THE AUSTRALIAN NATIONAL UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF THEORETICAL PHYSICS

ANNUAL REPORT 1972

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.

Enrolments unfortunately appear to be lagging. This may well be a reflection not only of the employment position as it exists at present but also the curious anti-scientific attitudes which have appeared on a world-wide scale in recent years. At any rate, in an effort to alleviate the situation two additional semester courses, one at second and one at third year level have been designed, to be given for the first time in 1973.

UNIVERSITY MEDAL

This year a student of the department was awarded a University Medal.

PROMOTION

Dr. D.B. Melrose was promoted to the grade of Reader in July.

ENROLMENTS AND EXAMINATION RESULTS

See Appendix.

WORK OF GRADUATE STUDENTS

W.N. Sy continued his work on problems involving non-linear interactions in a magnetoactive plasma and their astrophysical applications. Two papers, prepared jointly with Dr. Melrose, have

been published. Mr. Sy is preparing his thesis for submission in February 1973.

EXTERNAL SUPPORT

(a) Dr. P.J. Sands was supported throughout the year by a grant from the Australian Research Grants Committee.

(b) As a token of their interest Texas Instruments Incorporated honoured the considerable page charges incurred in the publication of long papers in the Journal of the Optical Society of America, although this is contrary to normal company policy.

STAFF

Professor:	H.A. Buchdahl, D.Sc. (Lond.), F.A.A.
Reader:	D.B. Melrose, B.Sc. (Tas.), D.Phil. (Oxon.)
Lecturer:	M. Andrews, B.Sc., M.Sc., (Qld.), Ph.D. (Birm.)
Postdoctoral Fellow:	P.J. Sands, B.Sc., Ph.D. (ANU)

OTHER ACTIVITIES

During the year Dr. Melrose gave a lecture at the May meeting of the Australian Astronomical Society, and a lecture at Adelaide University.

RESEARCH

M. Andrews

Investigations were carried out into the dynamic polarizability of systems of bound and unbound charged particles.

Numerical estimates were made of the polarizability of argon atoms in excited states and in ionized states [with P. Meier, Ph.D. student in Physics].

H.A. Buchdahl

It has been shown that, contrary to what has appeared in the literature, the scalar curvature of unitary spaces is always real. A paper has been accepted for publication in TENSOR.

It has been shown that, given any solution of the Brans-Dicke equation generated by a trace-free source, one can write down by inspection an adjoint solution generated by a source which differs from the original source only by a scalar factor. A paper has been accepted for publication in the International Journal of Theoretical Physics.

Within the framework of the Brans-Dicke theory two integrals over certain linear combinations of the diagonal components of the stress-energy tensor have been found which give exactly the values of those two constants which characterize the source, and which alone enter into the metric at points sufficiently remote from it. A concomitant result is that the field equations do not admit any everywhere regular, static, asymptotically flat vacuum solution. A paper has been accepted for publication in General Relativity and Gravitation.

The exact analogue in the Brans-Dicke theory has been found of the Reissner-Nordström solution of Einstein's equations. It turns out that ten different types of solution must be considered. A paper has been accepted for publication in Nuovo Cimento.

The Lagrangian aberration theory of optical systems without symmetry was investigated at length. An extensive paper laying the foundations of the theory was published by the Journal of the Optical Society of America.

The definition of the absolute temperature in classical thermodynamics was examined anew with pedagogic intent. By replacing the Zeroth Law by an accessibility statement which goes hand in hand with an appropriate formulation of the Second Law it becomes possible to define the absolute temperature function without ever previously talking about temperature at all. At the same time one can also talk about the metrical entropy function without prior introduction of energy, heat, or temperature. A paper on this work has been accepted for publication in the American Journal of Physics.

The problem of determining the rays in an axially symmetric medium with continuously varying refractive index was considered with the intent of systematically determining simple solutions. To make the problem well defined a strict definition of "simplicity" was

adopted. A paper on this work was accepted for publication in the Journal of the Optical Society of America.

The propagation of parabasal rays through the refracting surfaces of optical systems without symmetries is formally a sequence of symplectic transformations. A general symplectic formalism was developed, appropriate to the aberration theory of such systems. An extensive paper has been accepted for publication in OPTIK.

The question of the existence or otherwise of static solutions of the general relativistic field equations arising from quadratic Lagrangians was investigated, and a paper submitted to the Proceedings of the Cambridge Philosophical Society.

After providing a local definition of functional derivatives, the manifestly covariant form of the functional derivative of invariants of the curvature tensor of unitary spaces was investigated. A manuscript has been submitted to TENSOR.

D.B. Melrose

The properties of various suggested mechanisms for radio emission from the solar corona have been investigated. One paper with W.N. Sy [Ph.D. student] on the "plasma emission" mechanism has been published in the Australian Journal of Physics. Another paper on gyromagnetic emission has been accepted for publication in the same journal.

