Armagh Observatory

Annual Report

Calendar Year 2000

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Contents

Executive Summary

This report provides background information about the Armagh Observatory and a summary of the Observatory's principal achievements in research and other areas during calendar year 2000.

Staff at the Observatory have attracted external income totalling £222,000 (£212,000 in external research grants) during Financial Year 2000/2001 (1 April 2000 – 31 March 2001), and published more than 30 papers in refereed scientific journals during 2000, a fraction of their total research output. In the same period, the Observatory has maintained a high public profile, continued to present a positive image of Northern Ireland and of Armagh City and District to the outside world, attracted more than 170,000 distinct e-visitors to its web-site (http://www.arm.ac.uk/), and noted more than 230 citations mentioning the Observatory, its staff or their work in various mass-media including the national and international press, radio, and television.

The total DCAL grant-in-aid and the yearly trend of various performance indicators are shown in the following Table. Here, all items refer to calendar year, with the exception of DCAL Grant Income and External Grant Income which refer to the corresponding financial year (i.e. External Grant Income for 2000 refers to the financial year 2000/2001). In addition, the Observatory receives approximately £10k–£20k per annum from other (i.e. non-DCAL) external sources not shown in the Table.

Calendar Year	Total DCAL Grant Income (£000s)	External Grant Income (£000s)	Refereed Journal Publications	Identified Media Citations	Distinct e-Visitors (DEVs)
1993	445.0	35	13	–	
1994	425.0	58	22	11	
1995	468.5	172	19	14	
1996	480.0	264	45	45	
1997	473.2	275	42	108	66,000
1998	443.0	195	43	147	80,000
1999	458.5	293	32	233	134,000
2000	538.5	212	31	231	174,000

The tabulated items are self-explanatory, except that the number of distinct e-visitors is actually the number of distinct hosts served by the Observatory's web-site, a lower limit to the number of e-visitors, owing to caching by big servers and sharing or repeat visits from the same IP number. (For comparison, the number of 'hits' on the web-site, defined as the number of successful page requests, is typically 5–10 times greater than the DEV statistic.) During 2000 the number of 'hits' on the Armagh web-site exceeded 870,000, and the total number of file requests of all types exceeded 2,800,000. The DCAL grant-in-aid for financial year 2000/2001 was augmented by £80,000 (bringing the total to £538,500), to cover the required SALT contributions for 2000/2001 and 2001/2002. DCAL grant-in-aid for financial year 2001/2002 is £473,500.

Despite the very positive trend of these results, there is a serious cloud on the horizon: namely, a growing shortage of funds for the Observatory to carry out its work. The Observatory has had essentially flat funding in cash terms for almost the past ten years, a period in which it has grown in size almost three-fold and increased its research activity, external income, and public profile respectively by much greater factors.

Continued under-funding will inevitably lead to inefficiencies in operation, restricting the Observatory's capacity to fulfil its primary function, and the fabric of the main Grade A listed building and telescope domes will continue to deteriorate. **If a significant uplift in recurrent funding cannot be achieved within the next one or two years (approximately £150,000 per year is required), future projects will have to be abandoned and the future of the institution will be cast into question**.

Appended to this report for Calendar Year 2000 (Financial Year 2000/2001) are lists covering (A) Membership of the Management Committee and Board of Governors, (B) Staff Members, (C) Refereed Journal Publications, (D) Presentations by Observatory Staff, (E) Seminars at Armagh Observatory, and (F) Identified Media Citations. The Observatory's New TSN Action Plan is included as Appendix F.

1 Astronomy at Armagh

The Vision of the Armagh Observatory is:

> *"To maintain and build on its position as a thriving astronomical research institute, and to continue to expand our understanding of the Universe and of humanity's place in it."*

The Mission is:

> *"To advance the knowledge and understanding of astronomy and related sciences through the execution, promotion and dissemination of astronomical research nationally and internationally in order to enrich the intellectual, economic, social and cultural life of the community."*

1.1 Introduction

The Armagh Observatory is the oldest continuously functioning astronomical research institute in the UK and Ireland, founded by Archbishop Richard Robinson in 1790 as part of his dream to see a University in the City of Armagh. It stands close to the centre of the City of Armagh, together with the Armagh Planetarium, in approximately 14 acres of attractive, landscaped grounds that are managed by the Observatory and include a scale model of the solar system and the Universe known as the Armagh Astropark.

The principal function of the Armagh Observatory, a tertiary-level institute funded by the Northern Ireland Department of Culture, Arts and Leisure (DCAL), is to undertake original research of a world-class academic standard which broadens and expands our understanding of astronomy and related sciences. Current key programmes focus on Stellar Astrophysics, the Sun, Solar System astronomy, Sun-Earth relationships including Climate, and the Near-Earth Object hazard to civilization. The Observatory also maintains a unique 200-year long meteorological record and data-bank (http://climate.arm.ac.uk/), the longest in the UK and Ireland from a single site. The Observatory currently receives an annual budget from the DCAL of approximately £500,000, and attracts additional funding, mostly through peer-reviewed external research grant applications to the UK Particle Physics and Astronomy Research Council (PPARC), amounting to roughly half this figure, i.e. an average of £200,000–£300,000 per year.

1.2 Organizational Structure

The Armagh Observatory is a Statutory Body with powers described by the 1791 Act of the Irish Parliament entitled "An Act for Settling and Preserving a Public Observatory and Museum in the City of Armagh For Ever", an Amendment of 1938 ("The University and Collegiate and Scientific Institutions Act [Northern Ireland], 1938"), and the more recent (1995 No. 1622) "The Armagh Observatory and Planetarium (Northern Ireland) Order 1995".

The Observatory is managed by a Director who reports to (a) a Management Committee which meets three times per year, and (b) annual meetings of the Board of Governors. The Management Committee (15 members) and Board of Governors (15 members) are overlapping constituencies containing representatives from a wide range of interested parties, including the Church of Ireland (the Chairman of the Board is the Most Revd Lord Eames, Archbishop of Armagh), the Dublin Institute for Advanced Studies (DIAS), the Queen's University of Belfast (QUB), the UK astronomical community (e.g. UK universities and the Astronomer Royal), the PPARC, the DCAL, and other bodies. Core funding is provided by grant-in-aid from the DCAL (formerly the Department of Education Northern Ireland, DENI), while additional research funding is obtained from bodies such as the PPARC, the British Council, the Leverhulme Trust, the Heritage Lottery Fund (HLF), the European Union (EU), and other grant awarding organizations. The current membership of the Management Committee and the Board of Governors is summarized in Appendix ??.

Armagh Planetarium The Armagh Planetarium was founded in 1968 by Dr Eric M. Lindsay, seventh Director of the Armagh Observatory, as the main public outreach of the Observatory. Since its inception the Planetarium has operated as an independent institution, the first and perhaps best known Director being the writer and broadcaster Dr (now Sir) Patrick Moore. The present Director of the Planetarium is Dr Tom Mason.

Whereas the Armagh Observatory is primarily an astronomical research institute with an organization and infrastructure geared to maintain its position as an internationally recognized centre of research excellence, the Armagh Planetarium is primarily an educational establishment, seeking to attract visitors

to Armagh and to educate and inform visitors of all age groups. The Planetarium has both a tourism and educational role; it is one of Armagh City and District's principal visitor attractions, and one of the best known tourist destinations in Northern Ireland.

Senior management responsibility for both the Armagh Observatory and the Armagh Planetarium rests with the Management Committee and Board of Governors. The two organizations share a senior administrator.

1.3 Research Environment

Technical equipment at Armagh Observatory, which is used primarily for numerical analysis, computing and data reduction, is funded mostly by the PPARC and partly by the DCAL. Computer facilities are excellent and include a Starlink node comprising some 30 Linux-based personal workstations, 3 Compaq Alpha servers, and a range of peripherals including laser printers, colour printers, tape drives and scanners. In addition, 6 Alpha-based systems and an 8-CPU Origin2000 are used for computationally intensive research projects (solar system dynamics, stellar atmospheres and 3-D numerical magneto-hydrodynamics). The internal network has a bandwidth of 100 Mbps. The external network, which is connected to the Joint Academic Network (JANET), currently has a bandwidth of 512 kbps. Following the establishment of a Tertiary Education Metropolitan Area Network (MAN) for Northern Ireland, probably within the next two years, it is expected that this will be increased to at least 2 Mbps.

Armagh Observatory staff regularly receive awards of telescope time on national and international facilities, including satellites such as the Hubble Space Telescope (HST), the Solar and Heliospheric Observatory (SOHO), and the Transition Region and Coronal Explorer (TRACE), and frequently obtain research grants from the PPARC and other grant awarding bodies. The Observatory is also eligible to receive grants from the Natural Environment Research Council (NERC). Within the next five years, with the support of earmarked funds from the DCAL, the Observatory will also gain priority access to the Southern African Large Telescope (SALT), a large (10-metre class) telescope located at the Sutherland Observatory, an outstation of the South African Astronomical Observatory (SAAO) on the Karoo Plateau in the Northern Cape Province, South Africa.

Closer to home, it is expected that work to conserve and preserve the historic telescopes and telescope domes at Armagh will be completed within the next several years with partnership support from both the Heritage Lottery Fund (HLF) and the DCAL. The HLF project ('Conservation of Historic Telescopes and Domes of Armagh Observatory', Reference HF-00-00310) will bring the Observatory's own telescopes (an 18-inch reflector and a 10-inch refractor) back into use for public viewing and student training, and will restore the historically important domes and listed buildings in which they are housed.

1.4 Staff

There is a fluctuating population of approximately 30 staff, roughly half of whom are core-funded by the DCAL. Senior research staff at the Observatory are employed on a Research Astronomer scale equivalent to the NICS Grade 7, which equates roughly to the level of a university senior lecturer, reader or professor. On the average, each Research Astronomer will have 1 externally funded post-doctoral research assistant and between 1 and 3 research students. In the past, students have been registered at various UK and other European universities, but most are usually registered at the Queen's University of Belfast (QUB), an institution that has strong links with the Observatory and which has formally recognized the Observatory as an approved institution for the supervision of PhD and MPhil students. The Observatory currently employs 20–25 research staff including students, who are supported by a pool of 2 technical (computer-related) staff, 1 librarian, 1 group secretary, 1 finance officer, and a senior administrator shared (50%) with the Armagh Planetarium. The 14 acres of landscaped grounds, which include the Armagh Astropark, are maintained by a grounds/meteorological support officer who is also responsible for recording the daily meteorological observations. The current staff position of the Armagh Observatory (31 December 2000) is given in Appendix A.

1.5 Appraisal and Review

The system of staff appraisal and performance-related pay (PRP) follows that of the Northern Ireland Civil Service (NICS). In addition, the work of the Director and staff is regularly reviewed at meetings of the Management Committee and Board of Governors, and undergoes continuous scrutiny and peer review through grant applications, the preparation of final reports, publication of research findings, and the presentation of material at scientific meetings and conferences. The work of the Observatory as a

whole is reviewed periodically at meetings between the Director and the DCAL (e.g. through reviews of the Annual Report, and the annual Operational Plan) and at least annually by senior management and the Board of Governors. The performance of the Observatory is also assessed externally at slightly longer intervals, for example through the Quinquennial Review process and participation in the UK Research Assessment Exercise (RAE), held in 1992 and 1996 and again in 2001.

The results of the RAE give the DCAL and the Observatory's external partners, notably UK charities and the research councils, information upon which to base their funding allocations. They also provide a comparative scale against which the Observatory can gauge its performance relative to the approximately 190 UK universities and research institutes involved in the RAE, and the 50 or so UK university departments that submitted returns to the Physics Unit of Assessment (UoA 19) in 2001.

In previous RAE exercises (1992 and 1996), staff at the Observatory achieved a Grade 4 in the Physics Unit of Assessment on a seven-point scale 1–5*, with 5* the highest. In the 1996 RAE this grade corresponded to "Research quality that equates to attainable levels of national excellence in virtually all sub-areas of activity, possibly showing some evidence of international excellence, or to international level in some and at least national level in a majority." In recent years, and especially during the year under review, the Observatory has sought to place itself in the best possible position to make a strong submission to the 2001 RAE, seeking to maintain (or possibly improve) its present high grade. The Observatory is an independent research institute and selects 100% of its eligible staff for assessment.

BDS Review 2000 Towards the end of 1999 the DCAL announced its intention to review the position of Director of the Observatory as part of a wider review of the positions of Chief Executives and Directors in the DCAL sector, and to commission a wide-ranging strategic review of both the Armagh Observatory and the Armagh Planetarium. The reviews were carried out by the Business Development Service (BDS), a branch within the Department of Finance and Personnel (DFP). The purpose of the Strategic Review was to review and report on: (a) the effectiveness of the Strategic Planning System; (b) the effectiveness of operational performance, including the relationship between the Armagh Observatory/Planetarium and the Department; and (c) the effectiveness of the organizations' Financial Performance, including arrangements to bid for funds and mechanisms to demonstrate value for money (VFM). A draft version of the report was presented to the Observatory in June 2000, and the final copy was received in October 2000.

The principal recommendations in the report, identified here by their number ([]) in the report's Summary Recommendations include: (A) the need for the Observatory and Planetarium to maintain separate strategic and business planning processes [1], while examining how each can benefit from the other through interaction and partnership [4]; (B) that both organizations should remain under the auspices of the DCAL [2]; (C) that the DCAL should develop a Management Statement with the Observatory and Planetarium [3] and discuss and agree funding arrangements [5]; (D) that clear mandates for both the Observatory and Planetarium should be developed [6], with the aims and objectives of both organizations being aligned to those of the DCAL; (E) that the Financial Memorandum should be reviewed [9], and VFM and key financial and performance measures should be defined and agreed [11]; and finally (F) that a clear Strategic View and a clear forward strategy will be the key to the long-term success of both organizations.

1.6 Achievements

Astronomers at Armagh are ambassadors for Northern Ireland on the national and international astronomical stage, and play an important role in promoting the public understanding of science and raising the profile of Armagh City and District to the outside world. They serve on a wide range of professional committees and other bodies (e.g. the Royal Astronomical Society and the Astronomical Science Group of Ireland), and have worked with others at a high level (including members of both Houses of Parliament) to achieve national recognition of the significance of the comet and asteroid impact hazard for society as a whole. This subject, which represents a formerly neglected high-consequence, low-probability risk for the survival of civilization, demonstrates — perhaps *par excellence* — the societal benefits that flow from the nation's support of astronomy, in addition to its purely scientific and educational content.

Notable achievements during 2000 have included: the development and verification of a new model for the origin and evolution of helium stars; the detection of a firm link between solar variability and climate and the possibly crucial influence of cosmic rays on low clouds; and the discovery of a characteristic scale ($\sim$500 Mpc) in the redshifts of some distant galaxies and quasars, corresponding to the largest 'structures' seen in the Universe at visual wavelengths.

Further significant discoveries which have led to new understanding include: the completion of a comprehensive investigation into the evolution of the luminous blue variable star P Cygni over the past 400 years; recognition that the zodiacal cloud is time-dependent, leading to significant long-term climatic effects of cometary and asteroidal dust; fundamental progress towards understanding interstellar turbulence and shock waves in star-forming regions; and the use of satellites such as SOHO and TRACE to unravel the complexity of the Sun's outer atmosphere and corona.

During the past five years, Armagh Observatory staff have obtained external grants totalling more than £1.2M, exceeding 50% of the total grant-in-aid provided over the same period by the DCAL and its predecessor the DENI. Including the cost, where known, of the peer-reviewed external research facilities used by Observatory staff in the course of their work (e.g. PPARC-funded telescopes), total external support over the past five years has exceeded £2.4M — greater than the total DENI/DCAL grant-in-aid over the same period.

The Armagh Observatory is thus an organization that provides remarkable value for money and delivers a strong return on its core DCAL funding, a result of which the DCAL and the Observatory management and staff can be proud. The Observatory has maintained a high level of research activity during the calendar year 2000, attracting more than 170,000 distinct e-visitors to its web-site (http://www.arm.ac.uk/), producing more than 30 refereed journal publications, and gaining more than 230 identified citations in various mass-media (including more than 50 items on radio or television). In addition, external research grants totalled £212,000 during 2000/2001, approximately 40% of the total DCAL grant-in-aid for the same period (£538,500, including £80,000 for SALT).

1.7 Future Plans

Looking to the future, the Observatory seeks to expand its research base and consolidate its strengths in stellar astrophysics and solar system astronomy. A high priority is to strengthen its capability in the cool star arena (following a decline in this area with the death of Dr P. Brendan Byrne in 1997), in order to complement the highly successful solar and stellar astrophysics groups and to take advantage of the Observatory's involvement in the Southern African Large Telescope and new UK national facilities, including access to the European Southern Observatory (ESO).

The Observatory also seeks to appoint additional staff in solar system astronomy, to capitalise on expected developments in this area and the likelihood that new government or EU funding opportunities will be announced for research into planetary science and exploration of the solar system, possibly including various aspects of the near-Earth object (NEO) impact hazard to civilization. The Armagh Observatory has taken the lead in the UK to bring this subject to the attention of government and the general public, and it is right that it should be in a strong position to take advantage of expected developments in this area.

The Observatory also needs to strengthen its capability in the growing area of meteorology, climatology and environmental science. This will be addressed by recruiting a meteorologist or climatologist with interests and expertise in the problem of global warming (and cooling), and in how extraterrestrial processes (e.g. the variable Sun, and comet/asteroid impacts and interplanetary dust) affect the Earth and contribute globally to environmental change.

None of these future plans will come to fruition unless the Observatory can secure sufficient resources to do the job.

2 Heritage

The Armagh Observatory is the oldest continuously functioning astronomical research institute in the UK and Ireland. The Georgian Grade A listed building and nineteenth and twentieth century telescope domes, each with unique architectural features, together house one of the most valuable scientific archives and book collections in Northern Ireland, and contain scientific artefacts, instruments and historic telescopes which together encompass virtually every aspect of modern astronomy.

These are important assets. The more than 200 years of continuous astronomical activity in Armagh provides astronomers with a unique opportunity to explain the development of their subject over this period, the reasons for its location in Armagh, and the context in which modern research is carried out. The location of the Observatory, close to the centre of the City of Armagh, in attractive, landscaped grounds that include the Armagh Planetarium and a scale model of the Universe known as the Armagh Astropark, means that it is ideally positioned to explain the history of astronomy and related sciences in Northern Ireland — and the motivation and underlying reasons for astronomy's impressive growth over

more than 200 years. The Observatory has a key role to play in lifelong learning and the preservation and display of Northern Ireland's scientific and built heritage for future generations.

