Draft Annual Report 2002 School of Cosmic Physics

1 Research Work

1.1 Geophysics

A substantial amount of work during the year went into the process of finding a successor to the late Brian Jacob as head of the Geophysics Section. An international search committee was established and charged with the task of finding the best available person in the broad area of solid Earth geophysics. The position was widely advertised, but in addition the search committee was asked to actively approach individuals they thought might be suitable and interested. By Autumn the committee was able to produce a shortlist of six outstanding candidates. These were invited to Dublin to visit the Institute and give presentations about their work to the staff and representatives of the Universities and the Geological Survey on Thursday 14 November. The next day they were all interviewed by the search committee at the end of which the committee unanimously recommended to the Governing Board that it nominate Alan Menzel-Jones as the new senior professor and head of the Geophysics section. This recommendation was adopted by the Board at its meeting on 20th November and communicated to government. During the course of the year the routine administration of the Geophysics section continued to be ably carried out by the acting head of section, Peter Readman.



Figure 1: Location of stations for the ISLE experiment; the DIAS mobile stations are indicated in red, the Karlsruhe stations in blue and the DIAS permanent stations in black

1.1.1 ISLE (Irish Seismic Lithospheric Experiment)

V. C. Do, P. W. Readman and B. M. O'Reilly with Geophysics staff

This teleseismic project is designed to detect evidence of seismic anisotropy in the upper mantle below southwest Ireland. A particular focus is to investigate a result from the VARNET96 experiment in which anomalous traveltime residuals recorded from events in China and the Aleution Islands were found to spatially coincide with the surface trace of the Caledonian Iapetus Suture Zone. Planning the deployment pattern for the seismometers and obtaining permission from land owners started during the late summer and the final DIAS instrument deployment was complete by early December. Figure 1 indicates the location of the fourteen DIAS broadband seismic instruments.

The main technique being used will look for a possible traveltime difference in the arrival of the orthogonal horizontal components of converted S-waves from the core-mantle boundary, originating from earthquakes at 70-120 degree epicentral distance. These converted waves have a relatively low amplitude but have the advantage that source effects are not important. A deployment time of 9-12 months is planned as it is necessary to have records from many large (greater than about magnitude Mb 5.5) earthquakes. At most sites the disk change is being performed by the landowner who posts the disk back to Dublin for data extraction. The initial data collected indicates that most sites are recording well with little problem from cultural noise.

Suitable recording sites were found with the assistance of local Teagasc advisers and DIAS would like to thank Teagasc for this considerable help. Many thanks are also due to the landowners, who in most cases are changing the data disks from the recording instruments and posting them back to DIAS.

1.1.2 LEGS (LEinster Granite Seismics)

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

Following the completion of the 2-D wideangle seismic study of the Leinster Granite, a 3-D study using the data from this experiment has been initiated. The in-line data used in the 2-D study comprises only about one-third of the total data volume collected, the remaining twothirds of the data comprising off-line fan shots which can yield information on the 3-D structure of the region. To ascertain the feasibility of such a study the off-line data were processed and plotted to assess their quality. In addition, all data (both on and off-line) were inspected for the presence of shear-wave energy from P-to-S conversions which can provide valuable information on Poisson's ratio and the petrology of the crust and granite body. The indications are that much of the the data are of very high quality indicating that a 3-D study of the Leinster region, similar to that carried out for SW Ireland, but also incorporating the S-wave data, would be practical. The LEGS project was funded by a Basic Research Grant from Enterprise Ireland with additional funding provided by DIAS.

1.1.3 TRIM (TOBI Rockall Irish Margins)

B. M. O'Reilly and P. W. Readman with B. Austin (Hydrosearch Associates Ltd)

A report describing work undertaken with Bryn Austin of Hydrosearch was completed. This outlined the results of a careful interpretation of the upper portion of existing exploration 2-D seismic data from the eastern margins of the Rockall Trough, west of counties Donegal and Mayo. The region was selected on the basis of the TOBI deep sonar data gathered during the TRIM (TOBI Rockall Irish Margins) survey, notably the presence of complex slope failure structures associated with large-scale submarine canyon systems discovered during our earlier work (GLORIA and TRIM surveys). The aim of the present work was to identify and define the extent of individual slope-failure features and canyons by integrating the side-scan data with the seismic stratigraphic interpretation. It was hoped to constrain the 3dimensional geometry of the features and to evaluate the likely tectonic and palaeoclimatic controls on their formation. The investigation used the large RSG (Rockall Studies Group) seismic database of about 7000 line-km as well as available gravity core and borehole data for the region. Emphasis was placed on understanding the Neogene stratigraphical development of the margin using an established regional seismic stratigraphy constructed by other members of the RSG. The investigation successfully identified and mapped the 3-dimensional geometry of several important features critical in understanding the stability and geological development of the northeast Rockall region particularly during the Tertiary to recent timescale. A broad relative chronology of slope failure and mass flow events, related to subsidence/uplift cycles and eustatic sea-level change along the margin, was established. The work indicated that future progress in this area of research can only be made if the entire depositional system from basin plain in the Rockall Trough to the sediment catchment areas onshore and to the east of Ireland are incorporated in a regional study. This approach has the potential of providing an absolute time-scale for the geological development of the entire depositional system in the NE Rockall Trough and an insight into the causative geo-dynamic and climate controls. This work is funded with the assistance of the RSG of the Irish Petroleum Infrasructure Programme (PIP).

1.1.4 RAPIDS 3 (Rockall And Porcupine Irish Deep Seismics)

G. D. Mackenzie with P. M. Shannon and N. C. Morewood of UCD

The final phase of this stage of the wide-angle model development was completed in the early part of the year. This involved a preliminary analysis of converted S-waves and P-wave multiples of various types within the sedimentary and crustal layers. The results indicate that a significant amount of additional information could be extracted which would enable the present models, which are largely based on primary P-wave energy arrivals, to be refined. A comprehensive report for the RSG was prepared describing the acquisition, processing, modelling and interpretation of the RAPIDS 3 data. Further work will be continued on this data during the HADES (HAtton Deep Seismic) projects which will commence in 2003. RAPIDS 3 is funded by the RSG of the PIP.

1.1.5 Porcupine Basin Potential modelling

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

The Porcupine Basin is a large sedimentary basin to the southwest of Ireland that formed in response to multiple continental rifting episodes which also controlled basin subsidence in the neighbouring Rockall and Celtic Sea basins. In this project gravity and magnetic modelling along five petroleum industry seismic reflection profiles was carried out using seismic interpretations provided by the Porcupine Studies Group (PSG) of the PIP, and our knowledge of the regional crustal structure in the region. The results show that sedimentary basin and crustal structure change dramatically from north to south along the axis of the basin. The change in structure is sharp and supports earlier work at DIAS which suggests that NW-SE-trending fault systems are important in controlling large-scale structure and basin development in the North Atlantic region. The main feature of our model is a dense body that generates the gravity anomaly high across the basin axis. The distinctive set of NW-SE-trending gravity lineaments are interpreted cross-basin syn-rift faults that control large-scale segmentation of the extensional deformation at mid to upper crustal levels. In our newly developed model lithospheric stretching in the South Porcupine Basin involved a large anticlockwise rotation of the South Porcupine High, while to the north the stretching involved a smaller antipathetic clockwise rotation of the North Porcupine High. The NW-SEtrending fault systems may have been important in focusing fluid flow in the lithosphere causing rheologically controlled serpentinisation of the mantle, inferred from our earlier wide-angle seismic studies in the Rockall Basin. Similar linked rheological and fluid flow processes may also have occurred locally in the Porcupine Basin as coincidently low Pn and Sn seismic velocities in the Rockall Basin appear to be connected by such fault systems with the gravity anomaly high in the Porcupine Basin. This work received partial funding from the PSG. The study forms part

of a regional study of the development of Irish Offshore basins (NABASK: North Atlantic Basin Kinematics).

1.1.6 EAGLE (Ethiopia Afar Geoscience Lithospheric Experiment)

G. Wallace and L. Quigley

The EAGLE experiment is a multi-disciplinary international experiment designed to look at the structure of the Ethiopian and Afar rift systems. The project is being coordinated by the University of Leicester who invited DIAS to participate in the fieldwork related to the controlled seismic source seismology part of the project. During the year some help was given with the site finding and permissioning, and also with a preparatory experiment in November where our expertise in the design and implementation of underwater seismic shots was essential.

1.1.7 The Seismic Network (DNET, DSB and VAL)

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

Maintenance work on the network included repairs to the power supply at DCN (Croghan) in May, replacement of the amplifier-modulator at DMUB (Muff) in June and repairs to the aerial in DCN (storm damage) in July. The repaired 6channel recorder was reinstalled in Lyons Farm (DLF) in October.

The largest onshore event in the UK occurred in Dudley, West Midlands on 22 September, had a magnitude of 4.8ML and a felt intensity of +IV. There were five felt reports here in Ireland and information was forwarded to the British Geological Survey (BGS).

Since the morning of 21 October a relatively large number of earthquakes have been felt in the Greater Manchester area in the UK. More than 100 earthquakes (an earthquake "swarm") were recorded by the BGS, of which most were reported as being felt. The first felt earthquake occurred on 21 October at 07:45:15 (UTC) and had a magnitude of 3.2 ML. A smaller event at 08:04:58 had a magnitude of 2.3 ML. The largest recorded earthquake of the sequence (magnitude 3.9 ML), which was strongly felt throughout the Greater Manchester area, occurred a few hours later at 11:42:34. Minor damage in the area was reported for this event.

Seismic activity continued in the North Sea with events in January (3.5 ML), February (4.0 ML), August (3.3 ML), September (3.1 ML), October (3.5 ML) and November (3.1 ML). There were felt events in Germany/Netherlands Border Region on 22 July (5.1 ML); Sicily, Italy on 6 September (6.1MW) and northwest France on 30 September (4.5 ML).

