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THE AUSTRALIAN NATIONAL UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF THEORETICAL PHYSICS

ANNUAL REPORT 1979

GENERAL 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 most significant changes this year were in the staffing of the department. Dr Melrose left for his chair in Sydney in January and Professor Buchdahl left for a year of outside studies in February. Dr Davies was seconded from the Department of Applied Mathematics for a period of three years, commencing in January. Dr Andrews was Acting Head of the Department for 1979.

It was decided to drop the unit Theoretical Physics BO1 for this year only. It will be interesting to see the effect of this on enrolments in 1980; some students who would have tried BO1 in 1979 but not continued in theoretical physics may try the subject for the first time in CO1 in 1980, adding to the group in that unit who would not have done BO1 even if it had been offered.

It cannot be said that this was an outstanding year for student performance in undergraduate units. Only one High Distinction was awarded. Unfortunately, one very promising part-time student withdrew following increased responsibilities at work. The two minor units, CO5 and CO3, had only one enrolment in each and one of those ended in withdrawal. It appears that none of this year's third-year classes will go on to further study in this department. The two honours students, however, did well and both are seeking support for a higher degree. Both are presently writing up portions of their work for submission for publication in appropriate journals.

This year all the students of the unit Physics CO5 (Optical Physics) enrolled also in Theoretical Physics CO1. This enabled a useful collaboration in the two units, which contain some related material. One honours student and one masters qualifying student from the Physics Department attended, and were assessed in, the quantum mechanics part of Theoretical Physics CO1.

In the second-semester unit, Theoretical Physics CO2, two segments were given by members of the Research School of Physical Sciences - one from the Department of Theoretical Physics and one from Mt. Stromlo. Although we are grateful for their help, such arrangements are not for our benefit only; researchers benefit in acquiring teaching experience and from the stimulation of presenting basic material to interested and intelligent students.

Methods of assessment were in all cases decided by consultation with all the students concerned. With such small members of students, all can take part in discussion of departmental matters affecting courses; no committee mechanism is required.

STAFF

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

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

B. Davies, B.Sc., Ph.D. (N.S.W.)
(on secondment from Department of Applied Mathematics, S.G.S.)

RESEARCH

M. Andrews

The basic principles of classical thermodynamics were reformulated in such a way that the second law refers directly only to transitions between isometric states. This enables a development of the subject which avoids some of the problems of existing treatments and clarifies the status of some other assumptions that are commonly made.

In the light of these developments, simple quantum systems were examined for changes in the expectation value of the Hamiltonian under cyclic variations in external parameters. Despite some success for very simple systems, no general method of attack has been found but work is continuing.

R. Kleeman (Honours Student)

A truncated form of the quantum harmonic oscillator was investigated. Its relation to the normal harmonic oscillator was examined particularly in reference to its infinite-dimensional limit and to the existence of a correspondence principle for this hypothetical quantum system. The main body of research, however, was the application of this oscillator to a quantum field theory. A natural theory was seen to arise and the representations of this theory were extensively studied.

B. Davies

Quantum electrodynamics is a remarkably successful theory which has given accurate explanations of a multitude of phenomena. Despite this, it is beset by theoretical and conceptual difficulties, and in many practical calculations the quantum field concept is avoided in favour of a semi-classical approach. Investigations have been made into the relationship between quantum and semi-classical electrodynamics (some of the work has formed Mr Burkitt's fourth year honours project), and a paper which demonstrates the equivalence of quantum electrodynamics and semi-classical random electrodynamics has been submitted to *Aust. J. Phys.*

Extended models of particles are receiving considerable attention in the current research literature; one of the oldest is Dirac's model of an extended electron. In 1972 a paper was published on the vacuum fluctuation stresses for a spherical model; currently this work is being generalized and a paper will be written in due course.

During 1979 a joint project was completed with Dr Martin of the Applied Mathematics Department on the numerical inversion of Laplace transforms. A paper was published in the Journal of Computational Physics, and is included in the publication list of the Applied Mathematics Department.

PUBLICATIONS

Buchdahl, H.A. "Remark on the equation $\delta R^2/\delta g_{ij} = 0$", *International Journal of Theoretical Physics*, 17 (1978), 149-151.

Buchdahl, H.A. and Warner, N.P. "On the world function of the Schwarzschild field", *General Relativity and Gravitation*, 10 (1979), 911-923.

Buchdahl, H.A. "Nominal source of the Kruskal metric", *General Relativity and Gravitation*, 10 (1979), 941-945.

Buchdahl, H.A. "On a Lagrangian for non-minimally coupled gravitational and electromagnetic fields", *Journal of Physics A*, 12 (1979), 1037-1043.

Buchdahl, H.A. "Representation of the Einstein-Proca field by an A^*_4", *Journal of Physics A*, 12 (1979), 1235-1238.

Buchdahl, H.A. "Quadratic Lagrangians and Palatini's device", *Journal of Physics A*, 12 (1979), 1229-1234.

Buchdahl, H.A. "Regular general relativistic charged fluid spheres", *Acta Physica Polonica*, B10 (1979), 673-685.

Buchdahl, H.A. "Perturbed characteristic functions: Application to the linearized gravitational field", *Australian Journal of Physics*, 32 (1979), 405-410.

Buchdahl, H.A. "From phenomenological thermodynamics to the canonical ensemble", *Foundations of Physics*, 9 (1979), 819-829

Goenner, H.F.M.[+] "Nonlinear Lagrangian and Einstein Spaces", *International Journal of Theoretical Physics*, 18 (1979), No. 12.

Goenner, H.F.M.[+] "On the equivalence of the Palatini and Hilbert methods of variation", *Tensor, N.S.* 33 (1979), No.3.

Hoyng, P.,[*] Melrose, D.B.[†] and Adams, J.C.[*] "Relaxation and Bremsstrahlung of Thick Target Electron Streams", *Astrophysical Journal*, 230 (1979), 950-960.

Hoyng, P.,[*] Stevens, G.A.[*] and Melrose, D.B.[†] "Practical Use of the Legendre-expanded quasar-linear equations for anisotropic particles and Langmuir waves", *Astrophysical Journal*, 230 (1979), 961-966.

Melrose, D.B.[†] "Comments on 'The equation of polarization transfer in an inhomogeneous magnetized plasma; 1: Formalism' by F.T. Cheng and P.C.W. Fung", *Astrophysics and Space Science*, 64 (1979), 45-48.

Melrose, D.B.[†] "Propagation Effects on the Polarization of pulsar radio emission", *Australian Journal of Physics*, 32 (1979), 61-70.

+ Work done while a visitor to the department in 1978
* Not a member of this University
† Former member

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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	Distinc-tion	Credit	Pass	Fail
CO1	8	6	2	1	6	1	0	4	0	1
CO2	6	5	1	0	5	0	2	1	2	0
CO3	1	0	1	0						
CO5	1	1	0	0	1	0	0	0	1	0

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

			Results	
	Enrolled	Sitting	H1	H2A
Theoretical Physics IV	2	2	1	1