2.1 Astropark

The Armagh Astropark, which is located in the Observatory grounds, comprises a scale model of the solar system and the Universe together with other outdoor exhibits and interpretation panels. Its construction was completed in the two years leading up to 1994 under the supervision of Research Astronomer John Butler and the former Director Mart de Groot, supported by major grants from the European Regional Development Fund (ERDF). Responsibility for its subsequent development and maintenance was handed to the Armagh Planetarium on 1 April 1994, but later (March 1999) returned to the Observatory. The Astropark is an integral part of the Observatory's programme of public outreach, and the Observatory is committed to developing and maximizing its educational potential. The vision is to make the Armagh Astropark the leading outdoor exhibit for the public understanding of science in Ireland.

Although the Observatory currently has no core funding specifically to develop this highly attractive facility, senior staff (notably Simon Jeffery) have gradually improved its educational potential with the assistance of external grants from the PPARC and other bodies, and by installing interpretation panels at key positions in the grounds. Simon Jeffery has also implemented a 'virtual tour' of the Astropark, which may be reached from the Observatory web-site (see http://www.arm.ac.uk/astropark/).

In order to establish a baseline for the number of people who visit the Observatory grounds and the Armagh Astropark, a counter was installed at the entrance to the Astropark at the end of July 2000. Since then, approximately 400 visitors per week have been recorded. Many of these 'visits' are undoubtedly returns by a rather smaller number of local residents, for example school children, but the high weekly number demonstrates the importance of the Armagh Astropark at least within the local community, and suggests that approximately 10,000 people per year use the facility.

2.2 Cup-Anemometer

Thomas Romney Robinson, the third director of the Observatory, was a well-known astronomer and meteorologist, and besides his commitment to astronomy made experiments in many other fields of science. One of his most enduring legacies is the Robinson Cup-Anemometer, a device for measuring wind speed. The design was originally suggested to him by Richard Lovell Edgeworth, his future father-in-law, and the invention motivated in 1839 by the desire to monitor wind speed and its variability with precision, following the destructive Great Wind of 6 January that year.

An early version of the Robinson Cup-Anemometer was first erected on the roof of the Observatory at least as early as 1845. In 1867, when the Board of Trade decided to establish seven first-class meteorological stations throughout the British Isles, where complete sets of self-recording instruments working by photography would be in action day and night without interruption, it was natural, knowing Robinson's interests in meteorology, for the Armagh Observatory to be selected as one of the stations. From a note in the Observatory Minute Book, the clockwork of the registry of the anemometer had been in action since March 1847, and subsequently from November 1849 every hour for more than 57 years the wind direction and speed were recorded at Armagh. This is a remarkable record, of scientific interest and potential importance for studies of long-term climate change.

The original anemometer was taken down in May 1870 and replaced with the present version, constructed with a cast-iron outer casing, copper cups and rods, and bronze internal fittings. It is this historic instrument which can now be seen at the Observatory and which has been operating (albeit from slightly different locations) ever since. Renovation of the Robinson Cup-Anemometer was completed by Mr Bertie McClure during July 2000, and the instrument reinstalled on the roof of the building in August.

2.3 Buildings

Construction of the Observatory's principal buildings began in 1789, using plans drawn up by Francis Johnston, one of Ireland's most celebrated architects, a native of Kilmore, County Armagh who in later years became known as 'Ireland's Wren'. The main buildings, which are of considerable architectural merit, comprise in their original designation a residence for the Astronomer, a meridian room, a library and several telescope domes.

The interior of the residence is one of only a handful of eighteenth-century domestic interiors to survive in Northern Ireland and is remarkable for the quality of its joinery and fittings. It houses a valuable collection of historic clocks, archives and scientific instruments, together with the paraphernalia of modern

astronomical research, including a recently obtained Origin 2000 supercomputer. The conjunction of the 'old' and 'new' at Armagh, and the fact that the building is still used for its original purpose, gives the Armagh Observatory a unique capacity to provide — at essentially zero cost to the organization — the 'museum' pieces of tomorrow.

The telescope domes include: (1) the 1790 dome, completed in 1793, which is believed to be the second earliest surviving astronomical dome in the world and the earliest to survive with its original equipment (namely, the 1795 Troughton Equatorial Telescope) preserved in situ; (2) the 1827 dome, built originally to house a Herschel telescope but shortly thereafter converted for the 15-inch Grubb Reflector; (3) the Robinson Memorial Dome, which was built to house the 10-inch Grubb Refractor; and (4) a utility (Schmidt) dome built in 1950 to house the modified late nineteenth-century Calver Newtonian reflector, which had been converted that year to a 12/18-inch Schmidt photographic telescope.

Restoration of the 1790 dome and the Troughton Equatorial Telescope was completed in 1992. A programme of restoration of the six eighteenth-century astronomical regulators (clocks) belonging to the Observatory has also been largely completed and provision made for their preservation and display to the public within the main building. A number of items of scientific equipment were re-assembled and restored for the Bicentenary Exhibition in the Armagh County Museum, the Ulster Museum, Birr Castle, and the National Museum of Ireland during 1990–1991. Several of these artefacts are now on permanent display at the Observatory and have occasionally been placed on loan to exhibitions elsewhere. The Observatory's heritage policy is to place restored instruments in their original location in the building so far as possible, so that visitors may more clearly understand the context of their use.

A notable achievement during 2000 was Astronomer John Butler's success with another Heritage Lottery Fund application ("Conservation of Historic Telescopes and Domes of Armagh Observatory", reference HF-00-00310) for funds to restore three of the Observatory's historic telescope domes and their associated instruments.

The total estimated cost of this project is £381,375, the bulk of which (£286,000) will be provided by the HLF. The DCAL has been asked to provide the necessary balance of ∼£96,000, but has so far been unable to commit any additional funds to the restoration programme. The project will include (1) the Robinson Memorial Dome (1885), a listed building of considerable architectural merit, and the 10-inch Grubb telescope that it protects; (2) the 1827 Dome and its 15-inch equatorial reflecting telescope, which is the earliest example of a large equatorial reflector with a clock drive and of quite exceptional interest in the development of telescope design; and (3) the 18-inch Calver Telescope, currently converted for use as a Schmidt photographic telescope, and its dome.

The Robinson and Schmidt domes are now in a severe state of dilapidation and in urgent need of repair and reconstruction, while the 1827 dome is also in need of restoration and its original telescope (the 15-inch Grubb Equatorial Reflector) in pieces. The success of the HLF-funded project will ensure the survival of these unique and historically valuable telescopes and domes well into the 21st century.

Gifts Following the death in December 1999 of Mrs Sylvia Lindsay, the wife of the former Director (Dr Eric Lindsay), her surviving sister Mrs Edith Davis kindly donated a number of memorabilia and family photographs associated with the Observatory during the important Lindsay era (1937–1974). Mrs Davis also donated an oil painting showing the south side of the main residence during the early 1950s, which is on display in the main entrance of the Observatory.

The first public donation to the historic telescopes and domes project, namely £50, was received early in 2000 from a well known local amateur astronomer.

2.4 Future Plans

The policy of the Armagh Observatory is to preserve and progressively restore the historic instruments, buildings and telescopes for future generations, and where possible make them available for display to visitors and the general public.

In future years, subject to available funding, the Observatory plans to:

- construct a new archive and historic instrument repository including an extension of the Library and Library Annex;
- construct a reception and exhibition area to present the current and previous astronomical work at the Observatory;
- upgrade the grounds and Astropark and reinstate the area immediately around the Observatory to its original eighteenth-century design.

3 Research

3.1 Research Areas

Research interests of Observatory staff currently focus on (i) Stellar Astrophysics (including star formation, astrophysical jets, cool stars, hot stars, helium stars, star-spots, flares, circumstellar dust), (ii) the Sun (the dynamic solar atmosphere, chromosphere and corona), (iii) Solar System Astronomy (including celestial mechanics, the dynamical evolution and relationships between comets, asteroids and interplanetary dust), and (iv) Solar System – Terrestrial Relationships (including solar variability, climate, accretion of interplanetary dust and Near-Earth Objects). In addition, Observatory staff maintain an active programme of Public Understanding of Science (PUS), via lectures, popular astronomy articles, the provision of advice to the general public, Observatory tours, and interviews with the press, radio and television.

Staff at the Observatory have also investigated (i) the structure of meteor streams; (ii) an apparently regular periodicity in some extragalactic redshifts; and (iii) the role played by the variable Sun on climate change during the past two hundred years. The Armagh climate series, which is one of the longest in the world from a single site, can now be accessed over the internet by individuals, schools, and researchers from anywhere in the world (see http://climate.arm.ac.uk/). Further details concerning the research interests of all the Observatory staff may be obtained from the Observatory web-site at: http://www.arm.ac.uk/.

3.2 Impact

The results of the Observatory's research programmes into Stellar Astrophysics, the Sun, Solar System Astronomy, and the Earth's Climate, encompass areas of astronomy that promise to have a significant impact on our lives over the next few decades, and to provide lifelong learning opportunities and increased public understanding of science for all.

The 20–30 astronomers of graduate or postdoctoral status who work at the Observatory come to Northern Ireland from many countries around the world, and are actively involved in many international partnerships and collaborations. Together they generate a wide range of international contacts, a significant level of publicity for Armagh City and District, and a strong, positive image of Northern Ireland both home and abroad.

A separate indication of the value of the Observatory's research output is the amount of external research income, raised mostly through a process of competitive grant application and peer review. This is a fluctuating quantity, but the total external grant income for 2000/2001 — namely £212,000 — is again a good performance and a substantial fraction of the total DCAL grant-in-aid for the same financial year.

A subset of the total research output of Observatory staff, namely the list of 31 refereed journal publications during 2000, is given in Appendix B. A related subset, namely the list of 75 public and professional presentations delivered by Observatory staff during 2000, is given in Appendix C, while a third subset — the list of Observatory seminars — is given in Appendix D.

These examples illustrate some of the routes by which research results are communicated both by and to Observatory staff: through presentations or articles in the local, national or international media; at conferences, seminars and workshops; in books; in refereed scientific publications and journals (some of which nowadays are entirely in electronic form, e.g. The Journal of Astronomical Data); and in a variety of non-refereed publications.

The remainder of this section summarises, under the headings of the Observatory's senior research staff and associates, some of the principal research results obtained during 2000 by these staff and their colleagues.

3.3 Research Reports

3.3.1 C.J. Butler, Research Astronomer

John Butler has worked with Kieran Hickey and Armin Theissen (PDRAs), research students Enric Pallé Bagó, David García Alvarez, and Anna Maria García Suarez, and meteorology project staff Brenda Morrow, Mark Emerson, and Dierdre McCabe. The main research interests have encompassed the link between the variable Sun and climate, notably identifying a firm link between clouds and cosmic rays; and the flares and angular momentum evolution of late-type stars. During the year John Butler also acted as an external examiner for a PhD submitted to the University of Birmingham, and made a significant contribution to the public understanding of science by means of lectures, talks and media interviews.

Towards the end of 2000, he obtained a major Heritage Lottery Fund award to conserve and restore three of the Observatory's historic telescopes and telescope domes.

Clouds and Cosmic Rays Although evidence for a link between solar activity and climate has been mounting for many years, the physical mechanisms responsible have not been clearly established. The most direct link would be through the known change in the Sun's brightness as a result of the changing solar magnetic field. Such a mechanism can explain about 10–20% of the global warming over the past century. However, a much larger contribution could potentially derive from changes in the albedo and long wavelength radiation of the Earth brought about by changes in cloudiness.

A study of satellite cloud cover factors for the period 1983–1994 has shown that there is a clear correlation between specifically low cloud (1–3 km altitude) and the influx of cosmic rays over substantial areas of the Earth. Although the cosmic rays are of Galactic origin, their spectrum and strength are strongly modulated by the solar and interplanetary magnetic fields they encounter en route to Earth. Thus, the connection between the solar magnetic field, cosmic rays and terrestrial clouds is a strong contender as the missing link between solar activity and climate.

We have computed the regression lines of satellite cloud factors and the ionization produced by cosmic rays for a grid of points over the globe and studied the geographical distribution. We find that the correlation is stronger in the eastern hemisphere than the western hemisphere and is stronger in mid-latitudes than equatorial or high-latitude regions. These findings are difficult to explain by the known geographical variation in cosmic-ray flux.

Assuming that the correlations established have been operative over recent centuries, we have computed the net effect of the implied changes in albedo and the Earth's long-wavelength radiation on global temperatures. We find that the predicted changes in cloud factor are capable of explaining much of the current global warming and also the low temperatures observed in the period during the late 17th and early 18th centuries known as 'The Little Ice Age'.

A study of ground-based synoptic cloud data has also been made in order to see if the predicted fall in low cloud factors can be seen in historical data. In general, although there are some indications that low cloud is decreasing in the same way that the solar activity – cloud correlation predicts, overall, cloud amounts appear to be increasing. Thus the question of whether or not low cloud has actually changed over past centuries, as predicted, remains unresolved.

Clouds and Sunshine over Ireland The records of sunshine hours obtained since the late 19th century from four stations (including Armagh) distributed throughout Ireland were analysed. A gradual decrease in sunshine hours has occurred at all four sites since records began. Increasing cloud factors, resulting from enhanced evaporation rates over the Atlantic as sea surface temperatures have risen, is one possible explanation for the decline in sunshine.

A strong negative correlation was confirmed between sunshine factors from ground-based observations and satellite-based cloud factors over Ireland. In addition, it was found that cloud factors over Ireland correlated well with cloud factors over large oceanic areas such as the North Atlantic and mid-high latitudes generally. Thus cloud factors (and similarly sunshine factors) from regions on the boundaries of large oceans which lie in the direction of the prevailing wind could be useful in determining the long-term changes in cloud factors over more extended areas. Knowledge of such long-term variability in the Earth's cloud cover provides important input information for modelling past climate change.

Meteorological Archive Two grants were obtained during the year, in collaboration with other staff (Martin Murphy, Lawrence Young, Mark Bailey), to establish a Northern Ireland meteorological archive on the world-wide web: one from the Heritage Lottery Fund and the other from the Irish Sailors and Soldiers Land Trust. The object of the project is to make scanned images of the entire Armagh Observatory Meteorological Data Bank available over the internet, in order that the original records can be accessed by educational and research organizations as well as the general public. In addition, calibrated and homogeneous data series will be prepared for maximum and minimum temperatures, rainfall, humidity, sunshine, pressure, cloud factors, and ground temperatures for the Observatory site. This is believed to represent the longest series of homogeneous meteorological data for any site in the UK or Ireland. In addition, temperature data for Dunsink Observatory has been compiled and will be used to bridge a short gap in the Armagh records from May 1825 to December 1832.

Three staff joined the Observatory during the year to work on different aspects of this project, while the growing climate/meteorology team was augmented early in 2001 by the addition of two further staff: Kieran Hickey (PDRA) and student Anna Maria García Suarez. They are to work respectively

on calibrating the Armagh climate series and the effect of climate on tree-ring widths, the latter in collaboration with Professor Mike Baillie (QUB).

Late-Type Stars An escape probability code, originally developed by Stephen Drake, was previously modified and used by D. Jevremović to give fundamental parameters for flares on Gliese 866 based on fits to the observed Balmer decrements. As there were later some doubts as to whether or not the results were realistic, the code has been applied to two other flares, one on the Sun for which direct area information is available, and another on a second dMe star which was independently analysed using another method. In both cases, the escape probability code predicted electron temperatures, electron densities, areas and volumes of the flare plasma close to those found by the other methods. Therefore we are confident that this code is capable of giving reasonable results. It has subsequently been applied to a large flare observed on the star AT Mic with the 1.9 m telescope at SAAO, and a paper prepared for publication.

John Butler also completed a project on the angular momentum evolution of late-type stars, initiated by the late Brendan Byrne, with PDRA Armin Theissen. Although significant progress was made, particularly on the rich and poorly studied cluster Stock 2, the programme could not be completed as originally planned due to difficulties in obtaining the requisite allocations of large telescope time for high-resolution spectroscopy of faint stars.

Restoration of Telescopes and Domes A grant has been obtained from the HLF for the restoration of three of the Observatory's historic telescopes and domes. This will involve the reconstruction of the original 15-inch Thomas Grubb Equatorial Reflector, the renovation of the Howard Grubb 10-inch Refractor including the provision of a new objective, and the restoration of the Calver/Schmidt telescope to its original Newtonian design. The project will involve the erection of a new dome for the Calver Telescope and the restoration of the Robinson and 1827 Domes. It will be possible for the general public to view the telescopes from a network of wheelchair accessible paths. Site plans have been agreed and planning permission requested.

3.3.2 J.E. Chambers, Research Astronomer

John Chambers has continued to serve as an external supervisor of PhD student Nick Sleep (Open University), together with Mark Bailey and Barrie Jones (Open University), and has worked on extrasolar planets with Monika Kress, Robbins Bell and others of NASA Ames Research Center, California, USA.

The work has focused largely on theoretical studies of extrasolar planets. In particular, he has made a large number of computer simulations to test whether Earth-like planets could form in a wide variety of planetary systems. He has also examined terrestrial-planet formation in known extrasolar systems. The principal conclusion of this work is that stable Earth-like planets can exist orbiting other stars even if these stars have very massive giant planets, provided that the giants lie at least twice as far from the star as the Earth does from the Sun. However, if a star has giant planets moving on highly non-circular orbits, habitable, Earth-like planets are unlikely to exist.

Extending this work with the above collaborators, he has examined whether Earth-like planets in other systems could possess water and organic-rich materials needed to form life. The Earth and other habitable planets probably formed out of very dry material containing little carbon or nitrogen needed to make organics. However, these vital ingredients could have been delivered to a planet when asteroids collided with the planet early in its history. The group has found that this is likely to happen in a range of planetary systems, but by no means all.

Working with Greg Laughlin of NASA Ames, John Chambers has also begun a project to analyse data from observational programmes to detect extrasolar planets. To date, these surveys have found more than 50 low-mass objects orbiting other stars. These objects are most likely to have masses comparable to Jupiter. However, the observational technique used to find them can only place a lower limit on their mass rather than determining their true mass. Laughlin and Chambers are using improved analysis techniques that will make it possible to determine the true masses in many systems for the first time.

John Chambers is also collaborating with Pat Cassen of NASA Ames to make new computer models which will combine theories of planet formation with those of protoplanetary disks. This work is beginning to bridge the gap between these fields and will help improve our understanding of both subjects with important implications for understanding both our own Solar System and planetary systems in general.

3.3.3 J.G. Doyle, Research Astronomer

Gerry Doyle has worked on solar physics with Maria Madjarska (PDRA) and research students Luca Teriaca and Illía Roussev, and in the cool star area with Alex Löbel (a former PDRA), and Darko Jevremović (PDRA) and David García Alvarez (PhD student).

