SUMMARY

DIAS School of Cosmic Physics Annual Report 2001

Research activities in the **Astronomy Section** during the year focussed on galactic nuclei, evolving stellar populations, massive stars and clusters of galaxies. The main emphasis has been on high-energy (X-ray) observational data. An important development was the start of membership (together with UCD) of the Milan-led Rapid Eye Mount collaboration, a project to operate an automatic telescope for Gamma Ray Burst research in the Southern Hemisphere. In addition, together with UCD a CCD camera was acquired for Gamma Ray Burst observations and for monitoring projects, that will be employed at Abastumani Observatory in Georgia. The computer programme for simulating the high-energy output of evolving stellar populations was extended by incorporating detailed binary star evolution; supporting studies of massive stars nearby are being carried out. Dunsink Observatory's coordinating activities for securing Irish participation in future leading observing facilities was rewarded by a consultants' recommendation to Forfas for membership of the European Southern Observatory. A first Dunsink Colloquium was held, a day-long programme with specialist contributions on "The Nuclei of the Nearest Galaxies". Our successful involvement with the instrumentation for the Optical Monitoring Camera on board the INTEGRAL satellite resulted in ESA starting their pre-launch INTEGRAL Awareness Campaign from Dublin. Due to another academic staff retirement, the staffing level of the Astronomy Section has become a point of concern. Group visits and Open Nights at Dunsink Observatory remained highly popular.

The **Astrophysics Section** concentrated mainly on observational and theoretical studies of star formation and the associated outflow phenomena. One of the more interesting observational results obtained was a strong indication of rotation in a proto-stellar jet, as expected on theoretical grounds but never previously seen. On the theoretical front, this work was nicely complemented by the development of improved models (including a remarkable exact magnetohydrodynamic solution) for the jet formation process. Theoretical work on high-energy phenomena concentrated mainly on the interaction between pulsars, supernovae and their environment using computational models to simulate aspherical systems. Experimentally the section contributed to the construction of the HESS telescope system in Namibia and participated in discussions of the KLEM project as well as further refining the UHCRE analysis. The programme of radiation dosimetry at aircraft altitude continued successfully and was extended to include a series of measurements on the space shuttle Endeavour during a flight to the international space station.

In the ***Geophysics Section*** continued effort was directed towards projects investigating the tectonic development of the North Atlantic region. Interpretation of the RAPIDS-3 wide-angle seismic refraction/reflection data has been refined and a tomographic approach used to construct best-fit models for the upper lithosphere. In the TRIM project, high resolution seismic data was used to study slope processes and canyon development revealed by the sidescan data along the eastern margin of the Rockall Trough. Potential field modelling in the Porcupine Basin was started and will contribute to the understanding of the regional tectonic framework of the region to the west and southwest of Ireland. Onshore, 2-D models for the crustal structure of the Leinster region (the LEGS project) were completed and the 3-D interpretation of the VARNET data continued. Further afield, data acquisition in the Hawaiin Plume project was concluded and some initial analysis completed. The year was overshadowed by the continuing illness of Senior Professor Brian Jacob who died on the 5th of November. Brian is sadly missed by the members of the Geophysics Section.

ANNUAL REPORT
SCHOOL OF COSMIC PHYSICS, 2001

Annual Report of the Governing Board of the School of Cosmic Physics for the year ending 31 December 2001 adopted at its meeting on 30 July 2002.

STAFF, SCHOLARS AND ASSOCIATES

Senior Professors: L.O'C. Drury (Director), A.W.B. Jacob (until 05 November)*, E.J.A. Meurs.

Professors: A. Thompson (until 17 July), D. O'Sullivan, T.P. Ray.

Assistant Professors: P.W. Readman, B.M. O'Reilly, I. Elliott (until 04 September).

Visiting Professors: M. Burton (University of New South Wales, Australia, one year from 05 April).

Experimental Officers: T.A. Blake, B.D. Jordan, J.Walsh (computer manager, contract basis).

Visiting Scientists: B. Austin (Hydrosearch and Phillips Petroleum), H. Baty (Strasbourg Observatory, France), E. Benton (University of San Francisco, USA), A. Eckart (University of Cologne, Germany), J. Ellis (CERN, Geneva, Switzerland), A. Fabian (Institute of Astronomy, Cambridge, UK), J. Fiege (Canadian Institute for Theoretical Astrophysics, Toronto, Canada), P. Fenning, A. Fernandez-Soto (Brera Observatory, Milan, Italy), A. Frank (University of Rochester, NY, USA), T. Gardiner (University of Rochester, NY, USA), M. Gaye (24-31 January), F. Hauser (University of Karlsruhe, 26 February - 02 March), E. Houdebine (Armagh Observatory, NI), E. Josselin (GRAAL, Montpellier, France), R. Keegan (Trinity College, Dublin), J.-K. Lee (University of New South Wales, Australia), N. McCann (France), K.-H. Mack (Netherlands Foundation for Radio Astronomy, Dwingeloo, the Netherlands), A. McMurry (Institute of Theoretical Astrophysics, Oslo University, Norway), L. Maiani (Director General, CERN, Geneva, Switzerland), N. Morewood, N. Murphy (BP UK), B. O'Halloran (University College Dublin), S. O'Sullivan (University of Leeds, UK), D. Praeg (University College Dublin), L. Tommasino (Agenzia Nazionale per la Protezione dell'Ambiente (ANPA), Italy), P. Viola (Agenzia Nazionale per la Protezione dell'Ambiente (ANPA), Italy), D. Ward-Thompson (Department of Physics and Astronomy, Cardiff University,UK), F. Zerbi (Brera Observatory, Milan, Italy).

Technical and Clerical Staff: A. Byrne, A.M. Callanan, E. Clifton, P. Daly, W. Dumpleton, E. Flood, A. Grace-Casey, C.M. Horan, S. Ledwidge (part-time job-sharing basis), L. Quigley, M. Smyth, H. Sullivan, G. Wallace.

Scholars: M. Carr, O. Carroll, J. Cunniffe, J. Donnelly, Á. Gras Velázguez (from 01 October), J.A. Hodgson (until 31 January), M. Landes (without stipend, until 31 December), J.-K. Lee, K. McGrane (without stipend), F. McGroarty, L. Norci, E. Whelan (from 01 October), B. Xu (from 01 September), D. Zhou.

Project Supported Positions: S. Annibaldi (Differential Transport in Strongly Turbulent Fusion Plasmas, until 31March), T. Lery (Jets-2, Enterprise Ireland, until 30 September), G.D. Mackenzie (RAPIDS-3), L. Norci (High-Mass Stellar Evolution in Extragalactic Starbursts), E. van der Swaluw (Particle acceleration and Propagation in Astrophysical Environments, from 01 February), P. Viola (Dosimetry of Aircrew exposure to Radiation during Solar Maximum, 17 September – 14 December).

Professores Emeriti: T. Kiang, T. Murphy, A. Thompson (from 18 July).

Research Associates: C.J. Bean (UCD), D. Corcoran (UL), T. Downes (DCU), P. Duffy (UCD), A.J. Keane (ITB), R. Keary (GSI, retired), A. Lawrence (Edinburgh), B. McBreen (UCD), J. Makris (University of Hamburg), P. Morris (British Antartic Survey), N.P. Murphy (BP), F. Murtagh (QUB), W.E.A. Phillips (TCD), V.F. Polcaro (IAS, Frascati), C. Prodehl (Karlsruhe), P.M. Shannon (UCD), M. Wilkinson (Cambridge).

Project Students: C. Melody (TCD, from 24 September to 31 December).
Vacation Students: J. Razzano (Boston, from 12 June to 31 August).
Transition Year Students: Michael Day (Alexander College, 05 to 09 November).

* A.W.B. Jacob died on 05 November 2001.

1 POLICY

1.1 Strategic Planning
Luke Drury

Considerable effort was invested during the first half of the year in the development of an Institute Strategy Statement to provide a framework for the implementation of the School's research strategy. The main problem was that each of the three constituent schools of the Institute has a distinctive research character and identity, which produced somewhat divergent views on the optimal staffing structure of the Institute. However through extensive debate it was possible to evolve a common structure for the Institute within which each school felt reasonably comfortable. The key was the recognition that in the current research system we need to redefine the concept of scholar within the Institute and introduce a new category of high-level postdoctoral fellows. In the two science schools these will be called Schroedinger fellowships and will be offered for periods of three to five years. It is intended that the School should provide about ten such fellowships from its own grant-in-aid and

another ten through externally funded projects. In addition to the new fellows and some scholars (students studying towards a higher degree) each section of the School should have a senior professor and a professor as core permanent staff. The introduction of this new structure, which is designed to promote a more team-based approach to research and should address many of the problems of inflexibility, lack of critical mass, and absence of new blood identified in the past, required some minor changes to the School's research strategy.

Two other key issues were highlighted by the strategic planning discussions. One was the necessity for the Institute to concentrate on high-quality basic research as a central core value of the Institute. The Institute cannot, and should not, be attempting to undertake applied research except where this is an accidental by-product of basic research carried out for its own intrinsic interest. To ensure the high quality of the research it was agreed that more emphasis needed to be placed on monitoring and evaluation. The governing boards of the schools are of course primarily responsible for monitoring the research work of the schools, but it was accepted that the practice introduced by the School of Cosmic Physics, of commissioning an external expert review every five years, was a very useful way of obtaining an independent authoritative report on the status of the School and one which is now to be extended to the other schools of the Institute.

The final key point was the necessity for the Institute to develop closer and more formal linkages to the rest of the Irish research system. Although there are extensive networks at the personal level, these do not properly exploit the potential of the Institute to act as a focus and catalyst for inter-institutional collaboration. The independent status of the Institute, its ability to concentrate on specialist and interdisciplinary areas, and its strong international linkages and reputation give it unique advantages for this role.

1.2 Programme for Research in Third Level Institutions

Luke Drury

The call for proposals under cycle three of the Programme for Research in Third Level Institutions (PRTLI-3) provided the first major chance to implement parts of the School's research strategy. Building on concepts developed during the discussion of the Institute's strategy statement, on earlier experience with high performance computing, and on elements of the School's science strategy a proposal was developed on behalf of a consortium of nine organisations for "Grid-enabled computational physics of natural phenomena". The proposal passed the phase one assessment, and was substantially improved for the phase two evaluation with much help from all participants. In the closing days of the year the Institute was informed that the proposal had been accepted and awarded funding of just over nine million Irish pounds. This represents the single largest award ever obtained by the Institute.

The proposal was developed in close cooperation with physicists from NUI Galway, NUI Dublin, Met Éireann, Dublin City University and Armagh Observatory and computer scientists and networking specialists from Grid-Ireland (UCC and TCD) and HEAnet. It envisages a system of three large Beowulf clusters interconnected through grid middleware provided by Grid-Ireland over the high bandwidth network administered by HEAnet. The computer clusters will function as a single large virtual resource shared amongst all participants and will be used to address a range of fundamental problems in cosmic physics, from star formation phenomena to climate change to geophysical simulations. At full strength the project will involve about sixty participants and as well as addressing all the computational aspects of the School's science strategy, will plant the Institute firmly at the centre of the important and rapidly growing area of grid computing. The proposal also envisaged the construction of additional accommodation at the rear of 5 and 6 Merrion Square which it is hoped may form the nucleus of a possible single-site location for the whole Institute.

2 RESEARCH ACTIVITIES IN THE ASTRONOMY SECTION

2.01 Gamma Ray Bursts and Rapid Eye Mount Telescope

E.J.A. Meurs, B. Jordan and M. Smyth with B. McBreen (UCD) and F. Zerbi (Brera Observatory, Milan, Italy)

In order to participate in the important and topical research on Gamma Ray Burst (GRB) sources, Dunsink Observatory joined, in Spring 2001, an international consortium that is developing a fast response, automatic telescope. The collaboration is led by Brera Observatory (Milan-Merate, Italy) with further participation in the first place by the Catania and Rome Observatories (Italy), the Service d'Astrophysique (Saclay, France), and further the Randall Laboratory of Physics (Ann Arbor, USA) and various other university institutes and observatories in Italy (Bologna, Milan, Perugia, Palermo, Trieste, Ferrara).

The instrument, styled Rapid Eye Mount (REM) Telescope, is a 60 cm diameter fully automatic and fast-slewing telescope designed primarily to record the early phases of near-InfraRed emission from GRBs detected by space borne γ-ray alert systems such as INTEGRAL, HETE II, SWIFT, etc. The near-InfraRed region of the electromagnetic spectrum is chosen in order to be less hampered by obscuration from the GRB surroundings and to enable the (expected) detection of very high redshift counterparts that will provide unique probes of conditions in the very young Universe. The REM telescope will be installed at the ESO La Silla observatory, Chile, and will be a major facility within the GCN international network of fast robotic observatory systems for transients.

The telescope will be equipped with a near-InfraRed camera based on the Rockwell HgCdTe Hawaii focal plane array, covering the range 0.95-2.3 μm and an Optical Slitless Spectrograph covering the range 0.45-0.95 μm with 30 sample points. The telescope feeds the near-InfraRed camera and the spectrograph simultaneously via a dichroic mirror. The complete system provides a rapid pointing broad-band spectro-photometric

facility designed specifically to monitor and record sudden transient phenomena. Dunsink Observatory contributes the electronic controller for the near-InfraRed camera.

