

THE AUSTRALIAN NATIONAL UNIVERSITY.FACULTY OF SCIENCEDEPARTMENT OF THEORETICAL PHYSICSANNUAL REPORT 1977GENERAL COMMENTS. COURSES

The purpose of courses in theoretical physics is, on the one hand, to provide an appropriate background for those students intending to take up a career in the subject and, on the other hand, to lead to an appreciation of the formal notions which underlie the physical sciences in general.

The year represented a remarkable statistical fluctuation as regards the average quality of our third year students. For instance, in one semester unit out of seven students six obtained High Distinctions. It was a heartening experience indeed.

In the absence of Dr Melrose on study leave we received substantial and most welcome help from our sister department in the R.S.Phys.S., Dr Ian Enting and Dr Peter Tandy both taking an active part in both lecturing and examining.

ENROLMENTS AND EXAMINATION RESULTS

See Appendix. In the table actual members are given since these are too small to make percentages meaningful.

STUDENT PARTICIPATION

Methods of assessment were in all cases decided by consultation with all the students concerned. In the third year units we exceptionally agreed to lay much more emphasis upon continuous assessment though we still believe that in an average year the method is likely to place too great a load upon the students, other unsatisfactory features apart. As usual virtually no interest whatever was shown by students in the Departmental Committee. Its meetings were to all intents and purposes redundant. This is to be expected since in a department as small as this and run as unautocratically as this there should be no need for so much formal machinery.

STAFF

Professor: H.A. Buchdahl, D.Sc. (Lond.), F.A.A.

Reader: D.B. Melrose, B.Sc. (Tas.), D.Phil. (Oxon.)

Senior Lecturer: M. Andrews, B.Sc., M.Sc. (Qld.), Ph.D. (Birm.)

WORK OF GRADUATE STUDENTS

Mr R.J. Stoneham continued his research into the electromagnetic properties of a magnetized vacuum. He expects to submit his Ph.D. thesis in March 1978. The M.Sc. thesis of Mr J.E. Stenhouse, referred to in last year's report, was judged to be satisfactory and the degree was duly awarded.

OTHER ACTIVITIES

Dr Andrews continued as Sub-Dean of the Faculty of Science until July. He also prepared the 1978 edition of the Faculty's "Guide for Students" which was completed in September.

Professor Buchdahl attended the February meeting of the Science & Industry Forum of the Australian Academy of Science.

Dr Melrose left on study leave in May. Before then he visited the CSIRO Division of Radiophysics for three weeks in January and briefly in March and April, giving a lecture there in March. His two-volume work "Plasma Astrophysics" was submitted in completed form to Gordon & Breach in May.

RESEARCHM. Andrews

Spherical harmonics are usually introduced in texts on quantum mechanics through the series solution of a differential equation or else by successive application of angular momentum operators in spherical polar form. A new method has been developed for introducing spherical harmonics, deriving their basic properties and manipulating them in the sort of contexts in which they arise in quantum mechanics. This method uses a raising operator constructed from an arbitrary vector and has advantages over the usual techniques. A manuscript has been submitted to the American Journal of Physics.

Investigations are continuing into the foundations of quantum mechanics and measurement theory.

H.A. Buchdahl

From time to time a large number of solutions of Einstein's gravitational equations with scalar zero-mass source have appeared in the literature. It has been shown how almost all of these solutions can be generated by techniques basically developed by Buchdahl many years ago. Additionally there is the problem of determining solutions of the equations in question which are conformally flat. A paper incorporating this work will appear in General Relativity & Gravitation.

The algebra of four dimensional Weyl tensors can be dealt with in an elegant manner by constructing a certain five dimensional complex vector space. A paper containing this work will appear in Tensor.

The explicit relation between spheroidal harmonics and spherical harmonics was derived in an elementary manner jointly with P.J. Stiles

(Research School of Chemistry) and N.P. Buchdahl (a student in this department). This work has appeared in Journal of Physics A.

It has been shown that the age old Kepler problem and the classical problem of the so-called Maxwell fish-eye are formally equivalent, the theory of the latter being considered from the point of view of conformally equivalent optical systems, work which was published previously. A paper on this work will appear in the American Journal of Physics.

A common error in the literature concerning the theory of the polytrope of index 5 was tracked down and rectified. This work is contained in a paper to be published in the Australian Journal of Physics.