Solar Plumes An accurate understanding of the physical conditions in coronal holes is important for constraining models that describe the acceleration of the high speed solar wind. The measurement of line widths can provide information concerning ion temperatures, sub-resolution turbulent motions and velocity fluctuations associated with magnetohydrodynamic (MHD) waves in the corona. Line width variations combined with simultaneous electron density estimates, provides a very powerful diagnostic for the solar corona. Despite the fact that bright plumes are striking features within coronal holes that can extend to more than 30 solar radii from the Sun, the brightest plumes cannot be the source of more than a small percentage of the fast solar wind, because they only account for a tiny fraction of the solid angle subtended by the polar coronal holes. This means that the main source of the fast solar wind lies in the darker inter-plume regions. In order to shed some light on the mechanism responsible for the acceleration of the fast solar wind and to provide constrains for numerical modelling of the coronal holes, we need to know the magnitude and variability of the thermodynamic variables (such as density and temperature), particularly in the inter-plume regions.

Specifically, we have examined spectral time series of the transition region line O v 629Å, observed with the Coronal Diagnostic Spectrometer (CDS) on the SOHO spacecraft in July 1997. Both Fourier and wavelet transforms have been applied independently to the analysis of plume oscillations in order to find the most reliable periods. The wavelet analysis allows us to derive the duration as well as the periods of the oscillations. Our observations indicate the presence of compressional waves with periods in the range 10–25 min. We have also detected a 11 ± 1 min periodicity in the network regions of the north polar coronal hole. The waves are produced in short bursts with coherence times of about 30 min. We interpret these oscillations as outwardly propagating slow magneto-acoustic waves, which may contribute significantly to the heating of the lower corona by compressive dissipation and which may also provide enough energy flux for the acceleration of the fast solar wind. The data support the idea that the same driver is responsible for the network and plume oscillations with the network providing the magnetic channel through which the waves propagate upwards from the lower atmosphere to the plumes.

During these observations we also detected by chance a giant macro-spicule at the limb and were able to follow its dynamical structure. Blue and red-shifted emission in the O v line indicates that it is probably a rotating twisted magnetic jet. Emission is also detected in the Mg ix 368 Å line, at a temperature of 1,000,000K. We also present observations of O vi 1032 Å line profiles obtained with the SUMER instrument on SOHO extending from the solar disk to $1.5 R_\odot$ above the limb in the north polar coronal hole. Variations of the intensity and line width in the polar plume and inter-plume regions are investigated. We have found an anti-correlation between the intensity and the line width in the plume and inter-plume regions with detailed plume structures being seen out to $1.5 R_\odot$. Possible implications regarding the magnetic topologies of these two regions and related heating mechanisms were discussed. The O vi line width measurements are combined with UVCS/SOHO output to provide an overview of its variations with height extending up to $3.5 R_\odot$. We find a linear increase of the line width from 1 to $1.2 R_\odot$, then a plateau followed by a sharp increase around $1.5 R_\odot$.

Solar UV Explosive Events Primarily observed in the network lanes at the boundaries of the supergranulation cells, UV explosive events are preferentially found in regions with weak and mixed polarity fluxes that display magnetic neutral lines. However, despite the large amount of observational material on UV explosive events and blinkers, large uncertainties about their basic physical parameters such as electron density and temperature still exist. In this work we explore an electron density diagnostic involving the transition region ion, O v. The derived electron densities in an explosive events are then discussed. In another study, we determine the electron density for a range of solar features using new calculations for the O v line ratio, R=I(761.1 Å)/I(760.4 Å), in conjunction with observational data obtained with SUMER/SOHO. The densities obtained from this diagnostic are in good agreement with earlier measured values. We conclude from these results that this particular O v ratio is a useful diagnostic for many types of solar features.

Using measured line shifts and electron density enhancements in UV explosive events, an attempt has been made to correlate both observational phenomena, and to associate the observed density enhancements to magnetic reconnection sites. The corresponding local magnetic field strength in these sites is estimated. These values are of the same order as previously measured in photospheric cancelling flux

regions.

Solar Spectral Line Broadening The trend of the line broadening across the disk for optically thin lines has a fundamental importance in constraining which mechanism is operating in heating the corona. Full disk images from SUMER/SOHO taken in He I, C IV and Ne VIII were used to investigate whether there exists a center-to-limb variation in the line width. Both C IV and He I show such a variation but the higher temperature Ne VIII line is relatively constant. For C IV, this corresponds to a $\sim$3 km s^{-1} difference while He I is significantly larger particularly at the limb. Whereas this work may suggest that the non-thermal motions are slightly non-isotropic in the transition region and upper chromosphere, with the horizontal unresolved motions exceeding those in the vertical plane, a more probable explanation is that the lines are broadened due to opacity effects. The variation of the C IV 1548 Å line width could be explained by increasing the opacity from zero at disk center to $\sim$1 at the limb. For He I the opacity is significantly greater than unity at the limb, implying all mass motions in the chromosphere, transition region and corona are isotropic.

Cool Stars We modeled the spectral changes of late oxygen-rich Mira variables observed in different pulsation phases. From a combination of variable near-IR spectra and UKIRT spectro-photometry of the 9.7 μm silicate dust emission feature in different phases we studied the influence of the changing atmospheric circumstances on the conditions in the circumstellar dust shell. From a detailed modelling of TiO and VO bands in the near-IR spectra, we determined changes of the effective temperature and the effective atmospheric acceleration of the central star. The corresponding model spectral energy distribution is redistributed through the dust shell by means of radiative transfer calculations in order to perform a detailed modelling of shape changes observed in the silicate feature. We showed that the latter were mainly caused by changes in the flux distribution of the incident radiation field with stellar pulsation, whereas intensity changes of the dust emission result from stellar luminosity changes as they are enshrouded by very optically thin dust shells. In the case of the Mira variable, *o* Cet, we computed that the effective temperature increases from $T_{\rm eff} = 2,400$ K in the minimum phase, to 3,000 K $\pm$ 100 K around the maximum phase. The amplified momentum transfer around maximum light enhances the acceleration of the dust outflow near the dust condensation radius of $\sim$6 stellar radii. This produces variations of the terminal dust outflow velocity with phase, by an amount $\Delta v_{\rm infin} \simeq 5$ km s^{-1} at large distances from the star. The corresponding small changes in flux mean that opacity and gas mass-loss rates, from (2.8–3.2)$\times 10^{-7}\,M_{\odot}$ yr^{-1}, are sufficient to model the changes in shape observed in the dust emission feature. A comparison with the modelling results for another long-period Mira variable, U Ori, has also been completed.

We have also discussed the influence of the non-thermal velocity (micro-turbulence) on the formation of chromospheric lines in the atmospheres of late-type dwarfs. A review of previous work showed a variety of different approaches to the problem leading to different atmospheric structures and consequently different computed line profiles. In that light, we re-examined the formation of the hydrogen Balmer lines and the sodium Na I D lines using twelve different distributions of the micro-turbulent velocity throughout the atmosphere. Our results showed a wide range of possible line shapes. Using the analogy with the solar case and the latest results of the non-thermal component widths as derived from instruments on the SOHO spacecraft we have been able to model Hα and the Na I D lines in an active dMe star Gl 616.2.

A Fortran code which computes synthetic light and colour curves of active, spotted stars has been developed. The main feature of this code is that it can simultaneously model the V light curve and the $(V-R)_c$, $(V-I)_c$, $(V-K)$ colour data. It also uses new effective-temperature-colour and Barnes-Evans-like calibrations, temperature and gravity-dependent limb darkening coefficients and different effective surface gravities for the spotted and unspotted photosphere. The code allows for two-component spots, i.e. spots with umbral and penumbral components. Various problematic spot configurations were investigated and we conclude that, in order to be able to differentiate spots with various thermal structures (umbrae, penumbrae, faculae) or polar spots from equatorial bands, the modelling of the infrared colours, especially $(V-I)_c$ and $(V-K)$, is needed.

The active flaring binary CC Eri was studied via multi-wavelength observations involving multi-band photometry and ground and space-based spectroscopy. Combining early spectroscopic data with the present implies an orbital period $P = 1.5615$ days. Furthermore, the spectroscopic data suggest spectral types of K7 and M3 for the system. The optical photometry indicated a small spot coverage in late 1989, consistent with data taken a year later that showed CC Eri to be entering its brightest-to-date phase. Two flares were detected in the ultraviolet spectral data. These radiated 2.7×10^{24} J and and 1.6×10^{24} J in the C IV line alone, each with a total estimated radiative energy budget of $\sim 10^{29}$ J. For the higher temperature lines, such as C IV, there was no systematic variability with phase. The lower temperature

lines show a slight indication of rotational modulation. However, there is a much larger scatter in the individual measurements of the Mg II and C IV fluxes than would be expected from measurement errors alone, consistent with an atmosphere showing continual small-scale activity.

3.3.4 C.S. Jeffery, Research Astronomer

Simon Jeffery has worked with Vincent Woolf (PDRA), Regina Aznar Cuadrado (PhD student), Pilar Montañés Rodríguez (PhD student), Lorna Devine (TCD student), and Jacob Samuel (NISTRO scholar). The main area of research involves understanding the late stages of stellar evolution, and the nature and evolution of evolved or burnt-out stars close to the end of their lives as visible objects.

Stellar corpses are the burnt-out remains of stars that have exhausted their reserves of energy and ceased to shine. All that may be seen is a glowing ember as the star gently cools, or the signature of highly energetic material trapped in their enormous gravitational and magnetic fields. Well known examples include black holes, white dwarfs and neutron stars. They are amongst the most exotic objects in the Galaxy, and our mission is to discover how normal and benign stars like the Sun reach such macabre ends. In pursuing it, we also study the origin of elements essential to human life, the physics of matter under extreme conditions, and processes that affect the evolution of entire galaxies.

According to the standard picture, a star like the Sun will eventually swell up to become a red giant as it finishes converting hydrogen to helium. Pausing to convert helium to carbon and oxygen, the expansion then continues until the star sheds its outer layers as a planetary nebula and shrinks to become a white dwarf. This is shown by the solid line in the top right-hand panel of Figure 1.

However, many stars do not fit comfortably into this picture, particularly those that have become so mixed up that even their outer layers have no hydrogen left. These are the helium stars and the hot subdwarfs that together form a major area of the group's research interests.

The problem demands that we study stars that are in transition between hydrogen burning and death. Such phases frequently do not last long — a few thousand years or less — and hence such stars are rare. They are also of great interest as examples of stars showing astronomically rapid evolution on time-scales of human concern. For example, observations of one group of luminous extreme helium stars show that they are heating up at rates up to 100 °C per year as they contract to become white dwarfs: a fiery example of stellar global warming!

We must also measure their properties in as much detail as possible. For instance, we would like to know their mass, radius and luminosity at the very least. The chemical composition of their surface layers provides further clues to their history and past evolution, particularly if the material processed by nuclear reactions in their cores has been exposed at the stellar surface. It is also important to know if the star is (or was) one of a pair, a so-called binary star, because such stars can exchange mass with their companion as they evolve.

The team's approach has been to combine high-quality observations with the best possible theoretical models, covering every aspect of stellar structure from the deep interior to the outermost layers of the star's atmosphere. Our theoretical work involves making hypotheses about the origin of given stars. These define boundary conditions for solving the time-dependent equations of stellar structure. Such solutions show long-term evolution in response to changes in chemical composition at different points within the star, and short-term changes (pulsations) in response to instabilities in the energy flow from the star. Our theoretical work also involves the construction of detailed models of the outermost layers of the star and the spectrum of radiation they emit, for detailed comparison with observations.

Major Results Simon Jeffery and Dr Don Pollacco (QUB) completed an analysis of the radial motion of the surfaces of two pulsating subdwarf B (sdB) stars. Like the Sun, these very evolved stars pulsate non-radially, with a very small amplitude and oscillation periods in the range 2–3 minutes. Unlike the Sun, these stars are very faint, and therefore difficult to observe. Using time-series lasting about 5 hours and comprising approximately 2000 individual observations of each star, several independent modes of oscillation were resolved and the amplitude of the radial motion determined for each case. We also demonstrated that the orbital period of one star, known to be a binary, was between one and three days.

Meanwhile, Regina Aznar Cuadrado and Simon Jeffery completed an analysis of the energy distribution of some 30 sdB stars, using light from the ultraviolet to the infrared. The energy distributions are dominated by the surface temperature of the sdB star and the presence of any cool companion. The fitting software TFIT and BINFIT developed during 1999 was used to derive effective temperatures and relative luminosities for a number of binary sdB stars. The surprising result was that a sizeable fraction of these stars appear to have main-sequence companions, rather than the giant or sub-giant companions

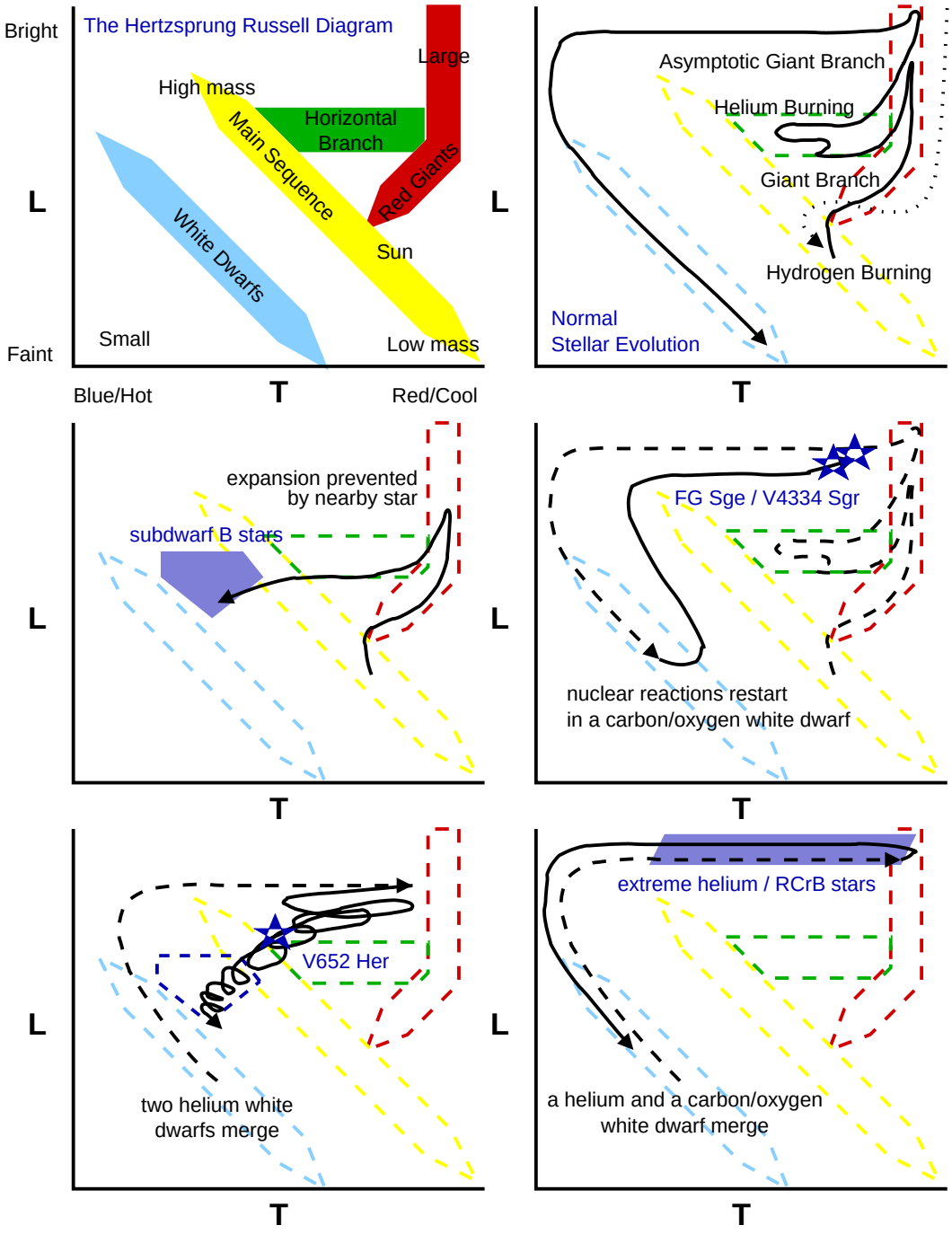

Figure 1: The distribution of stellar luminosity L and temperature T for normal stars divides into several broad bands on the Hertzsprung-Russell diagram (upper left-hand panel). Stars near the top left-hand side of this diagram tend to be of high mass, hot and blue; those near the bottom right-hand side of the diagram tend to be of low mass, cool and red. When nuclear burning occurs at a late stage of evolution, or when a star comes into contact with a close companion, 'normal' evolution breaks down. The work of the group focuses on explaining unusual and abnormal stars such as FG Sge, V652 Her, and RCrB and extreme helium stars.

previously supposed. This is of significant importance for understanding the evolutionary origin of sdB stars.

An observational programme to measure radius changes in extreme helium stars on both long and short time-scales was also concluded, in collaboration with R.L.C. Starling (a former Armagh summer student, now at Mullard Space Science Laboratory), P.W. Hill (St Andrews) and D. Pollacco (QUB). Approximately 150 spectra obtained with the International Ultraviolet Explorer between 1979 and 1995 were used to measure changes in surface temperature and apparent radius. Over a three-week interval changes due to radial pulsations were measured. These were used to measure directly the masses of radially pulsating helium stars for the first time. The values of $\sim 0.9\,M_{\odot}$ are in good agreement with previous estimates and evolution theory.

The second outcome of this work concerned changes over 10–15 years. From quite simple arguments we had predicted heating (or contraction) rates which, depending on the mass of the star, might reach over 100 °C per year. Given the long baseline of our observations, we were able to measure heating rates of between 30 and 120 °C per year for four stars, in excellent agreement with theory. Combining direct observations of pulsation and evolution for the same star (HD 168476) places strong constraints on any model for the formation and evolution of extreme helium stars.

TFIT and SFIT The analysis of stellar spectra is a time-consuming and often subjective task that involves fitting models with many free parameters to observations of varying quality. During 1999, a project to build software for the *automatic*, efficient and objective analysis of stellar spectra had enabled us to measure properties of both single and binary stars from their observed energy distributions (TFIT and BINFIT). During 2000, this software was extended to the analysis of high-resolution stellar spectra, again for both single and binary stars (SFIT and SFIT_SYNTH).

Other Work In 1900, FG Sagittae (FG Sge) was an unknown faint blue star. Since then it has expanded to become a cool giant helium star. With Schönberner (Potsdam), Simon Jeffery has continued work to measure changes in its surface composition during this expansion. This work complements another ongoing project with Pollacco (QUB) to study the chemical evolution of Sakurai's object — an even more rapidly expanding star that suddenly appeared in 1996. New models have been developed to measure the atmospheric parameters for both stars, which are changing their appearance on astronomically short time-scales, almost literally before our eyes.

