools in the UK and abroad to participate in observations with the Liverpool Telescope will be described. The primary motivation is to use the excitement of astronomy to stimulate young people's enthusiasm for science and technology. Further information on the Liverpool Telescope can be found at www.telescope.livjm.ac.uk.

**Michael F. Bode**
*Liverpool John Moores University, UK*

# Paper Run


***Northern Lights:*** *IAU newspaper distribution for the Internet Age!*

Many IAU delegates will have witnessed the excellent newspaper distribution service provided by our Editorial Assistant, Chris Lintott – aided by a borrowed supermarket trolley (and a koala). Taking delivery of the papers every morning at 8.15am, Chris has had only 45 minutes to make the drops at all seven distribution points before the start of the morning sessions at 9am. If ever pushing a shopping trolley around an obstacle course becomes an Olympic sport, Chris will be in with a good chance of a medal; the long ramp up the side of the Computer Science Building presented a particular challenge.

The morning paper run has not been without other difficulties. In the Computer Science Building, Chris was not allowed to use the only lift, because he was told it was a goods lift and he was clearly a passenger. However, in the Whitworth Building, he was told he couldn't use the only lift, because it was a passenger lift and he was clearly carrying goods!

# IAU Announcements

During the 74th Executive Committee meeting on August 17, it was decided to approve IAU sponsorship for the following meetings in 2001:

**IAU Symposia**

Extragalactic Star Clusters, Pucon, Chile, March 2001

Cosmic Masers: From Protostars to Black Holes, Rio de Janeiro, Brazil, March 2001

Planetary Nebulæ: Their Evolution and Rôle in the Universe, Canberra, Australia, November 2001

**IAU Colloquia:**

AGN Surveys, Byurakan, Armenia, June 2001

Radial and Nonradial Pulsations as Probes of Stellar Physics, Leuven, Belgium, July 2001

**IAU Regional Meeting:**

X Latin American Regional Meeting, Cordoba, Argentina, September 2001

In addition, two other meetings will be accepted, pending discussions between the IAU and the organizers.

**Oddbjorn Engvold**, *IAU Assistant General Secretary*

# Hendrik van de Hulst: 1918-2000

All of us at the IAU will be saddened to know of the death of one of the greatest astronomers of the twentieth century. 'Henk' van de Hulst.

He was born in Utrecht, and graduated from the University there. He was attracted to astronomy by the lectures given by M Minnaert and, though his career was interrupted during the War years, he gained his PhD in 1946, from Leiden.

In 1944 he worked with Jan Oort, who suggested observing a spectral line at radio wavelengths. Van de Hulst believed that the hydrogen line at 21 cm might be detectable, and this was indeed found in 1951; this was, of course, one of the most important discoveries in modern astronomy. Subsequently, van de Hulst became closely involved with space research as well as radio astronomy. He became the first president of COSPAR and played a major rôle in the development of both ESRO and ESA. From 1984 he was Professor Emeritus at Leiden. He died on July 31. It was rightly said of him that "he was true to himself, and to us, from beginning to end".

# Northern Lights Extinguished!

The official daily newspaper of the 24th General Assembly has had a short life – just eleven issues – and this issue is our last. The production of *Northern Lights* would not have been possible without good teamwork and, I have been particularly fortunate in having the support of a marvellous team.

There is no-one better than Patrick Moore, my Associate Editor, in producing accurate news stories of the right length, knocked out at lightning speed on an ancient typewriter, which he bought for £1! He is also brilliant at shortening overlength copy to fit available space.

Julie Semmence, my Admin. Assistant, has been fantastic, keeping all of us superbly organized, typing up most of the stories, and deciphering the handwriting of the many delegates who have contributed articles for us.

Chris Lintott, attending his first GA, has carried out a multitude of essential tasks, always cheerful, even when the laptop kept crashing or took half-an-hour to download one image.

Many delegates have commented on the superb design of the paper and this has been due entirely to the tireless efforts of Pam Rivers, Chris Bedford and David Exley of Ledgard Jepson Ltd.

To produce a newspaper, printed, folded and delivered by 0800hrs next morning, consistently for eleven nights, requires a great deal of communication, organization and reliability. In this regard our printers, Kendall Press Ltd of Trafford Park, Manchester, have been absolutely magnificent. Together we have made a formidable team.