The camera features a Rockwell focal plane array that comprises four 512x512 pixel quadrants, of which one high-quality quadrant will be used. The detector is mounted in a thermo-electrically cooled cryogenic dewar. The electronic system consists of a timing and drive board which provides the digital sequencing signals for controlling the focal plane array. A pre-amplifier and video processor board provides 16 bit processing electronics capable of acquiring and storing a full frame image in 0.8 seconds. Communication with a host computer with PCI interface card and control programme runs via a high speed fibre optic link. The computer is equipped with a CD writer for storing image data.

2.02 Searching for active cores in Local Group galaxies

E.J.A. Meurs and Z.Zang

Several minor points regarding the X-ray search for any signs of core activity in Local Group galaxies were sorted out, in order to finalise the reporting of this work in the literature. In addition to the Local Group galaxy selection studied so far, available ROSAT High Resolution Imager data were examined for the galaxy Leo A. Only recently an improved distance determination had become available for this dwarf galaxy, which now places it well within the Local Group. No detectable core source could be found and this result has been translated into limits on core flux and luminosity that are entirely consistent with those that had been obtained for several other Local Group members.

2.03 Long-term variability of nuclear X-ray sources in galaxies

J. Cunniffe and E.J.A. Meurs

Nuclei of otherwise normal galaxies may occasionally flare up due to the disruption of a star on a close flyby of the galactic nucleus. The stellar debris is expected to fuel a central massive Black Hole, which would notably lead to an increase of X-ray emission due to a short-term accretion disk being formed and high-energy radiation being visible for this duration. A broad-based search for such stellar disruption events is being carried out as an automated archival research project. For this search the entire data archive of the ROSAT satellite has been obtained, including both the pointed observations and the All Sky Survey data. The first analysis based on these data focusses on a sizeable sample comprising the brightest galaxies (till magnitude 13). The central region of the programme galaxies constitutes naturally the focus of interest.

Further work was done on the flaring candidate NGC 4552, an elliptical galaxy, which had shown an increase in brightness of a factor 5 followed by a decay back to its previous level in Hubble Space Telescope ultra-violet data, during the ROSAT PSPC observation period June 1990 -- October 1994. Notably more advanced data reduction of the data from the Einstein and ASCA satellites was pursued. For the ROSAT HRI detector data a clock error was corrected, leading to improved image definition and flux values, and a more comprehensive brightness profile analysis could be carried out. While some variability of the NGC 4552 core appears likely, the level of variability is much below that of other stellar disruption candidates. A possible interpretation is that the observed UV variability rather is connected with individual stellar X-ray sources near the centre of the galaxy.

2.04 Spectroscopy of candidate Active Galactic Nuclei

E.J.A. Meurs with K.-H. Mack (NFRA, Dwingeloo, NL)

Optical spectroscopic data obtained for classifying candidate Active Galactic Nuclei (AGNs) were reanalysed, adhering to strict quality and accuracy criteria. The programme objects had been chosen from objective prism surveys carried out by the Case Observatory and by Wasilewski. The intermediate resolution spectra from the Isaac Newton Telescope at La Palma yield redshifts, line widths and line ratios, which allow classifications to be pursued. The resulting activity assessments are to be used for comparative studies of various surveys aimed at finding candidate AGNs.

2.05 Einstein EMSS galaxy clusters

M. Carr, L. Norci and E.J.A. Meurs

During the Einstein X-ray satellite Extended Medium Sensitivity Survey, a total of 835 serendipitous sources have been detected, of which 97 are now recognised as clusters of galaxies. Around 20 of these EMSS galaxy clusters have subsequently been observed with the Position Sensitive Proportional Counter (PSPC) of the ROSAT X-ray satellite. The spectral information provided by the PSPC detector has so far not been exploited in previous analyses of these data, but instead a fairly standard assumption has been made for the temperature of the hot, X-ray emitting gas when calculating fluxes and luminosities. Obviously there may be temperature differences between individual clusters and, as an extension of the EMSS galaxy clusters project employing ROSAT All Sky Survey data, we are examining on the basis of these ROSAT pointed observations the validity of such a standard temperature assumption and the influence of any deviations from that on fluxes and on relations involving the temperature.

The relevant ROSAT PSPC data for these clusters have been analysed. The aim is to derive the physical parameters temperature, flux and luminosity and temperature from fitting Raymond-Smith models to their X-ray spectra. For some of the clusters temperatures have been measured with the ASCA satellite, which due to an energy coverage extending to higher energies is better suited for higher gas temperatures. A comparison with the ASCA values shows indeed that for comparatively lower temperatures the ROSAT PSPC yields reliable values, but that for higher temperatures they deviate systematically from the better ASCA values.

In addition to the spectral characteristics, also the spatial distribution of the X-ray emission has been investigated. An isothermal model is fitted to the radial profiles for each cluster and values of slope parameter and core radius are derived. The results of the radial profile fitting

are used to study a recently proposed X-ray isophotal size versus temperature relationship. Both as of spectral information and radial profiles the current results cover a more comprehensive EMSS cluster selection than in previous analyses.

For the extensive and nearly finished study of all EMSS clusters in the ROSAT All Sky Survey data, the calculated fluxes are being adjusted where required in order to take later revisions of the All Sky Survey data into account.

2.06 High-energy studies of starforming regions in extragalactic context

L. Norci and E.J.A. Meurs

Starforming regions in extragalactic objects have become attractive targets for X-ray observations due to the appreciable spatial and spectral resolution now available with X-ray satellites. At these high energies interesting information can be retrieved about the evolving stellar population and its interaction with the ambient Interstellar Medium. A large and complex population synthesis computer programme has been developed that monitors the X-ray active phases for each individual star (and each binary) while the stellar population evolves.

Much attention has lately been given to the simulation and evolution of binary systems in the computer programme. The Montecarlo simulation of mass ratios and binary separation was extensively studied and implemented. The evolution of the systems is followed through mass transfer till the occurrence of a supernova. Evolution of the system after the supernova event and the important case of X-ray emission upon transfer of mass on the compact component are currently being implemented.

2.07 Studies of WR stars

L. Norci with V.F. Polcaro, R. Viotti (IAS, Frascati) and C. Rossi (Istituto Astronomico Universita' di Roma)

Wolf-Rayet stars represent an advanced stage of massive star evolution, probably descending from the luminous and massive O stars. Notable emission lines signifying the atomic elements N, C or O have led to subtypes WN, WC and WO. The prevalence of these spectral emission lines is connected with the production of these elements by nucleosynthesis in the stellar interiors. These Wolf-Rayet stars exhibit very strong winds from their surfaces and experience correspondingly high mass loss.

A statistical analysis of the intensity (in Equivanlent Width) and width of the main emission lines common to the WC and WO stars has been made, based on an extensive set of spectral data. Up-to-date spectral types and binarity information have been used from the Seventh Catalogue of Galactic Wolf-Rayet Stars and the Fourth Catalogue of Population I Wolf-Rayet Stars in the Large Magellanic Cloud. To define the trends in EW, line ratios, and line widths over the WC and WO classes, median values of these parameters have been derived for galactic and non-galactic single-spectrum stars of different spectral class. The most noticeable features are:

(1) substantially smaller EW (C IV 581 nm) values for galactic WO and WC4 stars, compared to non-galactic objects;
(2) smoothly increasing values of EW (O V559 nm) towards early WC and WO stars, for galactic as well as non-galactic stars;
(3) a decrease in EW for the 465 nm blend at early WC and WO for both the galactic and non-galactic stars;
(4) a marked increase in C IV 581 nm and O V 559 nm line widths for the galactic WO stars.

The observed differences between galactic and non-galactic WCE[arly]/WO stars suggest environmental influences. It is argued that differences in stellar wind structure, in combination with the ambient metallicity, may be the cause of the anomalies. Variation of the 465 nm blend profiles indicates a substantial contribution of the He II 468 nm for the WCE and WO stars. Also considered are WC and WO carbon abundances, in relation to the evolutionary status of these objects.

2.08 Optical spectroscopy of the red supergiants BC Cyg and VES 145

L.Norci with V.F. Polcaro (IAS) and S. Bernabei (Loiano, Italy)

Red SuperGiants represent a crucial phase in the high mass stars evolution. A knowledge of their characteristics is essential for the computation of evolutionary tracks and for population synthesis models. The RSG have also an important role in the galactic evolution, due to their contribution to the chemical enrichment of the interstellar matter. Furthermore, due to their high luminosity and short life, RSG can be used as tracers of galactic structures such as the spiral arms. On the other hand, the study of the RSG evolution is extremely complex and their exact evolutionary paths are not yet fully understood. The present work focusses on analyses of the spectra of a number of RSG of different ages (and thus of different initial masses), in order to obtain a better understanding of the RSG evolutionary phase and in particular of the value of their initial mass.

2.09 Spectral variability of the extreme Of supergiant HD 15570

L. Norci with V.F. Polcaro (IAS), P. Eenens (Universidad de Guanajuato, Mexico), C. Rossi (Istituto Astronomico Universita' di Roma) and R. Viotti(IAS)

"Of" supergiants are believed to represent the early evolutionary stage of very high mass stars ($M_{\odot}>40M_{\odot}$). Because of their low numbers and extreme peculiarity, each of these objects is worth monitoring continuously. Numerous spectroscopic observations of a number of Of supergiants were performed during the last decade. Optical and very near IR (I band) spectra were analysed for one of the most extreme Of supergiants, the O4If+ star HD 15570, whose initial mass has been suggested to be as high as 100 $M_{\odot}$. Low, intermediate and high resolution data collected at the Loiano and S.Pedro Martir telescopes since 1992 reveal interesting line variability of this object.

2.10 Studies of runaway stars

E.J.A. Meurs, G. Fennell and L. Norci with C. Melody (TCD)

Some of the young massive stars appear to have left their places of birth at great speed, as "runaway" stars. This may have been caused either by being part of a binary system of which one member exploded as Supernova or by strong gravitational interactions with other massive stars during an early stage shortly after their birth when they were very close together. If they are post-Supernova binaries, then the expectation is that they are accompanied in many cases by the Neutron Star that was formed at the explosion.

An analysis of all available ROSAT X-ray data for a large selection of confirmed and candidate runaway stars was concluded. These measurements could reveal the presence of condensed companions, but no such case was found. Although this may seem to favour gravitational ejection from dense stellar groups as production mechanism of runaway stars, Supernova kicks are known to be a realistic phenomenon (e.g. some X-ray binaries).

In order to study the origin of runaway stars from another angle, a model scenario was constructed for groups of young stars evolving from an initial dense state. The well-known general expansion of such groups appears crucial in regulating (i.e., decreasing) the gravitational ejection probability. When such groups have become too sparse for this mechanism to be effective, the supernova naturally take over. The fractions of runaway stars produced by either mechanism in a series of simulations are promisingly close to a recent observational estimate of those fractions, based on astrometric data from the Hipparchos satellite and high-precision radio data of pulsars.

2.11 The Optical Monitoring Camera (OMC) for INTEGRAL

B.D. Jordan, M. Smyth and E.J.A. Meurs with B. McBreen and F. Quilligan (UCD)

After the final acceptance tests and delivery to ESA (the European Space Agency) of the Flight and Qualification Models of the Optical Monitoring Camera for the The INTErnational Gamma-Ray Astrophysical Laboratory (INTEGRAL) spacecraft, the Electrical Ground Support Equipment for the OMC was returned to Dublin from Madrid. The equipment was reassembled and installed in the dark room laboratory and maintained in good working order pending a possible request fron INTA, Madrid for any further use.

2.12 CCD Camera

B.D. Jordan, M. Smyth and E.J.A. Meurs with B. McBreen (UCD) and N. Smith (CIT)

In order to acquire an imaging facility in the Northern Hemisphere also (besides the REM Telescope in Chile), a scientific grade CCD camera was ordered that will be operated at the Abastumani Astrophysical Observatory in Georgia. A large array CCD camera was selected, based on the KODAK 1Kx1K detector. The CCD detector is mounted in a thermoelectrically cooled cryogenic dewar and incorporates 14 bit high-speed digital processing electronics. A programmable eight-position filter wheel driven by a synchronous motor and Geneva indexing mechanism was developed for this camera. The filter position is fully encoded by means of an eight bit absolute encoder. The camera will be incorporated into the international GCN (Gamma Ray Bursts Coordinates Network). Since the telescope in Georgia is not robotic a manual procedure will be in place to respond to GCN Gamma Ray Burst alerts. The further scientific use of this camera focusses on monitoring of quasars and blazars.

2.13 The observational confirmation of the island universes

E.J.A. Meurs

A pilot study was conducted on the spreading of the notion that part of the nebular celestial objects are galaxies like our own Milky Way, in professional and popular literature in the 1920s. The indications are that this idea was accepted in almost all popular sources but hardly affected professionals in their research activities, with mainly Hubble himself displaying the greatest involvement with the subject. Various circumstances could have given rise to the latter situation, and a literature survey with greater coverage than in this pilot study may be worthwile.

