# Dublin days: the 2003 NAM

**Mark E Bailey** and **Tom Ray** give an overview of the National Astronomy Meeting in Dublin, where record numbers of astronomers went to talk, listen and network.

The Dublin National Astronomy Meeting and UK Solar Physics Meeting 2003 was the largest astronomy meeting ever held in Ireland (with the exception of the IAU General Assembly in 1955). A record number of participants – more than 550 – attended some 65 formal and less formal sessions from 7–11 April 2003. The meeting was noteworthy not only for the quality of the presentations but also for the strong interaction between participants. In part this was no doubt due to the excellent venue, Dublin Castle, at which the meeting was held. Not only was a lot of science communicated, but opportunities to network, exchange ideas and collaborate were maximized.

The suggestion to host a National Astronomy Meeting in Dublin was first made by David Williams, then President of the RAS, to one of us during the highly successful "Solar eclipse NAM" in August 1999. The Astronomical Science Group of Ireland (ASGI) wholeheartedly welcomed the idea and promptly issued an invitation that was warmly accepted by the RAS Council. The organization of the meeting was delegated to a small Local Organizing Committee (LOC) from five universities and research institutes throughout the island of Ireland. Detailed arrangements for formal and informal sessions were devolved to over 40 individual session organizers, who did such a good job that the LOC was hardly involved. Not only did this encourage the delivery of a world-class scientific programme in areas where members of the LOC had no particular expertise, but it also ensured that many more people were actively involved in arrangements for the NAM, and so took "ownership" of the meeting.

1: Despite the seriousness of the asteroid threat, delegates enjoyed themselves, at the "Science in the Gravity Bar" event in the Guinness Hop Store.

## Covering the community

We made a conscious effort to encompass the interests of the whole UK and Irish astronomical communities, including solar-system astronomy, star and planet formation, space science, stellar astrophysics, solar physics and the solar–terrestrial relationships, the interstellar medium, galaxies, active galactic nuclei, gamma-ray bursts, particle physics and cosmology. In addition, the NAM provided a forum for an excellent history-of-astronomy session as well as sessions on astronomy education, archaeoastronomy and the usual, and some not-so-usual, lunchtime and evening events.

The proceedings got under way on 7 April with a welcome reception in Trinity College Dublin at which **John Hegarty**, the Provost of Trinity, spoke. He emphasized the important role played by astronomy in attracting young people to science. This role has become even more important in recent years with the declining number of physics students in British and Irish universities. Like Britain, Ireland is going through the process whereby many physics departments become physics-and-astronomy departments, partly to attract students.

At the opening ceremony, Minister **Michael Ahern**, from the Irish Department of Enterprise, Trade and Employment, focused on the long history of astronomy in Ireland dating back 5000 years to the building of the megalithic mound at Newgrange. More recently, he told us that from 1845 until 1917 Ireland had the largest telescope in the world, the Leviathan of Parsonstown, Lord Rosse's 72 inch reflector. With this telescope the spiral nature of many nebulae were first revealed, although the realization that they were "island universes" would have to await the work of Hubble. Ireland today, he said, valued membership of bodies such as ESA and the technical advances driven by astronomy. He also emphasized the importance of international collaboration as we strive to understand our wonderful universe.

**Nigel Carson**, representing the Northern Ireland Minister for Culture, Arts and Leisure, spoke about the role astronomy plays in culture and the attraction of the subject to the general public. He also stated how proud they are to support and work with Armagh Observatory. Like its sister observatory in the south, Dunsink Observatory, Armagh has a rich astronomical tradition stretching back over 200 years.

**Dervilla Donnelly**, from the Dublin Institute for Advanced Studies (DIAS), said that she welcomed the major investment being made by the Irish government in university research infrastructure. She noted that astronomers in Ireland have their focus firmly set on becoming partners, with Britain and other European states, in the European Southern Observatory.