The largest earthquake in 2002 was a 7.9 MW in central Alaska on 3 November. One person was injured and there was extensive damage to roads. At least 1000 people were killed, several hundred were injured and several thousand were left homeless following a 6.2 Mb earthquake in the Hindu Kush region of Afghanistan on the 25 March. Landslides blocked many roads in the epicentral area. Other large events that caused fatalities and severe damage occurred in the Afyon Province in Turkey on 3 February, 6.5 MW; Hindu Kush Region in Afghanistan on 3 March, 7.4 MW; Taiwan Region on 31 March, 7.2 Ms; Western Iran on 22 June, 6.5 MW and in Southern Italy on 21 October, 5.9 MW. Large events from depths greater than 550 km occurred in Fiji on the 19 August (7.6 MW and 7.7 MW) and on the Russia-China Border on the 28 June (7.3 MW).

There were the usual requests for general information on earthquakes from the public and requests to check records for possible events.

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

Broadband digital seismic station (DSB) The

DSB broadband station continued to function well throughout the year with only minor maintenance required.

1.2 Astronomy

1.2.1 Gamma Ray Burst Afterglows

E.J.A. Meurs, B. Jordan, M. Smyth, and L. Norci with B. McBreen (UCD), F. Zerbi (Brera Observatory, Milan, I), P. Collins (DIT) and C. Rebelo (TCD)

In a collaboration led by Brera Observatory (Milan-Merate, Italy), Dunsink Observatory participates in placing an automatic instrument, the REM (Rapid Eye Mount) Telescope, at ESO in Chile that primarily will search for afterglows of Gamma Ray Bursts. The instrument features an electronic camera controller that is supplied by Dunsink Observatory.

The Readout and Control electronics system for the Near-InfraRed Camera for the REM Telescope were tested at the InfraRed Labs facility at Tucson, Arizona. The design for this system is based on the San Diego State University standard CCD control electronics. The tests revealed that some modification to the Analog Electronics would be desirable. An improved Correlated Double Sampling, Pre Amplifier and bias potential circuitry was developed to optimize signal-to-noise ratio characteristics of the system for the Rockwell Near-InfraRed Array detector. This version of the Analogue Electronics will be installed in the camera head during the final acceptance tests when the system is integrated with the telescope at Brera Observatory. The initial test exercises were carried out using the San Diego State University CCD control software, which was adequate for the first development phase of the project. However, new software specific to the improved Analogue Electronics and REM Telescope Operating System is being developed. Control Electronics and software for the Leybold cryogenic cooling system for the camera head have also been developed. Final acceptance tests of the complete system scheduled for October had to be postponed because of delays in delivery dates of the Rockwell detector array and the Leybold cryogenic components. There delays were mainly due to restrictions on exports imposed on American manufacturers of high technology components by the US State Department's new stringent security measures. Final acceptance test is now scheduled to take place at the Brera Observatory in Milan-Merate during the first quarter of 2003. On completion of these tests the whole system will be transported to ESO, Chile and installed in a purpose-built dome at the La Silla site.

UCD in collaboration with Dunsink secured an Enterprise Ireland International Collaboration grant of 8000 Euros that covered most of the travels abroad in connection with the REM project participation.

A review of upper limit measurements to Gamma Ray Burst optical afterglows was conducted in preparation for an interpretative population model computer experiment. The simulations carried out with this computer model demonstrate that many Gamma Ray Bursts must be very faint or even completely dark. Some bursts with afterglows may on the other hand exhibit additional flares in the very beginning of the burst, which led to a project on the performance of CCD- and video cameras for this particular purpose, employing instrumentation at Dunsink. Another aspect of Gamma Ray Burst afterglows that was investigated concerns the applicability of various types of Supernova lightcurves for the bumps observed on several afterglow decays.

A project to use the UVES instrument on one of the ESO VLT Unit Telescopes for detailed spectroscopy of bright GRB Afterglows was activated two times. The data obtained in each case provide a detailed record of intervening and near- source absorbing material.

1.2.2 The cores of Local Group galaxies

E.J.A. Meurs

A few details of the analysis of a couple of ROSAT observations of the Local Group member Leo A were sorted out. The overall result is a useful upper limit on a possible central high-energy core source.

1.2.3 Flares in normal galaxy nuclei

J. Cunniffe and E.J.A. Meurs

The ROSAT All-Sky Survey data archive was examined to search for faint flares from normal galaxy nuclei which may have been missed by previous examinations. Such flares are expected to signal the disruption of a star on a close flyby of the galactic nucleus. After reprocessing of the archive data, upper limit fluxes were determined for ca. 10**5 galaxies from the LEDA database and compared with detections from the ROSAT pointed observations, which refer to a later epoch. None of the ca. 10**3 galaxies with pointed detection display unexpected variability and this determination lowers the upper limit on the stellar disruption flaring rate by an order of magnitude from a previous study.

In the course of the detailed X-ray variability study of the candidate nuclear flare galaxy M89, a few issues concerning data reduction and analysis seemed worth investigating further, in particular the effects of a small clock error on the image and the flux definition. Techniques were developed for assessing the spacecraft attitude error component for faint sources. These methods allow a determination of the level of broadening in the data but are not sufficiently accurate to de-blur the image.

1.2.4 X-ray study of an IRAS galaxy sample

E.J.A. Meurs with S. McGlynn (TCD)

Galaxies that were found to be strong emitters at infrared wavelengths during the all-sky survey of the IRAS satellite are called IRAS galaxies. Their strong infrared emission is normally the result of strong starformation or nuclear activity, or both. Therefore they are objects that are of interest for studying relationships between active nuclei and evolving, young stellar populations.

A substantial number of IRAS galaxies was detected at X-rays in the ROSAT All-Sky Survey. At these high energies the emission from the galaxies provides important clues as to the origin of the emission, viz. stellar population or nucleus. The All-Sky Survey detected galaxies have been checked for the existence of subsequent pointed data, which are of higher accuracy and go deeper in flux, and the available observations have been analysed. The resulting data for about 70 of these objects can now be used for the improvement of earlier discussions and interpretations of the Xray properties of IRAS galaxies and for the selection of interesting targets for new observations.

1.2.5 Galaxy Clusters

M. Carr, L. Norci and E.J.A. Meurs with L. Feretti (IRA, Bologna, I)

Around 20 of the galaxy clusters that had been recognized in the Einstein X-ray satellite Extended Medium Sensitivity Survey have been observed with the Position Sensitive Proportional Counter (PSPC) of the ROSAT X-ray satellite. The spectral information provided by the PSPC detector had 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. On the basis of the ROSAT PSPC data we have been examining the validity of such a standard temperature assumption. While some variety of spectral temperatures is encountered, better temperature determinations (derived with data from the ASCA satellite) exist for about seven of the clusters, which show that several of the ROSAT temperatures will be too low, due to the restricted energy window of ROSAT. This also shows that instead of making spectral fits for individual clusters, another method - iteration in a luminosity-temperature relation for galaxy clusters – is to be preferred.

Along with the spectral analyses, radial brightness profiles were modelled for each cluster, yielding values of slope parameter and core radius. A recently proposed X-ray isophotal size versus temperature relationship was found not to be real, probably as a result of the limited number of clusters included in that work.

A software tool that had been developed for evaluating high-energy spectral hardness ratios in terms of power law spectra was extended to include also thermal (Raymond-Smith) spectra. These tools will be made available on the Web.

Following the study of X-ray spectral characteristics of the sample of galaxy clusters, a similar investigation has been carried out on the highenergy emission properties of Elliptical galaxies. In this case the ROSAT PSPC determined spectral temperatures give more reliable results since the temperatures are lower than for clusters and fall generally in the energy range covered by ROSAT.

Towards the end of the year a previously started detailed X-ray study of the galaxy cluster A2241 was taken up again and extended to include two more Abell clusters that, like A2241, also contain tailed radio sources. Together with the hot gas seen with X-ray data the radio tails serve as probes of the physical conditions in the intracluster medium.

1.2.6 Infrared Space Observatory observations of Wolf-Rayet and Starburst galaxies

B. O'Halloran with B. McBreen (UCD), L. Metcalfe (Vilspa) and R. Laureijs (ESTEC)

Wolf Rayet (WR) galaxies are those galaxies in whose integrated spectra a broad emission feature at 4686 Angstrom has been detected. This feature has a width (Full Width at Half Maximum) of about 10-20 Angstrom and is a typical signature of WR stars. Though Seyfert galaxies and active galactic nuclei (AGN) generally often show a He II emission line, WR galaxies can be distinguished from them by their relatively narrow nebular emission lines. WR galaxies are found exclusively among emission line (EL) starburst galaxies, where the photoionization of the nebular line is stellar in origin, and possess a very blue continuum which is indicative of a large population of young hot massive stars. The broad HeII emission feature is very prominent in the spectra of Galactic and LMC WR stars, and by comparing the luminosity and width of this feature as it appears in the spectrum of a WR galaxy with the corresponding emission lines that appear in the spectra of Galactic WR stars, an estimate of the number of WR stars in a WR galaxy can be made. After installing the data reduction software, processing and analysis of Infrared Space Observatory images and spectra of several galaxies exhibiting starburst and Wolf-Rayet features was performed, amongst others for the Infrared Luminous galaxy Markarian 297. Initial work on follow-up programs using NASA's SIRTF observatory was also begun.

1.2.7 High-energy studies of starforming regions in extragalactic context

L. Norci and E.J.A. Meurs

At high energies, interesting information can be retrieved about evolving stellar populations and their 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. This year much work has been put into the final, post-mass transfer evolution of binary components, in order to account for the many possible outcomes of these systems. Towards the end of the year a start was made with incorporating rotation-dependent X-ray emission evolution for the individual stars.

The application of the population synthesis programme for a number of case studies proceeds now at a slower rate than before, due to manpower limitations. As a first test of the present code we have turned our attention once again at the giant starforming region 30 Doradus in the Large Magellanic Cloud, for which now a much more meaningful and accurate estimate of high-energy emission is obtained than previously had been possible.

1.2.8 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)

A spectroscopic study of the very young and massive Of supergiant HD15570 has revealed substantial spectral variability on a long timescale (decades) that was unknown for early-type supergiants. The variability is probably linked with stellar wind variations. The results are of interest for several evolutionary problems regarding this type of object. It is clear that each member of the rare, and extremely peculiar, Of supergiants is worth to be monitored continuously. These objects are believed to represent the early evolutionary stage of very high mass stars ($M_o > 40 M_{\odot}$).