3 RESEARCH ACTIVITIES IN THE ASTROPHYSICS SECTION

3.01 Magnetised Pulsar Winds

E van der Swaluw

Magnetohydrodynamical simulations were performed for magnetised pulsar winds using the Versatile Advection Code. The shape of the pulsar wind nebula can be studied as a function of the magnetisation parameter, i.e. the ratio of Poynting flux to plasma kinetic energy flux. The surrounding medium of the pulsar wind nebula is taken to be a uniform interstellar medium or freely expanding ejecta released in the event of a supernova explosion.

3.02 Pulsar Wind Bubble Evolution

E van der Swaluw with T Downes (DCU) and R Keegan (DCU)

Hydrodynamical simulations of pulsar wind nebulae were performed on the DIAS Cluster using the hydrodynamics code of Turlough Downes. The complete evolution of a pulsar wind nebula can be described in this way, starting with a centered pulsar wind bubble, which will be deformed into a bow shock when it is close to the shell of its associated supernova remnant. Ultimately the bow shock will break through the shell of the supernova remnant.

3.03 Particle Acceleration in Superbubbles

E van der Swaluw with A Marcowith (CESR, Toulouse), E Parizot (CNRS, Orsay) and T Downes (DCU)

The objective is to investigate the evolution and the associated particle acceleration in a superbubble. Of particular interest is the dense shell bounding the interior of the superbubble, which is a place where turbulence is being created by the evaporation of clouds by the superbubble shock. From the interior of the superbubble, expanding supernova remnant shocks will propagate and interact with the superbubble shell. Both mechanisms, the turbulence and the interaction of shocks will influence the propagation and acceleration of relativistic particles at the site of the superbubble shell.

3.04 The Ultra Heavy Cosmic Ray Experiment (UHCRE) on the LDEF Mission

A. Thompson, D. O'Sullivan, J. Donnelly and L.O'C. Drury with K.-P. Wenzel (ESTEC)

The dominant activity during the year was the experimental derivation of correction factors for small systematic differences in signal from etch to etch in relevant UHCRE detector plates from the many etches employed for actinide data extraction. This refinement resulted in a significant improvement in charge assignment and hence in charge spectrum resolution. It should be emphasised again that this is the only statistically significant sample of cosmic-ray actinides in existence at present. Thorium ($_{90}$Th) and uranium ($_{92}$U) peaks are now clearly prominent (see figure) and the value of the U/Th ratio is found to be $0.92 \pm 0.59/0.38$. Comparison of this ratio with predictions of r-process nucleosynthesis production and subsequent decay suggest an "age" for the Galactic Cosmic Ray actinides greater than 3×10^6 years and less than 10^9 years. A very interesting feature of the actinide charge spectrum is the presence of a probable curium ($_{96}$Cm) event, which, if genuine, would be the heaviest atomic nucleus detected in nature to date. However, the probability of a single plutonium ($_{94}$Pu) event shifting to this charge assignment is 9.3%, based on a Gaussian charge assignment distribution. Nevertheless, even if the event were classified as plutonium, this would also be of considerable interest. It may be noted that the relevant plutonium and curium isotopes have half-lives of 8.2 $x10^7$ and 1.6 $x10^7$ respectively.

The refinement of actinide data extraction and charge assignment has not changed the UHCRE value for the relative abundance of cosmic-ray actinides, defined as $(Z \geq 88)/(74 \leq Z \leq 87)$. This value, as expected, is still $0.0144 \pm 0.0031/0.0026$, which is consistent with propagated primordial solar system material. The latest actinide results, along with the updated ultra heavy cosmic ray spectrum, were presented at the 27th International Cosmic Ray Conference (Hamburg, Germany) during August.

3.05 The H.E.S.S. experiment

O Carroll and L Drury with MPIK Heidelberg and others

The HESS (High Energy Stereoscopic System) project aims to construct a system of Imaging Atmospherics Cherenkov Telescopes (IACTs) in order to explore the production and propagation of high-energy particles in the Universe. The telescope array is located on Farm Goellschau at an altitude of 1800m above sea level in the Khomas Highland at the foot of the Gamsberg Mountain in Namibia. The project is led by the Max-Planck-Institute for Nuclear Physics (MPIK) in Heidelberg, Germany and is run in conjunction with numerous institutes and universities throughout Europe. The School of Cosmic Physics forms part of this collaboration. With the assistance of a grant from the International Cooperation programme of Enterprise Ireland, Olwen Carroll made a number of trips to Namibia to assist with the construction of this facility.

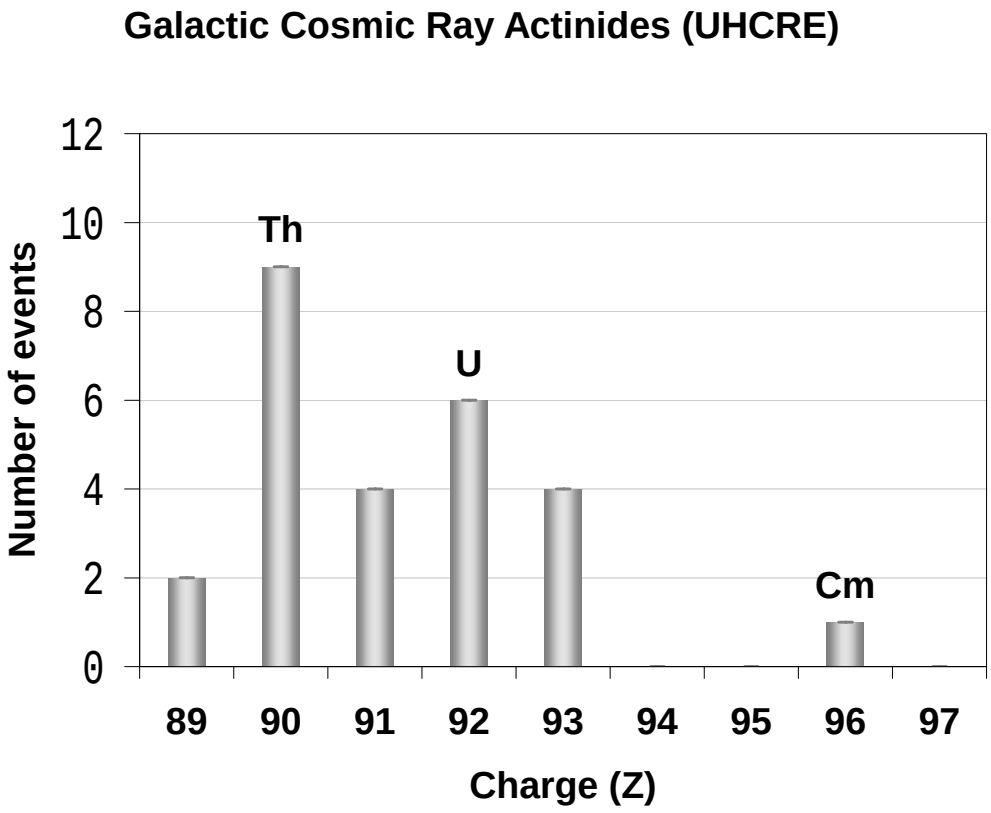
The first visit was in late January 2001 (Jan 20th – Feb 4th incl.) for two weeks where work on all four telescope foundations and measurements on the dish of the first telescope were carried out. Over the course of the two weeks, the foundations had to be cleaned and prepared for insertion of the precision-machined azimuth rails. Once inserted, the rails were aligned and, once they were deemed to be within specified tolerances, were secured with bolts and concreted in position. The two weeks allocated for securing the rails proved insufficient as heavy rain and missing infrastructure led to some significant delays. Work on this section of the project was completed after three weeks.

In addition to work on the foundations and telescope rails, measurements of concentrator one at the NEC steel works in Okahandja had to be made. These included distance measurements between bars in each sector of the concentrator (in all 12 sectors) and bar slopes. The bar slopes were measured using a self-calibrating digital Clino 2000. Ideally the positions and slopes of the mirror supports were to be measured also but time did not permit completion of measurements. A representative from MPIK subsequently completed all measurements.

On May 14th 2001, the dish of the first telescope was lifted onto the base frame and, on May 16th, the camera masts of the first telescope were installed. The above was performed on site. Following this a second two-week trip to Namibia was required (May 19th – June 1st incl.). By this time the concentrator for telescope two was almost complete and identical measurement procedures as those used for concentrator one were used to measure bar distances and slopes, along with mirror support distances and slopes. Several mirror supports were found to be falsely positioned, orientated or have slopes outside tolerance. These were subsequently removed, remounted and re-measured.

Having travelled from NEC, Okahandja, to the site on Goellschau, work began on mounting and assembling one of the drive systems for telescope one for testing. Once mounted, the system was tested and found to be working erroneously. Having eliminated other possibilities, it was finally discovered that the arm of the drive system from the central hub was sitting at the wrong angle. The arm was eventually raised by approximately 2cm, in steps of ~0.5cm, until the system was found to work satisfactorily.

The telescope wheels still had to be placed on the rails and secured but this could not be done until the gaps between the plates connecting the wheel blocks with the telescope base had been grouted. While specialist



engineers were working on this problem, time was spent using a cherry picker, which had been delivered from Heidelberg to investigate the possibility of accessing the mirror supports through the camera support masts for future mirror mounting. Several Aluminium plates to simulate mirrors were mounted during this exercise. Using one of the engineering drawings of the telescope concentrator with the supports numbered in each sector, it was found that one third of all supports were accessible with the cherry picker. It was therefore concluded that through symmetry all other supports were accessible with this method.

Originally a period of four weeks was envisaged for mirror mounting for the first telescope. This was later revised and there followed a third trip to Namibia in August 2001 (Aug 25th – Sept 14th incl.). Upon arrival at the site, mirror mounting was delayed due to one major unforeseen problem. The support masts for the camera box were found to be sagging by 25mm (the tolerance value being 14 ± 2mm). This meant that had we proceeded with mounting, the telescope would have been very unstable and so it was decided to wait for a team from NEC to travel to the site to remedy the problem. In the meantime, a special tent for mirror assembly was constructed– the mirror motors/drive systems had to be secured to the mirrors prior to mounting.

Apart from the first two rows of mirrors mounted, it was found to be easier for three people to mount each mirror, two in the cherry picker and a third behind the mounting blocks (on the telescope) to help secure the nuts, connect the motor cable and search for the mirror engraving, which was recorded in a log of mirror numbers and their corresponding positions on the telescope. In cases where mirror motors made physical contact with the telescope, preventing the assembly from sitting flush with the telescope, the assembly was rotated by 60°.

Progress in the final week was severely hampered by adverse weather conditions. However, on the last day the remaining mirrors were successfully mounted. Approximately 16 mirrors were left un-mounted due to missing motors. These were subsequently shipped from Heidelberg and the mirrors mounted by a technician on site.

In addition to the three trips to Namibia, Olwen Carroll made one trip to Heidelberg for discussion and training (March 10 to 15) and both Luke Drury and Olwen Carroll attended the HESS consortium meeting in Schloss Ringberg (Nov 4 to 8).

3.06 The KLEM Project

A. Thompson, J. Donnelly and L. Drury with G. Bashindzhagyan et al (Moscow State University), J. Adams (NASA Marshall Space Flight Center), M. Simon (University of Siegen, Germany), A. Chilingarian (Yerevan Physics Institute), N. Egorov (Zelenograd, Russia), V.Grebenyuk (Dubna), H.Nanjo (Hirosaki University, Japan), I.H.Park (Seoul National University, Korea) and O. Saavedra (Torino University, Italy)

During the year the KLEM (Kinematic Lightweight Energy Meter) project advanced considerably in terms of both prototype development and exposure opportunity. The central scientific objective of the KLEM Collaboration is to measure, directly, the elemental energy spectra of very high energy (10^{11}–10^{16}eV) cosmic rays using a large aperture lightweight detector system in Earth orbit. This is only feasible by employing a kinematic technique to obtain the primary particle energy, specifically by determining the angular distribution of secondaries

produced in a target layer using silicon microstrip detector technology.

The first significant accelerator test of a simple KLEM prototype was carried out at the CERN SPS during August using 180 GeV pions. Analysis of the exposure results confirmed that the energy of the particles could be measured, using the KLEM method, with a relative error of about 65%,. This is consistent with the results of the relevant current simulation work (67%) and reinforces confidence in the basic design concept.

A preliminary small scale version of a KLEM device has been designed for inclusion in the NUCLEON Russian satellite mission. Research and development work for this version were completed during the year. Construction is scheduled for 2002-2003 and launch is planned for 2004-2005. Despite its relatively small size of 36×36×30 cm^3, this instrument has an aperture of about 0.12 m^2 sr and can thus make an important contribution to data concerning the elemental energy spectra of cosmic rays up to and above 10^{15} eV. The full scale instrument, with a collecting area of $4m^2$ and a three-year exposure, will have the capacity to address the "knee" problem with a database sufficiently large to include at least 25 particles with $E>10^{16}$ eV. Launch of the full scale KLEM is currently scheduled for 2008.

