1. General Comments

This department is concerned with the teaching of physics to undergraduate students and also with research in physics which is intimately associated with the teaching of graduate students.

During the year there have been no changes in the research topics studied which are Aerophysics, Solid State Physics, Laser Physics and the Structure of Atomic Nuclei.

2. Courses

Courses presented this year were the same as those for 1970, apart from minor syllabus changes.

We have tried, and are continuing to try, to discourage first year students, who do not fully intend to continue with physics, from taking Physics A01 and instead to take Physics A02. The latter is a complete rounded one year course in physics, whereas the A01 unit introduces fewer topics but in greater detail and depth, with a view to completion of these and other topics in later years. Since a credit or better in A02 allows students to continue in physics, those taking A02 are not completely debarred from continuing.

3. Enrolments and Examination Results

The number of students taking first year physics (A01 and A02) increased by 20 to 160 in 1971. The percentage of first year students who passed was very similar to that for 1970.

The negative wastage of A02 students shown in the table indicates the number transferring from A01 to A02. The total net first year wastage was 18 out of 160, or 11%.

Four non-degree students took the B03 Electronics course in the second semester; these student numbers do not appear in the table.
4. **Student Participation**

Two meetings of the Staff-Student Liaison Committee were held during the year. The students were represented by one elected member from each unit and several staff members were present. There were useful discussions and general agreement to continue with the method of assignment introduced in 1970.

5. **Work of Graduate Students**

The graduate students in this department are all completely involved in the research described below. In their work they usually work closely with their supervisor for the initial part of their course. For the latter parts they become progressively more independent.

6. **Staff**

**Professor and Head of Department**

S. Hinds, B.Sc., Ph.D. (Liv.)

**Professor**

D.W.F. Dunbar, M.Sc. (N.Z.), Ph.D. (Melb.)

**Readers**

A.J. Mortlock, M.Sc. (Syd.), Ph.D. (R'dg), FAIP.
R.J. Stalker, B.Sc., M.Eng.Sc., Ph.D. (Syd.)

**Senior Lecturers**

L.O. Brown, M.Sc. (N.Z.), Ph.D. (Edin.)
C.E. Dahlstrom, M.A. (Sask.), Ph.D. (McG.)
R.J. Sandeman, B.Sc. (Adel.), M.Sc. (Melb.), Ph.D. (Cantab.)
M.M. Gore, B.Sc., Ph.D. (Leeds)

**Lecturers**

R.J. MacDonald, B.Sc., Ph.D. (NSW)
A.M. Baxter, M.Sc., Ph.D. (Melb.)

**Senior Demonstrators**

J.P. Rayner, M.Sc.
B.C. Harding, B.Sc. (Brist.), B.A. (Oxon), M.Sc.
W.E. Tiller, M.Sc. (Clemson, S. Carolina)

**Research Assistant**

S.M. Furler, B.Sc.

**Head Technician**

C.G.B. Wilmot
7. Visitors

Professor R.F. Meyer of the School of Engineering, University of Auckland, visited the department for about 10 weeks in the period November 1970 to February 1971. He worked with the Aerophysics group.

Professor J. Hart of Lakehead University, Ontario spent 4 months from April to August 1971 in the department. His main interest, the teaching of elementary physics courses, provoked much useful discussion.

8. Staff Movement

Dr Gore returned from study leave early in the year which had been spent mainly working and studying at Philips, Eindhoven.

In December Dr Sandeman left for the Harvard College Observatory, Massachusetts.

9. Research


a) Shock Tube and Optical Studies

Performance tests in the new shock tube employing the free piston double diaphragm technique (Stalker and Plumb 1969) have confirmed the viability of this method of producing shock speeds in excess of 16 km sec^{-1}. Electron density measurements using the channelled spectrum technique (Sandeman 1971) have confirmed the equilibrium calculations for the measured shock speeds.

Quantum mechanical calculations of the polarizability of the excited states of argon and helium have been completed and, by converting these to refractivities, of shock heated argon and helium; shock wave parameters have been deduced under which the excited state populations will be important. An experimental programme is now beginning in which channelled spectra will be used to determine refractivities for comparison with theory. This is coupled with a time resolved spectroscopic study of the emission of the gas.