Following their successful explanation of the pulsating helium star V652 Her as a He+He white-dwarf merger, Hideyuki Saio (Tohoku University) and Simon Jeffery calculated further white-dwarf merger models. These point towards an explanation of extreme helium stars and R CrB stars (a group of stars that fade spectacularly and unexpectedly by factors of 1,000 or more due to the formation of sooty clouds above the surface of the star) as the product of a carbon/oxygen+helium (CO+He) white-dwarf merger.

3.3.5 M.D. Smith, Research Astronomer

Turbulence in Star-Forming Regions Turbulence is a key concept in modern science. Astrophysical turbulence has fascinating properties and features produced by combinations of extreme physical and dynamical conditions. In particular, turbulence is dominant in molecular clouds, the nurseries for the stars. This implies that an understanding of the origins of stars and stellar systems will require a theory for molecular turbulence. Publication of the analysis of simulations of three-dimensional magnetohydrodynamic self-gravitating supersonic turbulence represents an advance in our understanding of the dynamical processes during star formation.

Unification Scheme The Unification Scheme is designed to model the evolution of protostars and their environments. The Unification Scheme, drawn out by Michael Smith, was reviewed in the Irish Astronomical Journal and applied in collaboration with others to one of the most well-studied star formation regions in Orion. The synthesis with observations continued with a comparison of data from the Infrared Space Observatory for many very young protostars. Specifically, we were able to model the infrared emission from shock waves produced by jets of fluid from the protostars and demonstrate unequivocally that an evolutionary sequence is consistent across all sets of observations. The results were presented at the meeting entitled "Star Formation 2000" at Ringberg Castle in Bavaria.

Star Formation The formation of massive stars appears to follow different rules from those applying to low-mass stars such as our Sun. Michael Smith began a collaboration during a visit to the Max-Planck-

Institut für Radioastronomie in Bonn in August 2000. Speckle interferometry data for one object, S140, allowed us to resolve sub-arcsecond structure and reveal the presence of multiple outflows.

A star forms through the collapse of molecular clumps, termed pre-stellar cores. What triggers a core to collapse? Michael Smith demonstrated that core collapse can be triggered by protostars which form in neighbouring collapsed cores. The protostar ejects bullets and jets which are likely to hit surrounding pre-stellar cores if the population of cores is sufficiently dense. These results were presented at a workshop entitled "The Modes of Star Formation" in Heidelberg during September 2000.

The doctoral project of Tigran Khanzadian will be based on observations of star formation regions. Classical optical telescopes reveal dark clouds in our Galaxy, but cannot reveal what is going on inside. Infrared observations, however, provide a glimpse of where stars are forming internally. Moreover, we can catch much more than a glimpse since modern detectors called 'wide-field cameras' can observe extremely wide areas. Telescopes of 3–4 metres aperture, focused on a cloud for thousands of seconds, then reveal a detailed pattern of protostars and their activity. Two observing trips to Calar Alto have resulted in an abundance of data. We also obtained time to observe in detail six specific bow-shaped shocks produced by protostars. The idea was to use the UKIRT telescope (Hawaii) with a high-resolution camera (UFTI) to get data which contains information on the physical nature of the shocks (i.e. the images of emission lines from vibrating molecules). Unable to attend the observing run, Chris Davis (UKIRT) performed the observations and has sent the data to Khanzadian.

Several papers on infrared observations and their interpretation were also published during the year. These were studies of the outflows from protostars, including proper motions of clumps over several years which reveal remarkable speeds, the first evidence for the detection of spinning jets, detailed modelling of the ISO data for Cepheus A, very high resolution images of Herbig-Haro Object HH 1, and a detailed study of the spatial distributions of the excitation of molecules in several outflows.

Origin2000 Supercomputer A supercomputer was delivered to the Observatory in April 2000, thanks to the JREI programme, funded by PPARC and with SGI as a partner. The arrival of the supercomputer, unique to Armagh, was greeted with much media interest. The 'Forge' is an 8-processor Origin2000. It is a supercomputer because the processors can communicate extremely fast, not only with each other but with large banks of data that they need to continuously update. The group immediately began work on three-dimensional turbulence calculations, involving cubes with 352 zones per side, and has now started to simulate molecular jets. The machine will be used to prepare even bigger computational problems which can be run on machines at the UK Astrophysical Fluid Facility (UKAFF), the national fluid simulation facility, which possess 128 processors. Moving images of some of these astrophysical jet calculations are available from the Armagh Observatory web-site (http://www.arm.ac.uk/~mds/ukaff.html). The UKAFF officially opened in November 2000.

Besides the supercomputer, of value £251,000, there were other grant successes. Dr Alex Rosen, with 3-year PPARC funding, and student Mr Georgi Pavlovski arrived to boost the research on numerical simulations of star forming regions. Furthermore, Michael Smith led a successful bid for a PPARC Theory Visitor Grant which will allow us to bring in computing experts.

Students from schools and universities were able to get the flavour of research in the area of star formation as well as the general nature of Observatory life. Shane Lynch from Trinity College, Dublin, did a 3-month project on Molecular Shocks and Herbig-Haro Objects. Matthew Davis (Friend's School, Lisburn) discovered what could be new Herbig-Haro objects by searching an archive of infrared observations. Michael Smith was a PhD examiner for the thesis of Thomas Stanke (Potsdam). He also updated the research pages for the Observatory's web-site and contributed an article to the annual Irish Scientist.

3.3.6 M.E. Bailey, Director

Mark Bailey worked with David Asher (PDRA), Scott Manley (PhD student) and Sandra Jeffers (MPhil student). Sandra Jeffers used and modified a collision code originally produced by Scott Manley to calculate impact velocities and collision probabilities of comets and various classes of near-Earth asteroid on the Earth and the Moon, and hence determined the frequency distribution of terrestrial and lunar craters according to different assumptions about the population of the different classes of projectile. Sandra Jeffers obtained her MPhil "Collisional Processes in the Inner Solar System" (co-supervised by Dr Alan Fitzsimmons, QUB) in July 2000.

Nature of the K/T Projectile Sandra Jeffers's results were applied to an interesting question, namely the nature of the projectile (i.e. comet or asteroid) that triggered the death of the dinosaurs, 65 million years (Myr) ago. While it is perhaps surprising that anything can be said about the cause of an event

which occurred so long ago, the Earth's geological record contains important clues, both physical and circumstantial, concerning the impact events and abrupt geological transitions associated with mass extinctions of life. Taken together, these allow a broad picture to be built up of the events surrounding each of the major environmental catastrophes.

The most famous example, namely the Cretaceous-Tertiary (K/T) boundary, is associated with both an exceptionally large crater (the Chicxulub crater, in the Yucatan peninsula, Mexico), approximately 180 km in diameter, and an anomalously high abundance of iridium (Ir) and other platinum group elements. Iridium is not found to any significant degree elsewhere in the Earth's crust, owing to its siderophile nature, but is believed to be a minor constituent of small, primitive bodies such as comets and asteroids. The presence of a large crater together with the anomalous Ir layer at the K/T boundary provide direct evidence associating the mass extinction with a major impact event. The question is, was the impact caused by a comet or an asteroid?

Sandra Jeffers, Scott Manley, David Asher and Mark Bailey, have addressed this question by considering possible constraints on the properties of hypothetical impacting bodies that might produce both the observed amount of iridium and a crater the size of Chicxulub. Assuming that comets and asteroids contain the usual cosmic abundance of iridium, a body at least 6 km in diameter is indicated. It is usually assumed that this was an asteroid, but asteroids this large on Earth-crossing orbits are very rare, and probably only run into the Earth on the average once every 300 million years.

The alternative hypothesis is that the projectile was a comet (or cometary fragment), and although many comets are much bigger than typical near-Earth asteroids, on the whole they also collide with the Earth much faster than the $\sim$20 km s^{-1} associated with asteroids. The difficulty with the cometary hypothesis is that such high-velocity collisions (at mean impact velocities greater than 50 km s^{-1}) completely destroy the incoming body and produce a plume of high-temperature ejecta that escapes the gravitational pull of the Earth. A typical cometary impact, while making a large crater, will tend to leave very little trace of its original make-up on the Earth, in particular it will leave very little iridium.

Our analysis considered both the size and velocity distribution of the different classes of impacting bodies, and estimated the frequency of impacts, both cometary and asteroidal, large and slow enough to deposit sufficient iridium to match observations. The results indicate that an impact by either a Halley-type or a long-period comet could not have caused the K/T extinction, as these bodies arrive far too fast and therefore leave little or no iridium. However, some short-period comets arrive more slowly, and considering their size distribution sufficiently large, slow comets hit the Earth more frequently than similar-sized asteroids. So, by a factor of approximately 3 to 1, it appears that a comet rather than an asteroid probably killed the dinosaurs.

Some caution has to be expressed in the interpretation of this result. First, the geological events surrounding the K/T boundary are exceptionally complex, including climate change (global cooling), volcanism (the outpourings of lava associated with the Indian Decan Traps), and changes or regressions in sea level. As the geologist R.E. Sloan has remarked: "When you see the late Cretaceous, you figure Murphy was an optimist — everything went wrong at almost the same time!".

However, in favour of a more complex cometary picture, instead of the random 'stray' asteroid hypothesis, one can also point to evidence for a high abundance of interplanetary dust both below (i.e. before) and above (i.e. after) the K/T boundary layer, suggesting (cf. Bill Napier's work, below) that an enhanced zodiacal cloud may also have been present at that time, perhaps produced by the break-up of a giant comet in a short-period orbit. Moreover, the K/T event sits exactly on one of the approximately periodic 30 Myr peaks in the extinction record, and this can be explained as the effect of an increase in the number of short-period comets arising from an increased long-period comet flux from the Oort cloud at that time, owing to the passage of the Sun through the Galactic plane in its orbit around the Galaxy. Our work shows that, on balance, the K/T projectile was more likely to be a comet or cometary fragment than an asteroid, and suggests that a more complete picture of both comets and asteroids is crucial to obtaining a full understanding of the evolution and history of life on Earth.

Near-Earth Objects (NEOs) It is now recognized that most species of primate are extinct or about to become so, and that in the event of mankind being extinguished there would be little prospect of intelligent life re-appearing on Earth for hundreds of millions of years, if ever. Should intelligent life be a rarity (and the string of special circumstances necessary for mankind to arise on Earth, not least the extinction of the dinosaurs, suggests that it is), such an extinction would make the difference between a Galaxy teeming with human-descended civilizations within a few million years, and one devoid of intelligent life.

These are important issues, and within the past twenty years, near-Earth objects (NEOs) have been identified as the greatest celestial hazard faced by mankind. Every year there is a 1 in 100,000 chance that

a one-km diameter object will collide with Earth, causing global catastrophe and over a billion deaths. For the UK alone, that means millions of fatalities. Even the smaller, so-called 'Tunguska' objects are believed to hit the Earth every 100 years or so, producing an actuarial risk (again for the UK alone) of several million pounds p.a. These low-frequency, high-consequence events exceed any risk the UK accepts from industries such as nuclear power or dangerous goods transport.

During the summer of 1999 the Government accepted the seriousness of the impact hazard and set up a special commission (the NEO Task Force) to investigate the potential threat posed by comets and asteroids on Earth-approaching orbits. Mark Bailey was invited to review the science of NEOs at one of the first meetings of the Task Force, in January 2000. The Task Force subsequently took expert advice from a wide range of sources (both domestic and abroad), and produced an influential report on the subject ("Report of the Task Force on Potentially Hazardous Near Earth Objects"), published in September 2000.

The Government's response to the NEO Task Force Report, providing comments on each of its 14 key recommendations, was published on 24 February 2001. Political interest in NEOs remains high, and the initial response was followed soon afterwards (7 March 2001) by a debate on the subject in the House of Lords.

What seems perhaps of most significance in these developments is the sea-change of opinion within government circles about the reality of the NEO threat, and the suggestion in the official response that the UK is preparing to play a major role in international efforts to solve the NEO problem. The government has requested a number of organizations to provide background information on the NEO problem (e.g. asking PPARC to provide costings to implement some of the Task Force recommendations) and has promised a further response on the Task Force report later in 2001.

Scientific Administration Mark Bailey continued to serve as Chair of the Astronomical Science Group of Ireland (ASGI) and as a member of the Royal Irish Academy National Committee of Astronomy and Space Research, the Royal Astronomical Society Education Committee, the Governing Board of the DIAS School of Cosmic Physics, and scientific working groups of IAU Commissions 15 and 20 (both concerning comets and minor planets). He was also invited to advise the Government Task Force on Potentially Hazardous Near-Earth Objects, and others, on various aspects of the NEO risk to civilization, and served as Editor-in-Chief of the journal *Earth, Moon, and Planets.*

3.3.7 W.M. Napier, Senior Research Fellow

Bill Napier has continued to work on the climatological effects of the accretion of cometary and interplanetary dust on the Earth, and (with Geoffrey Burbidge, University of California, San Diego) on a puzzling anomaly in the redshift distribution of galaxies and distant quasars.

Quasar Redshift Distribution It has long been known that the redshift distribution of quasars is spiky. For example, distinct peaks have been noted at around $z = 0.6$, 0.96, 1.41 and 1.96. In 1977 it was further claimed that these peaks form a periodic sequence $A + 0.089n\log(1+z)$, where A is a constant. Even more remarkably, it was stated that this periodicity only applied to QSOs which were angularly close to spiral galaxies, say within 40 arcmin. Such a phenomenon is not expected in standard cosmological models, and the claims have generated much controversy. The main problem is that quasars or quasi-stellar objects (QSOs) tend to be discovered preferentially in particular redshift ranges, due to instrumentation and emission-line effects, and the peaks might simply be due to discovery selection effects.

A project to examine this issue was started in 1999, jointly between Bill Napier and Geoffrey Burbidge. New samples of QSOs and rigorous statistical procedures were used throughout.

The first sample comprised 57 redshifts from all known close pairs of QSOs with image separations less than 10 arcsec; the second consisted of 39 QSOs selected through their X-ray emission and proximity to nearby active galaxies; and the third consisted of the 78 QSOs from the 3C and 3CR radio galaxy catalogues. For the first sample, discovery selection effects were controlled by comparing the results with QSOs selected from the general field, while the X-ray and radio QSOs in the second and third samples were not subject to spectroscopic or other discovery selection effects capable of inducing spurious peaks.

Extensive statistical testing, making use of Monte Carlo simulations, was carried out on these datasets, separately and together. Clear evidence was found that the claimed logarithmic periodicity is present in all the samples. The combined datasets confirm the periodicity at a significance level $\sim 10^{-5}$. Further, whereas the periodicity had previously only been seen out to $z = 1.96$, i.e. at red-shifts $z = 0.06, 0.30, 0.60, 0.96, 1.41, 1.96$, the new datasets extended the sequence, periodic in $\log(1+z)$ with peaks

separated by 0.089, to higher redshifts $z = 2.63, 3.46$, and 4.47. These had been predicted by the formula but never seen before. The long-standing (and controversial) periodicity claim has therefore been confirmed, apparently at a very high confidence level.

Its interpretation remains uncertain. Assuming that the QSO redshifts are primarily cosmological in origin and due to the expansion of the Universe, then the periodicity might be due to large-scale cellular structure, like the system of voids, filaments and walls seen in the distribution of galaxies. In that case the 0.089 coefficient implies a separation between QSOs of around $\sim 500h^{-1}$ Mpc, where h is the dimensionless Hubble constant $h = H_0/100\,\mathrm{km\,s^{-1}\ Mpc^{-1}}$. In a vacuum-dominated Universe, quasi-periodic oscillations in $\log(1+z)$ are predicted to occur, and it may be significant that recent observations of high-redshift supernovae indicate that the energy density of the Universe is indeed dominated by a vacuum term. The constancy of the QSO periodicity to the highest redshifts could then be used to constrain the evolution of the scale factor of the Universe, i.e. to give independent information back to the time of formation of the first stars.

This explanation does not, however, account for the fact that the periodicity is observed only in quasars that happen to lie close to active galaxies or other quasars. Unless an explanation for this latter aspect can be found, it may be that a non-cosmological interpretation of these quasar redshifts is required. Whatever the ultimate explanation, this work (Astron. J. **121**, 21–30, 2001) clearly has the potential either to illuminate or confuse the canonical cosmological story.

Gamma-Ray Bursters A similar exercise was carried out, again jointly with G. Burbidge, to investigate those γ-ray bursters whose sources have known redshifts. The sample was quite small (19 out of 500 bursters), and shows no evidence for redshift-periodicity.

Zodiacal Cloud and Climate The terrestrial planets orbit through a flattish disc of dust in the inner solar system. In favourable conditions this cloud can be seen from the Earth as the zodiacal light, lying along the ecliptic plane. Such dust discs are seen also around many other nearby stars. The evolution of this dust cloud is complex: dust enters the cloud through the disintegration of comets and asteroids, and leaves it by spiralling into the Sun, ejection from the planetary system or destruction by mutual collisions between the particles.

A computer model describing these effects has been developed and applied to examine the temporal behaviour of the cloud. The principal findings are that the zodiacal cloud is highly variable on relatively short time-scales and that the cloud is probably not currently in equilibrium. This work will be a springboard for an investigation into how the Earth's climate responds to prolonged, heavy dustings, which the model predicts should occur on time-scales of tens to hundreds of thousands of years. This may be relevant to the overall assessment of the NEO hazard, and to the ultimate cause of ice-ages.

3.3.8 D.J. Asher, Research Fellow

David Asher continued to work on meteoroid streams, notably the Leonids and June Bootids, extending existing collaborations with Professor Vacheslav Emel'yanenko (South Ural University) and Robert H. McNaught (Australian National University). In addition his work covered a number of other areas of dynamical astronomy, notably the dynamical evolution and origin of near-Earth asteroids (NEAs). In agreement with results of previous authors, he and Mark Bailey found that many observed NEAs have the potential to fall into the Sun on timescales below 1 Myr, for a variety of reasons. These include the strong action of Jovian mean-motion resonances, and the interaction (also known to affect orbits such as that of the short-period comet 2P/Encke) of the ν_5 and ν_6 secular resonances.

Perhaps one of the most interesting questions about solar system small bodies is where NEAs came from, and how, if some of them are extinct comets, they can now be entirely within and separate from Jupiter's orbit. David Asher has previously collaborated extensively with Dr Duncan Steel (University of Salford), and together with Mark Bailey extended earlier studies by a former Armagh PDRA, Nathan Harris, and by Steel and Asher, on whether the cometary non-gravitational force could play a significant role in the decoupling of orbits from Jupiter. The new work was able to demonstrate, in a more direct way than before, how the process of decoupling from Jupiter operates, for realistically sized non-gravitational forces. It is hoped in future to extend this work to look at the importance of Sun-grazing states in decoupling.