1.2.9 Studies of runaway stars

C. Melody, L. Norci and E.J.A. Meurs with M.I. Wilkinson (IoA, Cambridge, UK)

Some massive young stars have been observed far from their places of birth with high velocities. They stars are known as "runaway" stars, resulting from either dynamical gravitational interactions with their neighbours in an early stage of OB group development or due to one member of a close binary system exploding as Supernova.

For the purpose of creating a simplistic general model for runaway production in OB associations, an analysis was made of the feasibility in associating an ejection probability to stars in an OB group and evolving this probability as the group expands. Explorative simulations of OB groups, wich are essential to calculating these probabilities, have been performed with a desktop copy of the state-of-the-art NBODY6 code of S. Aarseth. It is further intended to adapt this code specifically to our problem, in particular to incorporate kick velocities due to Supernova explosion asymmetries. This is important for runaways produced by a Supernova in a binary system, as an extra kick to the companion may disrupt the system and provide an explanation for the apparent absence of compact companions to runaway stars. An investigation into this and other observable affects of asymmetric Supernovae was made as a precursor to creating a computer simulation of kick velocities.

1.2.10 Systematic trends for stellar X-ray Hardness Ratios

E.J.A. Meurs and L. Norci with P. Casey (Maynooth)

Extensive surveys with the Einstein and ROSAT satellites have established that X-ray emission is a common feature of normal stars. The stellar X-ray characteristics separate basically into OB stars, as a result of shocks in their strong stellar winds, and FGKM stars, as a result of coronal processes. These two different processes for X-ray emission in normal stars may be reflected in systematic X-ray spectral differences. A convenient way to characterize the overall spectral shape of X-ray sources is by employing Hardness Ratios (HRs), that compare the emission in a hard part of their spectra to a soft part. We have therefore conducted a comprehensive investigation of stellar HRs on the basis of the ROSAT All Sky Survey. There appears to be a clear systematic effect in the stellar HRs, from late-type dwarfs, via late-type giants to early-type stars. As it turns out, the observed trend in their HRs is however primarily due to differences in line-ofsight absorption, rather than an obvious variation in emission process.

1.2.11 Optical Monitoring Camera for The INTErnational Gamma-Ray Astrophysical Laboratory

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

ESA's INTEGRAL satellite was successfully launched on 17 October 2002 from Baikonur Kosmodrome with a Proton rocket. It was brought into a 72 hour eccentric orbit, with Perigee 9000 km and apogee 155000 km. Primarily a gammaray observatory, it carries also the Optical Monitoring Camera that contains the joint detector contribution by Dunsink and UCD. The event featured on national radio news. Satellite functions and instrument performances are satisfactory, in particular the First Light images from the Optical Monitoring Camera clearly demonstrate that the camera and its electronic system have survived the launch and are operating according to full specification. The first scientific results include the first detections of Gamma Ray Bursts, at the predicted rate of one a month, and a comprehensive observation of a prime target (Cyg X-1) involving all four instruments on board, which was presented by ESA at a press conference on 18 December at ESA Headquarters in Paris.

1.2.12 Northern Hemisphere CCD Camera

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

An Apogee Instruments CCD camera was purchased together with UCD. Tests at Dunsink showed this to be in good working order. It is intended to operate this camera on one of the telescopes of Abastumani Observatory in Georgia, as a Northern Hemisphere facility parallel to the REM Telescope in Chile. Besides Gamma Ray Bursts, an extensive programme of monitoring quasars and blazars is to be carried out. For the use of this camera an earlier acquired filter wheel has been adapted to present-day electronic steering systems. Development of the camera was completed during the year and various practical tests have been carried out using an 8" Celestron telescope mounted in the dome of the main building in Dunsink, including those for the research project on quick-reaction astrophotometry of Gamma Ray Bursts (see 1.2.01).

1.3 Astrophysics

1.3.1 Acceleration in Supernova Remnants

O. Carroll, L. O'C. Drury and E. van der Swaluw

Olwen Carroll completed work on her MSc by examining the implications of the recently proposed Bell-Lucek field amplification mechanism for the shape of the spectrum near the upper cutoff in supernova remnants. Encouragingly preliminary estimates using the box-model formalism indicate that it is possible to rather naturally produce spectra similar to the well-known "knee" in the cosmic ray spectrum.

1.3.2 Pulsar Wind Nebulae and Supernova Remnants

E. van der Swaluw, Turlough Downes (DCU) and Ronan Keegan (DCU)

Simulations have been performed of a pulsar wind, associated with a moving pulsar, which drives a pulsar wind nebula in its surrounding supernova remnant. A hydrodynamics code is used to simulate the several evolutionary stages, as the pulsar wind interacts with its expanding supernova remnant. The goal of the project is to simulate the three different stages of the pulsar wind nebulae. (1) the pulsar wind nebula is expanding supersonically through the freely expanding ejecta of the progenitor star, (2) the expansion of the pulsar wind nebula is not steady due to the interaction with the reverse shock of the supernova remnant, (3) the last stage occurs when the head of the pulsar wind nebula, containing the active pulsar, deforms into a bow shock, due to the supersonic motion of the pulsar. This bow shock structure will interact with the shell bounding the supernova remnant. The results from the simulations will be used to interpretate the several morphologies of observed pulsar wind nebulae.

1.3.3 Superbubbles and particle acceleration

E. van der Swaluw, Etienne Parizot (Orsay) and Alexandre Marcowith (Toulouse)

The physics of Superbubbles, structures blown into the interstellar medium by the combined power of multiple stellar winds and supernova explosions has been examined. We expect that these bubbles significantly contribute to the population of the observed cosmic rays. The main goal of the project is to investigate the differences between particle acceleration in a single supernova remnant and in a superbubble.

1.3.4 The Ultra-Heavy Cosmic Ray Experiment (UHCRE)

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

The actinide events were re-examined and the calibrations cross-checked in preparation for the publication of the final definitive result from this experiment.

1.3.5 Cosmic Ray Dosimetry of Aircrew - the DOSMAX project

D. O'Sullivan, D. Zhou, B. Xu (to July 31 2002), E. Flood

Measurements of primary and secondary galactic cosmic ray linear energy transfer spectra were made in detectors exposed on a British Airways Concorde on the London-New York route in May and July. This data completed an eight year study by DIAS on Concorde at supersonic altitudes starting near solar maximum of solar cycle 22, through the maximum of the cycle 23 which peaked in the period 2000-2002. Evidence of increase in dose equivalent rates was observed as the decrease in solar activity gave way to an increase in intensity of the galactic component. Dose rates were generally more than twice that observed on subsonic aircraft.

Detector exposures on an Air France route between Paris-Tokyo and the polar Paris-Fairbanks-Tokyo route were arranged through collaborators at IRSN, Paris. Data analysis was completed by October. A set of measurements made on Czech Airline route from Prague-Montreal-Toronto in Aug-October 2001 was analysed during the year. This work was arranged through the NPI, Prague who are subcontractors to the DOSMAX project.

All of the above data were collected near the final stages of the solar maximum period and form part of the data base being used to develop and authenticate various computer codes for predicting aircrew doses at subsonic and supersonic altitudes.

Emphasis was placed on the EPCARD programme (new version 3.2) being developed as part of a subcontract with DIAS, by the GSF group in Munich. All route data obtained and measured by the DIAS group was compared with the predictions of V3.2. Excellent agreement was found in most cases, but the supersonic Concorde data showed higher measured values than those predicted. Comparison with the CARI code showed good overall agreement also.

Calibration exposures (for comparison with a standard tissue equivalent proportional counter) were carried out at CERN in July in collaboration with colleagues at NRPB, Oxford.

During the period to Dec 31st 2003, measurements will continue on a number of routes. Global security problems have made negotiations with airlines more difficult but happily, the bulk of the data taking is now completed. Further investigation of detector characteristics and measurement techniques is planned. Overall, however, work will concentrate on collating data from all seven European laboratories and coordinating the final phase of the DOSMAX project.

1.3.6 Investigation of Cosmic Ray Charge Spectrum and Dosimetry in Low Earth Orbit

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

Following the successful exposure of DIAS detectors on Space Shuttle Endeavour (STS-108) in December 2001, the detectors were returned to DIAS in January. This was the twelfth shuttle mission to the International Space Station (ISS). The orbital inclination was 51.6° with an orbital altitude of 390 km. Processing of detectors began in February. Linear energy transfer spectra were measured by investigating signals due to short range recoils from protons, neutrons and heavy nuclear interactions in the detectors as well as tracks due to primary and secondary cosmic ray nuclei. The aim of the measurements is to determine the level of radiation exposure of astronauts in the ISS orbit and to estimate the contribution from protons, neutrons and heavy nuclei which have their origin in cosmic rays, nuclear interactions in the spacecraft wall and payload and the sun. This was also the first attempt to isolate the heavy nuclei contribution in detail. The charge spectrum observed is shown in Fig 2 where it is compared with a spectrum measured on the Russian MIR space station which had similar orbital parameters, and a spectrum calculated by the Siegen group. The DIAS results show very good agreement with the Siegen model, in particular for lower charges such as carbon and oxygen suggesting a higher efficiency of scanning than in the case of the MIR data.

The total dose rate, dose equivalent rate and quality factor observed above the energy threshold of 5KeV/ μ m were 17.2 μ Gy/day, 189.9 μ Sv/day and 11.8, respectively. The DIAS quality factor for higher charged nuclei (13.4) which assumes approximately 20 g/cm² of shielding, shows good agreement with a value calculated, using the Siegen computer code.

The success of this work led to a second invitation from the NASA group at Johnson Space Centre, Houston, to collaborate with them on an



Figure 2: Charge distribution of cosmic rays $(Z \ge 2)$ in low Earth orbit.

experiment launched on board the STS-112 mission in October 2002. Measurement and analysis of this data, which will include investigation of the isotropy of radiation in the ISS orbit will continue well into 2003.

