DEPARTMENT OF PHYSICS AND ASTRONOMY, UNIVERSITY OF GLASGOW

Chair of Astrophysics: Professor J.C.Brown
Observatory Director: Dr D.Clarke
Gravitational Wave Group Leader: Professor J.Hough
Professor of Plasma Physics: E.W.Laing

Report for the period 1993 January to 1993 December

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1 GENERAL

The major events of 1993 for the Astronomy and Astrophysics Group were the award of a SERC Rolling Grant and Starlink Node Grant and, at the end of the year, the move of the Group theorists to new accommodation. This is in the new 6th floor penthouse of the Physics and Astronomy Building, the refurbishment of which is approaching completion at a cost of £7.5M mainly from a UFC/HEFC Grant. Simultaneous removal of the Nuclear Structure Group from the Kelvin Laboratory (East Kilbride) brings the entire Department on to one site, apart from the Observatories.

During the Science Faculty Centenary Week in September, among various Astronomy events was the presentation to the Department of a portable 0.5-m Dobsonian Telescope by Mrs Helen Woodruff in memory of her late husband Professor Woodruff (Tropical Medicine, London) who had been a keen amateur astronomer all his life.

2 PERSONNEL

2.1 Astronomy and Astrophysics Group

Dr Declan A.Diver transferred from SERC to SHEFC support as Lecturer from 1993 April. Dr S.M.Kanbur was appointed as System Manager of the new Glasgow Starlink Node in 1993 September.

SERC funded PDRAs were Dr Norman Gray (ongoing) in YohKoh-related science, Dr Lorna L.Richardson (from 1993 October 1) in stellar polarimetry, and Mr Keith MacPherson in solar plasma physics. Dr Valentina Zharkova (RS VF) obtained SERC funding for a second year as Visiting Fellow in Solar Physics. Dr David Alexander completed his SERC PDRF in solar physics and joined Dr Acton’s YohKoh team in Montana while Dr Geoffrey Fox completed his polarimetry PDRA and joined the WUPPE Team in Wisconsin, Madison, to be joined there in 1994 January by Kenneth Wood with the support of a SERC PDRF. Steve Fullerton was appointed PDRA in polarimetry at Durham and Moray Anderson as EEC RA in jet modelling at Helsinki.

Postgraduate students were: solar and plasma astrophysics—Moray Anderson, Richard Barrett, Andrew Conway, Keith MacPherson, Sarah Matthews, Giota Petkaki, Douglas Cooper; polarimetry—Jaber Naghi-
zadeh-Khouei, Steve Fullerton, Richard Smith; cosmology—Aidan Keane, Andrew Newsam; plasma theory—Jack Ireland, David Keston, David Ramsay, Elizabeth Rooney, Andrew Wood. A total of 4 PhDs were awarded—Anderson, Fletcher, Stewart, K.Wood.

2.2 Gravitational Waves Group

Academic staff members were Professor J.Hough and Drs G.Newton, N.Robertson and H.Ward. PDRAs were Drs A.Campbell, D.Robertson and K.Strain. Dr J.Logan was awarded a SERC PDRF to work at the Max-Planck Institute for Quantum Optics in Garching, and at Glasgow, and went to Garching in 1993 April. J.Logan and E.Morrison were awarded PhDs. The group currently has four research students: S.Killbourn, A.McLaren, S.Rowan and K.Skeldon.

3 VISITORS

Short term visitors to the Astronomy and Astrophysics Group included Michele Piana (Genoa), Martin Hendry (Sussex), Lyndsay Fletcher (Utrecht) and Hugo Schwarz (ESO).

Research visitors to the Gravitational Waves Group included Hans Bachor, Mal Grey and John Sandemann (Australian National University), Peter Bender (Joint Institute for Laboratory Astrophysics), Peter Fritschel (MIT), Josh Goldberg and Peter Saulson (Syracuse), Ron Hellings (Jet Propulsion Laboratory), Laurie Mann (Stanford), Mark Notcutt (Perth, Western Australia), Justin Shuttleworth (Cardiff), Clive Speake (Birmingham), Stan Whitcomb (Caltech).

4 SERVICE ACTIVITIES

Professor Brown utilised the Department’s new Laser Disk image projection system in lectures to mark the Centennial of the Faculty of Science and for the Saturday Schools Science Club, and advertised on local radio the Perseid Shower which, despite thin cloud cover, provided locally a spectacular display in terms of very bright meteors, if not rate. The Royal Society of Edinburgh Cormack Vacation Scholarship scheme which Professor Brown introduced was deemed very successful and is to continue as an annual feature on the Scottish research scene.