## Astronomy not useless

After the opening ceremony, delegates were treated to an excellent plenary lecture on the long-term effects of the Sun on the Earth's climate by **Judith Lean** (Naval Research Laboratories, Washington). Her talk immediately put lie to the statement, made tongue-in-cheek the night before by the Provost of Trinity, that "astronomy is a useless subject". Then **Jocelyn Bell-Burnell**, as President of the RAS, opened an exhibition of David Malin photography, funded by the British Council, at the entrance to the state apartments in Dublin Castle.

The following evening the British Council also sponsored a novel event, "Science in the Gravity Bar" for NAM/UKSP delegates. The venue, on top of the Guinness Hop Store and with panoramic views of Dublin, proved to be the ideal place for **Duncan Steel** (University of Salford) and **Mark Bailey** to discuss the "asteroid threat". Master of ceremony for the evening was the Irish media presenter **Eanna Ni Lamhda**. The intricacies of the debate were, of course, washed down with large quantities of the local "dark matter".

This year the NAM public lecture, in association with the Royal Irish Academy, was delivered by **Steve Beckwith**, Director of the Space Telescope Science Institute. His talk, entitled "The beginning of time, looking back with the Hubble Space Telescope", attracted a capacity audience of 450 people to Trinity College. Only a few tickets were made available to delegates because the LOC wished to emphasize the true public nature of the event.

At the closing Gala Night Dinner, the RAS President reiterated what was said at the ordinary meeting of the RAS that day, i.e. how

much everyone had enjoyed their stay in Ireland and hoped to come back soon. She also thanked the organizers for their hard work. Several delegates then attempted Irish dancing. We felt, however, that many of them had a long way to go before achieving *Riverdance* status.

The Dublin NAM, as with previous NAMs, provided a great opportunity for our community to "display its wares" to the people who patiently support our work, often with little detailed understanding of what is done in their name, or why. The press office was busy throughout the meeting and there was a lot of interest from both the Irish and British media. In addition, Dublin attracted hundreds of young astronomers (half the attendees were students) to meet, hear new results first hand and, as was evident from the lively "buzz" during coffee breaks and more or less continuously around the posters, an unparalleled opportunity to network, meet old friends, discuss new ideas and forge new research collaborations.

Any success the meeting may have achieved in the long term should, we feel, be reflected straight back to the respective British and Irish astronomers who actively contributed to the meeting and embraced the warm Irish hospitality and equally (and surprisingly) warm weather. The sponsors (especially the RAS, PPARC, the Armagh Observatory, DIAS and the British Council, and their respective government funding agencies) have been thanked elsewhere; here, we merely note that without such generous support the NAM could not have taken place. ●

*Mark E Bailey and Tom Ray, Armagh Observatory and Dublin Institute for Advanced Studies, on behalf of the LOC.*

# Data and debate

**Sue Bowler** draws together some of the NAM scientific sessions, to capture the flavour of this lively and popular meeting.

At a meeting as diverse as NAM, it is hard to attend all the sessions relevant to a particular research field, let alone take the opportunity to explore other areas of interest. What follows is a collection of summaries made of their sessions by the organizers, drawn together to illustrate the scope of the meeting. It is not – and is not intended to be – a complete record of the NAM, nor does it provide an exhaustive breakdown of speakers and posters presented: that information remains on the NAM 2003 website (star.arm.ac.uk/nam2003/) and should be consulted if you want to find out more. But I hope this overview will convey something of the spirit of this extraordinarily successful meeting.

The scientific sessions began with a presentation about "The present state of Cosmic Vision" by **David Southwood**, Director of Science at ESA. A major overhaul of the ESA space-science programme took place last year and led to a new programme "Cosmic Vision" which packaged missions tightly in a programme of work to 2012. This year it is intended to roll forward the planning to beyond 2020. The programme uses an engineering approach that packs in more missions per euro but which has the inevitable downside of reducing programme flexibility. In robust style, Southwood gave an overview of the present state of the programme, past and present approaches to forward planning, and some appreciation of the impact of the grounding of Ariane 5. The audience appreciated his blunt presentation of the strengths and weaknesses of ESA's way of working and his assessment of the problems that member states have in undertaking timely payload development, for example. Southwood provided plenty of food for thought: I cannot have been the only person surprised to learn that the combined GNP of ESA's member states exceeds that of the US, for example.