A new KLEM experiment, the Polar Balloon Experiment for Astrophysics Research (Polar BEAR) has been designed for a long duration balloon flight around the North Pole. It is proposed that this work be carried out within the framework of a current agreement between NASA and the Russian Space Agency (Rosaviacosmos). The primary objective of the experiment is to measure the elemental energy spectra of high energy cosmic rays in the region up to 10^{15} eV. The planned instrument involves the combination of a large collecting area (≈1.0×1.0 m^2) KLEM device with an ionisation calorimeter having a smaller collecting area (≈ 0.5×0.5 m^2) integrated beneath the KLEM apparatus. Total weight will be about 1000 kg and the estimated power consumption will be less than 150 W. This combination has important advantages. On the one hand, a large exposure factor can be achieved with a long duration balloon flight (2-4 weeks), due to the large aperture (> 2 m^2 sr) of this KLEM device. On the other hand, the calorimeter will collect about 10% of the events already registered by the KLEM unit and thus provide effective cross-calibration for both energy measurement methods.

Four papers on aspects of the KLEM project were presented at the 27th International Cosmic Ray Conference (Hamburg, Germany) during August.

3.07 Near-Infrared Fabry-Perot Imaging of Herbig-Haro Energy Sources: Collimated, Small-Scale Molecular Hydrogen Jets and Wide-Angled Winds

T.P. Ray with C.J. Davis (Joint Astronomy Center, Hawai'I), L. Stern (Univeristy of Victoria) and A. Chrsysostomou (University of Hertfordshire)

To search for evidence of shocked molecular hydrogen line emission towards the central engines of young stars, near-infrared Fabry-Perot images of eight IRAS Class I outflow sources (SVS 13 [HH 7-11], L 1551-IRS5, HH 26-IRS, HH 72-IRS, SSV 63E [HH 24C], SSV 63W [HH 24J], HH 34-IRS and HH 111-IRS) and two Class 0 sources (HH 24-MMS and HH 25-MMS) were obtained. Elongated H_2 emission (on scales of a few arcseconds) was detected from four of the Class I YSOs. These small-scale "jets" are associated with the base of more extended, parsec-scale optical outflows (and the "Molecular Hydrogen Emission Line" regions, or MHELs, discovered last year by Davis, Ray et al.). In L 1551-IRS 5 two jet components were detected in H_2; these may be the molecular counterparts of the two known optical jets from this binary proto-stellar system, or they may represent H_2 excitation along the walls of a narrow, edge-brightened cavity. In addition to the small-scale MHEL jets, analysis of the data also suggests the presence of discrete molecular shock fronts formed along the jet axes close to the energy sources. In the most clear-cut example, SVS 13, an H_2 knot was seen at a distance of about 440 AU from the outflow source; assuming a flow velocity of about 200 kms^{-1}, the dynamical age of this molecular feature is only 10 years. In these data evidence was also seen for both collimated jets and wide-angled winds from the same sources. Indeed, in one of the two Class 0 sources, HH 25MMS, a poorly collimated flow component seems to be present. A two-component wind model may therefore be appropriate for outflows from Class I (and possibly even Class 0) proto-stars.

3.08 Hubble Space Telescope Observations of the FS Tauri Binary System

T.P. Ray with J. Woitas and J. Eislöffel (Thüringer Landessternwarte Tautenburg) and R. Mundt (Max-Planck-Institut für Astronomie, Heidelberg)

Hubble Space Telescope Wide Field Planetary Camera (WFPC2) observations of FS Tau and its environment were obtained in narrowband Hα and [S II] λλ6716, 6731 emission line filters. Based on these data, the morphology of the line emission was studied on a scale of 0.1 arcseconds for the first time. Despite the fact that FS Tau A has strong forbidden emission lines, there is no evidence for extended emission at these wavelengths beyond 0.5 arcseconds from the components of this close T Tauri binary system. In the FS Tau B outflow (located some 20 arcseconds away), interesting morphological properties were discovered at high spatial resolution. Here it was found that circular or elliptical knots in the outflow were correlated with minima of the jet width. The overall width of this jet decreases with distance from the source. The FS Tau B jet is thus a rare example of a jet that may be re-collimated far away from its source. The jet is much more prominent in Hα than in [S II], while the counter-jet shows the opposite behaviour. The line ratio Hα/[S II] was found to increase with lateral distance from the jet axis and this is indicative of entrainment of ambient material.

3.09 Indications for Rotation in the DG Tauri Jet

T.P. Ray with F. Bacciotti (Osservatorio Astrofisico di Arcetri, Florence), R. Mundt (Max-Planck-Institut für Astronomie, Heidelberg) and J. Eislöffel (Thüringer Landessternwarte Tautenburg)

High angular resolution studies of the optical blue-shifted jet from DG Tauri have revealed possible evidence for the first time of jet rotation within 0.5 arcseconds from the source (i.e. within about 100 Astronomical Units when de-projected along this flow). The evidence comes from a careful analysis of optical emission line profiles extracted from a set of seven long-slit spectra taken with the *Space Telescope Imaging Spectrograph* (STIS) on board the Hubble Space Telescope. The seven spectra were obtained by maintaining the slit parallel to the outflow axis while at the same time moving it transversely in steps of 0.07 arcseconds. For the spatially resolved flow of moderate velocity (peaking at –70 km s^{-1}), Ray et al. have found systematic differences in the radial velocities of lines from opposing slit positions i.e. on alternate sides of the jet axis. The results, obtained using two independent techniques, were corrected for the spurious wavelength shift due to the uneven illumination of the STIS slit. Other instrumental effects were shown to be either absent or unimportant. The derived relative Doppler shifts range from 5 to 20 km s^{-1}. Assuming the flow is axially symmetric, the velocity shifts are consistent with the south-eastern side of the flow moving towards the observer faster than the north-western side. If this finding is interpreted as rotation, the flow is then rotating clockwise looking from the jet towards the source and the derived toroidal velocities are in the range 6 to 15 km s^{-1}. Combining these values with previous estimates of the mass loss rate, one obtains an angular momentum flux, for the *low to moderate velocity* regime of the flow, of about 4.10^{-5} $M_{\odot}yr^{-1}$AU km s^{-1}. These findings *may constitute* the first detection of rotation in the initial channel of a jet flow. The derived values appear to be consistent with the predictions of popular magneto-centrifugal jet launching models although further studies of more flows are required. A large block of time has been allocated to this project with the Hubble Space Telescope starting in 2002.

3.10 Near-IR Echelle Spectroscopy of Class I Protostars: Mapping Forbidden Emission-Line (FEL) Regions in [FeII]

E. Whelan, T.P. Ray with C.J. Davis (Joint Astronomy Center, Hawai'I) and A. Chrysostomou (University of Hertfordshire)

Near-IR echelle spectroscopy is a very useful probe of the dynamics of outflows near embedded proto-stars. These stars are enshrouded in dust making them optically invisible. In particular spectra in [FeII] 1.644 μm can trace forbidden emission line (FEL) regions and, with this in mind, observations were made in late October/early November towards several embedded sources (SVS 13, B5-IRS1, IRAS 04239+2436, L1551-IRS5, HH 34-IRS, HH 72-IRS and HH 379-IRS) as well as a number of classical T Tauri stars (AS 353A, DG Tauri and RW Aurigae). The parameters of these emission regions were compared to the characteristics of the Molecular Hydrogen Emission Line (MHEL) regions recently discovered towards the same outflow sources. The [FeII] and molecular hydrogen lines both trace emission from the base of a large-scale optical jet and/or molecular outflow driven by a proto-star, although they clearly trace different components. It was found that that the [FeII] emission is associated with higher-velocity gas than the molecular hydrogen, and that the [FeII] emission peaks further away from the embedded source in each system. This is probably because the [FeII] is more closely associated with Herbig-Haro like shocks in the inner, on-axis jet regions, while the molecular hydrogen may be excited along the boundary between the jet and the near-stationary, dense ambient medium that surrounds the proto-star. Indeed, there is spatial and kinematic evidence that [FeII] and the more frequently used optical emission lines of [SII], trace almost the same shock-excited regions in Herbig-Haro jets and forbidden emission line regions alike.

3.11 Parsec-Scale Outflows from Intermediate Mass Stars

F. McGroarty, T.P. Ray with J. Bally (University of Colorado, Boulder)

Herbig-Haro (HH) objects are the shock-excited nebulous tracers of outflows from pre-main-sequence stars. In many cases the outflow is collimated in the form of a jet and its strength linked to accretion by the parent star. Most known optical jets emanate from low mass objects, typically T Tauri stars or embedded stars of similar mass. Outflows have also been observed from a small number of higher mass young stars, e.g. Herbig Ae/Be stars the optical higher mass analogues of T Tauri stars. Moreover in recent years it has been realised that outflows from low mass young stars are much more extensive than previously thought stretching for several parsecs rather than several thousand AU as previously thought. With this in mind, F. McGroarty et al. have undertaken a study of intermediate mass young stars to search for analogous parsec-scale outflows. A number of successful observing campaigns with the Wide Field Camera on the Isaac Newton Telescope have been conducted and a database established. Numerous new large-scale flows from intermediate mass stars (some optically visible and others highly embedded) have been discovered. Interestingly the size of the flows seems to be comparable to those from lower mass stars and similar to the scale size of the parent molecular cloud. This suggests that many of the flows traced are "blown-out" of the cloud and that their true sizes are much larger again. On such scales flows are seen through their interaction via shocks with their environment. Once a flow has moved outside of the cloud, there is little ambient material for them to interact rendering them invisible.

3.12 Shock Excitation of Molecular Hydrogen in the Orion Outflows

J.-K. Lee and M. Burton

Shock waves occur in a gas where the properties change rapidly due to strong disturbances. Two types of shocks can develop depending on the shock speed and the gas properties (e.g. density, magnetic field strength and ionisation fraction). The first is a hydrodynamic shock involving sharp change in the gas parameters over a few

particle collision lengths. These are termed J-shocks (J for jump). In comparison a magneto-hydrodynamic shock is termed a C-shock (C for continuous) referring to the fact that there is a smoother spatial change in gas parameters. Both shocks have quite different structures and this affects the emission properties of the shocked gas. C and J shock models predict different velocity profiles and line ratios, for example, and thus in theory it is possible to determine which model is appropriate through observation.

With these ideas in mind, J.-K. Lee and M. Burton have investigated the shock mechanism in the so-called Orion Fingers, concentrating on HH 117-114. The latter is one of a score of planetary-mass "bullets" emitting in [FeII], leading the trailing wake of "fingers" in molecular hydrogen H_2. The density-sensitive [FeII] line ratios have been measured and compared with synthetic [FeII] line ratios to deduce the gas density. The ratios of H_2 lines were also measured in different positions along the bow structure in this flow and its variation was investigated. They have found that the 1 -0/2-1line ratio is smaller than the values normally associated with shock excitation (typically 10). The study of the lines from the v=1 to v=3 energy levels, has shown that bow C-shocks or J-shocks with additional H_2 cooling, can explain the observed line ratios. A driving pressure of $\sim 10^{10}$ cm^{-3} K was also estimated. When combined with the gas density derived from the [FeII] line ratio analysis, they were able to deduce the density ($\sim 10^6$ cm^{-3}) and temperature ($T \sim 10^4$ K) in the shocks.

3.13 Magnetized outflows and numerical simulations

T. Lery and T.P. Ray with A. Frank (University of Rochester, USA), T. Jones (University of Minnessota, USA) and S. O'Sullivan (University of Leeds, UK)

From the theoretical point of view, magnetic confinement is a good candidate mechanism for collimating astrophysical jets and nicely complements the idea that the expulsion of the jet material is basically electrodynamic. This has led to the current work on magnetic models for rotating jets and winds that extend from the source to infinity. These simplified models make it possible to investigate the structure of outflows far from the magnetized rotating source without the need for too many restrictive assumptions and allow a calculation of the asymptotic regime with respect to the properties of the central emitting object. The ensuing equilibria can then be used to model the propagation of plasma jets into the interstellar medium. During the year the propagation of uniform jets and of pulsed jets into a homogeneous medium and also the propagation of molecular jets into inhomogeneous interstellar clouds have been modelled. Synthetic emission maps have been produced in all cases for comparison with observations. All the numerical simulations have been performed with the PC Cluster of the Dublin Institute for Advanced Studies.

By varying the properties of the source we can vary the properties of the jet itself. These physically motivated variations of the jet then give rise to more complex behaviour both in the jet and in the ambient medium. In the case of molecular jets, many features of the resulting simulations are in good agreement with observations, such as the molecular cavities, the location and shape of the shocks, as well as the variation with distance of the ionization fraction and of the density along the jet.

3.14 Analytic studies of Star Formation

T. Lery with R. Henriksen, M. Aburihan (Queen's University, Kingston, Canada) and J. Fiege (HIA, Victoria, Canada)

Analytically tractable time dependent models of the transition from protostar to star have been hitherto limited mainly to spherically symmetric collapse (neither magnetic field nor rotation being present) or employ perturbative and quasi-static techniques. Otherwise rather extensive numerical simulation is required and has been achieved only over a limited dynamic range.

Self-similar techniques have been used to reduce the study of time dependent anisotropic models to a system of PDE's in two variables and ultimately to an autonomous system of ODE's. The autonomous model applies to the central regions of the envelope dominated, self-gravitating stage in the presence of magnetic field and rotation. Both numerical and analytical solutions are found of a "settling" character that describe growing hydrostatic stellar cores and weak bipolar outflows. Remarkably, the collapse model admits an exact and completely analytic solution. This is one of the few known analytic solutions of this complexity in all of MHD.