On September 7 the A&A Group hosted a one day meeting on Natural and Laboratory Plasmas organised by Dr Diver on behalf of the Institute of Physics Plasma Physics Group Committee. The invited speakers were Prof Laing, Dr T.Edlington (AEA Technology Culham), Prof Brown and Prof H.P. Summers (JET), and the remit of the meeting was to explore mutual interest in the physics and astrophysics communities in the modelling and detection of plasma properties. The thirty or so delegates debated the properties of equal-mass plasmas, Faraday rotation in tokamak plasmas, and plasma beams in the laboratory and astrophysical contexts.

In September, Dr Clarke relinquished membership of the RAS Education Committee. On October 16, he organised and hosted a ‘Training the
Trainers’ Meeting at the Observatory (Acre Road); the lectures, workshops and displays attracted 35 teachers from local Primary and Secondary schools.

Drs Clarke and Diver contributed lectures on Telescopes/Detectors and Nuclear Fusion to the Department of Adult and Continuing Education’s course ‘Frontiers of Physics’; a 20-week course on an ‘Introduction to Astronomy’ was given at the Observatory. Group members continued to give talks to school pupils and astronomical societies as well as research colloquia at various universities and research centres. Dr N.Robertson gave a talk at the British Association annual meeting in Keele, and was interviewed for several radio and TV programmes, including BBC World Service, Radio Scotland and BBC Scotland.

Professor Laing was invited to be a member of the SHEFC (Teaching) Quality Assessment Committee for Physics. Professor Hough joined the RAS council.

5 UNDERGRADUATE TEACHING

Astronomy student numbers remained healthy, with the largest Honours Class ever, and with a growth in the new ‘Arts’ Class ‘Exploring the Cosmos’ to 100, double the level in the previous inaugural year. In line with a general Faculty trend, it was decided henceforth to split the Honours Examinations between Years 3 and 4. Honours Seminar Projects, formerly a Single Honours requirement, were introduced to the Combined Honours curriculum and produced reports of high calibre. Among technological developments introduced were the laser disk system, a new planetarium, a Departmental PC Cluster, CCD cameras and two portable telescopes.

6 STAFF TRAVEL

Professor Brown attended, with various Group colleagues, the IAU Colloquium on particle acceleration (College Park, MD, USA), the YohKoh Science Meeting in Tokyo, the CESRA workshop on fragmented energy release in the Sun and stars (Utrecht) and the workshop on stellar wind variability and instability (Quebec). Research visits included Genova (inverse problems), ESOC Darmstadt (neural networks), Amsterdam, Madison, Montreal (polarimetry), JHU APL Maryland, NRL (solar flares) and Sydney (plasma astrophysics).

In August, Dr Clarke attended the SPE Meeting on X-ray and ultraviolet polarimetry in San Diego with K.Wood, who presented a paper on spectropolarimetry of stellar winds and axisymmetric rotating atmospheres, and S.R.Fullerton, who presented a poster paper on Solar Polarimetry. Dr Clarke also visited the University of Wisconsin in connection with projects related to ultraviolet polarimetry of the Zodiacal Light and presented a seminar.

Dr Simmons attended the IAP Meeting in Paris (1993 July) on Cosmic Velocity Fields, jointly presenting three papers. He also made a collaborative visit to Dr Lachièze-Ray of Saclay in December for work on distance estimation in cosmology.
Dr Diver, accompanied by Mr J.Ireland, Mr S.Abdul-Rassak and Mr D.Ramsay, attended the Institute of Physics Congress in Brighton. Poster papers were presented on Unsteady Flows in Constrained Magnetic Geometries (Ireland & Diver), Transport Coefficients of Equal-mass Plasmas (Abdul-Rassak & Laing) and Mode Coupling in Cylindrical Plasmas (Ramsay & Laing).

Professor A.E.Roy organized and directed the NATO ASI 'From Newton to Chaos: Modern Techniques for Understanding and Coping with Chaos in N-Body Dynamical Systems', held in Cortina, Italy, in July and 1993 August.

Numerous collaborative visits have been made by members of the Gravitational Waves Group. The whole group participated in a collaborative meeting in Hannover, with colleagues from Cardiff, Max-Planck Institute for Quantum Optics in Garching and the University of Hannover. Visits were also made to our German colleagues at the Max-Planck Institute, to VIRGO collaborators at Frascati, Orsay and Pisa, and to members of the LIGO group at California Institute of Technology. Several members participated in discussions on the LISA space project in Noordwijk, and the group was represented at the 2nd William Fairbank Conference in Hong Kong.