Topical science results were to the fore in the three consecutive sessions on observational cosmology, which included a diverse mixture of talks on three main themes: galaxy surveys, high-redshift observations, and the cosmic microwave background (CMB). All three of these areas have seen dramatic progress in recent years, culminating most recently with the stunning measurements made by the WMAP satellite of temperature and polarization anisotropy in the CMB. It is interesting to see how the character of cosmological work is changing in the light of these observational advances.

## Cosmology comes of age

Observations of the CMB, galaxy clustering and high-redshift supernovae have led to the emergence of a credible standard cosmological model with a flat spatial geometry, a dominant component of cold, non-baryonic dark matter, and a non-zero vacuum energy density causing cosmic acceleration. This basic picture provides a secure framework within which observations can be interpreted and detailed ideas of how galaxy and large-scale structure formed can be developed. A standard paradigm has emerged for the formation of galaxies by the gravitational collapse of the cold matter component, but modelling the behaviour of gas and stars in this framework remains a challenge.

Only a few years ago, interest in cosmographic studies using local galaxy surveys was largely focused on their possible use in pinning down the basic parameters describing our universe. Better constraints on the value of $\Omega$ and other important numbers are now available using the WMAP data and supernovae data, so this aspect of local survey work was virtually absent from the presentations at NAM this year. But survey work is still important, as it yields important information about the clustering of galaxies of different types which, in turn, may unlock vital clues about the galaxy formation process. Wide-field observations are also being used to study the gravitational lensing of background objects by foreground mass concentrations. This field is still in its developmental stages, but has already begun to yield exciting results.

High-redshift observations enable astronomers to study the evolution of galaxies and large-scale structure, as well as the properties of the intergalactic medium. The era of 8 m telescopes is upon us and is allowing astronomers to undertake spectroscopic studies of very faint galaxies, including follow-up to observations. In particular, interpretation of the redshifts of objects detected in the submillimetre using SCUBA will lead to important clues about the interplay between dust and star formation during the galaxy formation process in the early universe. The stuff between galaxies, the intergalactic medium, is now also being exposed to detailed spectroscopic study, providing important challenges for theories of structure formation.

The Cosmic Microwave Background has entered a new phase of study owing to the recent release of WMAP data. Interest in this area in the future will not wane, however, and there are many exciting developments in the pipeline. For example, polarization has been detected and measured, but many details of the polarization pattern are not yet understood. These could yield important cosmological clues. Non-primordial sources of temperature anisotropy also promise a rich harvest, especially galaxy clusters observed through the Sunyaev-Zel'dovich effect.

Attention among theorists is likewise turning away from broad-brush phenomenological description towards more detailed understanding of the astrophysics of structure formation. Numerical simulations are set to continue their

## Careers for astronomers

More than 100 people attended the "Careers for astronomers" session. **Richard Wade** (PPARC) followed up Ian Halliday's comments on the impact of EU legislation on short-term contracts, and PPARC's setting-up of a small working party. In the future it seems likely that after the first post-doc position (which will be regarded as a training position), there will be a career review. **Anne Hennessey** (careers adviser from Trinity College, Dublin) spoke about the transition in Eire to a knowledge-based economy, and beyond (more service jobs likely – in health-care and financial services; hi-tech will decline). Anne gave a rather scary assessment of current interviewing techniques and some of the things employers look for (and look out for). **Ivan O'Brien** (publisher and astronomy graduate) addressed the topic "Who's afraid of the Big, Bad, World?" with a frank assessment of an astronomy graduate's advantages – for example, the many different computing systems we habitually use – and disadvantages, such as the fact that astronomy PhDs are scary people. There followed short presentations from astronomers working abroad at different stages in their careers: **Karen Masters** (grad student at Cornell), **Ed Polehampton** (post-doc in Germany), **Damian Audley** (fellowship in Japan), **Malcolm Currie** (contract in Hawaii). These excellent talks showed that it is often not the bureaucracy that causes problems, but things like finding a place to live. They recommended finding a contact where you want to work, rather than applying for anything. *Helen Walker (RAL).*

leading role. But the biggest change noticeable as cosmology enters its new regime is an ever-closer relationship between theory and observation. Such is the wealth of new observational data that idle speculation is no longer possible. Cosmology has come of age.