The "hook method" (Marlow 1967) of anomalous dispersion has been applied to the stagnation streamline of a circular cylinder in a CO₂ hypersonic flow (shock tunnel T3). The impurity concentration of iron and chromium have been measured and there are indications that the chromium ground and excited state populations are following the nonequilibrium behaviour of the CO₂ atoms through the bow shock. The method looks promising as a diagnostic technique in shock tunnel and shock tube flows.
The calculations of the influence of the bow shock on a hemispherical probe, designed to measure a magnetic field in a supersonic plasma flow, is complete. The calculations showed a pronounced reduction in the magnetic field on the probe axis which increased with magnetic Reynolds number. The effect has been qualitatively and partially quantitatively confirmed in an experiment in the free piston double diaphragm shock tube flow.

REFERENCES


b) Shock Tunnel Studies

Calibration and testing in the free piston shock tunnel T3 has shown that a useful test flow exists at stagnation enthalpy levels at least as high as those in flight at 60 km²/sec². Tests on a model of a re-entry glider supplied by Messerschmitt-Bölkow-Blohm indicated that boundary layer transition was taking place on the lifting surface of the model at a Reynolds number of 6x10⁵, and stagnation enthalpy of 24 km²/sec². Also, the pressure distribution on the lifting surface could be predicted by simple Newtonian theory, although the bow shock wave was detached.

A study of a hypersonic laminar boundary layer flow of Argon, at stagnation enthalpies of 30 km²/sec², indicated experimental heat transfer levels which were roughly one third of those predicted theoretically. This effect has been tentatively ascribed to the influence of ionization on the viscosity of Argon.

c) Non Equilibrium Reacting Flows

Numerical solutions and experimental results on nonequilibrium dissociating nitrogen flow over a circular cylinder have shown that the density field on the front part of the cylinder may be correlated by a reaction rate parameter which measures the dissociation rate after a normal shock scaled by cylinder radius and flow speed. This correlation enables model flows with free stream
non-equilibrium to be interpreted in terms of flows with an undissociated equilibrium free stream. This is complicated for small body sizes by the induction time phenomenon which is evident in the experimental results.

The salient features of nonequilibrium nitrogen flow over a wedge have been observed by optical interferometry in the free piston shock tunnel. Theoretical and experimental shock curvatures at the wedge tip agree at the lower enthalpies (~ 5 km/sec), but discrepancies due to a number of causes arise at higher enthalpies (up to 8 km/sec). Not all of these causes are understood at this stage.

d) Laminar Boundary Layer Separation at High Stagnation Enthalpies

Experimental observations have been made of the separated region induced by a compression corner on a flat plate in the T3 shock tunnel for seven different stagnation enthalpies spanning the re-entry flight region between 2.5 and 8.5 km/sec. The results show that the plateau pressure coefficient is well represented by the correlation obtained under adiabatic conditions in conventional supersonic tunnels. The length of the separated region, however, is found to be strongly dependent upon the density and temperature within the region. Generally, the density is relatively higher at high enthalpy leading to a reduction in the separated length. Attention has also been paid to the time development of the region.

9.2. Laser Physics (L.O. Brown, C.E. Dahlstrom, D.R.L. Davies and Lynda E. Merrill)

The pulsed Argon Ion Laser has been used to observe at least two Iodine absorption lives at the 5145A° Laser wavelength, and the Iodine transitions have been tentatively identified. However, efforts to observe the hyperfine structure of these transitions, using saturated absorption techniques, have not yet been successful. This is believed to be due to the difficulty in detecting the saturated absorption signals during the very small duty cycle of the pulsed laser. To overcome this difficulty a continuous, D.C. Argon Ion Laser has now been built. This uses the same optical system as the pulsed laser but the plasma tube is considerably more complicated since the large discharge currents (5010 amp.) require a specially designed cathode, quartz construction and water cooling. To date, this laser has operated at 4880A°, but not at the required wavelength 5145A°.
9.3. **Solid State Physics - Atomic Collisions in Solids**

(E. Zwangobani).