7 RESEARCH

7.1 Solar Physics

Brown (with Gray, Beekman and MacKinnon) developed his work on entropy considerations in particle acceleration and applied it to both solar flare and cosmic ray spectra. He also started investigation, with Matthews and Melrose, of the possible consequences of flare return current instability in the low chromosphere due to the low free charge density there. Zharkova, with Syniavskii and Brown, developed her flare hydro-/radiative transfer code to include the effects of field convergence and return currents on beam emission and heating. Effects of varying ambient heating terms were also studied. Gray, with Brown, developed models of flare energy transport in highly filamented structures, including cross field conduction, and with Brown, Matthews and Zharkova, explored simplified methods of modelling flare response to beam heating, to facilitate data comparisons. Fletcher and Brown completed work on Hα impact polarization by electron beams and by evaporative upflow impacts.

Alexander completed his work with Matthews on the relation between gamma ray signatures of Alfvén wave ion acceleration and XUV line broadening by the waves, and developed several collaborative projects on SMM, YohKoh, and Compton data. MacKinnon and Petkaki continued their work on particle acceleration in non-steady reconnection, incidentally developing a new model for extended high altitude hard X-ray events. MacKinnon and MacPherson began work on cellular automata models of fragmented energy release in plasmas. Cooper, with MacKinnon, began looking at a Hamiltonian description of particle acceleration by MHD waves and implications for solar flares. Under the GI programme for the Compton Observatory, Alexander and MacKinnon have been developing data inversion techniques for solar neutron observations from COMPTEL.
MacPherson extended his work on neural network prediction of sunspot numbers to geomagnetic data and showed the method to be superior to the usual McNish-Lincoln approach. Conway started extension of the method to short time scale events, and devised a new genetic algorithm approach to network training, which facilitates removal of the prediction delay effect to which networks prove prone.

7.2 Inverse Problems

Barrett continued his work on optimal inversion of helioseismic data. In collaboration with Bertero, Calvini and Piana (Genoa), Brown developed and applied optimal methods for deconvolution of particle acceleration spectra and plasma temperature structure from bremsstrahlung data and of stellar mass loss variations from spectropolarimetric data. With Wood he devised new methods of obtaining the inclination, density and velocity structure of circumstellar disks by inversion of polarimetric profiles of electron scattered stellar lines. Work is under way with Kanbur and Crowther (UCL) on the possibility of inversion of broad WR emission line profiles to yield wind velocity profiles.

7.3 Astrophysics

In collaboration with Moffat (Montreal) and colleagues, Brown and Richardson studied joint photometric/polarimetric diagnostics for density inhomogeneities in WR winds. Results yield ‘blob’ sizes, densities and distances and prove that polarimetric data demand that the inhomogeneities must already be present at the photosphere. It had previously been thought that this was precluded by spectral data on high excitation potential lines from the inner wind, but more careful scrutiny of the data reconciled them with the polarimetry. Richardson and Brown have also evaluated the depolarising effect of the simultaneous presence of many ‘blobs’ and explained the small observed ratio of WR polarimetric to photometric variability. Brown’s work with Petkaki and Mundell on SS433 jet heating neared completion and led to an explanation of the absence of the optical ‘bullet’ phenomenon at X-ray wavelengths. Wood, with Brown, extended the work cited in 6.1 on stellar disks to 3-D envelopes and electron thermal broadening of the diagnostic lines. With Simmons he also investigated scattering polarization in relativistic jets.

7.4 Observational Photometry and Polarimetry

In the investigation of the application of CCDs to the improvement of stellar polarimetric accuracies, Naghizadeh-Khouei has collected data of defocused stellar images using a two beam system (Savart plate) which avoids the need of flat fielding techniques. He has also continued making spectropolarimetric measurements of the daytime sky using a commercial CCD and associated software. Clarke, with Smith, has continued development of a high resolution spectropolarimeter for stellar studies of Hα.
emission lines (Be stars) and molecular lines (late-type supergiants) and has investigated the potential of a liquid crystal modulator. It is planned to use the instrument on the telescope in 1994 Autumn.

Data from the solar whole disk project have been reduced and analysed by Clarke and Fullerton with the result that the Sun's integrated light appears to exhibit polarization at levels ~ 0.0005 on days when activity is very apparent.

In collaboration with the University of Wisconsin, Clarke has analysed spectropolarimetric data of Be stars. For φ Per, excellent agreement has been found for the models which independently explain the wavelength dependence and temporal variations.