Work in the fields of quantum electrodynamics and quantum optics was initiated during the year. An extensive set of lecture notes was prepared for a course given at Honours Year level but attended by several interested members of the Engineering Physics Department. Copies of the lecture notes have been distributed within and without the University. Two papers on topics investigated in connection with the preparation of the lecture notes have been accepted for publication.

Three models for sources of synchrotron radiation were developed in an attempt to explain observations concerning the polarization in sources where synchrotron self-absorption occurs. The details of the models have been calculated numerically in co-operation with the

CSIRO Division of Radiophysics. One paper on this topic has been accepted for publication.

Preparation of a text book on plasma astrophysics continues slowly.

P.J. Sands

Considerable time was spent in the preparation of a computer programme for the analysis of compound insect eyes. The first stage of this work is completed, namely the production of a programme to trace rays through the omatidia of the eyes. Further work is now under way towards combining the images produced by individual omatidia. Preliminary analyses of several clear-zone eyes have been made and a comprehensive analysis of the fly eye is being performed in conjunction with Alan Snyder (Applied Mathematics, RSPhysS).

Papers presenting the first, second and third order theory of plane symmetric optical systems were extensively rewritten and combined; the work was published in the Journal of the Optical Society of America. Two companion papers, one on the third order aberrations of double-plane symmetric systems, the other on the third-order aberrations of thin double-plane symmetric lenses, have been accepted for publication in the Journal of the Optical Society of America.

The determination of the surface of best focus of a symmetric optical system from a knowledge of its aberration coefficients was investigated. A paper reporting this work has been accepted by the Journal of the Optical Society of America. An improvement to the usual paraxial method of predicting the effects of vignetting on the transmitted irradiance was devised and will also be published by the Journal of the Optical Society of America.

A short paper on the paraxial properties of zoom systems was published in the Journal of the Optical Society of America.

PUBLICATIONS

Buchdahl, H.A. — American Journal of Physics, 39 (1971), 158-162.
"Conformal flatness of the Schwarzschild interior solution".

Buchdahl, H.A. — General Relativity and Gravitation, 3 (1972), 35-41.
"Characteristic functions of Robertson-Walker spaces".

Buchdahl, H.A. — Optik, 35 (1972), 459-467.
"Hamiltonian Optics. III. On systems with discrete axial symmetry".

Buchdahl, H.A. — International Journal of Theoretical Physics, 6 (1972).
"Static solutions of the Brans-Dicke equations".

Buchdahl, H.A. — Journal of the Optical Society of America, 62 (1972), 1314-1324.
"Systems without symmetries: Foundations of a theory of Lagrangian aberration coefficients".

Buchdahl, H.A. — Nuovo Cimento, (1972).
"The analogue of the Reissner-Nordström solution in the Brans-Dicke theory".

Buchdahl, H.A. and Sands, P.J. — Optik, 35 (1972), 162-167.
"Reversible semi-symmetric systems in light and particle optics".

Melrose, D.B. — Nuovo Cimento, 7A (1971), 669-686.
"A classical counterpart to double Compton scattering".

Melrose, D.B. — Plasma Physics, 14 (1972), 1035-
"Symmetry properties of nonlinear responses in a plasma".

Melrose, D.B. and Sy, W.N. — Australian Journal of Physics, 25 (1972), 387-402.
"Plasma emission processes in a magnetoactive plasma".

Melrose, D.B. and Sy, W.N. — Astrophysics and Space Science, 17 (1972).
"Scattering of waves in a magnetoactive plasma".

Melrose, D.B. — Astrophysics and Space Science, 17 (1972).
"A Razin-Tsytovich effect for bremsstrahlung".

Sands, P.J. — Optik, 35 (1972), 151-161.
"Refraction of particles at discontinuities of electromagnetic potentials".

Sands, P.J. — Optik, 36 (1972), 196-201.
"Investigation of a correction term to the geometrical transfer function".

Sands, P.J. — Journal of the Optical Society of America, 62 (1972), 1009-1010.
"Many conjugate zoom systems".

Sands, P.J. — Journal of the Optical Society of America, 62 (1972), 1211-1220.
"Aberration coefficients of plane symmetric systems".

THE AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF THEORETICAL PHYSICS ANALYSIS OF STUDENT PERFORMANCE

		Percentage of Number Enrolled			Percentage of Number Sitting						
1	2	3	4	5	6	7	8	9	10	11	12
Subject or unit	Enrolled as at 30.4.72	Sitting	Wastage (i.e. 2 - 3)	Failure	Sitting	High Distinction	Distinction	Credit	Pass with Merit	Pass	Fail
CO1	6	6	0	0	6	2	0	1	-	1	3
CO2	5	5	0	1	5	0	2	1	-	1	1
CO3	5	5	0	0	5	1	2	0	-	2	0

	Enrolled (as at 30 April 1972)	Sitting	Results	(headings above do not apply)
Final Honours	1	1	H1	
Ph.D.	1	-	-	