Work has been completed on the study of sputtered atom ejection patterns of elemental and compound semiconductors bombarded with medium energy rare gas ions. These studies were extended to determining the transition temperatures of the targets, and the dependence of these temperatures on the parameters of the bombardments such as dose rates. Comprehensive reports of this work appear in articles published by the group.

Equipment has been assembled for studying relative sputtering yields of III and V elements from the bombardment of III-V compounds using a modulated mass spectrometric technique, and work on these measurements is commencing.

An atomic collisions laboratory and research group with post graduate students is being established at the Royal Military College by Mr Dennis, an ex-member of the group, who is now writing his thesis, and it is anticipated that our group will continue to collaborate with the R.M.C. group in this field.

9.4. **Solid State Physics - Diffusion in Solids**


Diffusion in Ceramics: Studies of cation self and impurity diffusion in the simple metal oxides MgO and CaO were continued. The influence of size, valence and concentration in controlling these diffusion rates was measured and the results obtained examined in relation to current theories. The measurements in MgO showed the presence of intrinsic diffusion in some cases; this is particularly interesting because the relatively low purity of the
available crystals has in the past caused only extrinsic diffusion to be observed. In other words the observed diffusion rates in the past have been controlled by background impurities: the present results, therefore, are characteristic of the pure crystalline structure.

Measurements of impurity diffusion in crystalline quartz and quartz glass were also continued. The idea here is to throw light on the operative mechanism of diffusion. Some difficulty has been encountered because of the small diffusion rates operating.

Near-Surface Diffusion in Metals: Studies of diffusion in the region within about one micron of the free surface have been made in the case of the noble metals. Micro sectioning techniques capable of removing layers about 100A thick are necessary in these experiments. The work for copper is now completed and shows that lattice diffusion may be measured in this region even though short-circuiting diffusion due to the presence of dislocations is present. This result opens the door to measuring lattice diffusion over wider temperature ranges than thought possible previously, a result which has implications for basic revelations concerning the details of the kinetics of diffusion processes.


Work has continued on the investigation of some apparent contradictions in the properties of the energy levels of $^{22}\text{Na}$. This work has been carried out in collaboration with several staff members of the Nuclear Physics Department of the Institute of Advanced Studies.

The study of the energy levels of $^{29}\text{Si}$ is continuing and a DWBA analysis of the data from the $^{29}\text{Si}(d,p)^{30}\text{Si}$ reaction is in progress.

A prototype of a $\beta$-spectrometer using a Si(Li) detector and magnet has been constructed.

This instrument is now being tested and calibrated using radioactive sources and will be tested soon on the EN tandem accelerator as an in-beam spectrometer using $(p,n)$ reactions. It is intended mainly for use on the heavy ion 14UD accelerator which is now under construction.
10. Other Activities

An investigation has been initiated into the use of cassette tape recordings in connection with laboratory teaching. This is a continuation of earlier work carried out by Dr M.M. Gore in collaboration with Dr N.J. Daly (F) in 1969. While on sabbatical leave in 1970, Dr Gore visited several universities and technological institutions in both Europe and the United States and had an opportunity to see some of the recent developments in tertiary teaching. The advent of the battery-operated portable cassette tape recorders has made their use much more flexible for teaching applications. The aim of the project, which it is intended to carry out in 1972, is to employ cassette recordings to instruct students in the purpose and use of scientific instruments in the laboratories. Such narrative but nevertheless essential instruction should thus permit the teaching staff to devote more time to other aspects of laboratory teaching.

F Member of the Department of Chemistry, S.G.S.
11. Publications

Darcey, W.‡, Chapman, R.‡ and Hinds, S. "A Study of the States of $^{66}\text{Ni}$, $^{64}\text{Ni}$, $^{68}\text{Ni}$ and $^{66}\text{Ni}$ using the (t,p) Reaction". Nuclear Physics A170, 253-272 (1971).


Hart, J.‡ "Polarization in Pulp". The Australian Physicist 8, 12, (1971).


‡ Not a member of this University.
* Former member. Based on work done while a member of the Department.
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