In addition, David Asher made the first of what will be several visits to the Bisei Spaceguard Center (BSGC) in Japan, to assist in setting up the new project there. When it becomes fully operational, the BSGC will be one of the world's leading observatories for the discovery of NEAs, with a 1 metre telescope and CCD camera covering a 3 degree $\times$ 3 degree field of view arriving in 2001; present observations use

two smaller telescopes. Asher's role there includes the development of techniques for automated processing of the asteroid data, and will strengthen links between Spaceguard UK and the Japan Spaceguard Association, and between Armagh and international Spaceguard work.

Research during the year has resulted in several research papers, as well as making a large contribution to the public understanding of science by means of popular articles, talks and media interviews.

3.3.9 M. de Groot, Consultant Research Associate

Mart de Groot completed a comprehensive investigation into the evolution of the luminous blue variable star P Cygni over the past 400 years, and organized a major international workshop at Armagh to celebrate the 400th anniversary of the discovery of this unusual star. The conference: "P Cygni 2000: Four Hundred Years of Progress", which involved more than 30 astronomers from more than a dozen countries, was held during 21–23 August 2000. The proceedings of this meeting, the Observatory's millennial conference, are being edited by Drs Mart de Groot and Chris Sterken (Brussels), and will be published during 2001.

The conference took place in the Royal School Armagh. In addition to a welcome reception on the evening of Monday 21 August hosted by Councillor James Clayton, Mayor of Armagh and City District Council, participants visited the Argory, where they enjoyed a tour of that historic building followed by a meal and traditional music.

Mart de Groot, eighth Director of Armagh Observatory (1976–1994), also took the occasion of the conference to announce his formal retirement from astronomy in order to devote more of his time to pastoral duties associated with his church. Mark Bailey replying on behalf of the Observatory management and staff, emphasized that Mart will be very welcome to continue to visit the Observatory, and made a small presentation to mark his contributions to the Observatory during the six years following his retirement from post.

3.4 Staff

In an important development, the Observatory and its senior research staff received formal recognition from the Queen's University of Belfast to supervise QUB MPhil and PhD students. Two students, namely Sandra V. Jeffers and Elena Pérez Pérez, successfully defended their MPhil and PhD theses, the respective titles being "Collisional Processes in the Inner Solar System", and "Dynamic Events in the Solar Atmosphere".

Simon Jeffery was appointed to serve as Observatory representative on the Court of the University of Ulster, for a 4-year period starting 1 October 2000. Simon succeeds John Butler, who had served in this capacity from 1 October 1996 to 30 September 2000. Mark Bailey was appointed to serve as a member of the Governing Board of the School of Cosmic Physics, Dublin Institute for Advanced Studies, for the period 1 April 2000 to 31 March 2005.

The Grounds and Meteorological Officer, Shane Kelly, passed the first stage of his Chainsaw course in March 2000. He subsequently also passed his first-aid refresher course.

Staff Movements Mart de Groot (Director of the Observatory from 1976–1994) decided formally to retire from astronomy at the end of September 2000 in order to allow more time to be spent on his pastoral ministry. He will continue to visit the Observatory from time to time, but will not expect to carry out astronomical research.

Michael Smith's new PDRA, Alexander Rosen, began his 3-year contract at the Observatory on 2000 September 1. Dr Rosen arrived from the University of Alabama at Tuscaloosa, USA to work on the PPARC-funded project "The Origin and Evolution of Protostars: Tracking with Magnetohydrodynamic Numerical Simulations". Gerry Doyle's new PDRA, Maria S. Madjarska, began her 3-year contract at the Observatory on 2000 October 1. Ms Madjarska recently completed her PhD at the Institute of Astronomy, Sofia, Bulgaria, and is working on the PPARC-funded project "New Insights into Transition Region Dynamics: Observations versus Numerical Modelling".

Two PhD students arrived at the Observatory during September 2000, namely Ms Monica Apostoliceanu, from Romania, who is working on solar physics under the supervision of Gerry Doyle; and Mr Georgi Pavlovski, from Belarus, who is working on theoretical aspects of star formation under the supervision of Michael Smith. An MPhil student, Ms Ana Maria García Suarez, was also appointed during the year to work on a tree-ring project ("The Influence of Climatic Variables on Tree-Ring Widths of Different Species") in collaboration with Professor Mike Baillie (QUB).

Four new staff, namely Deirdre McCabe, Brenda Morrow, Mark Emerson and Kieran Hickey, were recruited during 2000 to work on the historic meteorological records and climate archive. The four

Figure 2: Armagh Observatory staff, summer 2000. From left to right are: John McFarland, David Asher, John Butler, Geoff Coxhead, Simon Jeffery, Mart de Groot, Mark Bailey, Tigran Khanzadian, Vacheslav Emel'yanenko, Regina Aznar, Luca Teriaca, Ferhat Fikri Ozeren, Lawrence Young, Armin Theissen, Gerry Doyle, Hideyuki Saio, Vincent Woolf, Pilar Montañés Rodríguez, Enric Pallé Bagó, Martin Murphy, Margaret Cherry, Bill Napier, David García Alvarez, Aileen McKee, Sandra Jeffers, Shane Kelly, Darko Jevremović.

Meteorology Project staff, who are supervised primarily by John Butler and Martin Murphy, have offices in the refurbished Observatory Bungalow.

Finally, Kate Leer, an AO employed by the Armagh Planetarium, provided temporary cover at the Observatory during Aileen McKee's absence on Maternity Leave from the end of December 2000 to the end of April 2001.

The staff position at the Armagh Observatory on 31 December 2000 is shown in Appendix A. Individuals are identified by their 3-letter (sometimes 2 or 4) Starlink computer username (full e-mail address: xxx@star.arm.ac.uk), together with their job-title and an indication of their principal function in the Observatory. It is noteworthy that a very high proportion of Observatory staff are involved in core research and support activities, the entire administration being supported by less than three staff (mc, ambn, lfy), one of whom (lfy) is shared equally with the Planetarium. Figure 2 shows members of staff present for the staff photograph during summer 2000.

3.5 Visitors

The Observatory maintains an active visitors programme, encompassing students, postdoctoral research assistants and more senior researchers, and hosts a research seminar approximately once per week during the academic year. The calendar year 2000 saw working visits from 12 senior astronomers (postdoctoral status or higher), with additional visits by 3 PhD students based elsewhere. Observatory staff also supervised 12 school work-experience students, 2 A-level summer students under the Nuffield scheme, and 2 Trinity College Dublin (TCD) students on final-year undergraduate projects. The programme of research colloquia for 2000 (numbering 25 separate talks) is listed in Appendix D; almost two-thirds of these seminars were provided by external speakers, many coming to Armagh from abroad.

4 Public Understanding of Science

The Observatory actively promotes public understanding of astronomy and related sciences through a programme of talks and public lectures, and by encouraging visits and tours of the Observatory by members of the public and small groups. The Observatory also issues press information sheets on recent developments in astronomy or research carried out at Armagh, the list for 2000 numbering 54 separate press releases on various meteorological or astronomical topics. Of these, it is remarkable that at least 51 were published in one form or another, demonstrating the very high level of public and media interest in astronomy and an exceptionally high 'hit' rate ($\sim$95%) for press releases.

Contacts with the press are largely the responsibility of the Librarian, who together with other staff frequently answers technical (and sometimes less technical) enquiries from members of the public on a wide variety of different aspects of astronomy, and what is visible or has been seen in the night sky. The recorded list of public enquiries for 2000, which is undoubtedly incomplete, encompasses almost 200 separate responses.

4.1 e-Visitors

However, although the Observatory encourages visits to the Observatory, grounds and Astropark, and direct contact with members of the public, the main focus of its public outreach lies on serving a rapidly increasing number of e-visitors to its web-site (http://www.arm.ac.uk), and on mass-media interest in astronomy via the local and national press, radio and television. At the same time, the Observatory is keen to preserve the integrity of the historic buildings, instruments and archives in its possession, and to present the Observatory's rich scientific heritage to the greatest possible advantage. Modern electronic methods and modern communications dictate novel solutions to public understanding of science, and provide ways to reach large numbers of 'visitors', far in excess of those that can be reached by purely physical means.

The programme of continual improvement to the Observatory web-site, overseen by the Starlink Manager Martin Murphy, has now led to a position where in 2000 the Observatory attracted more than 174,000 distinct e-visitors from more than 130 countries world-wide. This highlights the increasing role of the internet in the public understanding of science, and the growing role of the Armagh Observatory as one of the main gateways for the promotion of Northern Ireland on the world stage.

4.2 Mass Media

The Observatory is now also a principal point of contact for astronomy amongst the mass media (press, radio and television), playing a major role in the promotion of astronomy and public understanding of science both locally (i.e. within Armagh City and District and Northern Ireland) and abroad. Astronomers at Armagh receive (and deal with) numerous questions from the general public, and are often invited by the national and international media to comment on recent research results or discoveries. These contacts frequently lead to articles or citations in the national and international press, and to sound-bites and media clips on radio and television.

The number of identified mentions of the Armagh Observatory and its staff in various mass-media has increased rapidly during the past few years, from about 10 in 1994 to more than 230 in 1999 and 2000. During 2000, the Observatory was noted in one or another of these mass media at least 231 times. The identified media mentions, which are a subset of the whole, are listed in Appendix E. Whilst many citations (about 30%) are in the local press (e.g. the Ulster Gazette, Armagh Observer etc.), some of which have among the highest local impact factors in the UK, a substantial number are on radio and television, in the national and international press, or in specialist and technical magazines.

Programme or Medium	Identified Citations	
	1999	2000
UK and Republic of Ireland local newspapers	71	81
UK national newspapers excluding Northern Ireland	30	12
Northern Ireland and Republic of Ireland national newspapers	18	27
Popular astronomy and specialist magazines	33	31
UK local radio and Republic of Ireland radio	22	23
UK national radio	9	4
UK and Republic of Ireland national television	14	13
Northern Ireland local television	6	9
Foreign newspapers	7	3
Foreign radio	3	6
Foreign television	2	1
Miscellaneous items	18	21

Table 1: Breakdown of known media citations for 1999 and 2000. The 231 identified citations for 2000 include 12 reports in UK national newspapers (e.g. Times, Guardian, Independent, Daily Telegraph, Daily Mail, Daily Express, and corresponding Sunday papers); 27 in Northern Ireland and Republic of Ireland national newspapers (e.g. Belfast Telegraph, Irish News, Newsletter, Irish Times, Irish Independent, Sunday Tribune); and 13 in UK local radio stations (e.g. Radio Ulster, Radio Foyle, Downtown Radio and others in Britain) and Republic of Ireland stations (RTE and local stations). The Observatory was featured 13 times on UK and Republic of Ireland national television news and documentary programmes (e.g. BBC1, BBC2, ITV3, ITV4, Channel 5, Sky, RTE), and 4 times on UK national radio (e.g. BBC Radio 4 Today and PM programmes, and Radio 5). The 3 known citations in foreign newspapers, and 6 and 1 respectively on foreign radio and television, are obviously extreme lower limits due to under-reporting.

The breakdown of known media citations versus type of publication is shown in Table 1. Many of the newspapers and radio or television programmes that mention astronomy at Armagh reach millions of people simultaneously, and it is clear that many tens of millions of people must have been exposed to Armagh Observatory or its research during each of the last two years, a remarkable result.

4.3 Tours, Lectures, Events

An important aspect of the visitor programme is the high frequency of visits and tours by members of the public and small groups. Observatory tours are usually conducted by the Librarian, who in 2000 showed approximately 500 individuals from 19 different countries around the Observatory. These figures highlight the success of the Armagh Observatory's 'open door' policy to attract visits by interested members of the public, groups and societies. During 2000 such groups included schools from Belfast and Dublin, and

parties from the Camphill Community Glencraig, the Armagh Natural History and Philosophical Society, the NHS Retirement Fellowship, the Queen's University of Belfast at Armagh, and other bodies.

In addition to tours, the Observatory also organized several public lectures, and hosted a number of special events during 2000. Many of these were attended by VIPs, notably the Minister of Culture, Arts and Leisure, Mr Michael McGimpsey MLA; the astronaut and 1971 Apollo 14 Lunar Module pilot, Dr Edgar Mitchell; and the 2000 Robinson Lecturer, Dr Ian Crawford (University College London). Drs Eleanor 'Glo' and Ron Helin, from the Jet Propulsion Laboratory, Pasadena, California, also visited the Observatory in August 2000.

The main purpose of the Minister's visit, on 9 February 2000, was to announce the minor planet '(9140) Deni', named after the former Department of Education for Northern Ireland. The full citation for DENI's asteroid (Minor Planet Circular 34351) is as follows:

> "**(9140) Deni = 4195 T-3.**
> Discovered 1977 October 16 by C.J. van Houten and I. van Houten-Groeneveld on Palomar Schmidt plates taken by T. Gehrels. Named after the Department of Education for Northern Ireland for its support of the Armagh Observatory, where Ernst Öpik carried out seminal work on the collisional evolution and dynamics of small bodies. The DENI has promoted lifelong learning and research across many disciplines, encompassing higher education, schools, museums, recreation and culture. It has sought for many years to advance knowledge and understanding of the natural world, and to provide the means by which as many people as possible may appreciate and continue to develop Northern Ireland's rich cultural heritage, its diversity and contributions to the scientific, intellectual and social life of the community."

In addition to the Minister, several other distinguished guests were present during the naming ceremony, including the former Robinson Lecturer Dr Duncan Steel, former Leverhulme Fellow Dr Victor Clube, and Dr Brian Marsden (Director of the International Astronomical Union Minor Planet Center). Later that evening, Dr Marsden delivered a public lecture "Spaceguard in the New Millennium" to a packed Rotunda Lecture Theatre, in St. Patrick's Trian, Armagh.

The visit by Glo Helin sowed the seed for a later benefit for Armagh. In the 1970s Glo Helin, whose initial interest in asteroids had been stimulated by the work of Armagh astronomer Ernst J. Öpik, initiated one of the first all-sky surveys for planet-crossing asteroids, the Palomar Planet-Crossing Asteroid Survey. She is now the principal investigator of one of the USA's leading asteroid discovery programmes, and was keen to revisit the former home of E.J. Öpik, after whom she had named the asteroid (2099) Öpik in 1978. Following her visit to Armagh in August 2000, the Observatory and the City of Armagh were delighted to receive a further asteroidal commendation: the naming of minor planets (10501) and (10502) after the City of Armagh ('Ardmacha') and the Observatory ('Armaghobs') respectively. The names were confirmed in January 2001, and announced to the general public at another naming ceremony held at the Observatory on 14 March 2001.

2000 Robinson Lecture The 2000 Robinson Lecture ("The Scientific Case for Human Spaceflight") took place in the Navan Centre, Armagh, on the evening of Friday 3 November 2000. The lecturer, Dr Ian Crawford of University College London, is the author of more than 60 scientific papers and the holder of one of the prestigious PPARC Advanced Fellow awards. His research interests mainly concern the physics, chemistry and dynamics of the interstellar medium, using high-resolution optical spectroscopy; but he has also taken a strong interest in the history and philosophy of science and in the philosophical implications of space exploration and the possibilities of human space flight. His lecture on the latter subject was well received and attended by more than 100 invited guests and members of the public. Popular accounts of the lecture have been written up in Astronomy & Geophysics (**39**, 6.14–6.17, 1998), Astronomy Now (**15**, No.4, 65–66, 2001), and Science and Public Affairs (p.4, June 2001).

Miscellaneous Items The Observatory received good coverage in the Armagh and City Council educational CD-ROM "Armagh a City Through Time", produced by the Northern Ireland Centre for Learning Resources (NICLR) for the City. John McFarland and Aileen McKee also produced a colour brochure "A Tour of Armagh Observatory" for distribution to visitors and other interested parties. Copies of both these items are available on request.

Two Armagh PhD students gave talks to schoolchildren at the 2000 NISTRO Pupil Researcher Initiative Conference "Express Yourself", at the King's Buildings, Belfast, on Monday 26 June 2000.

5 Southern African Large Telescope (SALT)

Mark Bailey and John Butler, representing the Armagh Observatory, attended the official Ground-Breaking Ceremony for SALT, at Sutherland on 1 September 2000. Valuable contacts with partner institutions and some related press coverage were obtained.

SALT is an international project currently involving astronomers from six countries. These include: South Africa (the SAAO and the South African National Research Foundation, under the auspices of the South African Department of Arts, Culture, Science and Technology); Poland (the Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences); the USA (the Hobby-Eberly Telescope Founding Institutions [the University of Texas at Austin and Pennsylvania State University], Rutgers University the State University of New Jersey, the University of Wisconsin-Madison, the Carnegie Mellon University, and the University of North Carolina); Germany (the Georg-August-Universität, Göttingen); New Zealand (the University of Canterbury); and a consortium of UK institutes (the Armagh Observatory, the University of Central Lancashire, the University of Keele, the University of Nottingham, Southampton University and the Open University). Further details about SALT and the UK SALT Consortium (UKSC) can be obtained from the SALT home page, available from both the Armagh Observatory web-page: http://www.arm.ac.uk/SALT/ and the University of Central Lancashire UKSC site: http://www.star.uclan.ac.uk/~aes/SALT/.

The Observatory's participation in SALT will provide valuable scientific and technological opportunities for Armagh Observatory staff, students and research associates over at least the next 15 years, as well as research collaborations with other national and international partners. This will facilitate Armagh's involvement in frontline astronomical research, and maintain the Observatory's position as a world-class astronomical research institute well into the 21st century.

A summary report of the SALT Ground-Breaking Ceremony was published in the December 2000 issue of Astronomy & Geophysics (**41**, 6.31, 2000). Images of the Ground Breaking Ceremony are available from the Observatory web-site, as too are up-to-date images of SALT construction in progress.

6 New Targeting Social Need (New TSN) Action Plan

The Northern Ireland Executive's New TSN policy is a key part of the Programme for Government. New TSN is the vehicle by which the Executive seeks to tackle deprivation and to reduce inequalities in the life experiences of citizens in terms of poverty, health, housing, educational and economic opportunity and disability.

The Armagh Observatory is fully committed to implement the New TSN Policy, and together with other Non-Department Public Bodies funded by the DCAL developed a New TSN Action Plan during 2000 for consultation during the first quarter of 2001. Following comments received during the consultation period (end January–April 2001), the draft Action Plan was revised and the final version placed in the public domain during June 2001.

A copy of the Observatory's New TSN Plan is available from the Observatory on request. It is also available on the web, at http://www.arm.ac.uk/TSN.html, and is appended for information in Appendix F.