### Feedback please!

About 35 people responded to an invitation from the RAS to all young astronomers, solar physicists and geophysicists to attend a lunchtime meeting. Lunch was provided, along with information about the RAS and attendees were asked for feedback. The meeting proved highly successful, giving people a welcome opportunity to network with others of their own age from a variety of disciplines. Several people applied to join the RAS as a result of the meeting, and members and non-members supplied useful suggestions for the Membership Committee. It is hoped to develop a young people's special interest group to organize similar meetings at future NAMs and elsewhere.

Meanwhile, the room allocated to binary-star discussions was bursting at the seams, uniting old and many new faces in this diverse and stimulating field of astrophysics. The session opened with a review of new reasons to be interested in binary stars: type Ia supernovae, stellar population and galactic chemical evolution studies and laboratories for stellar evolution and gas dynamics. But there are also elusive but fundamental processes, such as common envelope evolution, where research remains in its infancy. With the scene set in this way, speakers considered other aspects of binary stars: how much there is to be learnt from SdO stars that irradiate their companions in planetary nebulae, and an ambitious project to assess the hitherto neglected effects of duplicity on stellar nucleosynthesis and galactic chemical evolution. After a reminder of the potential benefits of the systematic observations of many systems now becoming possible, the session concluded with some exquisite spectra and light curves of eclipsing binaries in clusters.

The origins of dust and heavy elements were a recurring theme in several sessions. Stars of around 1 solar mass end their lives as cool giants on the Asymptotic Giant Branch (AGB). Three speakers on AGB stars described advances in precision modelling and high-resolution observations of individual stars. Modelling revealed non-LTE effects and the movement of the stellar atmosphere of U Equ, while VLBA and MERLIN radio interferometry observations of masers traced clumps, asymmetries and the polarization structures of circumstellar envelopes. Several years of roughly fortnightly monitoring of SiO emission from TX Cam provided dramatic confirmation of the role in mass-loss played by successive shocks due to stellar pulsation propagating through the wind inside the dust-formation zone.

The formation of the component elements of these stars was a topic of discussion. Enhanced abundances of heavy metals formed by the slow neutron capture process are found in globular clusters and there is evidence for similar nucleosynthesis in carbon stars. The "seed" heavy element nuclei required could have come from earlier generations of stars, from binary companions via AGB stars (and unpredicted hot carbon pockets) or from anomalous convection. WHT observations show that several different factors are involved in the sample of stars investigated.

AGB stars in the Magellenic Clouds appear to produce as much molecular gas as their Milky Way counterparts, with a high molecular content but less dusty. This can be explained if the main forces driving mass loss, pulsations and dust formation, become saturated at less than solar metallicity. These results challenge the assumption that old stars with low birth metallicity contribute relatively little to galactic enrichment in their old age.

### Cool stars

The first session on the theme of cool stars focused on the emerging field of very-low-mass stars. Star-formation theories predict that many such stars should be formed, but until the advent of surveys such as SDSS and 2MASSS we were unable to characterize their properties. Two main themes emerged from this session. First, knowledge of the spectra of such stars is crucial to searches for exoplanets and brown dwarfs, but their atmospheric structure and chemistry is complicated by the formation of dust layers, non-equilibrium chemistry and mixing. New atmospheric models drawing from work on planetary atmospheres are at the forefront of this work. The second theme was the role of low-mass stars in star formation. Studies of these stars in clusters are being used to test the nature and ages of clusters and also the theories of violent star formation that predict the ejection of many low-mass stars and frequent disruption of their disks. The low disk fractions observed are consistent with this scenario.