In addition, work has been carried out on self-similar models for the flows occurring during star formation. In these, the self-similar gravitationally driven convective circulation around a heated quadrupolar protostar envelope is solved rigorously. The molecular outflow is regarded as a natural consequence of the circulation established by the collapse of the pre-stellar cloud. The models give an outflow velocity that increases toward the axis of rotation, a convective pattern of infall/outflow, self-consistent axial collimating magnetic fields and rotation, and 'cored apple' type distributions of circumprotostellar gas as required by observations. Such radially self-similar circulation models give rise to a natural connection between the fast ionized jets and the slower and less-collimated molecular outflows that surround them. The model allows one to study both low and high mass protostars and the results are in good agreement with the observed properties of molecular outflows.

3.15 Cosmic Radiation in the Earth's Atmosphere

D. O'Sullivan, E. Flood, D. Zhou and B. Xu

By the end of 2001 the DOSMAX project was well on schedule on the programme of investigations into the radiation field at aircraft altitudes. Detailed studies had been completed during the minimum phase of the present solar cycle 23 and the present work seeks to complete investigations throughout the maximum phase between 2000 and 2003. The radiation field is produced by the interaction of galactic cosmic rays in the Earth's atmosphere, and the sun also plays an important role. The

galactic component at Earth varies in intensity over the 11-year solar cycle and reaches a minimum when the sun is at its most active, as interaction with the solar wind deflects lower energy particles away from the atmosphere. During this phase an increased number of coronal mass ejections and solar flares are expected and in this way, the sun increases the radiation field by emission of high energy particles which can penetrate down to aircraft altitudes. The DOSMAX project is measuring both low LET (Linear Energy Transfer) and high LET contributions using a wide range of active and passive detectors. Since the radiation varies with altitude, latitude and stage of solar cycle, the help of many airlines and NASA has been enlisted in order to cover the maximum range of measurements possible, over a three-year period. Scientific input form the DIAS group includes LET spectra from neutrons, protons and heavier nuclei over a wide range of altitudes and latitudes.

An important phase of the research work was near completion, namely the calibration and characterisation of passive and active detectors which have been flown at altitude, or will do so later in the project. The excellent facilities at CERN, TSL (Uppsala), UCL (Belgium), PTB (Germany) and HIMAC (Japan) have been used for these purposes and an in-depth investigation of details of responses is continuing, well on schedule. Co-ordination of the extensive documentation was undertaken by E. Flood for the European collaboration.

Activities related to computer simulation have focussed mainly on the EPCARD and CARI (LUIN) programmes. All contractors have access to these codes at present and they are in constant use as new results are added to the DOSMAX data from on-going flight exposures. The codes are being improved and every attempt is made to include any new information that is relevant, such as details of the primary cosmic ray spectra. A new version of EPCARD (Version 3.2) has been developed to take into account the solar reversal conditions between 1999 and 2001. In general, measured to calculated dose ratios vary from 0.8 to just over 1.2, showing good agreement at this stage.

3.16 DIAS Experiment on the Space Shuttle "Endeavour"

D. O'Sullivan, E. Flood and D. Zhou

The DIAS group was invited to carry out experiments on the STS-108 mission to the International Space Station, scheduled for December 2001. The DIAS detectors calibrated at CERN and the HIMAC (Japan) were installed by NASA personnel in November. Approximately 40hrs after launch Endeavour locked with the Space Station. The DIAS experiments were designed to study Linear Energy Transfer (LET) spectra for comparison with measurements made by a NASA team using different detectors. This data is used to estimate the radiation exposure of astronauts in low Earth orbit (LEO) and for developing models of radiation exposure for long term space travel in the solar system. A second experiment was designed to study the charge spectrum of cosmic ray nuclei in low earth orbit at typical space station orbit and shielding for the first time.

The mission lasted approximately 284 hrs and returned safely in mid-December. The DIAS detectors were returned and preparation was made for processing and analysis early in 2002.

3.17 Space Weather

D. O'Sullivan

D. O'Sullivan continued as a member of ESA's science working team on the Space Weather Project. His main function was contribution of up to date data and results on aircrew and astronaut dosimetry problems.

4 RESEARCH ACTIVITIES IN THE GEOPHYSICS SECTION

4.01 TRIM (TOBI Rockall Irish Margins)

B.M. O'Reilly, P.W. Readman and A.W.B. Jacob with P.M. Shannon, UCD

The final report describing the results of the TRIM (Tobi Rockall Irish Margins) Project was written during the earlier part of the year and submitted to the Rockall Studies Group together with the finalized interpretation maps and images of the sidescan mosaics in electronic format. This report covered all aspects of the project including data analysis, interpretative methodology, sedimentological processes, palaeoclimatic controls, environmental aspects and seismic hazards. It also included the results of 'ground truthing' studies and was very well received by the members of the Rockall Studies Group (RSG) of the Irish Petroleum Infrastructure Programme. The report is a synthesis of a very large amount of geophysical and geological data of great value not only to academics but also to a wide range of interest groups from fisheries to the hydrocarbon industry. Future work will involve the integration of the TRIM data with complimentary datasets gathered by others.

In particular accurate bathymetric data and high resolution seismic data across part of the northern margin of the Rockall Trough has allowed detailed digital elevation models (DEMS) to be constructed and combined with the sidescan backscatter to produce 3-D images of complex slope failure features. This work was done with colleagues from the Rockall Studies Group and the images produced when correlated with high-resolution seismic reflection data can in some cases demonstrate how these features develop on a geological timescale.

A paper was prepared which investigates the role of bottom currents in controlling the development of the cold water coral mound population on the western margin of the Porcupine Bank which was imaged in great detail during the TRIM survey. A theoretical model is presented in this paper based on the statistical properties of the mound population and the shape of individual mounds resolved by the TOBI (Towed Ocean Bottom Instrument) sidescan sonar data. The results from the model are discussed in the light of palaeoclimatic variations in the Rockall Trough and the wider NE Atlantic region. There is some evidence from recent work by other groups that the growth and colonization patterns of the mound population predicted by this development model are correlated with climate change in the late Pleistocene to Holocene.

4.02 RAPIDS-3 (Rockall and Porcupine Irish Deep Seismics)

G.D. Mackenzie and A.W.B. Jacob with P.M. Shannon and N.C. Morewood, UCD

RAPIDS3 is aimed at understanding of the tectonic evolution of the Irish continental margin. Throughout 2001, work has progressed on creating 2-D velocity-depth models for the four profiles using both finite difference tomography and classical ray tracing techniques. These models have been improved through the calculation of synthetic seismograms and comparison with the actual data. Comparisons of the modelled sedimentary succession on one the wide-angle profiles with a coincident normal incidence reflection profile has shown a good similarity and allowed a detailed seismic stratigraphy of the sedimentary succession to be developed.

Crustal thicknesses of 25-30 km are modelled beneath the basement highs but beneath the Basin thicknesses of only 5-6 km are modelled giving crustal thinning factors consistent with previous studies of this region. Moho topography is assymetric with a more gradual crustal thinning beneath the western margin of the Rockall Basin. Velocities within the mantle below the centre of the Rockall Basin are lower than would be normally expected and are consistent with an extensive region of serpentinisation similar to that observed on several passive margins. A mantle reflector is observed at ≈23 km depth which could mark the base of this serpentinised zone.

4.03 LEGS (LEinster Granite Seismics)

P.W. Readman, J.A. Hodgson and B.M. O'Reilly with P.S. Kennan (UCD)

The seismic modelling of the three profiles underaken in this project was completed. The seismically determined crustal structure was tested by modelling the Bouguer gravity anomaly using the DIAS gravity dataset. The results indicated that there is no exact correlation between seismic velocities found within the crust, i.e. 5.5-7.0 km s^{-1} and the densities required by the gravity inversion as constrained by published empirical relationships. However the required densities lie within the range determined experimentally from the generally sparse available dataset. Euler deconvolution techniques were used to further constrain the shape of the boundaries of the Leinster Granite batholiths and the depth to the base of these bodies. The results were found to be in broad agreement with the seismic models. A variety of filtering techniques was used to highlight subtle structure within the granite and its country rocks. The student working on the project, James Hodgson, completed and submitted his Ph.D. dissertation towards the end of the year.

4.04 Porcupine Basin potential field modelling

P.W. Readman and B.M. O'Reilly

A new research project to investigate the structure of the Porcupine Basin in the deep-water region to the south-west of Ireland began in the later part of the year. This project is been undertaken on behalf of the Porcupine Studies Group of the Irish Petroleum Infrastructure Program. The study will use potential field data (gravity and magnetic field) and seismic reflection data gathered by oil exploration companies to develop models of crustal structure for the Porcupine Basin. This research may lead to a greater understanding of the development of the Porcupine Basin, where there is very little deep-crustal seismic data. An improved understanding of its structural relationship to the Rockall Basin, where crustal structure is better resolved by the RAPIDS series of seismic experiments, may also result from this research.

4.05 VARNET (VARiscan NETwork)

M. Landes, B.M. O'Reilly, P.W. Readman, A.W.B. Jacob with colleagues from UCD and the University of Karlsruhe

Work on the 3-D inversion of the wide-angle-seismic fan data gathered during the VARNET96 experiment continued and a paper on the results of the study was prepared for publication. The paper discusses the three dimensional resolution of the seismic data and correlations between the derived velocity model for the crust of southwest Ireland and variations in the Bouguer gravity anomaly for the area. Michael Landes prepared and submitted a Ph.D. thesis on the results of his work on the VARNET data.

4.06 ISLE (Irish Seismic Lithospheric Experiment)

P.W. Readman and B.M. O'Reilly

This project will investigate the cause of a seismic P-wave travel time residual that has been found in the upper mantle beneath SW Ireland. This was discovered during our previous VARNET96 experiment during which several teleseismic events were recorded, in particular from the Aleutian Islands and China. The new experiment will test the possibility that this travel time residual is due to LPO anistropy (lattice preferred orientation anisotropy) due to alignment of olivine crystals in the upper mantle finite strain field. If anisotropy proves to be the cause of the travel time residuals then the experiment will test if it is due to spatial variations in LPO within the mantle lihosphere associated with closure of the Caledonian Iapetus Suture Zone. An alternative possiblility is that the lithosphere retains no memory of its early tectonic history and that the patterns of any detected anistropy reflect post-Variscan tectonic developments related to the formation of the north Atlantic Mesozoic basin system and the Cenozoic plate tectonic history of the north Atlantic. This experiment will be in collaboration with colleagues from the Universities of Karlsruhe, Germany and Montpellier, France and will be the first of its kind to be undertaken in Ireland.

4.07 Hawaii

A.W.B. Jacob, T.A. Blake, G. Wallace, C. Horan and L. Quigley

The data collection phase from the DIAS data loggers in this project ended in May 2001. Staff from the Geophysics Section and I. Woelbern from GeoForchungZentrum Potsdam travelled to Hawaii to dismantle the seismic array. Data download via computer connection from the

three US Geological Survey stations KHU, STC and UXL continued from Hawaii until June.

Preliminary results from this project have allowed a low velocity zone (LVZ) discovered in an earlier study to be more fully delineated. This zone is interpreted as a region of partial melt at a depth of about 140 km and seems to be circular in shape with a radius of about 35 km centrered somewhat southwest of the Mama Loa volcano. Above the LVZ the lithosphere-asthenosphere boundary (LAB) is deflected upwards causing delay times of P to S-wave conversions at the LAB to be reduced up to 2 s. Mantle discontinuities at 410 km and 660 km depth stand out clearly and show strong variations in depth along the island chain. The results indicate reduced S-wave velocity and therefore increased temperature in the upper mantle.

4.08 The Seismic Network (DNET, ENET and DSB)

A.W.B. Jacob, T.A. Blake, G. Wallace, C. Horan and L. Quigley

In July the recorder and aerial were removed from the ECP (Carnsore Point) station. Plans to convert the ETA (Tara Hill) station to digital recording have been postponed. The DNET station continues to function as a short period network.

Recorded events
There were three events off the north-west coast of Ireland on 27 January, 28 January and 02 September. The largest onshore event in the UK occurred in Melton Mowbray, Leicestershire on 28 October, had a magnitude of 3.8 M_L and a felt intensity of +V. A 3.6 M_L event off the Cornish coast on 31 May also had a felt intensity of +V.

Activity continued in the North Sea / Norwegian Coast area with events in March (3.4 M_L), May (4.2 M_L), June (2 events of 3.7 M_L and 3.9 M_L), and October (3.7 M_L). There were felt events in Italy on 17 July (5.0 Mb) and in Greece on 26 July (6.0 Mb).

Worldwide earthquakes
The year 2001 started with two major and damaging earthquakes. The 6.9 Mb earthquake which occurred in Gujarat State, India on 26 January resulted in over 20,000 fatalities with 8 times more injured. It was felt in neighbouring Bangladesh, Nepal and Pakistan. Deaths and damage resulting from the El Salvador earthquake (Mb 6.4) on 13 January were mainly due to landslides. A number of other events in this area also resulted in damaging landslides. On 23 June, a 6.7 Mb earthquake off the coast of Peru generated a tsunami of 7m in the epicentral area. There were large aftershocks in June and July. Other large events occurred in Indonesia, on 24 February (6.6 Mb), Washington State, USA on 28 February (6.5 Mb), W. Honshu, Japan, on 24 March (6.4 Mb), Kermadec Islands on 03 June (6.8 Mb) and in China on 14 November (7.8 Mb).