7 Conclusion

The Armagh Observatory has proven its ability to carry out advanced research projects, to attract external income and staff into Northern Ireland, and to play an influential role in international astronomy, public understanding of science, and education. In recent years, as shown in Table 2, the Observatory has regularly attracted external funding amounting to more than 50% of the DCAL grant-in-aid (more than 100% when the cost of external facilities used by Observatory staff is included). The Observatory is in a strong position to contribute to the objectives of both the DCAL and other Northern Ireland government departments for years to come, and is one of Northern Ireland's most successful research institutes for its size, with a rich scientific heritage extending more than 200 years.

Table 2 shows the yearly trend of DCAL grant-in-aid and external research income, together with the trends of performance indicators such as the number of refereed journal publications, the number of identified media citations, and the number of distinct e-visitors (DEVs) to the Observatory web-site. The number of distinct e-visitors is actually the number of distinct hosts served by the Observatory's web-site, a lower limit to the number of e-visitors, owing to caching by big servers and sharing or repeat visits from the same IP number. (For comparison, the number of 'hits' on the web-site, defined as the

Calendar Year	Total DCAL Grant Income (£000s)	External Grant Income (£000s)	Refereed Journal Publications	Identified Media Citations	Distinct e-Visitors (DEVs)
1993	445.0	35	13	–	
1994	425.0	58	22	11	
1995	468.5	172	19	14	
1996	480.0	264	45	45	
1997	473.2	275	42	108	66,000
1998	443.0	195	43	147	80,000
1999	458.5	293	32	233	134,000
2000	538.5	212	31	231	174,000

Table 2: Total DCAL grant-in-aid and the yearly trend of various performance indicators. All items refer to calendar year, with the exception of DCAL Grant Income and External Grant Income which refer to the corresponding financial year (i.e. External Grant Income for 2000 refers to the financial year 2000/2001). In addition, the Observatory receives £10k–£20k per annum from other (i.e. non-DCAL) external sources not shown in the Table.

number of successful page requests, is typically 5–10 times greater than the DEV statistic.) During 2000 the number of 'hits' on the Armagh web-site exceeded 870,000, and the total number of file requests of all types exceeded 2,800,000. The DCAL grant-in-aid for financial year 2000/2001 was augmented by £80,000 (bringing the total to £538,500), to cover the required SALT contributions for 2000/2001 and 2001/2002. DCAL grant-in-aid for financial year 2001/2002 is £473,500 (£384,000 at 1993/1994 prices).

Despite the very positive trend of these results, the growing shortage of core funding presents a significant threat to the future success of the organization. The Observatory has been limited to essentially flat funding in cash terms for almost the past ten years, a period in which it has grown in size almost three-fold and increased its research activity, external income, and public profile respectively by much greater factors.

With sufficient resources to carry out its work, the Observatory is well positioned to play a significant and influential role in both UK and international astronomy for years to come. However, the Observatory requires a significant funding uplift in order to maintain its present level of activity (approximately £150,000 per year is required), and access to additional development funds to pursue new projects (e.g. funds to progress the HLF Telescope Domes project). Without this support, none of the Observatory's future plans — which are within its grasp — will come to fruition, and a thriving, successful research organization may have to turn its back on an otherwise rosy future. The projected funding difficulty must be overcome if the institution is to survive as a body of national and international importance well into the 21st century.

A Armagh Observatory Staff 2000

	Title, Name and Starlink Username		Position	Notes	Base	Cost Centre
1	Professor Mark E. Bailey	meb	Director		OBS	OBS
2	Dr C. John Butler	cjb	Research Astronomer		OBS	OBS
3	Dr John E. Chambers	jec	Research Astronomer		OBS	OBS
4	Professor J. Gerry Doyle	jgd	Research Astronomer		OBS	OBS
5	Dr C. Simon Jeffery	csj	Research Astronomer		OBS	OBS
6	Dr Michael D. Smith	mds	Research Astronomer		OBS	OBS
7	Dr Bill M. Napier	wmn	Senior Research Fellow		OBS	OBS
8	Dr David J. Asher	dja	Research Fellow		OBS	OBS
9	Mr Geoff Coxhead	gc	Software/Hardware Support		OBS	OBS
10	Mr H. Martin Murphy	hmm	Starlink Manager		OBS	OBS
11	Mrs Margaret Cherry	mc	Accounts Officer		OBS	OBS
12	Mr Shane T. Kelly	stk	Grounds/Meteorological Officer		OBS	OBS
13	Mr John McFarland	jmf	Librarian/PRO/Archivist		OBS	OBS
14	Mrs Aileen McKee	ambn	Group Secretary/Admin. Support		OBS	OBS
15	Mr Lawrence F. Young	lfy	Joint Administrator		OBS/PLA	OBS/PLA
16	Mr Darko Jevremović	djc	Postdoctoral Research Assistant	PPARC	OBS	OBS
17	Dr Maria Madjarska	madj	Postdoctoral Research Assistant	PPARC	OBS	OBS
18	Dr Alex Rosen	rar	Postdoctoral Research Assistant	PPARC	OBS	OBS
19	Dr Vincent M. Woolf	vmw	Postdoctoral Research Assistant	PPARC	OBS	OBS
20	Mr E. Mark Emerson	eme	Meteorology Admin. Assistant	HLF	OBS	OBS
21	Ms Brenda R. Morrow	brm	Meteorology Admin. Assistant	HLF	OBS	OBS
22	Ms Deirdre M. McCabe	dmc	Meteorology Research Assistant	HLF	OBS	OBS
23	Mr David García Alvarez	dga	Research Student (PhD)	F/T QUB	OBS	OBS
24	Ms Monica Apostoliceanu	map	Research Student (PhD)	F/T QUB	OBS	OBS
25	Mr Enric Pallé Bagó	epb	Research Student (PhD)	F/T QUB	OBS	OBS
26	Ms Regina Aznar Cuadrado	rea	Research Student (PhD)	F/T QUB	OBS	OBS
27	Mr Tigran Khanzadian	tig	Research Student (PhD)	F/T QUB	OBS	OBS
28	Mr Georgi Pavlovski	gbp	Research Student (PhD)	F/T QUB	OBS	OBS
29	Ms Pilar Montañés Rodríguez	pmr	Research Student (PhD)	F/T QUB	OBS	OBS
30	Mr Ilía Iankov Roussev	ilr	Research Student (PhD)	F/T QUB	OBS	OBS
31	Mr Jim V. Scotti	jvs	Research Student (PhD)	P/T QUB	Tucson	OBS
32	Mr P. Nick Sleep		Research Student (PhD)	P/T Open Univ.	Home	Self
33	Mr Luca Teriaca	lte	Research Student (PhD)	F/T QUB	OBS	OBS

Armagh Observatory staff position at 2000 December 31.

B Refereed Journal Publications 2000

1. **Amado, P.J., Doyle, J.G., Byrne, P.B.**, 2000, "Photometric modelling of starspots – II. The FORTRAN code SPOTPIC", MNRAS, 314, 489–497.

2. **Amado, P.J., Doyle, J.G., Byrne, P.B.**, Cutispoto, G., Kilkenny, D., Mathioudakis, M., Neff, J.E., 2000, "Rotational modulation and flares on RS CVn and BY Dra stars. XX. Photometry and spectroscopy of CC Eri in late 1989, A&A, 359, 159–167.

3. **Asher, D.J.**, McNaught, R.H., 2000, "Expectations for the 2000 Leonids", WGN, Journal of the International Meteor Organization, 28, 138–143.

4. **Bago, E.P., Butler, C.J.**, 2000, "The influence of cosmic rays on terrestrial clouds and global warming", Astronomy & Geophysics, 41, 4.18–4.22.

5. **Banerjee, D.**, O'Shea, E., **Doyle, J.G.**, 2000, "Giant macro-spicule as observed by CDS on SOHO", A&A, 355, 1152–1159.

6. **Banerjee, D.**, O'Shea, E., **Doyle, J.G.**, 2000, "Long-period oscillations in polar plumes as observed by CDS on SOHO", Solar Physics, 196, 63–78.

7. **Banerjee, D., Teriaca, L., Doyle, J.G.**, Lemaire, P., 2000, "Polar plumes and inter-plume regions as observed by SUMER on SOHO", Solar Physics, 194, 43–58.

8. Cellini, A., Di Martino, M., Dotto, E., Tanga, P., Zappalà, V., Price, S.D., Egan, M.P., Tedesco. E.F., Carusi, A., Boattini, A., Persi, P., Muinonen, K., Harris, A.W., Castronuovo, M.M., **Bailey, M.E.**, Lagerros, J., Bussolino, L., Ferri, A., Merlina, P., Mariani, A., Brogi, S., Murdock, T.L., 2000, "Spaceguard – 1: a space-based observatory for NEO physical characterization and discovery", SPIE, 4013, 433–443.

9. **Chambers, J.E.**, Murison, M.A., 2000, "Pseudo-high-order symplectic integrators", AJ, 119, 425–433.

10. Chrysostomou, A., Hobson, J., Davis, C.J., **Smith, M.D.**, Berndsen, A., 2000, "High-resolution near-infrared observations of Herbig-Haro flows – I. H_2 imaging and proper motions", MNRAS, 314, 229–240.

11. Davis, C.J., Berndsen, A., **Smith, M.D.**, Chrysostomou, A., Hobson, J., 2000, "High-resolution near-infrared observations of Herbig-Haro flows – II. Echelle spectroscopy", MNRAS, 314, 241–255.

12. Davis, C.J., **Smith, M.D.**, Eislöffel, J., 2000, "New, high-resolution, near-infrared observations of HH1", MNRAS, 318, 747–752.

13. **Doyle, J.G., Teriaca, L., Banerjee, D.**, 2000, "Solar transition region line broadening: Limb to limb measurements", A&A, 356, 335–338.

14. Eislöffel, J., **Smith, M.D.**, Davis, C.J., 2000, "Spectroscopy of molecular hydrogen in outflows from young stars", A&A, 359, 1147–1161.

15. **Foster, D.C., Theissen, A., Butler, C.J.**, Rolleston, W.R.J., **Byrne, P.B.**, Hawley, S.L., 2000, "CCD photometry and proper motions of late-type stars in the young open cluster Stock 2", A&A Suppl. Ser., 143, 409–420.

16. **Jeffery, C.S.**, Pollacco, D., 2000, "Radial velocities of pulsating subdwarf B stars: KPD 2109+4401 and PB 8783", MNRAS, 318, 974–982.

17. **Jevremović, D., Doyle, J.G.**, Short, C.I., 2000, "The contribution of the micro-turbulent velocity on the modelling of chromospheric lines in late type dwarfs", A&A, 358, 575–582.

18. Löbel, A., Bagnulo, S., **Doyle, J.G.**, Power, C., 2000, "Modelling near-IR spectra and mid-IR dust emission of Mira variables at different phases", MNRAS, 317, 391–405.

19. Schmieder, B., Delannée, C., Yong, Deng Yuan, Vial, J.C., **Madjarska, M.**, 2000, "Multi-wavelength study of the slow "disparition brusque" of a filament observed with SOHO", A&A, 358, 728–740.

20. Morbidelli, A., **Chambers, J.E.**, Lunine, J.I., Petit, J.M., Robert, F., Valsecchi, G.B., Cyr, K.E., 2000, "Source regions and time scales for the delivery of water to Earth", Meteoritics & Planetary Science, 35, 1309–1320.

21. O'Shea, E., O'Neill, T., Keenan, F.P., **Doyle, J.G.**, 2000, "Electron density diagnostics for solar ultraviolet lines of O V", Solar Physics, 196, 321–328.

22. **Pérez, M.E., Doyle, J.G.**, "Physical parameters of EUV explosive events", A&A, 360, 331–334.

23. **Rosen, A.**, Hardee, P.E., 2000, "The effect of expansion on mass entrainment and stability of super-Alfvénic jets", ApJ, 542, 750–760.

24. Saio, H., **Jeffery, C.S.**, 2000, "The evolution of a rapidly accreting helium white dwarf to become a low-luminosity helium star", MNRAS, 313, 671–677.

25. Singer, W., Molau, S., Rendtel, J., **Asher, D.J.**, Mitchell, N.J., von Zahn, U., 2000, "The 1999 Leonid meteor storm: verification of rapid activity variations by observations at three sites", MNRAS, 318, L25–L29.

26. **Smith, M.D.**, 2000, "Evolutionary schemes for protostars, proto brown dwarfs and their environments", Irish Astron. J., 27, 25–34.

27. **Smith, M.D.**, 2000, "Bow shock models for the Cepheus A molecular outflow", Irish Astron. J., 27, 37–42.

28. **Smith, M.D.**, Mac Low, M.-M., Heitsch, F., 2000, "The distribution of shock waves in driven supersonic turbulence", A&A, 362, 333–341.

29. **Smith, M.D.**, Mac Low, M.-M., Zuev, J.M., 2000, "The shock waves in decaying supersonic turbulence", A&A, 356, 287–300.

30. **Woolf, V.M., Jeffery, C.S.**, 2000, "Physical properties of the pulsating hydrogen-deficient star LSS 3184 (BX Cir)", A&A, 358, 1001–1006.

31. Yu, Ka Chun, Billawala, Y., **Smith, M.D.**, Bally, J., Butner, H.M., 2000 "A multiwavelength study of outflows in OMC-2/3", AJ, 120, 1974–2006.

- Abbreviations of principal astronomical journals are as follows:

A&A: Astronomy and Astrophysics

AJ: Astronomical Journal

ApJ: Astrophysical Journal

MNRAS: Monthly Notices of the Royal Astronomical Society

C Presentations by Armagh Observatory Staff 2000

Date	Speaker	Location	Title
Wed 5 Jan 2000	M.E. Bailey	IAA Ronnie Ormonde Memorial Lecture, Belfast	Hale-Bopp: The Comet of the Century
Tue 11 Jan 2000	M.E. Bailey	NEO Task Force Presentation, Bampton, Oxford	Near-Earth Objects: Science, Impact Hazard, International Efforts and UK Opportunities
Wed 19 Jan 2000	C.S. Jeffery	Indian Institute of Astrophysics, Bangalore, India	Evolutionary Constraints Imposed by Pulsations in Extreme Helium Stars
Thu 20 Jan 2000	C.S. Jeffery	Indian Institute of Astrophysics, Bangalore, India	Hot Subdwarfs: Classification, Binarity, Chemical Composition and Pulsations
Thu 27 Jan 2000	W.M. Napier	Geology Department, Trinity College Dublin	The Ultimate Geo-Hazard
Fri 28 Jan 2000	D. Banerjee	Armagh Observatory	Polar Plumes and Interplumes of the Sun
Sat 29 Jan 2000	E. Pallé Bagó	University of Ulster, Jordanstown	Sunshine Records in Armagh and their Link to Solar Activity
Thu 3 Feb 2000	M.D. Smith	Max-Plank-Institute for Radio Astronomy, Bonn	Protostellar Outflows
Mon 7 Feb 2000	M.E. Bailey	Armagh City and District Council	New Projects and Armagh Observatory
Mon 7 Feb 2000	M.E. Bailey	East Antrim Astron. Soc., Ballyrobert	Near Earth Objects: Origin and Rate of Impacts with the Earth
Sat 26 Feb 2000	M. de Groot	Sale, Manchester	Lecture Series: "Origin and Future of the Universe"
Tue 29 Feb 2000	C.J. Butler	AGMET Conference, Geol. Soc. of Ireland, Dublin	Global Warming — Man or Nature
Mon 6 Mar 2000	M.E. Bailey	Irish Astronomical Society, Dublin	Near-Earth Objects: Origin and Potential Hazard to Civilization
Thu 30 Mar 2000	J.E. Chambers	NASA Ames Research Center, California	Terrestrial Planet Formation
Fri 31 Mar 2000	W.M. Napier	ASGI Meeting, University College, Dublin	Periodicity in the Redshift Distribution of Quasars
Thu 6 Apr 2000	D.J. Asher	Armagh Observatory	Dust Trails and Predictability in Meteor Stream Evolution
Apr 2000	J.E. Chambers	NASA Ames Research Center, California	Delivery of Volatiles to Habitable Planets in Extra-Solar Planetary Systems
Apr 2000	J.E. Chambers	Dynamical Astronomy Meeting, Yosemite, California	How Realistic are Computer-Generated Planetary Systems?
Mon 10 Apr 2000	D.J. Asher	IAU Colloquium 181, Canterbury, Kent	Predictability in Meteoroid Stream Evolution
Thu 13 Apr 2000	M.D. Smith	Armagh Observatory	Herbig-Haro Objects: UFOs or Identified Flying Objects?
Sun 16 Apr 2000	D.J. Asher	Leonid MAC Workshop 2000, Tel Aviv, Israel	Modelling Meteor Stream Structure: Application to the Leonids
Mon 8 May 2000	D.J. Asher	Global Robotic Telescope Mtg, Kuala Lumpur, Malaysia	Asteroids, Comets and Meteors in the Public Understanding of Astronomy
Wed 10 May 2000	C.S. Jeffery	Isaac Newton Group, La Palma, Spain	Evolutionary Constraints Imposed by Pulsations in Extreme Helium Stars
Thu 18 May 2000	M.E. Bailey	AMICO 2000, Nördlingen, Germany	Structure and Evolution of the Oort Cloud
Tue 30 May 2000	M.E. Bailey	St. Mary's Grammar School, Belfast	Near-Earth Objects: Origin, Collision Rate and Actuarial Risk
Tue 30 May 2000	E. Pallé Bagó	Climate Change Conference, Tarragona, Spain	Sunshine Records from Ireland and their Link to Solar Variability and Cosmic Rays
Wed 31 May 2000	C.S. Jeffery	American Museum of Natural History, New York, USA	Stellar Collisions, Mergers and their Consequences: V652 Her as a Helium+Helium White Dwarf Merger
Tue 6 Jun 2000	M.D. Smith	ITP, University of California, Santa Barbara	Supersonic Turbulence: Simulations and Observations of Shock Waves
Fri 9 Jun 2000	C.S. Jeffery	Joint Astronomy Centre, Hilo, Hawaii, USA	Evolutionary Constraints Imposed by Pulsations in Extreme Helium Stars
Thu 22 Jun 2000	M.D. Smith	Ringberg Castle, Germany	A Unification Scheme: Evolutionary Tracks of Protostars
Mon 26 Jun 2000	M. de Groot	World Ministerial Council, Toronto, Canada	Origin and Future of the Universe
Mon 26 Jun 2000	T. Khanzadian	Pupil Initiative Conference 'Express Yourself', Belfast	Star Formation — an Ongoing Astronomical Process
Mon 26 Jun 2000	P. M. Rodríguez	Pupil Initiative Conference 'Express Yourself', Belfast	Stellar Pulsations — the Puzzle of Helium Stars
Wed 28 Jun 2000	M. de Groot	World Ministerial Council, Toronto, Canada	Origin and Future of the Universe
Wed 28 Jun 2000	D.G. Alvarez	Armagh Observatory	Modelling of Flares on Late-Type Stars
Wed 28 Jun 2000	T. Khanzadian	Armagh Observatory	Environments of Protostars
Fri 30 Jun 2000	M.E. Bailey	ESTEC, Noordwijk, The Netherlands	Near-Earth Objects: Origin, Collision Rate and Actuarial Risk

Presentations by Armagh Observatory staff, 2000 January 1 to 2000 June 30.

