THE AUSTRALIAN NATIONAL UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF THEORETICAL PHYSICS

ANNUAL REPORT 1969

Academic Staff:

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

Senior
Lecturer: *D.B. Melrose, B.Sc.(Tas.), D.Phil.(Oxon.)

Lecturer: M. Andrews, B.Sc., M.Sc.(Q'land), Ph.D.(Birm.)

Temporary   **N.N. Trofimenkoff, B.Eng.(Sask.), M.Sc.(Sask.),
Lecturer: Ph.D.(A.N.U.)

*   From 1st July

**   To 9th July

Introduction:

     Training at both undergraduate and postgraduate level is provided for students intending to become theoretical physicists. The undergraduate course also provides a background in theoretical physics for other students.

     This year students of the department carried off two of the three University Prizes awarded, as well as a half share in the Tillyard Prize.

     Research has been carried out in the fields of tensor calculus, scattering theory, general relativity, geometrical optics, plasma physics.

Teaching:

     Student enrolments and examinations are set out in the attached table.

Research:

M. Andrews

     Work on a representation of partial waves for super-positions of Yukawa potentials together with a Coulomb potential has been prepared for publication.

     Formal investigations into scattering processes were continued, making use of representations based mainly on the formulation of the analytic properties of scattering amplitudes as a Riemann-Hilbert problem. (With M. Ilic [Ph.D. student])

     Methods were investigated for carrying out with the aid of a computer complicated algebraic manipulations in the context of geometrical optical aberration theory.

H.A. Buchdahl

The notion of the "harmonic radius vector" introduced by Fock was submitted to a critical examination. A manuscript has been accepted for publication in the American Journal of Physics.

Considerable simplification was achieved in the generic scheme for the computation of optical aberrations of high order by the introduction of redundant coefficients. A paper has been published in the Journal of the Optical Society of America.

A manuscript on invariants of the Riemann tensor which have the property that their functional derivatives vanish identically was revised, and has been accepted for publication in the Proceedings of the Cambridge Philosophical Society.

The problem of so-called reciprocal metrics satisfying field equations generated by non-linear Lagrangians was examined. A paper has been accepted for publication in Tensor N.S.

A problem of obtaining the explicit point characteristic of a plane refracting surface was considered in great detail. A manuscript has been submitted to the Journal of the Optical Society of America.

The point characteristics of a number of static spherically symmetric space times were obtained in explicit form. A manuscript has been submitted to Optica Acta.

A great deal of time was occupied in proof-reading a 350-page monograph on Hamiltonian optics. This is being published by the Cambridge University Press and is scheduled to appear in February 1970.

Miscellaneous work which should lead to a number of papers in the future, included (i) the relationship between the second and zeroth laws of thermodynamics, and the question of the definition of absolute temperature; (ii) the dependence of the gravitational redshift of a Wyman-Volkoff sphere on the strength of the central singularity (with T. Weir [Honours student]); (iii) an alternative method of iteration in optical aberration theory.

D.B. Melrose

Various problems relating to the interaction of relativistic particles with waves in plasmas were considered with astrophysical applications in view. In particular, manuscripts have been accepted for publication on the topics of the formation of the energy spectra of ultrarelativistic electrons in sources of synchrotron radiation, and on the isotropization of such electrons by particle-wave interactions. A manuscript (co-authored by D.G. Wentzel of the University of Maryland) has been submitted for publication on the topic of the coupling between cosmic-ray electrons and cosmic-ray protons via their interaction with the same waves.

The initial chapters of a text on particle-wave interactions in astrophysical plasmas were prepared. A preliminary form of the subject material for this text was published as a Technical Report by the University of Maryland.

M.Sc. Thesis Approved:

H.M. Raval - "Non-Linear Lagrangians in General Relativity".

This thesis was presented towards the end of the year and the examiners reported on it in favourable terms. Mr. Raval has since returned to India.

Publications:

Andrews, M. - Nuovo Cimento, $\underset{\sim}{63}$A (1969), 129-134.
"A representation of partial waves for superpositions of Yukawa potentials together with a Coulomb potential"

Buchdahl, H.A. - Journal of the Optical Society of America, $\underset{\sim}{59}$ (1969), 1422-26.
"Optical Aberration Coefficients. XIV. Simplified computational form of iteration equations"

Buchdahl, H.A. - Proceedings of the Cambridge Philosophical Society, $\underset{\sim}{66}$ (1969).
"ϵ- and γ-formalisms in the calculus of four-spinors"

Melrose, D.B.[†] - Astrophysics and Space Science, $\underset{\sim}{4}$ (1969), 143-164.
"Resonant interaction of hydromagnetic waves with charged particles"

Melrose, D.B.[†] - Astrophysics and Space Science, $\underset{\sim}{4}$ (1969), 165-181.
"Acceleration of ultrarelativistic electrons in the Crab Nebula"

Melrose, D.B.[†] - Technical Report #984, University of Maryland (1969).
"Plasma astrophysics"

Melrose, D.B.[†] - Astrophysics and Space Science (1969).
"On the formation of energy spectra in synchrotron sources"

Trofimenkoff, N.N.[††] - Annals of Physics, $\underset{\sim}{55}$ (1969), 146-165.
"$J^P = \frac{1}{2}^{\pm}$ baryon resonances and non-leptonic hyperon decays"

[†]   Based on work done while a member of the Astronomy Program in the University of Maryland.

[††] Based on work done while a member of the Department of Theoretical Physics, Research School of Physical Sciences, A.N.U.

THE AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF THEORETICAL PHYSICS ANALYSIS OF STUDENT PERFORMANCE

1 Subject or unit	2 Enrolled	3 Wastage	4 Wastage plus failure	5 Sitting	6 High Distinction	7 Distinction	8 Credit	9 Pass with Merit	10 Pass	11 Fail
Theor. Phys. 31	4	1	1	3	---	1	1	---	1	---
Theor. Phys. 32	3	---	---	3	1	---	---	---	2	---
Theor. Phys. 33	2	---	---	2	1	---	---	---	1	---

	Enrolled	Sitting	Results (headings above do not apply)
Final Honours	2	2	2 H1
Masters Qualifying	---	---	---
Masters Degree	1	1	1
Ph.D.	1	1	