The second cool-stars session concentrated on the consequences of dynamo-generated magnetic fields in the photospheres, transition regions and coronae of stars like the Sun. Many such stars, particularly those that are rapidly rotating by virtue of their youth or presence in a close binary system, are orders of magnitude more magnetically active than the Sun. As direct imaging is possible for the Sun but not other stars, a major goal of current research is to use more indirect methods to: (i) find the way that magnetic fields are structured in more active stars and (ii) to deduce how their outer atmospheres, particularly their coronae, are heated. Two distinct approaches were discussed: X-ray and UV spectroscopy to find emission measures, densities and velocity fields in the coronae and transition regions; and optical photometry and high-resolution spectroscopy to eclipse- and Doppler-image cool magnetic starspots in active stellar photospheres. The detailed analysis and modelling techniques were hotly debated. It is clear that the wealth of new data emerging from HST, XMM-Newton and FUSE is stretching our understanding of the magnetically dominated outer atmospheres of cool stars. A scaled-up version of active regions on the Sun may not be appropriate.

Wednesday lunchtime saw the reappearance of what is becoming a NAM regular, the women's lunch. This session was attended by more than 100 people. Women had an oppor-

tunity to meet women from other institutes and to discuss common interests and experiences (everything from science, through careers, to lifestyle). **Mary Mulvihill**, a science editor, consultant and author, gave a short lecture on "Torch-bearing women". She spoke about four pioneering Irish women who made careers in astronomy – Margaret Lindsay Huggins, Agnes Clerke, Annie Russell Maunder and Alice Everett. There was some time for general, open discussion after the lecture. This was a lively and unique session and everyone enjoyed the opportunity to get together.

## A question answered

In 1926, in the opening paragraph of his now-classic book *The Internal Constitution of the Stars*, Sir Arthur Eddington lamented, "What appliance can pierce through the outer layers of a star and test the conditions within?" We finally know the answer: asteroseismology. With the resounding success of helioseismology in determining the interior structure and rotation of the Sun, astronomers have been delighted with the recent discovery of solar-like oscillations in the stars $\beta$ Hyi, $\alpha$ Cen and $\chi$ Hya. There is now the true possibility of seismology of a variety of solar-like stars. However, for two decades already asteroseismic techniques have been applied to many other kinds of pulsating stars across the HR Diagram to study a wide variety of interior and surface conditions. Session 68 at NAM 2003 looked at a sample of these stars and the exciting physics that is being studied: crystallized cores in white dwarfs (a new kind of diamond the size of the Earth); the structure of horizontal-branch sub-dwarf B stars – He cores with their atmospheres torn away; an enigmatic red supergiant, as cool as the coolest L and T brown dwarfs with $T_{eff} \approx 1000$ K (L and T are new spectral classes cooler than M stars); the signature of the Coriolis effect in the complex interaction of rotation and pulsation; an enigmatic possible star spot on a single white dwarf; and the first three-dimensional resolution of stellar pulsation modes in any star other than the Sun, an exceedingly peculiar magnetic star. Recently over 250 astronomers across Europe, with strong UK participation, have formed ENEAS, the European Network of Excellence in AsteroSeismology, to exploit the expanding potential of this field. With the prospect of the COROT and Eddington European asteroseismic space missions to be launched in 2005–2008, the future of asteroseismology is bright.

Comparisons between the solar system and more distant space continued with extra-solar planets. The number of known systems has grown to about 100 since the first non-pulsar planet was discovered in 1995. UK astronomers have played an important part in these discoveries and in our understanding of the systems, and will continue to do so. This session was devoted largely to reviews of detection methods, system properties, and how systems might have formed. But it started with the tireless attempts of Peter van de Kamp to show from astrometric data that some nearby stars had planets. He died in 1995 believing that Barnards's Star had a planet, and his data, even when shorn of dubious data points, show some indication of this.