1.3.7 Star formation

T. P. Ray, E. Whelan, F. McGroarty, D. Coffey, A. Graz-Velasquez, J.-K. Lee T. Downes (DCU)

The project searching for evidence of rotation in a number of young stellar object (YSO) jets by using the Space Telescope Imaging Spectrograph (STIS) is advancing and three further systems were observed. The data is currently being analysed in collaboration with Arcetri Observatory (F. Bacciotti, former DIAS postdoc). In December T. Ray and D. Coffey visited Arcetri and D. Coffey spent 3 weeks working on the programme data, as part of her PhD work.

A dynamical study of an explosive bubble observed in HST data on the XZ Tauri binary system is now reaching its conclusion and a paper is currently being prepared. Simulations, carried out using the DIAS Beowulf cluster, by T. Downes (DCU) appear to match the observations well. The HST data appears to show that one of the binary components may be undergoing a rare EXor event.

F. McGroarty has discovered that a number of classical T Tauri stars with "micro-jets" possess hitherto unknown parsec-scale outflows. This suggests that young stars continue to disrupt their parent cloud for longer timescales than previously assumed. She presented these results in September at a conference in Mexico.

E. Whelan has completed her reduction of UKIRT echelle data concentrating on Paschen beta emission in a number of YSOs. In particular she has found it to be an excellent tracer of outflows close to their source. Such a finding is important because this line is in the near-infrared where the first new generation interferometers (e.g. AMBER on the VLT) will operate. Thus it is an excellent choice for exploring the "central engine" with high resolution.

A. Graz-Velasquez continued her study of disk evolution around low mass YSOs using data from ISOPHOT. Surprisingly she has discovered that a number of weak-line T Tauri stars, a class previously thought not to be surrounded by circumstellar matter, may have disks with large holes. An alternative possibility, that they have dusty envelopes with holes, will be examined through modelling.

P. Ward (TCD student) carried out his Final Year Astrophysics project with C. Davis (Joint Astronomy Center, Hawai'i) in collaboration with T. Ray. He reduced and analysed Keck infrared echelle data and produced an excellent report which should result in a publication. His visit to the JAC was partly financed by the School.

J-K. Lee, a visiting scholar from the University of New South Wales, worked on the analysis of molecular hydrogen data from the Orion star forming region.

1.3.8 MIRI

T. P. Ray

Tom Ray attended a number of meetings at ESA Headquarters and elsewhere as Co-PI of the

Mid-Infrared Instrument (MIRI) planned for the James Webb Space Telescope (JWST), the Hubble Space Telescope's successor. In collaboration with the University of Stockholm it is hoped to supply and test a suite of mid-infrared filters (and dichroics) as the Swedish/Irish contribution to MIRI. A submission was made to the Office of Science and Technology (OST) for 0.5 MEuro phased over 5 years to cover the proposed involvement.

1.3.9 Archeoastronomy

T. P. Ray and F. Prendergast (DIT)

The Knowth tumulus in the Boyne Valley was resurveyed to test the claimed equinoctial alignment of its two diametrically opposed passages. This work was carried out with the assistance of Duchas, the National Heritage Service. It was found that the official plans for the monument, and those in popular publications, were mislabelled and used magnetic rather than true north. The two passages are therefore not positioned along an east-west axis as has been proposed. These results, plus others in connection with Knowth's sister site at Dowth, were published in Archaeology Ireland.

1.4 Computer facilities

J. Walsh, T. Blake, B. Jordan, J. Cunniffe & M. Smyth

The external connectivity to HEANET (and the internet) was upgraded from 10 Mbit/sec to 16 Mbits/sec. An internal VLAN structure was implemented and required a number of router and switch configuration changes. A new Cisco switch was purchased to cope with the increased number of machines using the Network. The Domain Name Server (DNS) was upgraded to ISC BIND version 9 and had additional security features added. Regrettably there was a noticeable increase in the number of attempts to gain unauthorised access to the Institute's network.

The main file server in 5 Merrion Square had to be replaced due to a catastrophic hardware failure. While waiting on the new server one of the UMA cluster machines was removed and used as a temporary server. The new server (running BSD 4.7R with all security patches) was assembled in house and has substantially increased storage capacity and performance. The installation of the file system on the new server was complicated by the fact that the disks from the old system had to be transferred to the new system, reformatted and repartitioned, and the files restored from tape backups, but was successfully completed in one night. At the end of the year a new Solaris 280R (900 Mhz sparc based machine) was ordered as a general login server along with an automatic Tape backup system capable of holding fifteen 80GB tapes.

The UMA cluster continued to give good service throughout the year. The OS was upgraded to FreeBSD 4.6.1 and the master node replaced with an Athlon based system. The freely available Intel compiler suite version 7 for C and Fortran95 was ported to run under FreeBSD.

J. Walsh ported the ESO Midas02 data analysis software suite to Mac OS X. This port was incorporated into the standard distribution released by the European Southern Observatory.

In Dunsink a Hewlett-Packard HP2200DN laser jet printer was installed to replace a Laser Jet III printer which had been in continuous use for more than eight years. Routine maintenance of the computers and the Dunsink Local Area Network was carried out on an ongoing basis throughout the year.

1.5 La Palma

The La Palma Advisory Committee (Chair: E.J.A. Meurs) convened on 30 May at DIAS, Burlington Road. No requests were received for the funding of observing trips during the year.

1.6 CosmoGrid

The start of the PRTLI-3 funded project, "Gridenabled Computational Physics of Natural Phenomena", was seriously delayed by uncertainties relating to the release of capital funding, problems which were still unresolved at the end of the year. Nevertheless a project administrator, Anne Shaw, was appointed in August and recruitment started for other positions.

2 Publications

2.1 Books

Chapter on "Geophysical Evidence", by T. Murphy and A. W. B. Jacob, in "Geology of Ireland" edited by C. H. Holland.

2.2 Papers in refereed journals

- F. Bacciotti, T. P. Ray, R. Mundt, J. Eislöffel, & J. Solf: Hubble Space Telescope/STIS Spectroscopy of the Optical Outflow from DG Tauri: Indications for Rotation in the Initial Jet Channel. *Astrophysical Journal* 576 (2002) 222–231
- C. J. Davis, L. Stern, T. P. Ray, & A. Chrysostomou: Near-infrared Fabry-Perot imaging of Herbig-Haro energy sources: Collimated, small-scale H₂ jets and wide-angled winds. *Astronomy and Astrophysics* 382 (2002) 1021–1031
- F. P. Keenan, S. Ahmed, T. Brage, J. G. Doyle, B. R. Espey, K. M. Exter, A. Hibbert, M. T. C. Keenan, M. S. Madjarska, M. Mathioudakis, & D. L. Pollacco: The OIV and SIV intercombination lines in the ultraviolet spectra of astrophysical sources. *Monthly Notices of the Royal Astronomical Society* 337 (2002) 901–909
- 4. T. Lery, R. N. Henriksen, J. D. Fiege, T. P. Ray, A. Frank, & F. Bacciotti: A global

jet/circulation model for young stars. Astronomy and Astrophysics **387** (2002) 187– 200

- J. T. Mendonça & L. O'C. Drury: Resonant interaction of photons with gravitational waves. *Physical Review D* 65 (2002) 24026–
- J. M. Migliazzo, B. M. Gaensler, D. C. Backer, B. W. Stappers, E. van der Swaluw, & R. G. Strom: Proper-Motion Measurements of Pulsar B1951+32 in the Supernova Remnant CTB 80. Astrophysical Journal 567 (2002) L141–L144
- 7. T. Murphy: The seismology observatories of Mungret and Rathfarnham, Ireland. *Irish Journal of Earth Science* **20** (2002) 1-32.
- L. Norci, V. F. Polcaro, R. F. Viotti, & C. Rossi: The Effect of Binarity and Metallicity in the Spectra of WC and WO Stars. *Revista Mexicana de Astronomia y Astrofisica* 38 (2002) 83–95
- L. Norci, V. F. Polcaro & R. F. Viotti: Metallicity and binarity in WC and WO stars. *IAU Symp.* 212 (2002) 566-567
- L. Norci & E. J. A. Meurs: Synthetic X-ray emission from starburst regions. *IAU Symp.* 212 (2002) 568-569
- D. O'Sullivan, D. Zhou, D. T. Bartlett, P. Beck, J.-F. Bottollier-Depois, L. Lindborg, U. Schrewe and L. Tommasino: Recent Studies on the Exposure of Aircrew to Cosmic and Solar Radiation. *Radiation Protection Dosimetry* **100** (2002) 495-498.
- V. F. Polcaro, R. Viotti, L. Norci, C. Rossi, P. Eenens, L. Corral: Long term spectral variability of the extreme Of supergiant HD 15570 in IC 1805. *IAU Symp.* 212 (2002) 224-225
- 13. F. Prendergast & T. P. Ray: Ancient Astronomical Alignments: Fact or Fiction? *Archaeology Ireland* **16** (2002) 32.

