15/1

2.L.8.13

95/1976

THE AUSTRALIAN NATIONAL UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF THEORETICAL PHYSICS

ANNUAL REPORT 1975

GENERAL COMMENTS

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.

Poor enrolments were exacerbated by early withdrawals amongst students who had not previously enrolled in a Theoretical Physics unit. The poor enrolments presumably reflect the employment situation. The relatively high percentage of early withdrawals was due primarily to students who enrolled "to see what theoretical physics is like" finding the formal work not to their liking or too demanding. In any event, all the weaker students withdrew and those remaining were all considerably above "Pass" standard.

COURSES

Regular courses were given at Second Year and Third Year levels. Four Honours students from Physics, S.G.S. attended one of the Third Year courses as part of their Honours Year. A special lecture course on "Plasma Processes in Astrophysics and Geophysics" was given by Dr. Melrose, primarily for the Honours Year, and this was attended by representatives from Physics, S.G.S. and from Theoretical Physics, I.A.S. In Professor Buchdahl's absence Drs. R.L. Dewar and L.J. Tassie assisted in the teaching of these courses.

ENROLMENTS AND EXAMINATION RESULTS

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

STUDENT PARTICIPATION

As in previous years the students in each unit were asked to agree on how they should be assessed. In most cases assessment by examination was agreed, although different parts of courses were assessed by assignment work, by essays and, in one case, by seminar. Otherwise students were apathetic towards participation, as could be illustrated by citing the fact that no person in the largest unit would accept election as that unit's representative on the Departmental Committee.

STAFF

Professor:	H.A. Buchdahl, D.Sc. (Lond.), F.A.A. (on study leave July 1975 - January 1976)
Reader:	D.B. Melrose, B.Sc. (Tas.), D.Phil. (Oxon.)
Senior Lecturer:	M. Andrews, B.Sc., M.Sc., (Qld.), Ph.D. (Birm.)

VISITORS

Dr J.C. Brown of the Astronomy Department, Glasgow University visited for seven weeks from early July. He worked with Dr. Melrose on the theory of solar hard X-ray bursts.

There were also brief visits by Dr. P. Christianson of the University of Sussex, Dr. S.F. Smerd (twice), Dr. D.J. McLean (twice) and Dr. R.J.-M. Grognard all of the C.S.I.R.O. Division of Radiophysics, Dr. W.N.-C. Sy of The Flinders University and Dr. D.G. Cartwright of the Weapons Research Establishment.

WORK OF GRADUATE STUDENTS

Mr R.J. Stoneham has been investigating coherence effects on emission processes in astrophysics. He has also worked on quantum electrodynamics and a paper, prepared jointly with Dr. Melrose, has been submitted.

Mr. J.E. Stenhouse started work (in August) on the theory of type III radio bursts in the interplanetary medium.

OTHER ACTIVITIES

Professor Buchdahl went on study leave on 1st July and does not return until the New Year.

Dr. Melrose spent December 1974 to February 1975 in Boulder, Colorado, as a Visiting Professor in the Department of Astro-Geophysics and as a visitor at the High Altitude Observatory. He gave two lectures at each institution, and a lecture course of eight lectures to post-graduate students. While in the United States he also spent one week at the Center for Astrophysics at Harvard University where he gave a lecture. In June he attended a workshop on type III radio bursts at the University of California at Berkeley, and he also visited Stanford University.

Dr Melrose spent two weeks in the Soviet Union as a member of an Australian *ad hoc* group preparing an exchange agreement on radio astronomy between Australia and the Soviet Union. He gave a lecture at the Space Research Institute in Moscow.

Dr Andrews attended the A.N.U. Workshop on Tertiary Teaching on 12-13 February. He took up duty as Sub-Dean of the Faculty of Science from 30 September.

RESEARCH

M. Andrews

For quantum particles in one-dimension a simple criterion has been found to separate those singularities of the potential which allow the passage of particles from those which are impenetrable. If the potential is integrable transmission is possible; if it is not integrable the singularity is impenetrable. The effect of slightly smoothing the singularity in such potentials has also been investigated. A manuscript has been submitted to the *American Journal of Physics*.

An investigation is continuing into the interaction between diffuse wave-packets and systems of many particles capable of inelastic transitions and into the significance of such interactions in the quantum theory of measurement.

H.A. Buchdahl

(i) One usually considers the equilibria of (thermodynamic) systems in the absence of all motions. Landau and Lifshitz investigate the possible internal and external motions of an isolated system in equilibrium by appealing to the Principal of Increase of Entropy. Together with M. Simpson (a third year student in the department) it has been shown that on the one hand the demand of isolation may be dropped and, on the other, the possible motions can be determined by mechanical considerations alone, i.e. without appeal to the usual basic "laws" of thermodynamics.