Requests
In addition to the usual requests for general information on earthquakes, there were requests for information on specific major earthquakes from people who had relatives living in or who intended holidaying in the affected countries. There were also requests in relation to seismic hazard from both engineers and students from third level colleges. There was one enquiry in relation to ground temperatures in the Dublin area.

Broadband station at Valentia Meteorological Observatory
Technical support and advice was provided to Met Eireann staff running the seismic station in Valentia. Data sets from the station at Valentia continues to be archived along with the DIAS network data.

Broadband digital seismic station DSB
Timing problems as a result of a faulty GPS system at the DSB station were rectified and the station is back to full operation. New SEISCOM software was installed during the year which allows faster download of data via modem and a more comprehensive remote fault diagnosis.

5 FACILITIES

5.1 Computers and Network

Astrophysics Section and Geophysics Section Significant network infrastructure changes were made in 5 Merrion Square during the year. The main points were as follows:

1) The internal network infrastructure was completely overhauled, with the old BNC/Coaxial network cable being replaced by modern Cat 5e UTP cables. The connection between the Mews House and the Main Building was upgraded to fibre optic cable running at 100 Mbits/sec. Three Cisco 2900-XL switches were installed, two in the main computer room and one in the Mews.

Several 50 core cables were also installed which will allow the internal telephone system to be upgraded at a future date. The work was carried out by BootStrap Ltd over a five week period starting in June with due care paid to the architeectural features of the main building.

2) The external network connection was upgraded from a 2 Mbit/sec radio link (running at 512 Kbit/sec for performance reasons) to a Fibre Optic leased line capable of running at 10 Mbit/sec. This was installed as part of a HEAnet project to increase bandwith to deal with the current and future needs of subscibing members. The initial connection speed to HEAnet was at 2 Mbit/sec. A new Cisco 7200 router with STM-1 ATM module was purchased and the existing router (A Cisco 2500) was moved to Dunsink replacing an outdated router.

3) The NT 4.0 server was decommisioned and replaced with a new Windows 2000 server; all users and data were migrated to this platform. All machines that had been running Windows NT 4.0 in the Astrophysics Section were upgraded to Windows 2000. We have noticed some minor problems with this upgrade, but nothing serious. A thorough inventory was carried out to make sure that all machines were running only properly licensed or free Software.

4) Routine maintainance and patching of systems and software included updating Solaris systems from 2.6 to Solaris 8 on appropriate machines.

5) An uninterruptible power supply (UPS) was installed in the basement Network Control Room at No. 5 Merrion Square. This is now fully operational. Details of the UPS (which was transferred from Track Lab #3) are given in Section 5.2.

Astronomy Section At Dunsink, the main server was replaced with a 1.1 GHz Athlon based machine and all of the existing discs and services were transferred to this machine. A CISCO 2500 router was installed to replace the existing CISCO 1200. Security measures have been put in place to exclude external traffic from machines other than the main server.

General It may be noted that DIAS has become an affiliate member of CHEST (Combined Higher Education Software Terms). This enables DIAS to avail of significantly reduced pricing for computerised software on an Institute wide licensing system. This covers computer platforms such as Unix and Windows systems.

The DIAS Computer Committee, which has representatives from all sections DIAS, met twice (in January and October) to discuss IT requirements and developments in the Institute as a whole.

5.2 Nuclear Track Equipment

The six Leitz-ASL track-measuring microscope stations, the Nikon-Heidenhain track-measuring microscope station and the six Nikon stereo scanning microscope systems were maintained in fully operational status throughout the year. Etching equipment in Track Lab #3 was also maintained and serviced as necessary in order to implement the final part of the detector etching programme required for the Ultra Heavy Cosmic Ray Experiment. This programme was completed by the end of the year and the remaining large etching tank (Etch Tank #1) was left ready for decommissioning and disassembling. At this stage, the high capacity uninterruptible power supply (UPS) was transferred from Track Lab #3 to the Computer/Network Control Room in the basement of 5 Merrion Square. This UPS is an APC (American Power Conversion) Smart-UPS XL type SU2200XLINET unit with two additional battery packs, type UXBP48. Smaller scale etching facilities have been retained in Track Lab #3 for ongoing research on cosmic radiation in the Earth's atmosphere (DOSMAX work) and for dosimetry projects.

5.3 La Palma Observatory

Observing runs in 2001
Runs are listed chronologically, with the PATT reference numbers.

Ray and McGroarty (DIAS, 01A/INT/09): INT Wide Field Camera, four nights, February 2001. *Wide Field imaging of outflows from high luminosity stars*. Second and third epoch observations were made of a number of extended outflows which, in conjunction with data already obtained, will be used to determine their proper motions and dynamical timescales. Very little time was lost due to bad weather.

Smith (CIT, 01B/JKT/08): JKT, one week, September 2001. *Observation of a sample of five radio-intermediate quasars*. The weather was variable, with high humidity under relatively clear skies on some nights. A total of 5.5 nights of data were obtained, consisting of approximately 1000 data frames, 30 flatfields (in both B and R) and 40 zerobias frames. A master-flat with an integrated flux of approximately 500,000 counts was used to flatfield all the data frames. The run was awarded during bright time; moonlight reflected off light clouds reduced the effectiveness of the flatfielding. In addition, some of the sources were within 40 degrees of the moon on at least one night during the run. Sources were observed around their local zenith as much as possible to minimise effects of airmass changes on the photometry. The JKT itself worked very well throughout the run, with no need for technical assistance at any stage. Lightcurves for all five sources show stability in the ensemble of reference stars, with only small suggestions of variability in two quasars (at the 3-sigma level).

Ray, Whelan (DIAS, 01B/UKIRT/07): Three nights, UKIRT, Echelle (CGS4), November 2001. *[FeII] Emission from Embedded Protostars*. High dispersion long-slit echelle observations were made of a number of embedded protostars centred on the 1.64 micron [FeII] line. This was to see whether they have distinct high and low velocity outflow components as is the case with their more evolved counterparts, the classical T Tauri stars. Excellent results were obtained.

5.4 The case for an Irish ESO membership

Following discussions with astronomical staff in Ireland, held at Dunsink over the past couple of years, E.J.A. Meurs prepared a document with background information on a possible Irish membership of the European Southern Observatory (ESO). The information was submitted to a group of science policy consultants from Georgia Tech (USA) that had been commissioned by the Government to evaluate the potential Irish interest in four European collaborative scientific organizations (ESO, CERN, EMBL, ESRF). The final report of these consultants recommends that Ireland investigates ways to join ESO. Facilities at ESO's observatories in Chile that are being built, will be built soon or are planned, are expected to dominate observational astronomy in a few years from now.

6 SEMINARS, COLLOQUIA, LECTURES

6.1 Statutory Public Lecture

A. Fabian (Institute of Astronomy, Cambridge, UK) delivered the Annual Statutory Public Lecture for the School of Cosmic Physics. The lecture, which was entitled *The Search for Supermassive Black Holes in Galaxies* took place in UCD on 13 November. The lecture, which attracted a record audience of around 130 persons, was included in the programme for the National Science Week.

6.2 Seminars and Open Lectures in the School

E. Benton (University of San Francisco, USA): *Passive Dosimetry on the Russian Mir Station: A Preview of ISS,* 02 May.

M. Burton (DIAS and the University of New South Wales): *Our Place in the Cosmos,* 02 November.

J. Ellis (Theory Division, CERN): *Beyond the Standard Model of Particle Physics,* 3l May.

A. Fernandez-Soto (Brera Observatory, Milan, Italy): *Photometric redshifts: Overview and applications,* 27 November.

J.D. Fiege (Canadian Institute for Theoretical Astrophysics, Toronto, Ontario): *Star Formation in Magnetized Molecular Clouds,* l8 January

E. Houdebine (Armagh Observatory, NI): *Solar and Stellar Flares: Constraints from optical spectroscopy,* 21 August.

R. Keegan (Trinity College, Dublin): *Parallesisation methods for computational simulations of Jets from Young Stellar Objects,* 11 January.

G. Mackenzie (DIAS): *"Impact Cratering",* 01 March

A. McMurry (Institute of Theoretical Astrophysics, Oslo University, Norway): *Modelling the outer atmosphere of Alpha Tau,* 21 June.

D. Ward-Thompson (Cardiff University): *The Earliest Stages of Star Formation,* 30 November (jointly with TCD Physics Department).

A set of lectures was presented at Dunsink Observatory on 23 October, as a thematic colloquium on "The Nuclei of the Nearest Galaxies":

A. Eckart (Cologne, Germany): *The Galactic Centre*.

E.J.A. Meurs (Dunsink): *The cores of M32 and further LG members.*

J. Cunniffe (Dunsink): *The candidate nuclear flare in M89*.

B. O'Halloran (UCD): "*Nuclear emission from the WR galaxy in the interacting group NGC7714/7715*.

K.-H. Mack (Dwingeloo, the Netherlands): *On-going work by the CERES collaboration and on nuclear mega-masers*.

In the series of informal internal seminars at Dunsink Observatory the following talks were presented during the year:

M. Carr: *Design concept for an X-ray mission,* 21 March.

F. Zerbi (Brera Observatory, Milan): *Rapid Eye Mount telescope,* 27 March.

J. Cunniffe: *Tools for Data Intensive Searches in Astronomy,* 28 March.

L. Norci: *Set-up of high-energy population synthesis programme: single stars,* 09 May.

M. Carr: *Grids to convert ROSAT Hardness Ratios to spectral parameters,* 06 June.

C. Laver (TCD): *GRBs, Open Clusters and Dusty Desert Telescopes,* 13 June.

J. Cunniffe: *RASS data reduction with EXSAS,* 01 August.

M. Carr: *Exploiting ROSAT PSPC spectral temperature information on EMSS galaxy clusters,* 28 November.

6.3 Presentations to Scientific Meetings

T.A. Blake: *A detailed receiver function study of the Hawaiian Plume Conduit,* European Geophysical Society 26th General Assembly, Nice, 25-30 March; *A detailed receiver function study of the Hawaiian Plume conduit,* American Geophysical Union Fall Meeting, 10-14 December, San Francisco.

M. Burton: *Science with Antarctic Infrared and Sub-millimetre Telescopes,* 3rd International Conference on Astrophysics at Dome C, Antarctic Division, Hobart, Australia, 28-29 June; *Hot Molecular Cores and the Earliest Stages of Massive Star Formation,* Astronomical Society of Australia Annual Meeting, Lorne, Victoria, Australia, 02-04 July; *Ecosystems, from Life to Planets to the Galaxy,* Astrobiology Workshop, Macquarie University. Australia, 12-13 July; *Infrared Astronomy in Antartica,* Astronomical Science Group of Ireland, 07 September.

J. Cunniffe: *X-ray variability of M89,* The Astronomical Science Group of Ireland (ASGI) Autumn Meeting, Armagh Observatory, UK, 07 September; *The candidate nuclear flare in M89,* Colloquium on "The Nuclei of the Nearest Galaxies", Dunsink Observatory, Ireland, 23 October.

J. Donnelly: *The Abundances of Actinide Nuclei in the Cosmic Radiation as Clues to Cosmic-Ray Origin*, The27th International Cosmic Ray Conference, Hamburg, 07-15 August.

L Drury: *Computational Studies of Electron Injection*, The27th International Cosmic Ray Conference, Hamburg, 07-15 August.

G.D. Mackenzie: *The structure of southern Rockall Trough from wide-angle seismic profiling,* Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; *Deep seismic investigation of the Rockall Basin: The RAPIDS 3 project*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *The seismic structure of the southern Rockall Trough from wide-angle profiling*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *RAPIDS 3: Imaging beneath*

the southern Rockall Trough using wide-angle seismics, American Geophysical Union Fall Meeting, San Francisco, 10-14 December; *RAPIDS 3: Seismic stratigraphy of the southern Rockall Basin from wide-angle seismic modelling and normal incidence reflection data*, American Geophysical Union Fall Meeting, San Francisco, 10-14 December.

E.J.A. Meurs: *Changes in awareness of the surrounding Universe*, Conference on "Cosmology through Time", Rome, Italy, 18-22 June; *X-ray examination of runaway stars*, The Astronomical Science Group of Ireland (ASGI) Autumn Meeting, Armagh Observatory, UK, 07 September; *The cores of M32 and further LG members*, Colloquium on "The Nuclei of the Nearest Galaxies", Dunsink Observatory, Ireland, 23 October.

B.M. O'Reilly: *A model for the growth of a carbonate mound population incorporating biological and current flow processes*, European Geophysical Society 26th General Assembly, Nice, March 25-30; *Glacially controlled variations in slope geomorphology along the eastern margin of the Rockall Trough detected by deep-towed sidescan sonar*, Conference of Irish Geographers, Cork, 3-5 May; *A deep-towed sidescan sonar (TOBI) survey of the margins of the Rockall Trough: Environmental aspects*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *Seabed images from the margins of the Irish Rockall Trough*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *History of a slippery slope: Neogene to Quaternary sedimentary processes on the eastern Rockall margin*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *Controls on submarine canyon development along the eastern margin of the Rockall Trough*, American Geophysical Union Fall Meeting, San Francisco, 10-14 December.