- L. Testi, F. Bacciotti, A. I. Sargent, T. P. Ray, & J. Eislöffel: The kinematic relationship between disk and jet in the DG Tauri system. *Astronomy and Astrophysics* 394 (2002) L31–L34
- J. Woitas, J. Eislöffel, R. Mundt, & T. P. Ray: The Environment of FS Tauri Observed with Hubble Space Telescope Wide Field Planetary Camera 2 in Narrowband Emission Line Filters. *Astrophysical Journal* 564 (2002) 834–838
- J. Woitas, T. P. Ray, F. Bacciotti, C. J. Davis, & J. Eislöffel: Hubble Space Telescope Space Telescope Imaging Spectrograph Observations of the Bipolar Jet from RW Aurigae: Tracing Outflow Asymmetries Close to the Source. *Astrophysical Journal* 580 (2002) 336–342

2.3 Nonrefereed Publications

- F. Bacciotti, T. P. Ray, R. Mundt, J. Eislöffel, & J. Solf: High Angular Resolution Analyses of Herbig-Haro Jets. *The Origins of Stars and Planets: The VLT View. Proceedings of the ESO Workshop held in Garching, Germany, 24-27 April 2001, p. 253.* (2002) 253
- D. T. Bartlett, P. Beck, J.-F. Bottollier-Depois, L. Lindborg, D. O'Sullivan, L. Tommasino, F. Wissmann, F. D'Errico, W. Heinrich, M. Pelliccioni, H. Roos, H. Schraube, M. Silari, & F. Spurný: Investigation of radiation doses at aircraft altitudes during a complete solar cycle. Solspa 2001, Proceedings of the Second Solar Cycle and Space Weather Euroconference (2002) 525
- F. Fiore, S. Savaglio, L. A. Antonelli, A. Fontana, G. Marconi, L. Stella, A. P. di, G. Stratta, G. Israel, S. Covino, G. Chincarini, G. Ghisellini, P. Saracco, F. Zerbi, D. Lazzati, R. Perna, M. Vietri, F. Frontera, S. Mereghetti, E. J. A. Meurs, & N. Kawai:

GRB020813: high-resolution optical spectroscopy.. *GRB Circular Network* **1524** (2002)

- Y. A. Gallant, E. van der Swaluw, J. G. Kirk, & A. Achterberg: Modeling Plerion Spectra and their Evolution. ASP Conf. Ser. 271: Neutron Stars in Supernova Remnants (2002) 99
- 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. ASP Conf. Ser. 271: Neutron Stars in Supernova Remnants (2002) 57
- V. P. Perelygin, Y. V. Bondar, R. Brandt, R. L. Fleischer, L. L. Kashkarov, L. I. Kravets, M. Rebetez, R. Spohr, P. Vater, & D. O'Sullivan: Search for Relatively Stable Super Heavy Elements in Nature by Fossil Track Studies of Crystals from Meteorites and Moon Surface. *Lunar and Planetary Institute Conference Abstracts* 33 (2002) 1066
- T. P. Ray & R. Mundt: Exploring the Central Engines of Young Stars. *Revista Mexicana de Astronomia y Astrofisica Conference Series* 13 (2002) 83–89
- S. Savaglio, F. Fiore, G. Israel, G. Marconi, L. A. Antonelli, A. Fontana, L. Stella, A. P. di, G. Stratta, S. Covino, G. Chincarini, G. Ghisellini, P. Saracco, F. Zerbi, D. Lazzati, R. Perna, M. Vietri, F. Frontera, S. Mereghetti, E. J. A. Meurs, & N. Kawai: GRB021004: high-resolution optical spectroscopy.. *GRB Circular Network* 1633 (2002)
- E. van der Swaluw, A. Achterberg, & Y. A. Gallant: Rejuvenating the Shells of Supernova Remnants by Pulsar Winds. ASP Conf. Ser. 271: Neutron Stars in Supernova Remnants (2002) 135.

- Ph.B. Marty, J. Schultz, C. Bayer, A. Fritz, M. Netopil, W. Nowotny, M. Carr, C. Ferrigno, C. Jean, W. Koprolin, J. Rasmussen, L. Tanvuia, I. Valtchanov, M. Bavdaz, R. Much, A.N. Parmar: In.XS: project for a future spaceborne hard x-ray all-sky survey. *Proc. SPIE* 4497 (2002) 1-10
- B. M. O'Reilly and A.W.B. Jacob, 2002. Lithospheric structure around Ireland from wide-angle seismic studies: a review. RAS-G/BGA Discussion Meeting, The CTBT and advances in Earth Science, London, 7-8 February.
- 12. P. W. Readman, 2002. A review of DIAS onshore Irish wide-angle seismic work. Innovative approaches to studies of seismic structure, a meeting in memory of Brian Jacob, Dublin, 9-10 February.
- 13. B. M. O'Reilly, 2002. Insights into the geodynamics of the NE Atlantic from wideangle seismic studies. Innovative approaches to studies of seismic structure, a meeting in memory of Brian Jacob, Dublin, 9-10 February.
- 14. P.M. Shannon, 2002. Rifting and rift processes in the Irish offshore basins. Innovative approaches to studies of seismic structure, a meeting in memory of Brian Jacob, Dublin, 9-10 February.
- 15. B. M. O'Reilly, P. W. Readman, P.M. Shannon and A.W.B. Jacob, 2002. A model for the growth of a carbonate mound population on the western margin of the Porcupine Bank. Irish Geology Research Meeting, Dublin, 22-24 February, Irish Journal of Earth Sciences, 20 (2002) 97.
- 16. P. W. Readman, B. M. O'Reilly, P.M. Shannon and A.W.B. Jacob, 2002. Variation in submarine canyon morphology along the eastern margin of the Rockall Trough. Irish Geology Research Meeting, Dublin, 22-24

February, Irish Journal of Earth Sciences, 20 (2002) 99.

- D. Praeg, P.D.W. Haughton, P.M. Shannon and B. M. O'Reilly, 2002. Late Cenozoic sedimentary responses to rapid development of the eastern Rockall continental slope. Irish Geology Research Meeting, Dublin, 22-24 February, Irish Journal of Earth Sciences, 20 (2002) 98.
- B.M O'Reilly and P. W. Readman, 2002. A model for the development of the Porcupine basin west of Ireland: Evidence for regional syn-rift tectonic linkages? European Geophysical Society XXVII General Assembly, Nice, 21-26 April, Abstract No. EGS02-A-04866.
- P. W. Readman, B. M. O'Reilly, P.M. Shannon and A.W.B. Jacob, 2002. The influence of slope and shelf contour currents on the growth pattern of a cold-water coral mound population along the margins of the Rockall Trough. European Geophysical Society XXVII General Assembly, Nice, 21-26 April, Abstract No. EGS02-A-06163.
- I. Woelbern, A.W.B. Jacob, T.A. Blake, R. Kind, X. Li, S.V. Sobolev, F. Duennebier, K. Priestley and M. Weber, 2002. A detailed receiver function study of the Hawaiin Plume conduit. European Geophysical Society XXVII General Assembly, Nice, 21-26 April, Abstract No. EGS02-A-03379.
- 21. B. M. O'Reilly and P. W. Readman, 2002. Upper lithospheric structure in and around Ireland from seismic refraction studies. Book of Abstracts and Papers, 43-47. Irish Association for Economic Geology Meeting, Basement controls on mineralisation in the Irish orefield, Westport, 11-12 May.
- 22. B. M. O'Reilly and P. W. Readman, 2002. Marine wide-angle seismic studies around Ireland: A review of the last two decades.

Proceedings, 30-33. Marine Geophysical Investigations in Ireland Today, GAI meeting in association with GSI and PESGB, Dublin, 22 May.

- P. W. Readman, B. M. O'Reilly and P.M. Shannon, 2002. A cold-water-coral carbonate mound population along the western margin of the Porcupine Bank. Book of abstracts, 13. Natural and Cultural Landscapes: The Geological Foundation, Dublin, 9-11 September.
- B. M. O'Reilly, M. Landes, P. W. Readman, P.M. Shannon and C. Prodehl, 2002. 3-D tomography study of seismic refraction/wideangle reflection data across the Variscides, SW Ireland. American Geophysical Union Fall Meeting, San Francisco, 6-10 December, Eos Trans. AGU 83(47) F978.
- 25. P. W. Readman, B. M. O'Reilly and P.M. Shannon, 2002. A cold-water coral ecosystem development in the NE Atlantic: Evidence for strong coupling with Pleistocene and Holocene climate change. American Geophysical Union Fall Meeting, San Francisco, 6-10 December, Eos Trans. AGU 83(47) F274.
- I. Woelbern, A.W.B. Jacob, T.A. Blake, R. Kind, X. Li, S.V. Sobolev, F. Duennebier, K. Priestley and M. Weber, 2002. A detailed receiver function study of the Hawaiian Plume conduit. American Geophysical Union Fall Meeting, San Francisco, 6-10 December, Eos Trans. AGU 83(47) F1038.

2.4 Preprints

- astro-ph/0209464 L. Testi, F. Bacciotti, A. I. Sargent, T. P. Ray, & J. Eislöffel: The kinematic relationship between the disk and jet in the DG Tauri system.
- 2. astro-ph/0207447 A. Frank, T. Lery and

E. Blackman: "MHD Disk Winds and Planetary Nebulae I. Existence and Applicability,"

- astro-ph/0207307 J. Woitas, T. P. Ray, F. Bacciotti, C. J. Davis, & J. Eislöffel: Hubble Space Telescope Space Telescope Imaging Spectrograph Observations of the Bipolar Jet from RW Aurigae: Tracing Outflow Asymmetries Close to the Source.
- astro-ph/0203090 T. Lery, R. N. Henriksen, J. D. Fiege, T. P. Ray, A. Frank, & F. Bacciotti: A global jet/circulation model for young stars.
- astro-ph/0202232 E. van der Swaluw, A. Achterberg, Y. A. Gallant, T. P. Downes & R. Keppens: Interaction of high-velocity pulsars with supernova remnant shells.
- astro-ph/0202063 J. M. Migliazzo, B. M. Gaensler, D. C. Backer, B. W. Stappers, E. van der Swaluw, & R. G. Strom: Proper-Motion Measurements of Pulsar B1951+32 in the Supernova Remnant CTB 80.

2.5 Theses

- **Olwen Carroll** submitted her MSc thesis "Particle acceleration in Supernova Remnants" to DCU.
- **M. Carr** submitted his PhD thesis "Galaxy Clusters, Voids and Elliptical galaxies using the ROSAT PSPC" to TCD.
- **J. Cunniffe** submitted his PhD thesis "A search for X-ray flares in the nuclei of galaxies" to TCD.
- Michael Landes was awarded the degree of PhD by UCD for his thesis "A wide-angle seismic study of SW Ireland".
- **James Hodgson** was awarded the degree of PhD by UCD for his thesis "A seismic and gravity study of the Leinster Granite: SE Ireland".

2.6 Project reports

- G.D. Mackenzie, N.C. Morewood, P.M. Shannon and A.W.B. Jacob, 2002. RAPIDS
 3: Wide-angle seismic profiling, Report to the Rockall Studies Group.
- P. W. Readman and B. M. O'Reilly, 2002. Gravity and Magnetic modelling in the Porcupine Basin. Report to the Porcupine Studies Group.
- B. Austin, with contributions from B. M. O'Reilly, 2002. Slope instability investigation in NE Rockall. Report to the Rockall Studies Group.