The first review covered the techniques of extra-solar planet detection. These include astrometry, Doppler spectroscopy, gravitational lensing, transit photometry, pulsar timing, reflected light detection and direct imaging. Ground-based technology is rapidly advancing and powerful space missions, such as SIM, GAIA, Kepler, Eddington, Darwin and TPF, are expected in the next decade or so. One search will be made for planets around pulsating white dwarfs, by looking for modulation of the pulse period through reflex orbital motion.

Then known extra-solar planetary systems – typified by planets of the order of Jupiter's mass – were reviewed. A significant proportion is closer to the star than Mercury is to the Sun, and a significant proportion is in eccentric orbits. Observational selection effects have discriminated against the discovery of systems like our own. Transit detections and direct observation will greatly enhance our knowledge of these planets in years to come. Except for a few planets around pulsars, there are no definite Earth-mass planets (there is a possible candidate from gravitational lensing), but this again could be due to observational selection effects. A poster showed that Earth-mass planets could have stable orbits in the habitable zones of a significant proportion of known systems.

The session went on to consider how extra-solar planetary systems might have formed from circumstellar disks of gas (and dust). Migration of planets resulting from planet–disk interactions can explain many of the observed properties of single and multiple systems, including the orbital resonances that are found in several of the multiple systems. Simulations of gas accretion by a Jovian planet core show that much of the accreted gas can be returned to the disk, and so there is a dynamical circulation. The session concluded with a discussion of the consequences of planet migration due to planet–planetesimal interactions on the structure of extra-solar Edgeworth-Kuiper belts. Clumps in the dust disk around Vega constrain the mass and migration history of a Neptune analogue to be very similar to those in the solar system.

An explosion of extra-solar planet discoveries is expected in the next few years, from transit photometry and other techniques. This, plus the large and growing number of theoretical and modelling studies, will ensure that extra-solar planet research, already a vibrant field, will continue its rapid expansion.

Another thriving field is adaptive optics and interferometry. High angular resolution imaging is the last frontier for ground-based visible and near-infrared telescopes. Gone are the days when astronomers squandered the diameter by using it only to collect more photons: now, using the new techniques of adaptive optics and interferometry, an increased diameter (or baseline) is the key to increased angular resolution and deeper sky coverage. In this session we were treated to a feast of spectacular images from the world's newest and best adaptive optics system, NAOS, installed at the VLT. Other contributions focused on the UK's adaptive optics system, NAOMI, at the WHT, and on increasing the field-of-view using multi-conjugate adaptive optics. Optical interferometry has the potential to yield milliarcsecond angular resolution at near-IR wavelengths; the VLT-Interferometer and Magdalena Ridge Observatory (MRO) has immense potential. The MRO interferometer is a particularly interesting project as the system will be a true snapshot imager. New imaging techniques need new CCDs, and the final talk focused on the Marconi low light level CCD. The speaker convinced us that there is still no ideal detector but we are slowly getting there.

"Life and death from space" proved to be another popular topic. The Earth is a target for asteroids and comets – and has been ever since its formation at the birth of the solar system, some 4570 million years ago. Some impactors bring water and organic compounds, the ingredients that could have been the building blocks of life. Other bodies arrive in a blaze of fire and fury, the results of their impact being death, destruction and extinction. And, as we find planets orbiting other stars, we must also assess their potential as impact targets. This well-attended session began with comets and panspermia. Some form of panspermia is coming to be regarded as a plausible mechanism for the beginnings of life on Earth. To assess the possibilities of such a mechanism it is desirable to know first hand what comets are actually made of. The Rosetta mission aims to address this issue, in part by means of a UK experiment (Ptolemy) on board the part that will land on a comet. In additionm experiments have now tested the possibility of recovering material from cometary dust around Earth, using cryosamplers collecting large volumes of air at 41 km in the stratosphere.