D. O'Sullivan: *LET Spectra at Aircraft Altitudes*, DOSMAX Meeting, IPSN, Paris, France, 13-16 January; *Recent Studies On The Exposure Of Aircrew To Cosmic And Solar Radiation*, Invited talk at The International Conference on Solid State Dosimetry, Athens, Greece, 06-16 July; *LET Spectra at Aircraft Altitudes*, DOSMAX Meeting, Oxford University, UK, 09-11 September; *Charge Spectra in Low Earth Orbit*, International Space Station Conference, Oxford University, UK, 12 September.

T. Ray: *The Propagation of Young Stellar Object Jets: What the Codes Tell Us*, Interstellar Medium Workshop in Honour of John Dyson, University of Leeds, 04-06 January.

P.W. Readman: *Changes in slope failure systematics along the eastern margin of the Rockall Basin*, Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; *The LEGS experiment: A seismic study of the Leinster Granite and its setting within the crust of SE Ireland*, Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; *Glacially controlled slope processes along the eastern Rockall margin in the NE Atlantic, resolved by deep towed sidescan sonar*, European Geophysical Society 26th General Assembly, Nice, March 25-30; *A deep-water carbonate mound population in the Rockall Trough: the role of the bottom currents on growth processes*, Conference of Irish Geographers, Cork, 03-05 May; *Gravity modelling across the Porcupine Basin: insights into crustal structure*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; *Images of slope failure along the glaciated eastern margin of the Rockall trough from TOBI sidescan sonar*, Ireland's Deep Water Frontier: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September. *Gravity variations in the Rockall and Porcupine basins west of Ireland: evidence for a linked structural development*, American Geophysical Union Fall Meeting, San Francisco, 10-14 December.

E. van der Swaluw: *Supernova Remnants, Pulsar Wind Nebulae and their Interaction*, The Astronomical Science Group of Ireland (ASGI) Spring Meeting (Cork, Ireland), 23 March; *Nonthermal X-ray emission from young Supernova Remnants*, The27th International Cosmic Ray Conference, Hamburg, Germany, 07-15 August; *Rejuvenating Shells of Supernova Remnants by Pulsar Winds*, Workshop on "Neutron stars in Supernova Remnants", Boston, USA, 14-17 August; *Pulsar Wind Bubble Evolution*, The 12th TMR Workshop, Santorini, Greece, 01 October.

6.4 External Seminars

T.A. Blake: *Irish Geology and Seismology*, GFZ, Potsdam, 11 June.

M. Burton: *Astronomy in Antarctica*, Royal Observatory Edinburgh, 26 April; *Astronomy in Antarctica*, University of Kent at Canterbury, 1 May; *Comparing the Optical Universe to the Infrared*, University of Kent at Canterbury, 2 May; *Photo-dissociation Regions*, European Southern Observatory, Chile, 14 August; *Astronomy in Antarctica*, European Southern Observatory, Chile, 17 August; *Hot Molecular Cores and the Earliest Stages of Star Formation*, European Southern Observatory, Chile, 22 August.

L Drury: *Computer GRID(s) and Ireland*, Invited talk at HEAnet's first National Networking Conference, Tipperary Institute, Thurles, 15-16 November.

T. Lery: *Revisited History of Flows during Star Formation*, Max Planck Institute for Astronomy, Heidelberg, 14 February; *Outflows During Star Formation*, Meudon Observatory, 21 March; *Models for Magnetized Winds*, University of Turin, 23 March; *Models for Magnetized Winds*, Lyon Observatory, 24 March; *Outflows During Star Formation*, Grenoble Observatory, 28 March; *Outflows During Star Formation*, Marseille Observatory, 31 March; *Models for Star Formation*, Tübingen, 24-27 April; *Star Formation in Magnetized Molecular Clouds*, Saclay, 12-15 June; *Effects of Magnetic Fields During a Star's Lifetime*, Montpellier, 16 June.

E.J.A. Meurs: *The cores of Local Group galaxies and the prevalence of nuclear activity in galaxies*, Astronomical Institute, University of Innsbruck, 02 March; *Cores of Local Group galaxies at X-rays: searching for the nearest supermassive black holes*, Brera Observatory, Milan, Italy, 29 May.

B.M. O'Reilly: *Marine geophysics in the wild North Atlantic: insights into geological processes*, Trinity College lunchtime "Brown Bag" Seminar, 08 February; Presentations to the Rockall and Porcupine Studies Groups, various dates.

T. Ray: *Exploring the Central Engines of Young Stars*, John Moores University, Liverpool, 7 November; *From Protostars to Planets*, NUI, Maynooth, 7 December

P.W. Readman: Presentations to the Porcupine Studies Group, various dates.

6.5 Lecture Courses

L Drury: Lecture Course 343 (*Astrophysical Gas Dynamics*) in the Department of Mathematics, TCD, during Michaelmas term.

E.J.A. Meurs: Lecture course of nine hours on *Physics of Galaxies* at TCD during Hilary Term; Lecture entitled *The Universe: a Laboratory of Extremes*, a one-hour contribution as part of a four hour introductory "What is Physics" lecture series for first year Theoretical Physics students at TCD. Guidance provided for the research project of a fourth year (astro)physics student from TCD.

L. Norci: Course of nine lectures on *Stellar Structure and Evolution* in TCD during Hilary term.

T.P. Ray: Lecture Courses entitled *Galaxies: from the Milky Way to Quasars* (to Junior Sophister students) and *The Interstellar Medium* (to Senior Sophister students) at the Department of Physics, TCD, during Hilary Term.

L. Drury (two hours), E.J.A. Meurs (four hours) and L. Norci (one hour), with Dr M. Cawley (Maynooth; one hour): Joint course of eight hours on *Topics in High-energy Astrophysics* at TCD during Michaelmas term.

6.6 Popular Lectures

M. Burton: *Astronomy in Antarctica*, Irish Astronomical Association, Belfast, 19 September; *Astronomy in Antarctica*, Irish Astronomical Society, Dublin, 8 October; *Our Place in the Cosmos*, NUI, Galway, 2 November; *Our Place in the Cosmos*, Virginia, County Cavan, 29 November; *Our Place in the Cosmos*, School of Philosophy and Economic Science, Drogheda, 1 December; *Our Place in the Cosmos*, John Scottus School, Dublin, 21 December.

I. Elliott: Presentation on Teaching Junior Certificate Astronomy, H.Dip.Ed. course, UCD, 23 January; Lecture on "Cosmic Explosions" at the COSMOS meeting of the Tullamore Astronomical Society, Tullamore, 24 March.

E.J.A. Meurs: *Runaway Stars*, Irish Astronomical Society, 23 April; *Modern views of Stars and Galaxies*, Blanchardstown Library, 21 November (as part of their National Science Week activities).

7 ORGANISATION OF MEETINGS AND PUBLIC FACILITIES

7.1 Workshop on Star Formation

An intensive mini-workshop, organised by T. Lery and entitled *Star Formation; from Theory to Observation*, was held in 5 Merrion Square from 06 to 10 August 2001. It was attended by ten participants from Europe and North America, in addition to local participants. The main goal of the meeting was to review the current understanding of outflow phenomena associated with star formation and to initiate new international collaborations in this area in anticipation of advances in the areas of cluster and grid computing. The main focus was on the study of non-relativistic magneto-hydrodynamic (MHD) jets and outflows. This includes the launching of the flow, its collimation, propagation, stability, and its effects on the surrounding medium. Recent advances allow the use of MHD outflow models whose properties depend directly on those of the emitting source. Ultimately the models and the simulations will be compared with observations of Young Stellar Objects (and Planetary Nebulae).

7.2 Thematic Colloquium

An international thematic colloquium on "The Nuclei of the Nearest Galaxies" was organised to take place at Dunsink Observatory on 23 October. Details of the programme are given in section 6.2.

7.3 Dunsink Open Nights, Visitor Facilities and Public information

The interactive Visitors' Facility in Dunsink Observatory continued to attract groups (from schools and otherwise). Open Nights for the general public were held twice monthly during the winter half year, led by W. Dumpleton. Members of the Irish Astronomical Society provided organizational support on these evenings. Information services included, amongst other issues, viewing data for satellites, background to various celestial phemomena and precise timings for sunrise and sunset, Lighting Up Times, beginnings of seasons and changes between winter- and summer times. Trial observations were made with a Celestron telescope in the restored dome on top of the main building. Appropriate equipment was prepared for taking part in an international observing campaign of a stellar occultation by one of Uranus' moons (Titania) in September, but weather conditions inhibited observations from Dunsink (B. Jordan, W. Dumpleton, M. Smyth).

8 EXTERNAL WORK

8.1 Astronomy Section

M. Carr: The Astronomical Science Group of Ireland (ASGI) Spring Meeting, CIT, Cork, 23 March.

J. Cunniffe: The Astronomical Science Group of Ireland (ASGI) Spring Meeting, CIT, Cork, 23 March; The Astronomical Science Group of Ireland (ASGI) Autumn Meeting, Armagh Observatory, UK, 07 September.

I. Elliott: CERN, Geneva, Switzerland, 11-13 May.

E.J.A. Meurs: European Southern Observatory, Garching, Germany, 01-03 March; Brera Observatory, Milan - Merate, Italy, 27-30 May; Conference "Cosmology through Time", Rome, Italy, 18 - 22 June; The Astronomical Science Group of Ireland (ASGI) Autumn Meeting, Armagh Observatory, UK, 07 September; REM Science Team Meeting, Brera Observatory, Milan, 17-18 October.

B. Jordan: Abastumani Astrophysical Observatory, Georgia, 12-18 January; CCD Software Requirements Meeting, CIT, Cork, 23 March; REM Camera Engineering Start Up Meeting, Brera Observatory, Milan, and Rome Astronomical Observatory, Monte Porzio, Italy, 08 - 16 May.

8.2 Astrophysics Section

M. Burton: Royal Observatory Edinburgh, 26 April; University of Kent at Canterbury, 01-02 May; The 3rd International Workshop on Astrophysics at Dome C, Hobart, Australia, 28-29 June; Astronomical Society of Australia Annual Meeting, Victoria, Australia, 02-04 July; Mobra Telescope, Coonabarabran, Australia, 05-11 July; Astrobiology Workshop, Macquarie University, Australia, 12-13 July; Conference on *The Early Stages of Massive Star Formation*, Boulder, Colorado, 06-08 August; European Southern Observatory, Santiago, Chile, 14-22 August; Australia Telescope Compact Array, Narrabri, Australia, 27 August – 02 September; Astronomical Science Group of Ireland, Armagh, 07 September.

J. Donnelly: The 27th International Cosmic Ray Conference, Hamburg, Germany, 07-15 August; The 12th Maryland Annual Astrophysics Conference (Two Years of Science with Chandra), Washington DC, USA, 05-07 September; X-Ray Astronomy School, NASA Goddard Space Flight Center, USA, 10-12 September.

L. Drury: APP network workshop, Savigny-les-Beaune, France, 23-26 Jan; NUI-G, discussions of PRTLI appplication, 2 March; EU proposal writing, Intitute d'Astrophysique, Paris, France, 26-28 March; HESS consortium meeting, College de France, Paris, France, 09-11 May; Thesis examination, University of Utrecht, The Netherlands, 05-07 June; Management Committee, Armagh Observatory, 20 June; International Cosmic Ray Conference, Hamburg, Germany, 06-15 August; Collaboration with J Kirk and colleagues, MPI fuer Kernphysik, Heidelberg, 15 Aug - 01 Sep; Fachbeirat meeting, MPI fuer Kernphysik, Heidelberg, 24-28 Sep; HESS Consortium meeting, Schloss Ringberg, Germany, 04-08 Nov; HEAnet national networking meeting, Tipperary Institute, Thurles, 14-16 Nov.

E. Flood: DOSMAX Meeting IPSN, Paris, France, 13-16 January; DOSMAX Meeting Jesus College, Oxford, UK, 09-11 September; Detector Calibration Exposures at CERN, Geneva, Switzerland, 06-10 October.

T. Lery: Max Planck Institute for Astronomy, Heidelberg, 11-16 February; Meudon Observatory, 21 March; University of Turin, 22-23 March; Lyon Observatory, 24 March; Grenoble Observatory, 28 March; Marseille Observatory, 31 March; Tübingen, 24-27 April; Saclay, 12-15 June; Montpellier, 16 June.

F. McGroarty: Isaac Newton Telescope, Canary Islands, 8-18 February; Astronomical Science Group of Ireland, Cork Institute of Technology, 23 March; NEON Observing Summer School, Observatoire de Haute-Provence, France, 09-21 July; Astronomical Science Group of Ireland, Armagh, 07 September.

D. O'Sullivan: DOSMAX Meeting IPSN, Paris, France, 13-16 January; EURADOS Working Group Meeting, Braunschweig, Germany, 24-28 January; CERN Campaign Meeting, CERN, Geneva, Switzerland, 17-20 March; International Conference on Solid State Dosimetry, Athens, Greece, 06-16 July; The 27th International Cosmic Ray Conference, Hamburg, Germany, 08-13 August; DOSMAX Meeting Jesus College, Oxford, UK, 09-11 September; International Space Station Conference, Jesus College, Oxford Oxford University, UK, 12 September; Space Weather and Solar Cycle Euro Conference, Naples, Italy, 24-29 September; Detector Calibration Exposures at CERN, Geneva, Switzerland, 08-10 October.