3 Events

3.1 Lectures Organised by the School

- 1. E. Daly (ESTEC): "Space Weather", Burlington Road, 31 May
- 2. E. van der Swaluw: "Supernova Remnants, Pulsar Wind Nebulae and Their Interaction" Dunsink Observatory, Dublin (Ireland), 4 June.
- 3. I. R. Stevens (University of Birmingham) "Chandra and XMM X-ray Observations of Starburst galaxies", 11 June.
- 4. L. Feretti (Istituto di RadioAstronomia, Bologna): "Non-thermal emission from galaxy clusters: radio halos", 15 October.
- 5. B.N.L. Kennett, Seismic studies in Australia, 15 April, DIAS.
- 6. Steven Arrowsmith, Seismic images of the upper mantle beneath Britain and Ireland, 4 October, DIAS.
- 7. Franz Hauser, Seismic studies across an earthquake zone in Romania, 17 December, DIAS.

- 8. Mark McCaughrean, The Next Generation Space Telescope, 15 February (jointly with TCD Physics).
- 9. Duncan Steel, Scientific Aspects of Near-Earth Objects, 25 October (jointly with TCD Physics).
- 10. In the series of informal internal seminars at Dunsink Observatory the following talks were presented during the year:
 - J. Cunniffe "Report on RAS X-ray meeting" 6 March;
 - C. Melody "A simple runaway star scenario" 14 August;
 - M. Wilkinson (IoA, Cambridge, UK) -"Star Clusters in the LMC – Observations and Nbody Simulations" - 30 October;
 - M. Carr "Extragalactic objects studied with ROSAT PSPC data" - 6 December;
 - E. Meurs "Stellar Hardness Ratio distributions" - 13 December.
- 11. J Walsh and T Blake organised a short inhouse HTML training course for staff and students

3.2 Symposia, Conferences, Workshops organised

• A symposium entitled *Innovative approaches to studies of seismic structure* was held in memory of the late Brian Jacob on 9-10 February with speakers:

Peter Readman A review of DIAS onshore Irish wide-angle seismic work.

- **Brian O'Reilly** Insights into the geodynamics of the NE Atlantic from wideangle seismic studies.
- **Patrick Shannon** Rifting and rift processes in the Irish offshore basins.

- **Aftab Khan** The lithospheric structure of the East African Rift from wide-angle measurements.
- Peter Maguire The EAGLE (Ethiopian Afar Geoseismic Lithospheric Experiment) experiment.
- **Randy Keller** Lithospheric structure and evolution of continental rifts: a global perspective.
- **Jannis Makris** Ocean bottom seismic techniques and their application in the eastern Mediterranean.
- Walter Mooney The structure and evolution of North American lithosphere.
- **Claus Prodehl** Lower lithospheric structure in western Europe by seismic longrange profiles.
- James Mechie Recent advances in combined active and passive seismic experiments - some personal experiences.
- **Jim Luetgert** Crustal structure from earthquake sources - new techniques and opportunities.
- Hans Thybo High-resolution seismic imaging of the shallow to deep mantle.
- **Rainer Kind** A seismic study of the Hawaiian Plume conduit.
- Chris Browitt BGS UK seismic monitoring.
- John McCloskey Searching for characteristic microearthquakes in the Gulf of Corinth.
- Chris Bean Seismic imaging in complex media.
- **Stuart Crampin** A review of shear-wave splitting and consequences of a crack critical crust.
- Alan Douglas Why is P from 10-ton explosions in the sea seen at long range.

- A series of talks was presented at Dunsink Observatory on 5 November, as a thematic colloquium on "Gamma Ray Bursts and their Afterglows":
 - **S. McBreen** (UCD): "Timing aspects of GRBs";
 - **E. Ramirez-Ruiz** (IoA, Cambridge) "Theoretical overview";
 - **D. Watson** (Leicester) "XMM and Chandra observations";
 - **J. Hjorth** (Copenhagen) "Afterglow science";
 - **E. Ramirez-Ruiz** "GRBs and their environment";
 - **E. Meurs** (Dunsink) "Simulations of the dark GRB population".
- A mini-workshop on *Astrophysics of the ISM* and the IGM was held in 5 Merrion Square on 2 December
 - **Robin Williams** (Cardiff) The stability of ambipolar flows: another fine mess?
 - **Will Henney** (UNAM, Mexico) Photoevaporation flows, large and small.
 - **Gary Ferland** (U Kentucky) Testing the big bang: the primordial abundance of Helium

3.3 Exhibitions

The CosmoGrid project featured in the Higher Education Authority's exhibition of PRTLI funded projects in the Burlington Hotel, 30–31 October.

4 Presentation of research

4.1 Talks and papers presented at conferences and seminars

M. Carr "ROSAT PSPC observations of EMSS clusters", ASGI Spring meeting, TCD, 22

March.

- **J. Cunniffe** "Frequency of X-ray flares in galactic nuclei", X-ray Surveys in the light of the new observatories, Santander, Spain, 4–6 September.
- E.J.A. Meurs "The REM Gamma Ray Burst Telescope", ASGI Spring meeting, TCD, 22 March; "Systematics of the soft X-ray characteristics of various stellar types in RASS data" and "The ROSAT Survey of the EMSS galaxy cluster sample: effects of data reprocessing", X-ray Surveys in the light of the new observatories, Santander, Spain, 4-6 September; "Dark Bursts and the optical upper limit distribution", "Estimates of optical afterglow emission levels for dark bursts" and "GRBs and SNae", Gamma-Ray Bursts in the Afterglow Era: 3rd Workshop, Rome, 16-21 September; "GRBs and Afterglows", Armagh Observatory, 21 August; "X-ray emission and origin of runaway stars", Astronomical Observatory Rome, 20 December.
- L. Norci "Metallicity and binarity in WC and WO stars", "Synthetic X-ray emission from starburst regions" and "Long term spectral variability of the extreme Of supergiant HD 15570 in IC 1805", IAU Symposium 212, Lanzarote, Spain, 24–28 June.

J. Cunniffe, E.J.A. Meurs and L. Norci presented poster contributions at the ASGI Spring meeting in TCD on 22 March.

- **T. Kiang** "Rhombic Cell Analysis A New Way of Probing the Large Scale Structure of the Universe", University of Science and Technology of China, Hefei, 21 October.
- **D. Zhou** gave a presentation of the status of DIAS work and results to the DOSMAX meeting in Vienna, 18th- 20th March 2002.
- **D. O'Sullivan** presented recent DIAS results from the space shuttle mission STS-108

to the 7th Workshop on Radiation Measurements in the International Space Station, Paris Sept 2nd-4th 2002. Details of the DIAS results related to the DOSMAX project were presented at a meeting in the Czech Academy of Science, Prague Sept 23rd -24th 2002.

- L. O'C. Drury "The CosmoGrid project", TER-ENA meeting in Limerick, 2–5 June; "The origin of cosmic rays in historical perspective" and "Where's the cut-off in SNRs?", H.E.S.S. first light symposium, Windhoek, Namibia, 2–4 September.
- **E. van der Swaluw** "Superbubbles: evolution and particle acceleration" AstroPlasma-Physics Network meeting, Tromso, Norway, 7 february 2002; "Supernova Remnants, Pulsar Wind Nebulae and Their Interaction" FOM, Nieuwegein, The Netherlands, 14 August 2002; "Do we really observe a bow shock around N157B?" (poster) 34th COSPAR Scientific Assembly, Houston, Texas, USA, 10-19 October 2002.
- **DOSMAX Collaboration** "Radiation Fields at Aircraft Altitudes - A Decade of Progress" World Space Congress 2002 - COSPAR, Houston 10-19 Oct 2002; "Investigation of Radiation Doses at Aircraft Altitudes during a Complete Solar Cycle: DOSMAX A collaborative Research Programme" 12th Biennial RPSD Topical Meeting, Santa Fe, NM, April 14-18, 2002, American Nuclear Society, La Grange Park, Illinois.
- **F. McGroarty** "Parsec scale outflows from intermediate mass stars." Winds, Bubbles and Explosions: a conference to honour John Dyson, Pátzcuaro, Michoacán, Mexico, 9– 13 September.
- **T. Ray** "Generating YSO Jets; what the HST has to tell us." Winds, Bubbles and Explosions: a conference to honour John

Dyson, Pátzcuaro, Michoacán, Mexico, 9– 13 September; "Archeoastronomy: Fact or Fiction?" Arcetri Observatory, 5 December.

- **E. Whelan** "Near Infrared Spectro-astrometry of Young Stellar Objects", NATO ASI on Optics in Astrophysics, Cargèse, 16-27 September
- **D. Coffey** "High Spatial Resolution Demands of Studies in Star Formation", NATO ASI on Optics in Astrophysics, Cargèse, 16-27 September
- Fiona McGroarty "Parsec-Scale Outflows from Intermediate Mass Stars", ASGI Autumn Meeting, NUI Galway, 18 October
- Jung-Kyu Lee "Shock Excitation of H₂ in HH 117-114", ASGI Autumn Meeting, NUI Galway, 18 October
- **T.A. Blake** A detailed receiver function study of the Hawaiin Plume conduit, European Geophysical Society XXVII General Assembly, Nice, 21-26 April; A detailed receiver function study of the Hawaiin Plume conduit, American Geophysical Union Fall Meeting, San Francisco, 6-10 December.
- B. M. O'Reilly Lithospheric structure around Ireland from wide-angle seismic studies: a review, RAS-G/BGA Discussion Meeting, The CTBT and advances in Earth Science, London, 7-8 February; Insights into the geodynamics of the NE Atlantic from wideangle seismic studies, Innovative approaches to studies of seismic structure, a meeting in memory of Brian Jacob, Dublin, 9-10 February; A model for the growth of a carbonate mound population on the western margin of the Porcupine Bank, Irish Geology Research Meeting, Dublin, 22-24 February; Late Cenozoic sedimentary responses to rapid development of the eastern Rockall continental slope, Irish Geology Research

Meeting, Dublin, 22-24 February; The influence of slope and shelf contour currents on the growth pattern of a cold-water coral mound population along the margins of the Rockall Trough, European Geophysical Society XXVII General Assembly, Nice, 21-26 April; Upper lithospheric structure in and around Ireland from seismic refraction studies, Irish Association for Economic Geology Meeting, Basement controls on mineralisation in the Irish orefield, Westport, 11-12 May; Marine wide-angle seismic studies around Ireland: A review of the last two decades, GAI meeting in association with GSI and PESGB, Marine Geophysical Investigations in Ireland Today, Dublin, 22 May; A cold-water coral ecosystem development in the NE Atlantic: Evidence for strong coupling with Pleistocene and Holocene climate change, American Geophysical Union Fall Meeting, San Francisco, 6-10 December.