No exact, explicit "non-trivial" solutions of gravitational field equations generated by non-linear Lagrangians appear in the literature. One such solution (of "Kasner-type") has been determined. A paper has been submitted to Journal of Physics A.

Further work on these and other topics will be reported upon next year when they have been brought to a successful conclusion.

D.B. Melrose

The major project (before departing on study leave in May) was the completion of the manuscript for a book entitled "Plasma Astrophysics", which is to be published in two volumes by Gordon & Breach.

A new theory for the radio emission mechanism of pulsars was developed, and included initially as a chapter in "Plasma Astrophysics".

Investigation of the properties of the natural modes in a pulsar magnetosphere was undertaken in collaboration with R.J. Stoneham (Ph.D. student), and a paper has been published in the Proceedings of the Astronomical Society of Australia.

A theoretical study, in collaboration with G.A. Dulk of the University of Colorado, was initiated into the polarization of radio emission at the second harmonic of the plasma frequency, with the intention of applying the results to the interpretation of recent observations of significant polarization in solar radio bursts.

PUBLICATIONS

- Brown, J.C.† and Melrose, D.B. "Collective plasma effects and the electron number problem in solar hard X-ray bursts", Solar Physics, 52 (1977), 117-131.
- Buchdahl, H.A. "Systems Without Symmetries. VI.: Continuous systems. Optik, 48 (1977) 53-68.
- Buchdahl, H.A. "On solutions of Einstein's equations with scalar zero-rest mass sources", General Relativity and Gravitation, 8 (1977).
- Buchdahl, H.A., Buchdahl, N.P. and Stiles, P.J. "On a relation between spherical and spheroidal harmonics", Journal of Physics A (1977), 1833-1836.

† not a member of this University

- Buchdahl, H.A. "Kepler problem and Maxwell fish-eye", American Journal of Physics, 45 (1977).
- Melrose, D.B. "Vacuum polarization and photon propagation in a magnetic field", Il Nuovo Cimento 32A (1976), 435-447.
- Melrose, D.B. "Diffusion processes in magnetized plasmas", Physics of Solar Planetary Environments, American Geophysical Union, Washington, D.C. [ed. D.J. Williams], Vol. 1 (1976), 232-240.
- Melrose, D.B. and Stenhouse, J.E. "Emission and absorption of Langmuir waves by anisotropic unmagnetized particles", Australian Journal of Physics, 30 (1977), 481-493.
- Melrose, D.B. "Remarks on plasma emission and its application to solar radio bursts", Radiofizika (in Russian), 20 (1977), 1369-1378.
- Melrose, D.B. and Stoneham, R.J. "Generalized Kramers-Kronig formula for spatially dispersive media", Journal of Physics A, 10 (1977), L17-L20.
- Melrose, D.B. "Mode coupling in the solar corona. III. Alfvén and magnetoacoustic waves", Australian Journal of Physics, 30 (1977), 495-507.
- Melrose, D.B. and Stoneham, R.J. "The polarization tensor for a magnetized vacuum", Journal of Physics A, 10 (1977), 1211-1224.
- Melrose, D.B. and Simpson, M.A. "Mode coupling in the solar corona. IV. MHD waves", Australian Journal of Physics.
- Melrose, D.B. "Mode coupling in the solar corona. V. Reduction of the coupled equations", Australian Journal of Physics, 30 (1977).

THE AUSTRALIAN NATIONAL UNIVERSITY
DEPARTMENT OF THEORETICAL PHYSICS ANALYSIS OF STUDENT PERFORMANCE

1	<u>Number Enrolled</u>				<u>Number Sitting</u>					
	2	3	4	5	6	7	8	9	10	11
<u>Unit</u>	<u>Enrolled</u>	<u>Sitting</u>	<u>Wastage</u>	<u>Failure</u>	<u>Sitting</u>	<u>High Distinction</u>	<u>Distinction</u>	<u>Credit</u>	<u>Pass</u>	<u>Fail</u>
BO1	7	6	1	0	6	3	0	1	2	0
CO1	12	11	1	0	11	4	1	4	2	0
CO2	4	4	0	0	4	3	1	0	0	0
CO3	6	6	0	0	6	4	1	1	0	0
CO4	0	0	0	0	0	0	0	0	0	0
CO5	8	7	1	0	7	6	0	1	0	0

N.B. The actual numbers are given since these are too small to make percentages meaningful.

	<u>Enrolled</u>	<u>Sitting</u>	<u>Result</u>
Masters Degree	1	1	1