Reports from Observatories, University Departments and Research Establishments

DEPARTMENT OF PHYSICS AND ASTRONOMY, UNIVERSITY OF GLASGOW

Professor J.C. Brown: Chair of Astrophysics Dr D. Clarke: Director of the Observatories Professor J. Hough: Gravitational Wave Group Leader

Report for the period 1995 January to 1995 December

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I PERSONNEL

1.1. Astronomy and Astrophysics Group (A&A)

Professor J.C. Brown was appointed 10th Astronomer Royal for Scotland in February.
Professor E.W. Laing retired at the end of September.
Dr G. Woan (of MRAO Cambridge) was appointed Lecturer in Astronomy in December.
Mr G. Deighan left the Department in the summer to take up a post with EDS, Uxbridge.
Dr J. F. L. Simmons was on study leave at Saclay, January–September.
Dr A. L. MacKinnon (Department of Adult and Continuing Education) has continued his collaborations with the Department with both undergraduate events and research.
Dr N. Gray completed his term as YohKoh PDRA, being succeeded by Dr A. J. Conway.
Drs L. L. Richardson and K. P. Macpherson continued as PDRAs in astrophysical polarimetry and plasma theory respectively.
RSE Cormack Undergraduate Vacation Scholars were E. Bell, With Dr Clarke (Ha spectroheliogram recording with a CCD camera), F. Kirton with Dr Macpherson (neural network solar activity predictions) and P. Phillips with Dr Kanbur (stellar pulsation models) while J. Lunny, Carnegie Summer Scholar, helped establish a CCD camera system for the investigation of bacterial bioluminescence in a collaboration between Dr Clarke and the Institute of Biological and Life Sciences.
Three PhDs were awarded – Elizabeth Rooney, David Ramsay and Jack Ireland; Drs Rooney and Ramsay joined commercial computing companies while Dr Ireland continued as Research Assistant at St Andrews Solar Physics Group.

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1.2 Gravitational Waves Group (GW)

Academic staff members were Professor J.Hough and Drs G.P.Newton, N.A.Robertson and H.Ward. Drs Newton and Ward were promoted to Senior Lecturer. Dr K.A.Strain was an advanced research fellow. PDRAs were Drs J.E.Logan (till September 1995), D.I.Robertson, S.Rowan and Mr K.Skeldon (from October 1995). Research Associates were Mr R.Hutchins and Mr A.Grant. Dr Logan left to take up a Senior Research Fellowship in Caltech. Research students during this period were: M.Casey, S.Killbourn, A.McLaren, P.McNamara, K.Skeldon and S.Twyford.

2 VISITORS

Research visitors to the A&A Group included: about 25 European plasma astrophysicists for the culmination meeting of a 5 Lab EEC Network; Dr R.Yudin (Pulkovo) to establish an observational collaboration in stellar polarimetry; Dr L.van Driel-Gesztelyi (Meudon) to work on YohKoh WLF data; Drs M.Hendry (Sussex) and A.Newsam (Southampton) for cosmology collaborations; Drs M.Piana and P.Calvini (Genova) for collaboration on solar and stellar inverse problems; Dr E.Antonello to work on Cepheid modelling of double mode stars in the LMC and Galaxy.

Those to the GW Group included Dr J.Faller (Joint Institute for Laboratory Astrophysics) for 1 month, Dr R.Poggiani (INFN Pisa) for 1 week, and members of the GEO collaboration for two 3-day group meetings.

3 EXTERNAL SERVICE AND PUBLIC UNDERSTANDING OF SCIENCE ACTIVITIES

Professor Brown won grants totalling £10,000 from the Royal Society COPUS, PPARC PUST, and the SOED, for schools work with interactive video material. In response to a SHEFC Special Regional Initiative, he was awarded £78,000 jointly with Professors A.Lawrence (Edinburgh) and K.D.Horne (St Andrews) for Starlab Planetaria and related AV equipment to provide Scotland-wide schools astronomy visit facilities. He also acted as adviser to the Scottish Schools Science Curriculum development.

In addition to talks by several A&A members to various schools, Amateur Astronomical Societies and the University Saturday Science Club, Dr Clarke and Professor Brown presented lectures at the Scottish Astronomy Weekend in Stirling (October 13–15) and ran workshops on observational projects with small instruments and astrophotography.

Professor Brown, in his ARIS capacity became convenor of the RSE Cormack Committee which administers Scholarships and schools lectures and runs an annual Scottish Astronomy meeting (held in Glasgow in 1995).