Date	Speaker	Location	Title
Wed 19 Jul 2000	C.S. Jeffery	Armagh Observatory	Radial Velocities for Pulsating Subdwarf B Stars
Wed 19 Jul 2000	E. Pallé Bagó	NCAR Summer School, Boulder, USA	Possible Climatic Consequences of a Cosmic-Ray Influence on Earth's Cloud Cover
Thu 27 Jul 2000	M.D. Smith	Armagh Observatory	Leprechauns in Orion
Aug 2000	J.E. Chambers	NASA Ames Research Center, California	Eccentric Giants and Unstable dwarfs
Thu 3 Aug 2000	C.S. Jeffery	Keele University, England	Optical Spectroscopy of V4334Sgr
Thu 3 Aug 2000	C.S. Jeffery	Keele University, England	Secular Contraction in Helium Stars and the Future of V4334Sgr
Fri 4 Aug 2000	C.S. Jeffery	Keele University, England	Model Atmospheres for V4334Sgr: Future requirements
Fri 11 Aug 2000	M.E. Bailey	IAU General Assembly, Manchester	Historical Variations of the Interplanetary Complex
Tue 15 Aug 2000	M.D. Smith	Max-Plank-Institute for Radio Astronomy, Bonn	Star Formation in Orion
Sat 2 Sep 2000	M. de Groot	East Antrim Astron. Soc., Ballyrobert	The Universe from Beginning to End
Tue 5 Sep 2000	C.J. Butler	XIX Scientific Instrument Symp., Oxford	Surviving Astronomical Instruments in Ireland from the 18th and 19th Centuries
Tue 5 Sep 2000	E. Pallé Bagó	International School of Space Science, L'Aquila, Italy	Cosmic Rays and Clouds
Tue 12 Sep 2000	M.E. Bailey	BAAS Annual Meeting, Imperial College, London	Comets and Their Kin: Threats and Opportunities
Fri 22 Sep 2000	D.J. Asher	International Meteor Conference, Pucioasa, Romania	Explaining the 1998 June Boötid Outburst
Tue 26 Sep 2000	E. Pallé Bagó	First SOLSPA Euroconference, Tenerife, Spain	Sunshine, Clouds and Cosmic Rays
Wed 25 Oct 2000	J.E. Chambers	32nd DPS Meeting, Pasadena, California	Terrestrial Planet Formation in Extra-Solar Systems
Tue 3 Oct 2000	M.E. Bailey	Dromore High School, Co. Down	Origin of the Solar System: Comets and Asteroids
Fri 6 Oct 2000	C.S. Jeffery	Dr Remeis Sternwarte, Bamberg	White Dwarf Merger as Origin for Extreme Helium Stars
Fri 6 Oct 2000	M.D. Smith	Vienna Observatory, University of Vienna, Austria	Star Formation
Tue 10 Oct 2000	M.D. Smith	MPIA Workshop, Heidelberg	Triggering Stars with Protostars: Modes of Star Formation
Tue 10 Oct 2000	M.E. Bailey	Dromore High School, Co. Down	Impacts of Comets and Asteroids: the Near-Earth Object Hazard
Fri 13 Oct 2000	C.S. Jeffery	Royal Astronomical Society, London	White Dwarf Merger as Origin for Extreme Helium Stars
Fri 13 Oct 2000	V.M. Woolf	Royal Astronomical Society, London	The Pulsating Extreme Helium Star LSS 3184
Tue 17 Oct 2000	J. McFarland	Dromore High School, Co. Down	The Astronomical Zoo
Tue 24 Oct 2000	J. McFarland	Dromore High School, Co. Down	Kenneth Essex Edgeworth: Great Irish Astronomer
Fri 27 Oct 2000	M.E. Bailey	International Schools Observatory, EU Mtg, Liverpool	Astronomy at Armagh: New Projects and Public Understanding of Science
Sat 28 Oct 2000	M. de Groot	SOPHIA, Paris	L'Origine de l'Univers
Sun 29 Oct 2000	M. de Groot	SOPHIA, Paris	Le Future de l'Univers
Sun 29 Oct 2000	D.J. Asher	Sendai Astronomical Observatory, Sendai, Japan	Meteor Storms
Tue 7 Nov 2000	T. Khanzadian	Dromore High School, Co. Down	Starbirth: Discs and Jets from Young Stars
Fri 10 Nov 2000	E. Pallé Bagó	ESF SPECIAL Workshop 2000, Katlenburg-Lindau	Sunshine, Clouds and Cosmic Rays
Tue 14 Nov 2000	J. McFarland	Dromore High School, Co. Down	Meteors and the Leonid Meteor Shower
Tue 21 Nov 2000	C.S. Jeffery	Dromore High School, Co. Down	The Star of Bethlehem
Tue 24 Nov 2000	M.E. Bailey	Dromore High School, Co. Down	Nebulae: Gas Clouds, Star Clusters, and Galaxies
Sun 3 Dec 2000	D.J. Asher	International Schools Observatory, Tokyo	Asteroids and Impacts
Tue 5 Dec 2000	M.E. Bailey	Dromore High School, Co. Down	Cosmology: the Origin and Evolution of the Universe
Wed 6 Dec 2000	D.J. Asher	Institute of Space and Astronautical Science, Tokyo	How Newtonian Dynamics gives Accurate Predictions of Meteor Storms
Tue 19 Dec 2000	J.E. Chambers	Armagh Observatory	Terrestrial Planet Formation in Extra-Solar Systems: Eccentric Giants and Unstable Dwarfs

Presentations by Armagh Observatory staff, 2000 July 1 to 2000 December 31.

D Armagh Observatory Seminars 2000

Date	Speaker	Affiliation	Title
Wed 12 Jan 2000	**C. Davies**	**UKIRT, JAC, Hawaii**	**Serpens — the Big Picture. Wide-Field Observations of a Star-Forming Cloud Core**
Fri 28 Jan 2000	D. Banerjee	Armagh	Polar Plumes and Interplumes of the Sun
Thu 10 Feb 2000	**W. Löffler**	**Astron. Inst. der Universitaet Basel, Switzerland**	**The Theory of Non-Radial Pulsations in Gamma Doradus Variables**
Thu 6 Apr 2000	D.J. Asher	Armagh	Dust Trails and Predictability in Meteor Stream Evolution
Thu 13 Apr 2000	M.D. Smith	Armagh	Herbig-Haro Objects: UFOs or Identified Flying Objects?
Wed 19 Apr 2000	**S. Ipatov**	**Keldysh Inst. Appl. Math., Moscow**	**Migration of Celestial Bodies in the Solar System**
Mon 1 May 2000	**W. Livingstone**	**National Solar Observatory, Tucson**	**The Case of the Missing Solar Cycle**
Thu 4 May 2000	**M. Groves**	**Charis Consultancy Services**	**Good Practice Guidelines for the Protection of Children and Young People**
Thu 11 May 2000	**H. McCracken**	**Lab. d'Astronomie Spatiale, Marseille**	**Investigating Field Galaxy Evolution with Ultra-Deep Wide-Angle Imaging Surveys**
Thu 18 May 2000	**M. Murphy**	**Univ. New South Wales, Australia**	**Does the Fine-Structure Constant Vary in Space-Time?**
Tue 30 May 2000	**M.J. Valtonen**	**Turku Observatory, Finland**	**On the Oort Cloud Origin of Short-Period Comets**
Wed 28 Jun 2000	D.G. Alvarez	Armagh	Modelling of Flares on Late-Type Stars
Wed 28 Jun 2000	T. Khanzadyan	Armagh	Environments of Protostars
Wed 19 Jul 2000	C.S. Jeffery	Armagh	Radial Velocities for Pulsating Subdwarf B Stars
Thu 27 Jul 2000	M.D. Smith	Armagh	Leprechauns in Orion
Fri 28 Jul 2000	**F. Ward**	**St. Louis School, Ballymena**	**Interactive Web Design and Programming**
Fri 28 Jul 2000	**J. Samuel**	**Pretora Royal School, Enniskillen**	**Wavelet Analysis of Pulsating Helium Stars**
Fri 4 Aug 2000	**M. Dimitrijevic**	**Belgrade Observatory, Yugoslavia**	**The Influence of Collisions with Charged Particles on Astrophysical Spectra**
Thu 21 Sep 2000	**F. Bacciotti**	**DIAS, Dublin**	**HST and STIS Observations and Spectral Diagnostics of Herbig Haro Jets**
Thu 5 Oct 2000	**J. Tate**	**Spaceguard UK**	**Spaceguard — The Inside Story**
Fri 3 Nov 2000	**A.E. Roy**	**University of Glasgow**	**Heavy Rock at Matellica: An Astronomical Detective Story**
Thu 30 Nov 2000	**R.H.D. Townsend**	**University College London**	**A Random Walk through Hot-Star Pulsation**
Thu 7 Dec 2000	M.E. Bailey	Armagh	Targeting Social Need: Staff Training and Review of Draft Consultation Document
Tue 12 Dec 2000	**K. Olah**	**Konkoly Observatory, Budapest**	**Cool Stars and Solar-Stellar Connections**
Tue 19 Dec 2000	J.E. Chambers	Armagh	Terrestrial Planet Formation in Extra-Solar Systems: Eccentric Giants and Unstable Dwarfs

Table 1: Seminars at Armagh Observatory, calendar year 2000. Organized by D. Banerjee and V.M. Woolf.

E Identified Media Mentions 2000

Armagh Observatory Media Mentions: Calendar Year 2000. Observatory-authored items indicated by 'OBS'.

Running Total		Approximate Date	Main Subject, Author, and Other Details	Newspaper, Radio, TV Programme etc.
1		01-Jan-2000	Joy to the World (Ben Forde — video)	Christian Video Productions
2		01-Jan-2000	'Leonides 1999: Enfin, une pluie d'etoiles'	Ciel & Espace (Jean-Francois Hait)
3		04-Jan-2000	NEO Task Force	BBC Newsline
4		04-Jan-2000	NEO Task Force	Downtown Radio
5		04-Jan-2000	NEO Task Force	BBC Radio Ulster
6		04-Jan-2000	Whitehall appoints a team who will save the world	Independent (Steve Connor)
7	OBS	06-Jan-2000	Gerry Doyle's column	Ulster Gazette
8	OBS	12-Jan-2000	Drenched December (jmf)	Tyrone Courier
9	OBS	13-Jan-2000	Drenched December (jmf)	Armagh Observer
10	OBS	13-Jan-2000	Death of Professor Derek Lindsay (jmf)	Ulster Gazette
11	OBS	13-Jan-2000	Gerry Doyle's column	Ulster Gazette
12		13-Jan-2000	The Buildings of County Armagh (Sir Charles Brett)	Ulster Gazette
13	OBS	13-Jan-2000	Death of Professor Derek Lindsay (jmf)	Armagh Observer
14	OBS	20-Jan-2000	Gerry Doyle's column	Ulster Gazette
15	OBS	20-Jan-2000	Total Lunar Eclipse (jmf)	BBC TV Newsline
16	OBS	27-Jan-2000	'Top Astronomer to Visit Armagh (meb, jmf)'	Ulster Gazette
17	OBS	29-Jan-2000	'Top Astronomer to Visit Armagh (meb, jmf)'	Belfast Telegraph
18		31-Jan-2000	'Solar variability, clouds and global warming'	BBC Good Morning Ulster
19		01-Feb-2000	The 1999 Leonids observed from the Sinai desert (N. James)	Journal of the British Astron. Ass.
20		01-Feb-2000	The Leonids Storm on Schedule (Edwin L. Aguirre)	Sky & Telescope
21		01-Feb-2000	Meeting notice: Near Earth Objects (John McConnell)	Astronomy Now
22		07-Feb-2000	Near Earth Objects (Alison Fleming)	UTV Life
23		09-Feb-2000	Minor Planet (9140) Deni	Good Morning Ulster Radio
24	OBS	09-Feb-2000	Minister to Visit Armagh (jmf)	Ulster Gazette
25		09-Feb-2000	Minor Planet (9140) Deni	BBC Newsline TV
26		09-Feb-2000	Weather in January (John Mareno)	Tyrone Times
27		09-Feb-2000	Earth breathes a sigh of relief as asteroid's aim goes astray	Belfast Telegraph
28	OBS	10-Feb-2000	'Top Astronomer to Visit Armagh (meb, jmf)'	Ulster Gazette
29	OBS	10-Feb-2000	Gerry Doyle's column	Ulster Gazette
30	OBS	10-Feb-2000	'Top Astronomer to Visit Armagh (meb, jmf)'	Armagh Observer
31	OBS	10-Feb-2000	Minister to Visit Armagh (jmf)	Armagh Observer
32	OBS	10-Feb-2000	Minister to Visit Armagh (jmf)	Belfast Telegraph
33		14-Feb-2000	Spaceguard in the New Millennium	BBC Radio Ulster: Across the Line
34	OBS	14-Feb-2000	Shuttle Endeavour visible over Ulster (jmf)	BBC Raio Ulster: Evening Extra
35	OBS	15-Feb-2000	Supercomputer destined for Armagh (mds)	BBC Radio Ulster: Good Morning Ulster
36	OBS	15-Feb-2000	Supercomputer destined for Armagh (mds)	BBC Teletext Service
37	OBS	15-Feb-2000	Supercomputer destined for Armagh (mds)	UTV
38		16-Feb-2000	Supercomputer destined for Armagh (mds)	BBC Radio Ulster Newsdesk
39		16-Feb-2000	Supercomputer destined for Armagh (mds)	BBC Northern Ireland News
40	OBS	17-Feb-2000	Shuttle Endeavour visible over Ulster (jmf)	Ulster Gazette
41	OBS	17-Feb-2000	Top Comet Finder (jmf)	Ulster Gazette
42	OBS	17-Feb-2000	Minor Planet (9140) Deni	Armagh Observer
43	OBS	17-Feb-2000	The Minister in waiting (Neil Johnston)	Belfast Telegraph
44	OBS	17-Feb-2000	Shuttle Endeavour visible over Ulster (jmf)	Armagh Observer
45	OBS	17-Feb-2000	Supercomputer destined for Armagh (mds)	Belfast Telegraph
46		17-Feb-2000	Supercomputer destined for Armagh (mds)	Monaghan Northern Sound Radio
47		17-Feb-2000	Supercomputer destined for Armagh (mds)	Armagh Observer
48		20-Feb-2000	Ulster to help stop Armagh-eddon (Karen McManus)	News of the World
49	OBS	24-Feb-2000	Supercomputer destined for Armagh (mds)	Ulster Gazette
50	OBS	24-Feb-2000	Minister to Visit Armagh (jmf)	Ulster Gazette
51	OBS	24-Feb-2000	Gerry Doyle's column	Ulster Gazette
52	OBS	24-Feb-2000	Supercomputer destined for Armagh (mds)	Armagh Observer
53		24-Feb-2000	Asteroids (Marie-Louise Kerr and Gareth McConnell)	BBC Choice: 11th Hour (Ralph McLean)
54		29-Feb-2000	Global warming	RTE 1 Radio
55		02-Mar-2000	Observatory funding lessening	Armagh Observer
56		08-Mar-2000	Local Astronomers Society goes from strength to strength	East Antrim Gazette
57	OBS	09-Mar-2000	February milder than usual (jmf)	Armagh Observer
58	OBS	09-Mar-2000	February milder than usual (jmf)	Ulster Gazette
59	OBS	09-Mar-2000	Gerry Doyle's column	Ulster Gazette
60	OBS	16-Mar-2000	Mir visibility (jmf)	Community Telegraph
61		18-Mar-2000	Astronomer who united study of astronomy in a divided Ireland	The Irish Times
62	OBS	23-Mar-2000	Wife of former Observatory director dies (jmf)	Ulster Gazette