P. W. Readman A review of DIAS onshore Irish wide-angle seismic work, Innovative approaches to studies of seismic structure, a meeting in memory of Brian Jacob, Dublin, 9-10 February; Gravity and magnetic modelling in the Porcupine Basin, Porcupine Studies Group Workshop, Dublin, 13 February; Variation in submarine canyon morphology along the eastern margin of the Rockall Trough, Irish Geology Research Meeting, Dublin, 22-24 February; A model for the development of the Porcupine Basin west of Ireland: Evidence for regional syn-rift tectonic linkages? European Geophysical Society XXVII General Assembly, Nice, 21-26 April; A cold-water-coral carbonate mound population along the western margin of the Porcupine Bank, Natural and Cultural Landscapes Conference: The Geological Foundation, Dublin, 9-11 September; 3-D tomography study of seismic refraction/wide-angle reflection data across the Variscides, SW Ireland, American Geophysical Union Fall Meeting, San Francisco, 6-10 December.

5 Collaboration with wider research community

5.1 National

Lecture Courses

- **T. P. Ray** Lecture courses "Galaxies: from the Milky Way to Quasars" (TCD, 3rd year Physics), "The Interstellar Medium" (TCD, 4th year Physics), "Exploring the Universe" (NUIM, 1st year Astrophysics). Also coordinated final year Astrophysics projects for TCD.
- **E.J.A. Meurs** course of nine hours on Physics of Galaxies at TCD during Hilary Term. Guidance provided for research projects of two 4th year physics students from TCD and one last-year applied sciences student from DIT.
- **L. Norci** Course of nine lectures on Stellar Structure and Evolution in TCD during Hilary term.
- **E.J.A. Meurs** together with L. Norci and M. Cawley (NUIM) gave a course of eight hours at TCD on Topics in High-energy Astrophysics, during Michaelmas term.
- **P.W Readman** Lecture on gravity and its measurement in Ireland, to Dublin Institute of Technology degree students.
- **C. Horan** Demonstration of gravity equipment and measurement to Dublin Institute of Technology degree students.
- **T. Blake** Lecture on 28th Feb to the Radiological Protection Institute of Ireland, "The Pattern of onshore and offshore seismic event distribution around Ireland".

Visiting Irish Researchers

- Th. Delahunty (UCD),
- P. Duffy (UCD),
- B. Espey (TCD),
- S. McBreen (UCD),
- E. McGlynn (DCU),
- L. Oosterweghel (Dublin Zoo),
- E. Prodanov (DCU)
- T. Downes (DCU)

Project students

- P. Collins (DIT), December.
- S. McGlynn (TCD), October December.
- C. Rebelo (TCD), October December.

Vacation Students

- P. Collins (DIT)
- P. Casey (Maynooth)
- C. Melody (TCD)

Staff acting as external examiners

T. P. Ray examined a PhD thesis for the Department of Geology, TCD, on 18th January and one for QUB and Armagh Observatory on 15 November.

5.2 International

Collaborative agreements

• The High Energy Stereo System (H.E.S.S.) collaboration is a European consortium of 19 research institutes led by the Max-Planck-Institut für Kernphysik in Heidelberg which is constructing a next-generation system of

imaging atmospheric Cherenkov telescopes in Namibia.

- The Optical Monitoring Camera consortium contributes one of the four scientific instruments onboard ESA's INTEGRAL satellite (OMC PI: Dr M. Mas-Hesse, INTA, Madrid, Spain).
- The Rapid Eye Mount (REM) Telescope is a small automatic telescope that will carry out fast follow-up searches for afterglows of Gamma Ray Bursts, from ESO at La Silla, Chile. The project is led by Brera Observatory, Milan-Merate, Italy.
- Via DIAS, Ireland participates in the La Palma Observatory; the Agreement governing this collaboration is expected to be terminated next year, following closure of the Jacobus Kapteyn Telescope. The case for an Irish membership of the European Southern Observatory, which is actively being pursued by DIAS, is therefore now particularly relevant.
- The ISLE project was extended by a collaboration with the University of Karlsruhe. Deployment of an additional eight German seismic instruments was started and the project will now include tomography and receiver function analyses.
- There were negotiations with the Geological Survey of Ireland and the Rockall Studies Group concerning the extension of the RAPIDS project to include analysis and interpretation of new wide-angle seismic data collected in 2002 as part of the Irish National Seabed Survey. This project, HADES (HAtton DEep Seismic) was designed by DIAS and UCD to continue our study of the development of the Hatton Basin and Continental Margin. A further seismic line (RAPIDS4) in the Porcupine Basin was proposed and acquired by the Porcupine Studies Group consortium during 2002. DIAS and UCD are

collaborating with the University of Hamburg on both these projects and contracts for the interpretation phases are expected to be finalised early in 2003.

Visiting Researchers

Dr Luigi Tommasino (U Rome), Mr Eric Benton (University of San Francisco), Dr M Dieckman (U Linschöping), Prof T Weekes (Tucson), Dr M. McCaughrean (Astrophysikalisches Institut Potsdam), D. Steel (U Salford), W. Henney (Instituto de Astronomía, UNAM), G Ferland (U Kentucky), R Williams (U Cardiff) L. Feretti (IRA Bologna, Italy), I.R. Stevens (University of Birmingham), M. Stift (Vienna), M.I. Wilkinson (IoA Cambridge, UK), A. Khan and P. Maguire (University of Leicester), R. Keller (University of Texas at El Paso), J. Makris (University of Hamburg), W. Mooney and J. Luetgert (USGS, Menlo Park), C. Prodehl (University of Karlsruhe), J. Mechie and R. Kind (GFZ Potsdam), H. Thybo (University of Copenhagen), C. Browitt (BGS, Edinburgh), J. McCloskey (University of Ulster), C. Bean (UCD), S. Crampin (University of Edinburgh), A. Douglas (Blacknest), M. Arceri (Basilicata University, Italy), V. C. Do (University of Leeds), S. Arrowsmith (University of Leeds), M. Landes (University of Karlsruhe), F. Hauser.

Research visits by School staff

- **D** Zhou Prof. Benton, University of San Francisco, USA.
- **E. van der Swaluw** Alexandre Marcowith (CESR), 18-22 February 2002, Toulouse, France; Rony Keppens (FOM) 12-16 August 2002, Nieuwegein, The Netherlands; Etienne Parizot (CESR), 28-30 October 2002, Orsay, France.
- **T. P. Ray** Arcetri Observatory, Florence, 3-6 December.
- **D. Coffey** Arcetri Observatory, Florence, 3-21 December.

- **B. Jordan** First test of the Control and Readout electronics for the REM NIR camera, Infra Red Labs, Tucson, USA, 26 January 2 February.
- **E.J.A. Meurs** Astronomical Institute Anton Pannekoek, University of Amsterdam, 16 and 17 April; Astronomical Observatory Rome, 29 April – 10 May and 23 – 25 September.
- **P. W. Readman and B. M. O'Reilly** University of Hamburg and University of Karlsruhe.

6 Public outreach activities

E. J. A. Meurs, in collaboration with T. Dorlas (School of Theoretical Physics) wrote a detailed submission to the Task Force on the Physical Sciences. The submission made the case, *inter alia*, for an expanded outreach programme in the Institute and especially for increased use of Dunsink as a public resource.

6.1 Public Lectures organised

Statutory Public Lecture

The Statutory Public Lecture, entitled "Space Travel and other Journeys - the Solar and Galactic Hazards" was given by Denis O'Sullivan on 3 December in TCD.

McCrea Lecture

The School acted as host for the McCrea lecturer, Prof Martin Rees, during his visit to Dublin 11-12 March.

Science week lectures

In collaboration with the School of Theoretical Physics a week-long course of lectures was organised as part of the National Science Week, 11-15 November, on the general theme of "New Views of the Universe". Sile de Valera, minister of state in the Department of Education and Science, formally launched this initiative which attracted large audiences every night (despite monsoonlike weather on the Thursday evening).

The School contributed the following lectures:

- P. W. Readman "What lies beneath"
- T. Weekes "The gamma-ray sky"
- E. J. A. Meurs "The distant early universes"

External public lectures

- L. Norci: "Very Massive Stars and Starforming Regions", Irish Astronomical Society, 18 February.
- E.J.A. Meurs: "History and research at Dunsink Observatory", Astronomy Ireland, Dunsink Observatory, 12 October.
- E.J.A. Meurs: "Chasing Gamma Ray Burst Afterglows", Irish Astronomical Society, 11 November.

6.2 Dunsink Outreach Programme

Groups (from schools and otherwise) and general public visited Dunsink Observatory throughout the year. The regular Open Nights programme for the general public was 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.

Eight Transition Year pupils spent a week at Dunsink Observatory as part of their Work Experience programme.

6.3 Media coverage

P. W. Readman and B. M. O'Reilly contributed to various articles in national and local newspapers and interviews for local radio, concerning the earthquake that occurred near Dudley, England on 22 September.

6.4 Irish Scientist Yearbook

The School published two articles in the 2002 Yearbook, one by E.J.A. Meurs and B. McBreen on "An automatic telescope for Gamma Ray Burst research" and one by L. Drury on the CosmoGrid project.

