THE AUSTRALIAN NATIONAL UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF THEORETICAL PHYSICS

ANNUAL REPORT 1980

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.

This year has been, on the whole, rather depressing for the department. Small enrolments, the paucity of papers actually published in 1980, difficulties over assessment procedures all contributed to this state of affairs; but on the basis of past experience their coming together is probably a statistical fluctuation. Thus, lack of enrolments caused the abandonment of the unit CO5 in the first semester. The assessment procedures in another department gave rise to student performance in the first semester which can only be described as disastrous. (Year after year there is a fiddling around with methods of assessment in response to suggestions, or sometimes demands, by students; but it is not easy to find evidence that this is to their advantage. The contrary may well be the case; and possibly the virtues of continuous assessment are a chimera. Yet as long as the firm exercise of one's considered judgment is taken to be merely a form of illiberality and evidence of inflexibility things may well go from bad to worse.)

In Theoretical Physics CO3 a course on elementary particle theory was given by Dr Hamer of the Research School of Physical Sciences. It was well received by the students and provided the kind of lecturing experience for Dr Hamer which he was seeking.

One well-motivated part-time student who is employed at Russell Hill was forced to be content with a non-degree enrolment since he could not get enough time off to come to all the lectures. Eventually he had to withdraw altogether. It is regrettable, to say the least, that the system is so inflexible that attendance at a mere three lectures per week is precluded.

The brevity of the list of publications is due to such factors as delays in the publication of accepted papers and the fact that one of us (HAB) did not attempt to write any papers whilst on study leave in 1979. (On the other hand, the "lecture notes" which he did then write are now on the verge of acceptance for publication by reputable publishers.)

STAFF

Professor:	H.A. Buchdahl, D. Sc. (Lond.), F.A.A.
Reader:	B. Davies, B.Sc., Ph.D. (N.S.W.) (on secondment from Department of Applied Mathematics, Science)
Senior Lecturer:	M. Andrews, B.Sc., M.Sc. (Qld.), Ph.D. (Birm.)

ENROLMENTS AND EXAMINATION RESULTS

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

RESEARCH

M. Andrews

A paper by A. Peres on "Constants of the Motion" which change sign as the motion proceeds was analysed (together with H.A. Buchdahl) and it was concluded that the work of Peres is substantially trivial. A paper yet remains to be written.

The time evolution of the root mean square deviation from the mean of position and momentum variables was studied in detail, not least to correct certain misleading conclusions to be found in the literature. A manuscript has been submitted to *Journal of Physics A*.

A beginning of a method for calculating directly the point characteristic of optical systems was developed, but more work needs to be done, especially on its practical implications.

H.A. Buchdahl

The nth moment of the energy fluctuations of a thermodynamic assembly of N particles, described by a canonical ensemble, was considered for arbitrary values of n and N, with particular references to asymptotic limits, in which n or N or both go to infinity. A manuscript has been submitted.

The quality of a rational approximation to the first zero ξ_n of the Emden function of order n ($0 \leq n < 5$), suggested previously, was re-examined by finding the behaviour of ξ_n in neighbourhoods of $n = 0$, 1 and 5. A manuscript has been submitted.

Other work is as yet in a state which makes detailed comment inappropriate. It concerns (i) the geometric representation of the charged Einstein-Proca field; (ii) certain questions surrounding the asymmetry of the canonical energy momentum tensor; (iii) the work of A. Peres referred to earlier; (iv) approximative methods for the geometrical optics of gradient-index systems based on the variation of point characteristics; and other topics.

B. Davies

Because of the complexity and theoretical difficulties of quantum field theories, there have been continued proposals to use semi-classical and neo-classical methods in electrodynamic problems. A favourite subject is the explanation of the Lamb shift, and papers offering alternatives to quantum electrodynamics continue to appear. The relationships between these methods, as applied to the Lamb shift, have been thoroughly investigated, and a paper

has been submitted to the *American Journal of Physics*, following an earlier paper with A.N. Burkitt, which was accepted by *Australian Journal of Physics*.

Non-linear equations are at present the subject of intense research activity, and two of the equations which are exactly soluble are of direct interest in quantum field theory. Early attempts by two research groups, one in USSR and the other in USA, to extend the classical methods to quantum fields had some obvious success, but investigations showed that they were internally inconsistent. A paper to this effect was accepted by the *Journal of Physics A*. Further work has shown how one of the two equations may be second quantized in a mathematically consistent way, and a second paper has been submitted to *Journal of Physics A*. Also, a paper on the classical (non-quantized) equation with periodic boundary conditions has been submitted to *Physics Letters A*. Further work is in progress on a number of problems in this important area of theoretical physics.

PUBLICATIONS

Buchdahl, H.A. Scale covariant Lagrangians and spaces reciprocal to static Einstein spaces. *Jour. Australian Math. Soc. B* 21 (1980), 338-344.

Warner, N.P. and Buchdahl, H.A. On the world function of the Gödel metric (with N.P. Warner). *Jour. Phys. A.* 13 (1980), 509-516.

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	Distinc-tion	Credit	Pass	Fail
BO1	5	2	3	1	2	1	0	0	0	1
CO1	16	14	2	3	14	2	1	3	5	3
CO2	6	6	0	0	6	2	0	4	0	0
CO3	6	5	1	1	6	2	1	0	1	1

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