T.P. Ray: Workshop on the *Interstellar Medium* in Honour of John Dyson, University of Leeds, 04-06 January; Royal Astronomical Society, London, 12 January; Isaac Newton Telescope, Canary Islands, 08-18 February; Astronomical Science Group of Ireland, Cork Institute of Technology, 23 March; National Astronomy Meeting, Cambridge, 02-07 April; Workshop on *The Origins of Stars and Planets: The VLT View*, European Southern Observatory, Garching, 23-27 April; PATT, Swindon, 10-11 June; NGST MIRI Meeting, ESTEC, Noordwijk; 03 July; Astronomical Science Group of Ireland, Armagh, 07-08 September; United Kingdom Infrared Telescope, Mauna Kea, Hawai'i, 27 October – 05 November; Liverpool John Moores University, 07 November; NUI, Maynooth, 07 December; Royal Astronomical Society, London, 14 December.

E. van der Swaluw: Collaboration meeting, The Astronomical Institute, Utrecht University, The Netherlands, 01-09 March; The Astronomical Science Group of Ireland (ASGI) Spring Meeting (Cork, Ireland), 23 March; Collaboration meeting, The Astronomical Institute, Utrecht University, The Netherlands, 16 May - 11 June; Collaboration meeting, Centre de Spectromtrie Nuclaire et de Spectromtrie de Masse, Orsay, France, 12-14 June; The 27th International Cosmic Ray Conference, Hamburg, Germany, 06-13 August; Workshop on "Neutron Stars in Supernova Remnants", Boston, USA, 14-17 August; The 12th TMR Workshop, Santorini, Greece, 29 September -03 October.

J. Walsh: Heanet Conference, Tipperary Institute, November; Annual meeting of the Irish Association for High Performance Computing (IAHPC), Trinity College Dublin, December.

E. Whelan: United Kingdom Infrared Telescope, Mauna Kea, Hawai'i, 27 October – 05 November.

8.3 Geophysics Section

T.A. Blake: Demobilisation and retrieval of seismic instruments, Hawaii, 01-12 May; Visit to GFZ Potsdam

for Hawaiian seismic data analysis, 09-13 June; Win2000 System Administration Course, Dublin, 12-16 November.

C. Horan: Gravity tutorial at Dublin Institute for Technology, Bolton Street, 14 March; Survey Ireland Conference, 27 March; Demobilsation and retrieval of seismic instruments, Hawaii, 1-15 May.

K. McGrane: Irish Geological Research Meeting (IGRM-44), Coleraine, 25-27 February; Ireland's Deep Water Frontier Conference: Results from the Petroleum Infrastructure Programme (PIP), 12-13 September, Dublin.

G.D. Mackenzie: Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; Petroleum Infrastructure Meeting, Dublin, 22 March; RSG (Rockall Studies Group) Technical Forum, Dublin, March ??; National Seabed Technical Advisory Committee, Dublin, 8 May; Ireland's Deep Water Frontier Conference: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September, American Geophysical Fall Meeting, San Francisco, 10-14 December.

B.M. O'Reilly: Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; Post Carboniferous Structural Geology Seminar, Dublin, 14 March; Petroleum Infrastructure Technical Forum, Dublin, 22-23 March; European Geophysical Society Meeting, Nice, 25-31 March; PSG Workshops and Meetings, Dublin, 25-26 April, 11 July; Conference of Irish Geographers, Cork, 3-5 May; Visit to Phillips Petroleum, Woking, 3-6 July; Visit to RV Atlante, Foynes, 15 August; Ireland's Deep Water Frontier Conference: Results from the Petroleum Infrastructure Programme (PIP), Dublin, 12-13 September; EURESCO Deep Earth Conference, Oporto, 15-21 September; Recent Developments in Seabed Mapping seminar, Galway, 17 October; Porcupine Studies Group Workshop, Dublin, 13 November; National Seabed Survey Seminar, Dublin, 16 November; Porcupine Studies Group Workshop, 5 December; American Geophysical Fall Meeting, San Francisco, 10-14 December.

L. Quigley: Survey Ireland Conference, 22 May; GIS Ireland meeting (IRLOGI), 2 October; Demobilisation and retrieval of seismic instruments, Hawaii, 01-12 May.

P.W. Readman: Irish Geological Research Meeting (IGRM-44), Coleraine, 23-25 February; Post Carboniferous Structural Geology Seminar, Dublin, 14 March; Petroleum Infrastructure Technical Forum, Dublin, 22-23 March; European Geophysical Society Meeting, Nice, 25-31 March; PSG Workshops and Meetings, Dublin, 25-26 April, 6 July, 11 and 26 July; Conference of Irish Geographers Cork, 3-5 May; Visit to RV Atlante, Foynes, 15 August; Ireland's Deep Water Frontier Conference: Results from the Petroleum Infrastructure Programme (PIP), Dublin 12-13 September; EURESCO Deep Earth Conference, Oporto, 15-21 September; Porcupine Studies Group Workshop, Dublin, 13 November; Recent Developments in Seabed Mapping seminar, Galway, 17 October; National Seabed Survey Seminar, Dublin, 16 November; Porcupine Studies Group Workshop, December 5; American Geophysical Fall Meeting, San Francisco, 10-14 December.

9 MISCELLANEA

L.O'C. Drury was invited by the Max Planck Society to serve on the external advisory body (Fachbeirat) of the Max Planck Institute for Nuclear Physics in Heidelberg. The Fachbeirat carried out an evaluation of the Institute from 25-27 September and subsequently communicated its findings and recommendations to the Society.

L.O'C. Drury continued to serve as Vice-Chairman of the *Commission on Cosmic Rays* of the International Union of Pure and Applied Physics and as a DIAS representative on the *National Committee for Astronomy and Space Science* of the Royal Irish Academy.

E.J.A. Meurs served on the National Committee for Astronomy and Space Science of the Royal Irish Academy and as Chairman on the La Palma Advisory Committee. He was appointed Expert Referee for research project evaluations for the Italian Space Agency (ASI).

A.W.B. Jacob continued as a member of the National Committee for Geodesy and Geophysics. He also continued as a Research Associate of University College Dublin.

P.W. Readman continued as Secretary to the National Committee for Geodesy and Geophysics of the Royal Irish Academy. He also continued as a Research Associate of University College Dublin.

T.P. Ray served as the DIAS representative on the National Committee for Physics and continued as President of the Trinity College Astronomical Society. He was also a member of the "Life in the Universe" Committee. This committee ran a competition, aimed at secondary school students, that was jointly sponsored by the EU and European Southern Observatory. In addition the committee also organised a number of public lectures by well-known figures such as the popular science writer John Gribbin, the astro-biologist Chandra Wickramsinge and others in Dublin, Cork and Galway. T.P. Ray has become a Co-Principal Investigator for the Mid-Infrared Imager (MIRI) on board the Next Generation Space Telescope (NGST). MIRI is a joint ESA/NASA supported instrument. T.P. Ray was also made Chairman of the DIAS Partnership Forum.

D. O'Sullivan continued as chairman of the Ireland-CERN Campaign. He had meetings with Prof Maiani, the director general of CERN and Prof John Ellis at CERN in March and arranged for their visit to Dublin in May under the auspices of the Royal Irish Academy. He oversaw the preparation of documents in support of the Irish case and organised several meetings throughout the year. The government decision on the matter was announced in September, namely that further development of particle physics was necessary in Ireland before a commitment to full membership of CERN would be made.

The O'Ceallaigh medal, jointly sponsored by the estate of the late Cormac O'Ceallaigh, the School of Cosmic Physics and the IUPAP commission on Cosmic Rays, was awarded at the 27th International Cosmic Ray Conference in Hamburg to Academician V I Ginzburg to

mark his outstanding contributions to Cosmic Ray physics.

The European launch of ESA's INTEGRAL Awareness Campaign was held in the Royal Irish Academy on 4 October and was addressed by the Minister for Science, Technology and Commerce, Mr Noel Treacy, and by the Director of Science of ESA, Prof. David Southwood. The satellite and in particular its Optical Monitoring Camera were described by the Irish OMC Co-Investigators B. McBreen (UCD) and E.J.A. Meurs.

RTE filmed E.J.A. Meurs at Dunsink (12 May) for a news item on the release of a movie recalling the media coverage of the first Moon landing in 1969 (broadcast 13 May). A Channel 4 television crew visited Dunsink on 05 July to film sequences for science education programmes featuring Prof. Michio Kaku and Mr Adam Hart-Davis.

Dunsink provided national support for the Life in the Universe Competition, organized under the auspices of CERN, ESA and ESO. The National Steering Committee was chaired by I. Elliott, who in May visited CERN in Geneva for a planning meeting of the National Representatives. The purpose of the Competition was to stimulate interest among second level students across Europe about some of the issues raised by the search for extraterrestrial life. The Competition attracted an entry of about 100 Irish students and eight of these were chosen to take part in the Super Contest at CERN (8-11 November).

A group of participants at an international conference of physics students at DCU visited Dunsink on 14 August.

I. Elliott continued as a member of the National Committee for Science and Engineering Commemorative Plaques and as a member of the Science and Technology Committee of the Royal Dublin Society. He also continued as Chairman of the Irish Science Centres Association Network. A reception to mark his retirement was held in Dunsink on 28 September.

One Transition Year pupil spent a week at Dunsink Observatory as part of his Work Experience programme.

I. Elliott and E.J.A. Meurs prepared about twenty certificates of Lighting-Up Time and other astronomical information for legal purposes. I. Elliott also supplied routine information on the positions of the Sun and Moon to architects, sporting organisations and film companies; this service had to be restricted after the retirement of I. Elliott.

I. Elliott completed historical articles on the School of Cosmic Physics, Dunsink Observatory and twelve former directors of Dunsink for The Encyclopaedia of Ireland which will be published in September 2003 by Gill and Macmillan. It will appear in North America under the imprint of the Yale University Press. He also collected historical material for entries on fifteen Irish astronomers which will appear in the Biographical Encyclopedia Of Astronomers to be published by Kluwer Academic Publishers.

Mr G. Daly continued work on the Shortt Free Pendulum Slave Clock, examining in detail the synchronization between the Master Pendulum and the Slave Clock.

C. Horan continued to give a Gravity Practical and Tutorial to Geo-Surveying students at Dublin Institute for Technology, Bolton Street.

B.M. O'Reilly continued on the editorial board of the Irish Journal of Earth Sciences.

L. Quigley continued to edit *Survey Ireland* and the *Institute of Irish Surveyors News (IIS News).*

T. Lery left the Star Formation Group on 30 September to take up a post in Strasbourg.

M. Bridges and C. McGealy, Physics Department, T.C.D. were supervised by T.P. Ray from September to December for their final year astrophysics projects. This involved the installation of a 3-metre radio telescope on the roof of the Old Physics Building in TCD with the aim of carrying out a small 21cm survey of the Galactic Plane. Excellent data was obtained for the Sun but a problem with the super-heterodyne system meant the receiver had to be shipped back to the manufacturer. Fortunately Jodrell Bank and the University of Cardiff obliged by providing survey data to the students.

T.P. Ray supervised Emmet Martin, a Transition Year Student from Belvedere College. He put together a project on measuring the height of craters on the Moon for the Junior Freshman Physics Lab in TCD.

10 PUBLICATIONS

10.1 Refereed Publications

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J. Adams, G. Bashindzhagyan, P. Bashindzhagyan, A. Chilingarian, **L. Drury**, N. Egorov, S. Golubkov, N. Korotkova, W. Menn, M. Panasyuk, D. Podorozhnyi, J. Procureur, T. Roganova, O. Saavedra, A. Sidorov, M. Simon, L. Sveshnikova, **A. Thompson**, A. Turundaevsky, and I. Yashin: *An Instrument to Measure Elemental Energy Spectra of Cosmic-Ray Nuclei up to 10^{16} eV*, Advances in Space Research, Vol 27, pp 829-833 (2001).

C.J. Davis, **T. P. Ray**, L. Desroches & C. Aspin: *Near-Infrared Echelle Spectroscopy of Class I Protostars: Molecular Hydrogen Emission-Line (MHEL) Regions Revealed*, Monthly Notices of the Royal Astronomical Society, Vol 326, pp 524-538 (2001).

J. Donnelly, A. Thompson, D. O'Sullivan, L.O'C. Drury, K.-P. Wenzel: *The cosmic ray actinide charge spectrum derived from a 10m^2 array of solid state nuclear track detectors in Earth orbit*, Radiation Measurements, Vol 34, pp 273-276 (2001).

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J.M. Migliazzo, B.M. Gaensler, D.C. Backer, B.W. Stappers, R.G. Strom, **E. van der Swaluw**: *PSR B1951+32 and SNR CTB 80: Association Confirmed*, Workshop on "Neutron Stars in Supernova Remnants", Boston, USA, 14-17 August 2001 (ASP Conference Proceedings, eds P.O. Slane and B.M. Gaensler).

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