Dr D.A.Diver was invited to rejoin the IOP Plasma Physics Committee.

Professor Hough continued on the RAS council and he is also chairman of the Scientific, Technical and Advisory committee for VIRGO (the French/Italian Gravitational Waves project), and chairman of the physics section panel of the Royal Society of Edinburgh.

GW Group members continued to give talks to school pupils and student
societies. Once again the popular ‘Arches and Sparks’ demonstration given by K. Skeldon and R. Crawford during SET 95 was strongly attended.

PPARC PUS money was won for Physics activities by the Department.

4 UNDERGRADUATE TEACHING

This year saw in train several revisions to the structure of degree courses including modularization and introduction of MSci degrees alongside the BSc. The non-mathematical ‘Exploring the Cosmos’ class continued to grow while others remained steady, and a ‘Space Environment’ option was introduced for Honours Aerospace Engineering students. Astronomy Level 2 was extensively reviewed, and a new structure and content was implemented in the academic session 1995–96. An innovation for this Class was an Observing Weekend in February at the University’s Marine Biological Station on the Isle of Cumbrae. Although the weather was not ideal, some observing with portable telescopes was achieved, and a number of demonstration lectures given, the occasion proving a great success.

5 STAFF TRAVEL

Professor Brown paid three visits to UW Madison for collaborations in polarimetric modelling of stellar mass loss, one to the Czech Astronomical Institute to work with Dr M. Karlicky on particle transport, one to HAO Colorado to work with Dr P. Judge on SOHO spectrum analysis problems, and attended the BAAS in Newcastle. He was invited to be the after dinner speaker at the NASA GSFC HESSI Workshop and gave an invited talk at the RAS Particle Acceleration Meeting in January. He gave seminars to a number of institutions including NRL, UW Madison, St Andrews and Manchester.

Dr Clarke attended the IAU Colloquium ‘Physics, Chemistry & Dynamics of Interplanetary Dust’ at Gainesville, Florida (14–18 August) and presented a paper on the Interpretation of Radial Velocity Measurements of the Zodiacal Light. In December, he also visited UKAEA, Culham, in connection with experiments to determine the Faraday rotation in Tokamak plasmas.

Dr Simmons spent 9 months as an invited research fellow at the ASP, Saclay, working with Dr M. Lachieze-Rey. He gave an invited talk at the workshop on Gravitational Lensing organized by the Observatoire de Strasbourg. He also made research visits to Marseille to work with Dr R. Triay, and Strasbourg to work with Dr D. Valls-Gabaud and gave seminars at Marseille, QMW, and Saclay. Collaborations were also conducted with Drs J-M. Alimi and E. Audit at Meudon.

Dr Diver attended the 22nd UK Plasma Physics Conference and presented a paper on ‘Alfven Waves in a Dusty Plasma’.

Dr MacKinnon spent a week with the Radioheliograph Group at Meudon, collaborating on the interpretation of pion decay gamma-rays from the PHEBUS experiment on the GRANAT mission.

With Dr Macpherson he visited the University of New Hampshire to collaborate with Dr J. Ryan on the Comptel GI program. Dr Macpherson
presented a talk on GRO solar flare neutrons at the UK Solar Physics meeting in Guildford and attended the SoHO CDS/Summer Science meeting in Oslo, presenting a talk on plasma DEM analysis and spectral inverse problems.

Dr S.Kanbur attended the Stellar Pulsation Conference in CapeTown, South Africa.

Dr Newton spent 3 months at the Australian National University, Canberra as a Visiting Fellow. Dr Logan spent 1 month as a Visiting Fellow at the same institution. Dr S.Rowan spent 4 months as a visiting researcher in the Gintzon Laboratory, Stanford University.

Drs H.Ward and D.I.Robertson participated in the International Gravitational Wave Workshop in Aspen, Colorado. Several members of the GW Group attended the GR14 meeting in Florence.

J.Hough gave an invited talk at JENAM in Sicily, and the whole group attended a GEO workshop in Hannover.