7.5 Cosmology and Statistical Astronomy

Simmons has continued research in the application of statistical techniques to cosmological problems, in particular analysing the effect of biased distance estimation on the reconstruction of velocity fields. This work is being done in collaboration with Newsam, Lachièze-Rey of Saclay and Triay of Marseilles. Simmons is also looking at applications of group theory to cosmological models and Hamiltonian formulations of General Relativity with Dr Y.-C.Ge of Southampton University and Dr Tim Blackwell.

Further work has been done by Clarke and Naghizadeh-Khouei on the understanding of the statistics of polarimetric measurements both on the behaviour of unpolarized standard stars and on data of workers who claim that the majority of stars displaying interstellar polarization exhibit temporal variability. Clarke (with summer students Claire Halliday (Carnegie) and Paul McNamara (Departmental Funding)) has investigated problems associated with noise-induced bias in the determinations of stellar magnitudes and colour indices via Pogson's Equation.

7.6 Astrodynamics

Professor A.E.Roy, with Dr B.A.Steves (Glasgow Caledonian University), visited the Department of Planetology, CNR, in Rome to continue their collaboration with Drs E.Valsecchi and E.Porozzi on the main lunar problem as part of Project POINCARE (Periodic Orbits Involving Numerous Circuits: Applications, Research and Exploration) an ongoing international research programme in the many-body gravitational problem with application to the stability of the Moon. The method is now being extended to the Sun-Jupiter-Saturn dynamical system.

7.7 Plasma Theory

Diver, with Ireland, is continuing research into non-linear plasma flows and has begun to develop a novel computer simulation of 2D MHD based on cellular automata and Lattice–Boltzmann techniques. This fluid code, being developed with help from A.Wood, can recover the full incompressible MHD fluid equations, and will be applied to plasmas with sharply defined boundaries in order to study the dynamical evolution of such finite plasmas.
Ongoing research in the field of Genetic Algorithms has led to the development of a prototype 2D partial differential equation solver, extending the capacity of the self-adapting code beyond the solution of ordinary differential equations. A further advance has been the creation of a Genetic Algorithm pattern searcher for spectral analysis which will be applied initially to Laser Ionisation Spectroscopy, with extension and further development as an astronomical data analysis tool.

Diver was awarded £10,000 by the University’s Senate Initiative Scheme as a contribution towards the purchase of a small parallel computer, to be used in the continuing development in parallel algorithms.

7.8 Gravitational Waves

The group aims its work towards the detection of gravitational waves from astrophysical sources, using laser interferometry between mirrors hung as pendulums a long distance apart. The British groups in Glasgow and Cardiff along with their German colleagues in the Max-Planck Institute for Quantum Optics in Garching and the University of Hannover are looking into the possibility of collaborating on a project called GEO 600 to build a large baseline detector near Hannover. They are at present working independently of the French/Italian VIRGO group and the American LIGO group, although there are strong collaborative links with both groups.

Research in the Glasgow group covers several areas. The central focus is a 10 m prototype gravitational wave detector sited in the Department. Work here involves developing the detector to achieve more sensitive measurements of relative changes in arm length of the two arms of the interferometer. During 1993 a major rebuild of the detector was initiated, to coincide with essential maintenance and refurbishment work taking place in the Department. This rebuild will allow more flexibility to test new optical schemes and will also incorporate better suspensions and control systems for the mirror test masses in the detector.

Another research area being pursued is the development of frequency doubling of a Nd-YAG laser as a potential replacement for the inefficient argon lasers presently being used in the prototype detector.

Work has continued in improving the understanding of optical and mechanical properties of materials and suspensions for the test masses, in particular in the areas of optical birefringence of silica and thermal motion of masses suspended as pendulums. The group has continued to play a key role in a collaborative team from Europe and the USA which is carrying out an ESA assessment study for LISA, a space-based low frequency gravitational wave detector. Glasgow’s main role at present lies in the optics design for the proposed detector. Professor Hough is the chairman of the ESA working group on interferometry for this project.

8 OBSERVATORY ACTIVITIES

In 1993 Spring a new GOTO Planetarium (Model—E5) was installed.

Further increase in activity is noticeable in terms of interest by schools. Thirteen visits by outside parties were arranged in addition to the regular
course of Introductory Astronomy and additional evenings for Extra-Mural Classes and the Science Access Course arranged by the Department of Adult and Continuing Education.

The Observatory was also a popular venue during the Centenary Celebration for the Faculty of Science when Open Nights were held on 1993 September 20–23, attracting over 600 visitors. On Saturday 1993 October 16 an all-day event for teachers was organised by Dr Clarke under the title of ‘Training the Trainers’.

Graduates, families and friends were invited to a Party on 1993 July 15.

The Astronomical Society of Glasgow made use of the facilities during the winter on a regular monthly basis.

PUBLICATIONS

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