(ii) Whereas 2-dimensional conformal transformations have occasionally been considered in geometrical optics the same is not true of 3-dimensional conformal transformations. Since rays can be thought of as geodesics of a 3-dimensional conformally flat Riemann space any element of the group C(3) in effect generates from a system K with given refractive index N a "conformally equivalent" system K* with refractive index N*. When $N = N^*$ K is "conformally invariant" and Noether's Theorem provides one or more integrals of the ray-equations. The whole theory was developed at length and a paper containing it appeared in OPTIK.

D.B. Melrose

Streaming instabilities are the only sources of Langmuir waves usually considered in connection with solar radio bursts, and yet there is no direct evidence for streaming motion in most types of burst. A theory for the generation of Langmuir waves in the absence of streaming was developed and applied to solar radio bursts. Also, the observed polarization of the bursts appears to lead to inconsistent conclusions unless the solar corona is inhomogeneous on a fine scale. Two papers were published in *Solar Physics*.

The decametric radio bursts from Jupiter are strongly influenced by the innermost Galilean satellite Io, and theory of the bursts has been dominated by attempts to explain the Io-effect. Recent space-craft based observations show that the Earth emits similar radio bursts and that they correlate with certain auroral precipitations. A theory for emission by precipitating electrons was developed and applied to be the Jovian and terrestrial cases with the Io-effect being attributed to a deformation of the Jovian auroral zone by Io causing enhanced precipitation. A paper has been submitted to *The Astrophysical Journal*.

The vacuum polarization tensor in the presence of a magnetic field may be renormalized simply by representing it in terms of its eigen-vectors. A paper, prepared jointly with R.J. Stoneham (Ph.D. student) has been submitted to *Il Nuovo Cimento*.

One model for solar hard X-ray bursts involves energetic electrons trapped in a magnetic bottle. The inter-particle collisions, whose rate may be determined from the X-ray emission, implies that electrons precipitate from the trap, and the precipitating electrons provide an additional source of hard X-rays. A quantitative model was developed,

and a paper prepared jointly with Dr. J.C. Brown of Glasgow University has been submitted to *Monthly Notices of the Royal Astronomical Society*. An investigation on the possible role of plasma processes in X-ray sources was carried out jointly with Dr. Brown and a paper is in preparation.

An investigation is continuing into parametric instabilities in a plasma. Different methods of treatment used in the literature lead to incompatible results.

Investigation of the propagation of waves in inhomogeneous plasmas is also continuing. Two papers are in preparation, one jointly with M. Simpson (Honours student).

PUBLICATIONS

H. A. Buchdahl

A.

'Hamiltonian Optics. IV. On the angle characteristic of a general refracting surface'. *Optik*, 42 (1975), 57-64.
'Hamiltonian Optics. V. On the point characteristic of a spherical refracting surface'. *Optik*, 42 (1975), 135-146.
'Conformal transformations and conformal invariance of optical systems'. *Optik*, 43, (1975), 259-274.
'Remark on the equilibrium of moving systems'. *Amer. J. Phys.* (1975).

B.

Twenty Lectures on Thermodynamics (Pergamon Press, 1975), pp. 106 + vii.

D.B. Melrose

'A Relationship between the Brightness Temperatures for Type III Bursts', Gordon Newkirk Jr. (ed.), *Coronal Disturbances*, (Proceedings of I.A.U. Symposium No. 57) 285-287 (1974) (Abstract).
'Resonant Scattering of Particles and Second Phase Acceleration in the Solar Corona', *Solar Physics*, 37, 353 (1974).
'Three-Wave Interactions Involving One Whistler', *Australian Journal of Physics*, 28, 101-113 (1975) (RPP 1779).
'A Scattering Hypothesis for Type V Solar Radio Bursts', *Proceedings of the Astronomical Society of Australia*, 2, 261-263 (1974).
'Plasma Emission due to Isotropic Fast Electrons, and Types I, II, and V Solar Radio Bursts', *Solar Physics*, 43, 211-236 (1975).
'Small-Scale Inhomogeneities in the Solar Corona: Evidence from Meter-λ Radio Bursts', *Solar Physics*, 43, 79-86 (1975).

THE AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF THEORETICAL PHYSICS ANALYSIS OF STUDENT PERFORMANCE

			Number Enrolled		Number Sitting					
1	2	3	4	5	6	7	8	9	10	11
Unit	Enrolled	Sitting	Wastage	Failure	Sitting	High Distinction	Distinction	Credit	Pass	Fail
B01	6	3	3	0	3	1	2	0	0	0
C01	10	5	5	1	5	2	1	0	1	1
C02	3	3	0	0	3	2	1	0	0	0
C03	1	1	0	0	1	0	1	0	0	0
C04	1	0	1	0	0	0	0	0	0	0
C05	1	1	0	0	1	1	0	0	0	0

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

	Enrolled	Sitting	Result
Final Honours	1	1	H1