I would also like to thank everyone who contributed material for the paper; regrettably there were one or two articles which didn't make it into print due to shortage of space.

Finally, to answer the question as to why *Northern Lights* was printed on glossy paper: it is true that any photographs look much better than on thin, absorbent paper. However, the real reason is that any paper which is going to be read on the streets of Manchester must be waterproof!

I wish the Editorial Team in Sydney the best of luck.

**John Mason**
*Editor, Northern Lights.*

# 10 The Naming Game

Did you know that you can look up the existence and meaning of an acronym in the On-line Reference Dictionary of Nomenclature of Celestial Objects? See http://cdsweb.u-strasbg.fr/cgi-bin/Dic

**Helene R. Dickel**
*University of Illinois, USA*
*& Netherlands Foundation for Research in Astronomy*
*Chair, Commission 5 TG Designations*

# An Invitation for 2009

In recent years remarkable economic growth has been achieved in China. Based on this rapid progress, Chinese astronomy is entering a new era, including unprecedented developments of the facilities of observatories, research, technology, education and popularization of astronomy. Our authorities are viewing astronomy as an important discipline to attract young people into a science education, and many bright young scientists are now swelling the ranks of Chinese astronomy. In parallel, a flourishing development is also taking place in the nationwide popularization of astronomy, taking advantage of special celestial events such as the apparition of Comet Halley in 1985-1986 and the total solar eclipses of 1986 and 1997.

Moreover, a series of new facilities for professional astronomical research has been put into operation, including our 2.16-metre and 1.56-metre telescopes, a solar magnetic field telescope, a solar tower telescope, a 13.7-metre millimetre-wave radio telescope, a network of VLBI with 25-metre dishes, and a synthesis aperture radio telescope consisting of 28 dishes. In addition, one of the National Mega-science Projects, the Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) was approved by the State Planning Committee of China in 1997 and is now under construction. Moreover, two space projects, a Solar Space Telescope (SST) and a High-energy X-ray Modulation Telescope (HXMT), have been proposed and are being studied in detail. These facilities will be open to astronomers from all over the world, in conformity with the stated policy of openness of the Chinese government.

Against the background of these great developments, the Chinese Astronomical Society has informed the Executive Committee of its intention to invite the IAU to hold the 27th IAU General Assembly in Shanghai in 2009. This date has been selected not only because we need time to prepare for an event of this magnitude, but also because of a total solar eclipse of long duration on 2009 July 22, which will pass precisely through the Shanghai–Nanjing area. Modern conference and other facilities are being developed in Shanghai at a tremendous rate, and will be more than adequate to host a General Assembly by 2009.

**Cheng Fang**
*President, Chinese Astronomical Society*
*Nanjing University, China*

# Singing in the Rain

*Alan Pickwick - prepared for the Manchester weather.*

There has been plenty to see and do during this General Assembly outside the scientific programme. Our very grateful thanks go to Alan Pickwick and a small band of helpers (Dennis and Pam Walsh, Anne Cohen and WEM staff Phil Ross and Marina Conrad-Evers) who organized the varied programme of visits to interesting localities within reach of Manchester. On most days coach parties have been whisked off to places such as Jodrell Bank, Tatton Park, Chatsworth House, Quarry Bank Mill, York, Liverpool, North Wales and the Lake District. Longer two-day tours on the middle weekend took parties to Stratford-upon-Avon and Stonehenge, and across the Irish Sea to Dublin and Birr Castle.

Planning started 18 months ago and Alan himself visited many of the places to be included in the tours. During the General Assembly he has personally led six guided tours around Manchester city centre dodging the sometimes heavy showers which have unfortunately been a feature of this August fortnight. ∎ Alan clearly enjoyed researching the city's rich heritage to give visitors a fascinating two-and-a-half hour tour of this lively city.

Despite the weather and a few other minor hiccups, we hope that visitors and locals alike have been able to enjoy this traditional aspect of the General Assembly, during which so many long lasting international friendships are often forged.

**Margaret Penston**
*Secretary RAS and NOC*

# Take Them Down!

Please note that all poster papers should be removed from poster boards no later than **1 pm today, Friday August 18**. After this time any remaining posters will be removed, and since there are no storage facilities you may not see your posters again! Even if you do not wish to retain your poster, please help us by removing it anyway.

**Dennis Walsh**
*Co-Chairman, LOC*