7 Participation in outside committees

- L. Drury served on the Space Science Advisory Committee of the European Space Agency, the Fachbeirat of the Max-Planck-Institut für Kernphysik in Heidelberg, the Joint Management Committee of the Armagh Observatory and Planetarium, the Council of the Royal Irish Academy, the National Committee for Astronomy and Space Research and was vice-chairman of the Commission on Cosmic Rays of the International Union for Pure and Applied Physics.
- **E. J. A. Meurs** served on the Astronomy Working Group of the European Space Agency and the National Committee for Astronomy and Space Research. He also served as an expert referee for research project evaluations on behalf of the Italian Space Agency (ASI).
- **T. P. Ray** served on the National Committee for Physics, as chairman of the Astronomical Science Group of Ireland, as Chairman of the Local Organising Committee for the NAM2003 conference and became a member of the Scientific Organising Committee

for IAU symposium 221, Star Formation at **F. McGroarty** Winds, Bubbles, High Angular Resolution. sions: a conference to honor

- **B. M. O'Reilly** served on the Editorial Board of the Irish Journal of Earth Sciences.
- **P. W. Readman** Research Associate of UCD. Titular Member of European Seismological Committee. Member of the Consultative Committee of the Geological Survey of Ireland. Secretary of the National Committee for Geodesy and Geophysics of the Royal Irish Academy. National correspondent of the International Association of Seismology and Physics of the Earth's Interior.
- **L. Quigley** Continued to edit the Institute of Irish Surveyors News (IIS News).
- **D. O'Sullivan** was appointed to the joint international ICRP/ICRU Committee on Cosmic Radiation and Aircrew and to the Review Panel of the Swedish National Space Board.

8 Attendance at external conferences, seminars and meetings

8.1 Conferences attended

- **E. van der Swaluw** COSPAR: High Energy Studies of Supernova Remnants and Neutron Stars, 10-12 October 2002, Houston, Texas, USA;
- **L. O'C. Drury** H.E.S.S. First Light Symposium and Inauguration Ceremony, Namibia, 2-4 September.
- **T. P. Ray** National Astronomy Meeting, University of Bristol, 10-12 April; Winds, Bubbles, and Explosions: a conference to honor John Dyson, Pátzcuaro, Michoacán, Mexico, 9-13 September;

- **F. McGroarty** Winds, Bubbles, and Explosions: a conference to honor John Dyson, Pátzcuaro, Michoacán, Mexico, 9-13 September
- **E. Whelan** Optics in Astrophysics, NATO Advanced Study Institute, Cargse, Corsica, 16-27 September.
- D. Coffey Optics in Astrophysics, NATO Advanced Study Institute, Cargse, Corsica, 16-27 September; Arcetri Observatory, Florence, 3-21 December.
- J. Cunniffe RAS meeting on "X-ray astronomy in the new millenium", London, 19–20 February; "X-ray Surveys in the light of the new observatories", Santander, Spain, 4–6 September.
- **B. O'Halloran** SIRTF Observation Planning Workshop, SIRTF Science Center, California Institute of Technology, Pasadena, USA, 22–23 November.
- **E.J.A. Meurs** "X-ray Surveys in the light of the new observatories", Santander, Spain, 4–6 September; "Gamma-Ray Bursts in the Afterglow Era: 3rd Workshop", Rome, 16–21 September.
- **T.A. Blake** European Geophysical Society XXVII General Assembly, Nice, 21-26 April; Young Scientists Training Course, Analysis of Digital Broadband Data, Genoa, 30 August - 1 September; European Seismological Commission, Genoa, 1-6 September.
- C. Horan IRLOGI meeting 15 October.
- **B. M. O'Reilly** RAS-G/BGA Discussion Meeting, The CTBT and advances in Earth Science, 7-8 February; Porcupine Studies Group Workshop, Dublin, 13 February; Irish Geology Research Meeting, Dublin 22-24 February; Symposium on Challenges for

Earth Sciences in the 21st Century, Karlsruhe, 18-19 April; European Geophysical Society XXVII General Assembly, Nice, 21-26 April; Irish Association for Economic Geology Meeting on Basement controls on mineralisation in the Irish orefield, Westport 11-12 May; Marine Geophysical Investigations in Ireland Today, Geophysical Association of Ireland Meeting, Dublin, 22 May; Natural and Cultural Landscapes: The Geological Foundation, Dublin Castle, 9-11 September; Intermargins Meeting, San Francisco, 9 December; American Geophysical Union Fall Meeting, San Francisco, 6-10 December.

- P. W. Readman Porcupine Studies Group Workshop, Dublin, 13 February; Irish Geology Research Meeting, Dublin 22-24 February; Symposium on Challenges for Earth Sciences in the 21st Century, Karlsruhe, 18-19 April; European Geophysical Society XXVII General Assembly, Nice, 21-26 April; Irish Association for Economic Geology Meeting on Basement controls on mineralisation in the Irish orefield, Westport 11-12 May; Marine Geophysical Investigations in Ireland Today, Geophysical Association of Ireland Meeting, Dublin, 22 May; European Seismological Commission, Genoa, 1-6 September; Natural and Cultural Landscapes: The Geological Foundation, Dublin Castle, 9-11 September; American Geophysical Union Fall Meeting, San Francisco, 6-10 December.
- L.Quigley Erdas Imagine Training Course, Cambridge, UK, 3-6 March; Natural and Cultural Landscapes: The Geological Foundation, Dublin Castle, 9-11, September; IRLOGI meeting 15 October.

8.2 Lectures and meetings attended

E. van der Swaluw The AstroPlasmaPhysics TMR Network workshop, 4-8 February 2002, Tromso, Norway.

- **T. P. Ray** Royal Astronomical Society, London, 11 Jan; Astronomical Science Group of Ireland, Trinity College Dublin, 22 March; Royal Astronomical Society, London, 11 October; Astronomical Science Group of Ireland, NUI, Galway, 18 October.
- L Drury Centre for Supercomputing in Ireland meeting in NUI-G, 29 Jan; AstroPlasma-Physics Workshop in Tromso, Norway 3-8 Feb; ESA SSAC meeting, Paris, 13 Feb; ESA AWG and SSAC meetings, ESTEC, Holland, 17-20 Apr; ESA SSAC meeting, Paris, 1-3 May; HEAnet AGM, Dublin, 10 May; Virtual presentation of the NSF Extensible Teraflop Facility (QUB access grid node), 20 September; NIFAST Health & Safety Course for Managers, DIAS 2-3 October; ESA SSAC meeting, Paris, 7 October; ASGI, Galway, 18 October; Robinson lecture, Armagh, 22 November; Science and the Media workshop in the RDS, 25 November; IAHPC AGM in UCD, 29 November.
- T. P. Ray MIRI, Advanced Technology Centre, Edinburgh, 23-24 Jan; NAM2003 LOC, Trinity College Dublin, 22 March; MIRI, Advanced Technology Centre, Edinburgh, 8-9 April; La Palma Advisory Committee Meeting, Dublin, 30 May; National Astronomy Meeting, LOC, Armagh Observatory, 3 September; MIRI, Astrium UK Ltd, 4-5 September; National Astronomy Meeting, LOC, NUI, Galway, 17 October; MIRI, European Space Agency Headquarters, Paris, 5 November; Irish Radio Telescope Campaign Committee, Armagh Observatory, 28 November; Arcetri Observatory, Florence, 3-6 December.
- **E.Flood** DOSMAX contractors' meetings in Vienna, 18-20 March, and Prague, 23-24 September.

- A. Graz-Velasquez ASGI Spring Meeting TCD, 22 March; Symposium on "Exploiting the ISO Data Archive, Infrared Astronomy in the Internet Age", Sigenza, Spain, 24-27 June; NATO Advanced Study Institute, Accretion Discs, Jets and High Energy Phenomena in Astrophysics, Les Houches, 29 July -23 August; The Third NEON Summer School, sponsored by Asiago Observatory, Italy, 9 - 21 September; ASGI Autumn Meeting, NUI Galway, 18 October
- **E. Whelan** ASGI Spring Meeting TCD, 22 March, ASGI Autumn Meeting, NUI Galway, 18 October + Cargese
- **F. McGroarty** ASGI Spring Meeting TCD, 22 March, ASGI Autumn Meeting, NUI Galway, 18 October
- **D. Coffey** ASGI Spring Meeting TCD, 22 March, ASGI Autumn Meeting, NUI Galway, 18 October + Cargese
- M. Carr ASGI Spring meeting, TCD, 22 March.
- J. Cunniffe ASGI Spring meeting, TCD, 22 March.
- **B. Jordan** Meeting with N. Smith to discuss progress on CCD camera to be used in Abastumani Observatory, CIT, Cork, 21 February; Progress meeting and report of REM NIR camera project, Brera Observatory, Milan-Merate, Italy, 22–25 April; Enigeering meeting to discuss Hardware and Software developments for the REM NIR camera, Astronomical Observatory Rome, Monte Porzio, Italy, 7–10 October.
- **E.J.A. Meurs** ESA Astronomy Working Group, Paris, 27–29 January; National Committee for Astronomy and Space Research, RIA, Dublin, 12 March; ASGI Spring meeting, TCD, 22 March; ESA Astronomy Working Group, ESTEC, Noordwijk, NL, 24– 26 March; ESA Astronomy Working Group,

ESTEC, Noordwijk, NL, 18–19 April; REM Science Team meeting, Merate, Italy, 24 April; McBrierty Symposium, TCD, 16 May; Astro Committee, TCD, 12 June; EU TMR Information, Enterprise Ireland, 11 September; GRB collaboration meeting, Astronomical Observatory Rome, 16 September; ESA Astronomy Working Group, Leicester, UK, 1–2 October.

9 Miscellanea

Members of the McCrea family visited Dunsink Observatory on 13 March, following the first RIA McCrea lecture the evening before.

The Irish Astronomical Society Astronomy Day took place at Dunsink Observatory on 21 September.

On 16 October the annual Hamilton Walk started at Dunsink Observatory, featuring a brief address in the Meridian Room by Nobel Laureate Gell-Mann.

ESA's INTEGRAL satellite was successfully launched from the Baikonour Kosmodrome on 17 October. Together with UCD, Dunsink Observatory had contributed instrumentation for one of the four on-board instruments, the Optical Monitoring Camera.

E.J.A. Meurs and two other members of ESA's Astronomy Working Group produced a report reevaluating the importance of the Next Generation Space Telescope for the scientific programme of ESA.

G. Daly continued restoration work on the Shortt clock at Dunsink Observatory.

On October 30 T. Kiang participated in the Celebration of the 80th Anniversary of the Founding of the Astronomical Society of China, held in Nanjing.