Impacts from both asteroids and comets happen on planets in our solar system and elsewhere. For extra-solar planets, some of the closest solar-type single stars have belts of dusty debris much brighter than our own Kuiper Belt. This may trace a much larger population of comets that would affect the development of life on Earth-analogues. But the pattern of bombardment on Earth is not clear. Small asteroids (less than 1 km across) constitute the most

2: Some of the delegates outside the state apartments in Dublin Castle. The UKSP group could not make it as their programme was running 20 minutes late.

immediate impact hazard to human populations, and yet the rate at which they arrive at Earth's surface is poorly known. Small craters on Earth are rapidly eroded, and many bolides are disrupted in the atmosphere. A numerical model shows that even large stony impactors may experience severe atmospheric disruption, resulting in a calculated impact rate for these objects 40 times less than some earlier estimates.

Earthly concerns continued in the session on archaeoastronomy. During the seven years that have passed since the "Current issues in archaeoastronomy" discussion meeting at the RAS in May 1996 (see *The Observatory* **116** 278–85), both theory and practice have advanced. This is largely as a result of improved integration of techniques, methods and interpretative approaches which result from active co-operation between, on the one hand, archaeologists and historians and, on the other, astronomers and statisticians. Papers in this session presented case studies that illustrate these advances and the issues they raise. The issue of how to reconcile what might be called the "general" (statistically rigorous, "scientific") and "specific" (interpretative, contextual, "historical") methodological approaches, was addressed using the example of an enigmatic group of Bronze Age monuments in mid-Ulster. Then the orientations of medieval churches in the English Midlands proved useful in addressing the issue of how best to integrate archaeological and historical (documentary) evidence. And analyses of the relationships between prehistoric monuments, the surrounding landscape and the sky allowed the exploration of how prehistoric communities perceived their place in the cosmos. This was illustrated with preliminary results from Loughcrew cemetery. The session closed with a review of technical advances that improve our ability to visualize astronomical alignments in prehistoric architecture.

## Things are looking up

Astronomy in education – in schools and elsewhere – is aiming high, if the lively and informative session is anything to go by. The technological advances that characterize such projects as the Astro-Grid and virtual-observatory projects have enormous potential for education, even at primary level. The ability to tailor a search for data to individual levels and interests means that schools could establish their own virtual observatories, on a small but relevant scale. Websites that could be models for such access already exist in some subjects. (Organizations such as the Joint Information Systems Committee provide listings and guidance about educational resources). SunTrek is a solar–terrestrial website for school students that will be launched later this year. This project grew out of interest in the total solar eclipse of 1999, but has evolved into a resource tailored through direct interaction with schools. A similar tailored approach has grown out of newspaper science coverage. Good local papers cover science stories at a simple level, complete with figures and explanations of concepts, suitable for use in school. The support of one newspaper – *The Belfast Telegraph* – and PPARC has led to compilations of articles on space topics, supplemented by additional illustrations, explanations and activities and eminently suitable for school use.

Speakers from the Royal Observatory Greenwich and Armagh Planetarium reflected on the continuing strong public interest in astronomy and related subjects, and the cost of meeting this demand. Again, schools played an

## The career of Len Culhane

Leading international scientists met at Dublin Castle to celebrate the career of Prof. Len Culhane, who was educated at University College Dublin, receiving a degree in physics followed by an MSc. This led to an impressive career in the field of astronomy and space science spanning more than 40 years, which included involvement in more than 10 space missions and many rocket flights. He has worked with scientists in many countries across the world including the USA and Japan. His major scientific achievements include pushing forward the understanding of the solar flare mechanism, establishing the presence of hot gas in clusters of galaxies, obtaining the first maps of supernova remnants and clusters from orbiting spacecraft, the first detection of X-ray line emission from supernova remnants and clusters of galaxies, and mapping X-ray emission in stars.

3: Len Culhane as a schoolboy and, right, recieving an honorary doctorate at Wroclaw University, Poland.

He has been honoured by the international community many times. He was made a fellow of the Royal Society in 1985 and was awarded an honorary doctorate of science from the University of Wroclaw, Poland, in 1993. However, the meeting this week to describe his career will hopefully be one of the greatest personal honours to someone who has inspired many into the world of science. Seven world-renowned scientists described different eras in his career, and provided us with a picture of the person behind the career.
*Louise Harra.*

important part. A clear message from all those involved in schools was that resources must fit in with National Curriculum requirements, or they will not be taken up by teachers.

