

## PROBLEMS OF COLLECTIVE MOTION IN PHYSICS

A CONFERENCE on various aspects of collective behaviour in physics, sponsored by the Physical Society, was held in the Department of Physics in the University of Birmingham during January 2-3; the visitors were received by the vice-chancellor, Dr. R. S. Aitken. It was hoped that the main talks would be suitable as an introduction to the subject for theoretical physicists not familiar with the theory of collective motion and also for experimental physicists. It must be said, however, that apart from the talks on the electron theory of metals and on liquid helium, the talks were clearly addressed to physicists actively working on the subject under discussion: this was even more the case with the discussions.

The first session was devoted to gaseous plasmas. W. B. Thompson (Atomic Energy Research Establishment, Harwell) described a method for deriving the hydromagnetic equations by taking suitably chosen moments of the Boltzmann equation in cases in which collisions may be neglected. This procedure is the counterpart to the Hilbert-Chapman-Enskog method of deriving the equations of ordinary hydrodynamics. S. F. Edwards (Manchester) discussed methods of describing the dynamics of a plasma in thermal equilibrium, including a derivation of the Debye-Hückel screened potential, of the equation of state, and of the plasma oscillation frequency. He also discussed briefly a variational method for deriving the electrical conductivity of a plasma. In the discussion following these two papers it was pointed out that although the equations used by Thompson will break down, thus indicating the possible occurrence of shock-waves, they cannot be used to describe such shock waves as they are essentially an adiabatic approximation. R. Balescu (Brussels) reported briefly on work in Prigogine's group on obtaining by iteration methods asymptotic solutions of the Liouville equation valid for long times and large distances.

The second session dealt with plasma problems in the electron theory of metals. S. Raimès (Imperial College of Science and Technology, London) gave a lucid account of the Bohm-Pines theory of plasma oscillations in metals and of their introduction of a cut-off wave-number  $k_c$  above which no collective degrees of freedom will occur. He discussed the shortcomings of Pines's original variational method for determining  $k_c$ . Dr. Raimès then showed how this theory can account for the observed density of states curve for such metals as sodium, pointing out the importance, shown by Fletcher and Larson, of second-order effects. In the discussion, Prof. H. Fröhlich (Liverpool) pointed out that  $k_c$  should be determined by using a trial wave function in conjunction with the correct Hamiltonian, and not with an approximate Hamiltonian as was done by Pines. S. F. Edwards (Manchester) and R. Leigh (Atomic Energy Research Establishment, Harwell) reported on work in progress along those lines. Edwards is using wave-functions including two-body correlations, whereas Leigh uses wave-functions of the de Shalit-Weisskopf type. In this connexion Fröhlich suggested the consideration of a one-dimensional plasma for investigating the accuracy of the results obtained.

D. Bohm (Bristol) discussed the difficulties connected with degrees of freedom with wave-numbers of the order of magnitude of the Debye wave-number. In that connexion, C. G. Kuper (St. Andrews) reported work on a charged boson gas, where a Bogoliubov-type transformation can be used leading to a smooth transition from particle to collective degrees of freedom.

The third session covered liquid helium and superconductivity. The talk by G. V. Chester (Birmingham) was probably for most people one of the most interesting aspects of the conference. In it he discussed the four main kinds of collective motion which occur in liquid helium below 1.6° K. These are the superfluid hydrodynamic potential flow, phonons, rotons and the Onsager-Feynman vortices. Feynman and Cohen's determination of the excitation spectrum was dealt with, and also the experimental work of Hall and Vinen which shows the existence of vortex lines and probably their quantization. In the discussion following this paper, Prof. H. Fröhlich (Liverpool) and Prof. R. E. Peierls (Birmingham) voiced objections to the Feynman-Cohen calculations, while Kuper directed attention to the influence of self-energy corrections. Both O. Penrose (Imperial College of Science and Technology, London) and Kuper asked how far the concept of independent collective excitations was valid. In reply, Chester said that the inelastic neutron scattering data, on helium II, strongly suggest that the concept is valid up to about 1.7° K.

J. G. Valatin (Birmingham) gave an account of the Bardeen-Cooper-Schrieffer theory of superconductivity, mentioning in passing the work of Martin and Schwinger, Gorkov and Galitskii, who are using a Green function approach. He also briefly discussed how the recent theories can account for the electromagnetic properties of superconductors. A lively discussion followed in which Prof. Fröhlich warned against non-gauge invariant theories, because spurious Meissner effects are only too easily obtained. He also pointed out that in the present form of the theory the total momentum fluctuates in the superflow. These fluctuations and those in the number of quasi-particles make it difficult to prove that a superconductor in the present theory has, indeed, zero resistance, as was pointed out by Kuper, who also asked when an energy-gap leads to a superconductor and when to an insulator. Prof. Peierls defined a superconductor as a substance in which a current-carrying state with an energy close to the ground-state level is possible, and in which no transitions are possible from such a state to states with lower current densities, not even through intermediate states, as happens in normal metals. Prof. Peierls also pointed out the difficulty of estimating the errors involved in the present theory and suggested an approach similar to Feynman's approach to liquid helium, since in that case a variational method could be used to estimate the energy gap.