Running Total		Approximate Date	Main Subject, Author, and Other Details	Newspaper, Radio, TV Programme etc.
63	OBS	23-Mar-2000	Wife of former Observatory director dies (jmf)	Armagh Observer
64		28-Mar-2000	Nine grants for Province	News Letter
65		30-Mar-2000	Weather archive to go online	Ulster Gazette
66		01-Apr-2000	Astrophysics in 1999 (V Trimble and M J Aschwanden)	PASP
67		01-Apr-2000	ASSA Observations of 1999 Leonid Meteor Shower	MNASSA (T. P. Cooper)
68		01-Apr-2000	Further thoughts on Dr Eric Lindsay (Patrick Corvan)	Stardust
69		06-Apr-2000	Moon and planets configuration	BBC Radio Ulster: Evening Extra
70	OBS	06-Apr-2000	Mild dry March (jmf)	Ulster Gazette
71		07-Apr-2000	Moon and planets configuration	Irish News
72		10-Apr-2000	Best sighting of Aurora Borealis in 30 years (Lisa Magee)	Ballymena Guardian
73		15-Apr-2000	Northern Lights and the Dundalk skyline (Margaret Roddy)	The Argus Weekender
74		17-Apr-2000	Future Proof?	BBC TV Newsline
75		20-Apr-2000	11th Hour	BBC Choice: 11th Hour
76		26-Apr-2000	20/20 Visions: The Environment	BBC 1 TV
77		29-Apr-2000	Your Place and Mine: Observatory weather records online	BBC Radio Ulster
78		01-May-2000	Besog pa Armagh Observatorium (Lars Poort)	Knudepunktet
79	OBS	01-May-2000	Cool April showers (jmf)	Downtown Radio
80	OBS	02-May-2000	Cool April showers (jmf)	News Letter
81		02-May-2000	Lottery towns all winners	Irish News
82		03-May-2000	Sun set to shine for another few days (Stephen Alexander)	Irish News
83		04-May-2000	'I LOVE YOU' Loves eating MP3s (Brad King)	Wired News
84		07-May-2000	On the Record	BBC 1 TV
85	OBS	13-May-2000	Long-Lost Asteroid Found (jmf)	News Letter
86		15-May-2000	Edgar Mitchell visits Armagh	Downtown Radio
87	OBS	18-May-2000	Long-Lost Asteroid Found (jmf)	Ulster Gazette
88		25-May-2000	Collone ladies at Observatory	Ulster Gazette
89		30-May-2000	Reach for the Stars	St Mary's Christian Bros. Grammar School
90		01-Jun-2000	Will the Leonid Storms Continue? (Joe Rao)	Sky & Telescope
91		01-Jun-2000	The Leonids' Rising Stars	Sky & Telescope
92		01-Jun-2000	Sad death of popular city lady.	Ulster Gazette
93		01-Jun-2000	Authors Bill and Anne in treat for book lovers.	Ulster Gazette
94	OBS	08-Jun-2000	Dry Sunny May (jmf)	Ulster Gazette
95	OBS	08-Jun-2000	Dry Sunny May (jmf)	Armagh Observer
96		16-Jun-2000	Filming at Armagh Observatory	RTE 1 TV
97		19-Jun-2000	Armagh observatory (Milan Zboril)	Kozmos
98		26-Jun-2000	Young Innovators 2000	SetPoint Northern Ireland
99	OBS	29-Jun-2000	Amateur astronomers launch rocket from Armagh	Ulster Gazette
100		01-Jul-2000	What are the easiest NGC objects to see?	Astronomy (Ken Hewitt-White)
101		01-Jul-2000	Het geluid van meteoren (Sound of Meteors) (J. Cuypers)	Heelal: J. Belgium Amat. Astr. Ass. (VVS)
102	OBS	05-Jul-2000	June slightly drier and duller than usual (jmf)	Tyrone Courier
103	OBS	06-Jul-2000	June slightly drier and duller than usual (jmf)	Ulster Gazette
104	OBS	06-Jul-2000	June slightly drier and duller than usual (jmf)	Armagh Observer
105		23-Jul-2000	Comet LINEAR	Belfast City Beat Radio
106	OBS	27-Jul-2000	A new moon discovered orbiting Jupiter (jmf)	Ulster Gazette
107		01-Aug-2000	The History of Daramona Observatory and W.E. Wilson	Orbit (John McConnell)
108		01-Aug-2000	Armagh: a natural gateway to the North	Enterprise
109	OBS	03-Aug-2000	Director of Belgrade Observatory Visits Armagh	Armagh Observer
110	OBS	03-Aug-2000	Dry July (jmf)	Downtown Radio
111	OBS	03-Aug-2000	Director of Belgrade Observatory Visits Armagh	Belfast Telegraph
112	OBS	03-Aug-2000	Director of Belgrade Observatory Visits Armagh	Irish News
113	OBS	09-Aug-2000	Dry July (jmf)	Tyrone Courier
114	OBS	10-Aug-2000	Dry July (jmf)	Ulster Gazette
115	OBS	10-Aug-2000	Meteors by moonlight (jmf)	Ulster Gazette
116	OBS	10-Aug-2000	Director of Belgrade Observatory Visits Armagh	Ulster Gazette
117	OBS	10-Aug-2000	Director of Belgrade Observatory Visits Armagh	Armagh Observer
118		18-Aug-2000	Strange Hypergiant (Chris Sterken)	'IAU: Northern Lights, No.11'
119	OBS	24-Aug-2000	International astronomers gather in Armagh (mdg)	Ulster Gazette
120		28-Aug-2000	Watercolour Challenge (Hannah Gordon)	Channel 4
121		29-Aug-2000	Asteroid impact hazard	BBC 2 Horizon
122	OBS	31-Aug-2000	International astronomers gather in Armagh (mdg)	Armagh Observer
123	OBS	31-Aug-2000	Armagh to join Southern African Large Telescope project	Ulster Gazette
124		01-Sep-2000	SALT: Africa's Giant Eye in the Sky	A Cape Argus Commercial Feature
125		01-Sep-2000	Big or Biggest Telescope? (Ian Elliott and Scott Teare)	Mercury
126	OBS	07-Sep-2000	UK-Japan astronomy team explores cannibal stars (csj)	Armagh Observer
127		07-Sep-2000	European Heritage Open Days (Historic Buildings Council)	Armagh Observer
128		09-Sep-2000	The Advancement of Science Conference (Dick Ahlstrom)	The Irish Times
129		09-Sep-2000	British Association Science Festival (Nick Nutall)	The Times

Running Total		Approximate Date	Main Subject, Author, and Other Details	Newspaper, Radio, TV Programme etc.
130		09-Sep-2000	British Association Science Festival (Alan Hamilton)	The Times
131		13-Sep-2000	Impact hazard	Daily Telegraph
132		13-Sep-2000	Impact hazard	Annanova News
133		13-Sep-2000	Astronomer puts price on armageddon (Aeneas Bonner)	Irish News
134		15-Sep-2000	Southern African Large Telescope	Times Higher Education Supplement
135		16-Sep-2000	Impact hazard (Tim Radford)	Guardian
136		17-Sep-2000	Impact hazard (Jonathan Leake)	The Sunday Times
137	OBS	17-Sep-2000	UK-Japan astronomy team explores cannibal stars (csj)	Ulster Gazette
138	OBS	17-Sep-2000	Warm wet August (jmf)	Ulster Gazette
139	OBS	17-Sep-2000	SALT	Armagh Observer
140		18-Sep-2000	Impact hazard	BBC News Online
141		18-Sep-2000	Impact hazard (Geraint Smith)	London Evening Standard
142		18-Sep-2000	Impact hazard (Desmond McCartan)	Belfast Telegraph
143		18-Sep-2000	Impact hazard	BBC News Online
144		18-Sep-2000	Impact hazard	BBC Radio 5 Live Breakfast Programme
145		18-Sep-2000	Impact hazard	BBC Radio 4 Today Programme
146		18-Sep-2000	Impact hazard	BBC Radio Ulster Good Morning Ulster
147		18-Sep-2000	Impact hazard	BBC1 TV Breakfast News
148		18-Sep-2000	Impact hazard	BBC Radio Scotland
149		18-Sep-2000	Impact hazard	BBC News 24
150		18-Sep-2000	Impact hazard	BBC World Service, Newshour
151		18-Sep-2000	Impact hazard	Sky News TV
152		18-Sep-2000	Impact hazard	BBC TV National News
153		18-Sep-2000	Impact hazard	BBC TV National News
154		18-Sep-2000	Impact hazard	RTE TV National News
155		18-Sep-2000	Impact hazard	Channel 24 KVUE Evening News TV, Austin, TX
156		18-Sep-2000	Impact hazard	BBC Radio London Live
157		18-Sep-2000	Impact hazard	CFRA Radio, Newstalk, Radio Ontario, Canada
158		19-Sep-2000	Impact hazard (James Chapman)	Daily Mail
159		19-Sep-2000	Impact hazard	BBC World Service, Calling the Falklands
160		19-Sep-2000	Impact hazard	Belfast Telegraph
161		19-Sep-2000	Impact hazard	South African Broadcasting Company
162		20-Sep-2000	Impact hazard	The Age, Australia
163		20-Sep-2000	Impact hazard	Canadian Radio (CBC), French Service, Alberta
164		20-Sep-2000	Armagh may be Earth's first line of defence	Irish News (Andrea McKernon)
165		21-Sep-2000	Impact hazard	Science in the News
166		21-Sep-2000	Impact hazard	Canadian Broadcasting Company
167		22-Sep-2000	Armagh Planetarium refurbishment (Rosie McCann)	Belfast Telegraph
168		23-Sep-2000	Impact hazard	New Scientist
169		24-Sep-2000	Impact hazard	Sunday World
170		28-Sep-2000	Impact hazard	Ulster Gazette
171		29-Sep-2000	Various contributions to Target Earth book	Target Earth (Duncan Steel)
172		29-Sep-2000	Impact hazard	BBC 2 Final Frontier
173		01-Oct-2000	SALT (Sue Bowler)	Astronomy & Geophysics 41(5)
174		01-Oct-2000	RAS Annual Report	Astronomy & Geophysics Supplement 41(5)
175		01-Oct-2000	RAS Annual Report	Astronomy & Geophysics Supplement 41(5)
176	OBS	01-Oct-2000	Comet C/1999 S4 (LINEAR) (jmf)	Astronomy & Geophysics
177		01-Oct-2000	Spaceguard (Jay Tate)	Radio Ulster
178	OBS	05-Oct-2000	September Weather (jmf)	Ulster Gazette
179	OBS	05-Oct-2000	September Weather (jmf)	Armagh Observer
180		07-Oct-2000	Can Armagh save the Planet Earth? (Ciaran McGuigan)	Belfast Telegraph
181		10-Oct-2000	The Moonlit Leonids 2000	Science @NASA
182	OBS	12-Oct-2000	Robinson Lecture (jmf)	Armagh Observer
183		18-Oct-2000	World weather stations list	http://www.stationmeteo.fr.st/
184		26-Oct-2000	Lunar Leonids 2000	Science@NASA
185		26-Oct-2000	Visit the Planetarium at Hallowe'en	Ulster Gazette
186		01-Nov-2000	How the north can save the planet! (Mairtin Crawford)	Fortnight
187	OBS	02-Nov-2000	Japanese Discover Large Earth-Crossing Asteroid (meb)	Armagh Observer
188		02-Nov-2000	Asteroid 2000 UV13	BBC Radio Ulster: Good Morning Ulster
189		04-Nov-2000	Armagh starman spots giant asteroid (Gary Grattan)	Belfast Telegraph
190		07-Nov-2000	Mir and global warming (Ann Madden)	Irish News
191		08-Nov-2000	Prince denounced as 'arrogant and ignorant'	The Times (Craig Clarke)
192	OBS	08-Nov-2000	October wetter than normal (jmf)	Tyrone Courier
193	OBS	09-Nov-2000	October wetter than normal (jmf)	Ulster Gazette
194	OBS	09-Nov-2000	Observatory honours former Director (jmf)	Ulster Gazette
195	OBS	09-Nov-2000	Observatory honours former Director (jmf)	Armagh Observer
196		09-Nov-2000	Robinson Lecture	Armagh Observer

Running Total		Approximate Date	Main Subject, Author, and Other Details	Newspaper, Radio, TV Programme etc.
197		09-Nov-2000	Tá muid slán — go ceann tamaill (Ciarán Ó Pronntaigh)	Lá
198		10-Nov-2000	Almost a month's rain has soaked the area in a week	Portadown Times
199		11-Nov-2000	Damned spot (Eugenie Samuel)	New Scientist
200		14-Nov-2000	Here come the Leonids (David Whitehouse)	BBC News Online
201		15-Nov-2000	Leonid Meteors: Astronomers Announce Results and Predictions	Sky & Telescope: Online Current News
202	OBS	16-Nov-2000	Two Hundred Years on the Net (cjb)	Ulster Gazette
203	OBS	16-Nov-2000	Japanese Discover Large Earth-Crossing Asteroid (meb)	Ulster Gazette
204	OBS	16-Nov-2000	Two Hundred Years on the Net (cjb)	Irish News
205		16-Nov-2000	The Moonlit Leonids 2000	Science @NASA
206		16-Nov-2000	Leonids	BBC TV
207		16-Nov-2000	The Lion's main attraction (Duncan Steel)	The Guardian
208		17-Nov-2000	Leonids	BBC Radio 4 Today Programme
209	OBS	17-Nov-2000	Leonid Meteors by Moonlight (jmf)	Portadown Times
210	OBS	17-Nov-2000	Leonid meteor shower (meb)	Irish News
211		17-Nov-2000	Leonids	Radio company: www.now.com
212		17-Nov-2000	Leonids 2000: will it storm? (Neil Bone)	Spaceflight Now
213		18-Nov-2000	Leonids in 2000: A First Look	Sky & Telescope: Online Current News
214		21-Nov-2000	Leonids Galore. Predicting Leonids becomes a science?	Science@NASA
215	OBS	22-Nov-2000	Two Hundred Years on the Net (cjb)	CCNet (B J Peiser)
216	OBS	23-Nov-2000	Observatory honours former Director (jmf)	Armagh Observer
217		28-Nov-2000	Sun's warming influence 'under-estimated' (D. Whitehouse)	BBC News Online
218		29-Nov-2000	Site Seeing: Site of the Month	www.sciencenet.org.uk/Siteseeing/index.html
219		01-Dec-2000	Leonid Alert for Eastern North America	Sky & Telescope
220		01-Dec-2000	Out of Africa (Anthony Fairall)	Astronomy Now
221	OBS	01-Dec-2000	De dag dat de aarde schudde? (jmf)	Zenit
222		01-Dec-2000	UK Government Announces Asteroid Hazard Report	Astronomy & Space
223		01-Dec-2000	International Meteor Organisation — Early Summary of Leonids 2000	Orbit
224		05-Dec-2000	Dull skies (Mike McKim)	BBC correspondent
225	OBS	07-Dec-2000	Dull wet November (jmf)	Ulster Gazette
226	OBS	07-Dec-2000	Saturn's Satellites (jmf)	Ulster Gazette
227		09-Dec-2000	Doomed asteroids point to Earth-like planets fit for life	New Scientist
228	OBS	13-Dec-2000	Mysterious Meteors (jmf)	News Letter
229		17-Dec-2000	Sun-weather climate change	BBC Newsline
230	OBS	28-Dec-2000	Christmas Stars (meb/jmf)	Ulster Gazette
231		29-Dec-2000	Jodrell Bank and Merlin	BBC Radio 4 Today Programme

F New TSN Action Plan

Armagh Observatory

New Targeting Social Need (New TSN) Action Plan 2001

The Vision of the Armagh Observatory is:

> *"To maintain and build on its position as a thriving astronomical research institute, and to continue to expand our understanding of the Universe and of humanity's place in it."*

The Mission is:

> *"To advance the knowledge and understanding of astronomy and related sciences through the execution, promotion and dissemination of astronomical research nationally and internationally in order to enrich the intellectual, economic, social and cultural life of the community."*

Who We Are

The Armagh Observatory (see http://www.arm.ac.uk/) is the oldest continuously functioning astronomical research institute in Great Britain and Ireland, founded by Archbishop Richard Robinson in 1790 as part of his dream to see a University in the City of Armagh. It stands close to the centre of the City of Armagh together with the Armagh Planetarium in approximately 14 acres of attractive, landscaped grounds that are managed by the Observatory and which include a scale model of the solar system and the Universe known as the Armagh Astropark.

The principal function of the Armagh Observatory, which is a tertiary-level institution funded by the Northern Ireland Department of Culture, Arts and Leisure (DCAL), is to undertake original research of a world-class academic standard which broadens and expands our understanding of astronomy and related sciences. Current key programmes focus on stellar astrophysics, solar system astronomy, the Sun, Sun-Earth relationships including climate, and the Near-Earth Object hazard to civilization. The Observatory also maintains a unique 200-year long meteorological record and data-bank (http://climate.arm.ac.uk/), one of the longest in the world from a single site.

What We Do

Astronomy provides a singular perspective on our place in the Universe, addressing fundamental questions such as the origin of the Earth, the origin of Life, and 'Are we Alone?'. Research into astronomy plays an increasingly important role in the whole of modern society, for example by:

- contributing to understanding global climate change, for example global warming;
- predicting the effects of asteroid impacts, and the impacts of space debris and meteoroids on artificial satellites.

Important research areas currently under investigation include: (1) climate change — the Observatory holds a unique 200-year long meteorological record; (2) involvement in the international programme to detect, and increase public understanding of potentially hazardous comets and asteroids; (3) involvement in construction of the 10-metre class Southern African Large Telescope (SALT). Complementing this active research role, the Observatory is also committed to the preservation and presentation of its valuable scientific heritage and related scientific ideas.

Astronomy is also a key culture activity. It enjoys a high public profile in the printed and electronic media, and in books and film, for example in Hollywood classics such as *2001: a Space Odyssey*, and through blockbusters such as *Armageddon* and *Deep Impact*. The fruits of astronomy have inspired scientists, poets, authors, and philosophers, and have provided the basis for works of art, musical composition, and theatrical performances.

Astronomy also provides a valuable primary resource for exhibits in science centres, among them the National Space Science Centre in Leicester, the new science centre in the Belfast Odyssey Complex, and the Armagh Planetarium. Astronomical topics provide primary source material for education, entertainment and leisure. The subject is featured in books, magazines and television documentaries seen by millions worldwide.

How We Contribute to New TSN

Astronomy is an involving, inspirational activity with the capacity to attract people, especially the young, towards science, engineering and information technology. The Armagh Observatory seeks to develop this interest by disseminating the results of its scientific research through a programme of public outreach and public understanding of science (PUS). The principal elements of this policy include:

- attracting visitors to Armagh, primarily to the Armagh Astropark;
- providing talks and presentations to interested groups and organizations which together represent individuals of all ages and backgrounds;
- partnership with groups and institutions having similar aims and objectives, for example the Astronomical Science Group of Ireland and amateur astronomy organizations;
- disseminating astronomical results to the press, radio and television;
- maintaining a web-site to facilitate access to the latest research findings on astronomy and related sciences;
- providing advice and assistance to amateur astronomy organizations with similar public education objectives (e.g. the Irish Astronomical Association).

The Armagh Observatory is fully committed to implement the New TSN Policy. The Observatory encourages a culture in which resources in appropriate areas of its activities and interactions with the public are targeted so far as possible on individuals, groups, agencies or geographical areas, that have greatest social need. In this way, the Observatory contributes directly to the Northern Ireland Executive's TSN Policy and Programme for Government, especially in providing enhanced access and choice for those in education, and lifelong learning opportunities for the general public.

Armagh Observatory New TSN Action Table 2001

Business Area:	**Astronomy and Related Sciences**
Social Need to be Tackled:	**Access to scientific knowledge amongst socially disadvantaged groups**
Desired Outcome:	**Increased access to scientific knowledge, thereby promoting lifelong learning opportunities amongst socially disadvantaged groups**
New TSN Objectives:	**Targets or Actions and Time-Scales:**
Objective 1 Improve opportunities among disadvantaged sections of the community to experience scientific research in a high-technology environment	(a) work with a suitable partner to facilitate an inclusive work experience programme leading to an improved quality of life for people with disabilities (Year 1) (b) take measures to enhance applications for student programmes and placements from disadvantaged groups and areas (Year 2) (c) establish baseline information on participation on student programme placements with reference to New TSN (Year 1)
Objective 2 Reduce inequalities in knowledge of and access to science	(a) analyse the results of media coverage to assess whether news of Northern Ireland science is reaching as many people as possible (Year 1) (b) take steps to ensure the dissemination of research outputs in an accessible form to as wide an audience as possible (Year 2)
Objective 3 Improve access to the Northern Ireland scientific and cultural heritage	(a) engage with others to encourage visits by people from socially disadvantaged groups (Year 1) (b) develop the web-site and promote e-access to astronomical and meteorological information (Year 1)

Armagh Observatory
June 2001