### Satellite infrared astronomy

There were three strands to this session: the past (ISO), the present (SIRTF), the future (HERSCHEL). The ISO data have produced some significant results and large statistical surveys are now being undertaken using the ISO archive. In addition, there are galaxies that ISO observations have demonstrated to be more distant counterparts to the Antennae galaxies. For the present, the SWIRE Legacy programme plans to observe a million galaxies in a wide-area survey. SIRTF was due for launch in April (postponed until August), and will follow an Earth-trailing orbit, moving away at 0.1 AU/year (so the Earth will lap SIRTF in 60 years). For the future, long-wavelength analysis for the HERSCHEL instrument HIFI shows that different packages for characterizing the optics gave different answers. We concluded with a review of the HERSCHEL mission, which will be launched in 2007 and will operate from L2, with a series of "key" programmes executed early in the mission, as well as survey and follow-up phases.

Moving up the energy spectrum, the High Energy Cosmic Rays session began with the Auger Observatory. The northern and southern halves of the observatory will be used to make measurements of the highest energy cosmic rays. Each array will cover 3000 $km^2$ – about the size of Lancashire – and will measure 300–500 events with energy $10^{20}$ eV during 10 years of operation. The prototype array of Auger South is already operating in Argentina, with completion due in 2006. The question of what accelerates cosmic rays up to around $10^{15}$ eV then came under scrutiny. Because directional information is lost due to effects of galactic magnetic fields, one must search for the γ-ray signatures of cosmic-ray production. The next generation of very-high-energy (VHE) gamma-ray telescopes should be capable of detecting this emission if it exists. These arrays, VERITAS and HESS VERITAS, will be built in Arizona, with the first telescope completed this year and four by 2005. HESS is under construction in Namibia; two telescopes are currently operating, four should be complete by early 2004. These telescope arrays will be used to study acceleration processes in a range of objects including AGN, SNR and microquasars. The session ended with an overview of ANTARES, a neutrino detector being built in the sea off the south coast of France. It detects the Cherenkov light generated in sea water by muons produced by incoming neutrinos. From next year, the detector will be used to search for point sources of neutrinos as well as complement direct dark-matter searches.

Astronomy progresses through the confrontation of models and observations. Most observations made with modern instruments are spectroscopic, and atomic and molecular data – sometimes in very large quantities – are required for their interpretation. The session on "Astrophysical atomic and molecular data" touched on these issues. Speakers showed that models of planetary nebulae and of high-redshift galaxies require a range of atomic and molecular data to determine the physical conditions in the objects observed and the abundances of key elements. Electron temperatures determined from optical recombination lines, for example, can suggest lower temperature gas. Interpreting spectra also brings difficulties, in determining reliably the magnitudes of oscillator strengths, notably for intercombination transitions in Fe II.

Many astrophysical sources emit or absorb by molecular transitions. For example, in the interstellar medium a large number of sometimes complex molecules has been observed, bringing problems of line identification and of providing sufficiently comprehensive data sets, derived from laboratory measurements. Such problems become even more acute in the rapidly developing field of astrobiology. The discussion made it very clear that future progress in astronomy will rely increasingly on developments in experimental and theoretical atomic and molecular physics.

All in all, this NAM was an optimistic and forward-looking conference, whether considering the scientific vistas opened up by new techniques and instruments, or the healthy state of astronomy shown by the presence of so many young researchers. ●

*Many thanks to session organizers who provided this information: Dierdre Coffey, Peter Coles, Paula Chadwick, Chris Dainty, David Flowers, Monica Grady, Louise Harra, Moira Jardine, Rob Jeffries, Barrie W Jones, Don Kurtz, Anita Richards, Clive Ruggles, Robert Smith, David Southwood, Christopher Tout, Helen Walker.*