6 RESEARCH

6.1 Solar physics

In flare physics Professor Brown worked with: G.McArthur, S.McIntosh and M.Piana on bremsstrahlung spectrum inversion problems; Dr N.Gray on cross-field effects on energy transport in filamented structures and on entropy in particle acceleration; I.Coleman on analytic descriptions of chromospheric evaporation; L.Fletcher on $H\alpha$ polarization; A.Conway, A.L.MacKinnon and D.Alexander (Montana) on YohKoh HXT images. S.Matthews completed her work with D.Alexander on Alfven waves in SXR and $\gamma$-ray flares and with L.van Driel-Gesztelyi studied YohKoh HXT and white light events to test the Brown et al. model of deep chromospheric unstable return current heating. In active sun physics, Brown worked with Conway and Macpherson on neural network predictions, with P.Judge on inversion of plasma XUV line spectra to yield density and temperature structure and with Dr D.A.Diver and Dr D.M.Rust (Johns Hopkins APL) on Ellerman Bombs.

With Dr MacKinnon (DACE), Dr Macpherson studied cellular automaton and avalanche models for solar flare occurrence. These aim to explain the fragmented nature of solar flare emission and produce similar power-law distributions of flare event size as those found in SMM and CGRO data. This work involves increasing collaboration with Professor L.Vlahos (Thessaloniki).

In collaboration with Dr J.Ryan (University of New Hampshire) and Dr D.Bhattacharya (University College Riverside) Drs MacKinnon and Macpherson are studying observations of neutron emission from large solar flares as part of the NASA GRO GI program. This study involves work on COMPTEL instrument response alongside modelling solar flare neutron production and flare proton acceleration and can be extended to the first synoptic study of Earth-albedo neutrons with respect to solar cycle phase and Earth latitude.

As an extension to his thesis research on Neural Networks for predicting solar activity, Dr Macpherson with Ms F.Kirton looked at the predictability
of rapid variations in solar output using neural networks. Professor Brown with Dr Macpherson and Mr S.McIntosh, is applying GUIPS software to inversion of the density and temperature differential emission measure of solar plasmas, in relation to line-ratio data which will become available from SoHO.

6.2 Inverse problems

A wide variety of inverse problems, as cited elsewhere, has been investigated, and a special astronomy issue of Inverse problems Journal edited by Brown. In addition, a more precise solution than hitherto has been obtained for the synchrotron spectral inverse problem and an analytic inversion obtained for the problem of thick target bremsstrahlung from a nonuniformly ionized target.

6.3 Astrophysics

Professor Brown and Dr L.Richardson completed their work on variability of WR stars in relation to wind inhomogeneities and in collaboration with Dr J.P.Cassinelli and Mr R.Ignace (Wisconsin) further developed their work on deriving wind structure from emission-line profiles in the optical and IR (ISO). With Dr J.Bjorkman, Professor Brown started work on constraining ellipsoidal circumstellar shell models by joint study of optical polarization, IR excess and optical interferometric images. Work has recommenced on Crab nebula polarization maps in anticipation of new HST data.

6.4 Observational photometry and polarimetry

Development of the liquid crystal modulator for stellar spectropolarimetry has continued. Technical problems being investigated relate to the attachment of compensation plates to allow for the non-zero retardation offset when the liquid crystal cell is de-energized, to the temperature stability of the arrangement, and to the wavelength calibration of the system.

Collaborations with the polarimetric group at the University of Wisconsin have continued. Analysis of data of ϕ Per reveal temporal changes related to the apparent changes in geometry displayed by this spectroscopic binary. The deduced information agrees remarkably with that obtained from analysis of the wavelength dependence of polarization. This is the first Be star for which both kinds of analysis have been performed.

Mr V.Ameijenda commenced a CASE research project associated with UKAEA at Culham with the aim of determining the current density profile by measuring Faraday rotations in the light paths along chords of a magnetized plasma.

6.5 Cosmology and statistical astronomy

Dr Simmons has worked on large-scale structure formation, and the statistical distance analysis of distance estimators and their implications for the determination of cosmological density and velocity fields. He has also
been investigating the effects of microlensing on stars with extended envelopes and on gravitational lensing on cosmological scales. The application of symmetries and group theory to cosmological models has been another area of research.

Dr Clarke has continued investigation of the statistics associated with the determinations of stellar magnitudes and measurements of power when expressed in decibel units. Both systems which involve conversion of basic flux measurements with noise by a logarithmic process are prone to bias.

6.6 Stellar pulsation

Dr S.Kanbur continued a collaboration with Professor D.Mihalas on an adaptive grid 1-D radiation hydrodynamic code for stellar pulsation. This should produce substantially more accurate models than hitherto and be suitable for a wide range of astrophysical computational problems. He has also completed a study which explains the behaviour of RR Lyraes and Cepheids at minimum and maximum light in a common framework, suggesting that the mass lying above the hydrogen ionization front is related to the structure of the observed light curve. This should become a useful tool in the study of asteroseismology.