B. Bayman (Copenhagen) discussed the Bohr-Mottelson explanation of the 'energy-gaps' found in nuclei. Empirically, it is found that the first excitations of a single-particle nature—as distinct from a

collective one—in the region of large deformation are much higher in energy than one would predict from the Nilsson model, in which the particles are assumed to move independently in a distorted well. This can be explained by a correlation between pairs of particles of opposite magnetic quantum number, in an unfilled shell. This pairing in angular momentum is similar to the pairing in linear momentum in the Bardeen, Cooper and Schrieffer model. Bayman discussed calculations of Beliaev, who incorporated the pairing simply by making a transformation to a quasi-particle representation. In the region near closed shells, the pairing correlation leads to so-called

vibrational states. Their energy spectrum is essentially that produced by Racah's pairing force, so that many of the results of the seniority scheme can be used. In the discussion J. P. Elliott (Southampton) reported on the status of his generalized shell-model approach, and Prof. Peierls discussed briefly the variational scheme for obtaining rotational levels.

The conference was considered by all present to have been a great success, and I for one hope that another conference on the same subject can be arranged in a few years time to review the progress made in the intervening period. D. TER HAAR

## INDUSTRIAL HEALTH IN BRITAIN

THE annual report of the Chief Inspector of Factories on Industrial Health for the year 1957\* is the first report on industrial health to be published separately and is, to some extent, experimental. Its first chapter, reviewing the year, deals with general questions, including references to new and developing problems and to progress made in solving old problems. The second chapter deals with cases of industrial disease, poisoning and gassing which occurred during the year, and the third chapter deals more extensively with industrial dermatitis. Points which were raised on the statutory draft Compressed Air Special Regulations were all resolved by the end of the year, and the Regulations came into operation on April 21, 1958. The report of the pilot industrial health survey of Halifax was studied in detail by a sub-committee of the Industrial Health Advisory Committee, and afterwards an abridged version of the report was published and arrangements were made for the survey team to approach occupiers of factories in Halifax employing more than 250 workers with the view of interesting them in the advantages of the provision or extension of medical and nursing services.

A committee of inquiry into precautions against anthrax was set up in February 1957, and there was evidence during the year that factory occupiers pay insufficient attention to making adequate provision for first-aid treatment, as required under the Fac-

tories Act. In the light of discussions between representatives of Government departments which have responsibilities for first aid, including representatives of the Medical Research Council, the contents of first-aid boxes in factories, as prescribed by the First Aid in Factories Order, 1938, and the leaflet giving advice on first aid treatment have been reviewed, while measures to stimulate recruitment and training of first-aid personnel were also discussed. The third interim report of the Joint Advisory Committee of the Cotton Industry on "Dust in Card Rooms" has been brought to the notice of all firms concerned, and it has been made clear to occupiers that, since a satisfactory system of removing dust in card rooms is now available, it is expected that early action will be taken. Plans were made for extending the Inspectorate's facilities for collecting and analysing dust by formation of a second dust-counting team.

The chapter on industrial dermatitis summarizes known facts on the cause and particularly the prevention of this disease which have already been made known in departmental and other publications. Predisposing factors are also indicated, and stress is laid on the importance of taking appropriate measures before and not after trouble has occurred. These include replacement of the harmful agent by one that is non-irritant or less harmful; selection of personnel; reduction of contact to a minimum, or complete elimination of contact; regular and frequent inspection by trained observers; and cleansing of the skin.

\* Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1957. Pp. 50. (Cmd. 553.) (London: H.M. Stationery Office, 1958.) 3s. net.

## INTERNATIONAL STANDARDS FOR DRINKING-WATER

THERE is at present a wide diversity in water treatment and quality in different countries, and the need for some sort of international agreement on what constitutes a safe supply of drinking-water has long been apparent. The question was raised at the Congress of the International Water Supply Association in Amsterdam in 1949 and again in Paris in 1952, but the prospect of accord in the near future seemed remote. In 1953 the matter was taken up by the World Health Organization, and a questionnaire was circulated to member States. The replies served to reiterate the differences in attitude, and in view of the increase in international travel, particularly by air, to emphasize the desirability of agreed standards.

Regional study groups of experts were convened to study the problem in the European, Eastern Mediterranean, and South-east Asia and Western Pacific regions. The reports of these various groups were used as a basis for discussion by a further group meeting in Geneva in 1956 and the standards now proposed were put forward by this body. It is not suggested that these standards represent perfection; on the contrary, as the preface specifically points out, they are tentative and subject to modification after experience of their application. In some cases the standard proposed is not as high as that habitually achieved by some undertakings, but the sources of water supply used for public consumption are so