With Dr M.Hendry (Sussex), Dr Kanbur implemented a composite calibration procedure for Cepheids in SNIa host galaxies. The technique also takes account of luminosity selection effects. Its application to estimate Hubble's constant using HST data is underway. Drs Kanbur, Hendry and Clarke have discovered a PL relation at maximum light for Miras in the LMC that has smaller dispersion than its counterpart at mean light in the J, H, K and bolometric magnitudes. This not only has implications for distance estimation, particularly since Miras are observed in the Virgo supercluster, but also as a tool to study Mira internal structure and evolution.

With Dr E.Antonello, Dr Kanbur finished a study of double mode Cepheids in the LMC and in the Galaxy. This showed that overshooting mass luminosity relations fare slightly better in reproducing observed periods in the LMC and Galaxy, but CO Aur cannot be so explained without adopting unrealistically high metallicities.

6.7 Plasma theory

With Dr MacKinnon, Ms Petkaki continued to investigate particle acceleration resulting from the passage of a wave through a magnetic neutral point. An attempt was made to couple MHD and kinetic descriptions by adjusting the resistivity until wave energy losses and particle energy gains were equal. This attempt failed, but in a way that illuminates the means by which collisionless reconnection must be described. Extension to 3-D has begun in Cooper's work on particle orbits near the 3-D versions of magnetic nulls.

Dr Diver with A.Wood are investigating the non-linear behaviour of plasma flows in the photosphere. Using the Lattice–Boltzmann Cellular Automata code developed by Wood on the in-house parallel computer, studies are being conducted (in conjunction with L. van Driel-Gesztelyi,
Meudon) on simulating the evolution of vorticity in the wake of plasma flow past an emerging flux tube.

With Dr Diver, D.Keston is continuing to investigate the properties of Bernstein modes in relativistic equal mass plasmas, building on the pioneering work of Laing & Rooney. Mr Keston is studying the plasma response intermediate between non- and ultra-relativistic, gaining an insight into how these fundamental modes alter their character with increasing temperature and species mobility.

Dr Diver is continuing to develop new applications of Genetic Algorithm Pattern searching routines, developing with the assistance of D.Ireland (Nuclear Physics Group, Glasgow), their possible use in analysing gamma ray spectra.

6.7 Gravitational waves

This has been a particularly successful year for the Gravitational Waves group with the confirmation of UK funding from PPARC for the joint British/German GEO 600 detector. In addition ESA has adopted the proposed space borne gravitational wave detector LISA as a third cornerstone mission in its post Horizon 2000 programme.

Construction of GEO 600, a detector with two perpendicular arms, each of length 600 m, and using laser interferometer for motion sensing, commenced at a site near Hannover in November 1995.

Research has continued in improving the low frequency performance of the 10 m prototype detector, leading to a better understanding of future requirements ion detector design. Development of seismic isolation stacks and monolithic fused silica suspensions for GEO 600 and future advanced detectors is being actively pursued. In addition, the development of control systems for test masses and interferometers in modern gravitational wave detectors is a major research objective. The group is currently pursuing research on interferometry and laser control for LISA.

Collaborations with the American LIGO project and the French/Italian VIRGO project, which use similar detection technology, have been strengthened over the last year. In addition, the group is initiating collaborations with Stanford and JILA on development of different aspects of gravitational wave detectors.

7 COMPUTING FACILITIES

A new colour X term was installed, together with extra memory for the departmental print server. The mail host and NIS master was moved to one of the new STARLINK machines, resulting in a much more reliable system.

8 OBSERVATORY ACTIVITIES

The Meade (250 mm) telescope has been relocated in the Ceoolstat Dome and has been fitted with a Daystar Hα filter for solar observations. A new Meade (300 mm) system is now in operation in the Main Dome for student experiments and as a general purpose instrument.

The evening Introductory Astronomy Courses organized by Dr Macpherson and run in conjunction with the Department of Adult and Continuing Education continue to flourish. Activities with schools have continued to expand, particularly at the Primary level. Fifteen schools made organized visits with some contacts followed by in-school support. Visits were also popular with Brownies, Cubs and Beaver Scout Packs. Over 900 people signed the visitors book.

9 PUBLICATIONS

1993


1995


