SOCIETIES AND MEETINGS

THE FIFTH WASHINGTON CONFERENCE ON THEORETICAL PHYSICS

THE theory of low-temperature physics was the focal point of discussion held in Washington from January 26 to 28 under the joint auspices of the George Washington University and the Carnegie Institution of Washington, acting through its Department of Terrestrial Magnetism. The properties of liquid helium and of liquid hydrogen and deuterium, the interpretation of data on the adiabatic demagnetization of paramagnetic salts at temperatures below 1° K and the phenomenon of superconductivity were the subjects discussed. In addition, the theory of certain very recent developments in nuclear disintegration of atoms and the theory of nuclear binding forces were discussed. Professors Niels Bohr, Harold C. Urey, Enrico Fermi, F. London, G. E. Uhlenbeck, J. H. Van Vleck, H. A. Bethe, G. Breit, E. U. Condon, I. I. Rabi, A. E. Ruark, F. Bitter, H. Grayson-Smith, F. Seitz, O. Stern, L. Rosenfeld and many other physicists active in research were present.

Certainly the most exciting and important discussion was that concerning the disintegration of uranium of mass 239 into two particles, each of whose mass is approximately half of the mother atom, with the release of 200,000,000 electron-volts of energy per disintegration. The production of barium by the neutron bombardment of uranium was discovered by Hahn and Strassmann at the Kaiser-Wilhelm Institute in Berlin about two months ago. The interpretation of these chemical experiments as meaning an actual breaking-up of the uranium nucleus into two lighter nuclei of approximately half the mass of uranium was suggested by Frisch of Copenhagen together with Miss Meitner, Professor Hahn's long-time partner, who is now in Stockholm. They also suggested a search for the expected 100,000,000-volt recoiling particles which would result from such a process. Professors Bohr and Rosenfeld had arrived from Copenhagen the week previous with this news, and observation of the expected high-energy particles was independently announced by Copenhagen, Columbia, Johns Hopkins and the Carnegie Institution shortly after the close of the conference. Professors Bohr and Fermi discussed the excitation energy and probability of transition from a normal state of the uranium nucleus to the split state. The two opposing forces, that is, a coulomb-like force tending to split the nucleus and a surface tension-like force tending to hold the "liquid-drop" nucleus together, are nearly equal, and a small excitation of the proper type causes the disintegration.

An interesting connection between nuclear physics and low temperatures, as pointed out by Professor Teller, is the fact that the balance between zero-point energy and potential energy is very similar in the liquid-droplet model of the atomic nucleus and in liquid helium-II. In fact, a similarity-transformation of linear dimensions by $1/10^5$ and energies by 10^{10}, in accordance with experiment, will transform the model of liquid helium-II into something very similar to the liquid-droplet model of the nucleus.

Professor Uhlenbeck introduced the discussion of the differences in the physical properties of the isotopic modification of hydrogen, H_2, HD and D_2 at low temperatures with a consideration of how these differences arise. Classical physics would lead one to expect that the equilibrium properties, that is, properties which do not involve the time explicitly, as for example, vapor-pressures and molecular volumes, should be independent of the molecular weight if the interatomic forces of atoms of H and D are alike. These forces for isotopic atoms are so nearly the same that it has been concluded that the differences in these equilibrium-properties of the isotopes must be the result of quantum-effects. Two essentially different quantum-effects arise. The first arises because the de Broglie wave-length of a gas molecule depends upon its molecular weight and at low temperatures becomes so large compared with the size of the molecule that the diffraction-effects of the de Broglie waves upon collision of gas molecules become important. This has an important bearing upon the equation of state of the gas and the differences between the virial coefficients of H_2 and D_2 may be accounted for upon this basis. The second class of quantum-effects arises because of the large differences between the zero-point lattice-energies. These are responsible for the large differences in the vapor-pressures, molecular volumes, triple points and heat-capacities of H_2, HD and D_2. Calculations based upon simple harmonic oscillators and the simple considerations of Debye's theory of the solid state have been able to account quantitatively for the observed differences in the properties. Professor London gave an account of the theoretical considerations of Mr. Hobbs and himself based upon a similarity of the intermolecular-force fields and high zero-point energies in condensed hydrogen and helium. Thus the hydrogen molecules are in effect contained in small volumes having a large confining force at the boundaries but only small forces in the interior. Calculations of the heats of vaporization of the solids and molecular volumes at 0° K are in agreement with the experimentally derived values. The anomalous character of the heat-capacities of the solid and liquid isotopes were discussed.

The differences in the properties of the ortho and para varieties of H_2 and D_2 were discussed. Dr. Karl Cohen, of Columbia University, outlined a theory developed by Professor H. C. Urey and himself to account for the larger heats of vaporization and smaller molecular volumes of the rotating ($j=1$) varieties of H_2 and D_2. These differences in the properties of the ortho and para varieties arise because of the rotation of the ortho molecule. One important effect is that the centrifugal force resulting from the rotation stretches the inter-atomic distance in the molecule and in effect makes the rotating molecule larger.

Professor F. London, of the Institut Henri Poincaré of the University of Paris, who has been visiting professor at Duke University for some months, recently developed a theory which accounts for many of the phenomena observed in liquid helium at and below the "λ" transition point. As is well known, the phenomenon is such that the liquid helium does not become a solid upon lowering its temperature but, after passing through the λ point (sudden change of specific heat at 2.2 K), it becomes a superfluid having extremely low viscosity, a high heat-conductivity in the region of the λ point and other very strange effects such as the "fountain-effect" and an astounding ability to "creep" up the walls of containers and tubes are observed. London has proposed that this behavior is a condensation of the Bose-Einstein gas into the lowest energy-states. However, the liquid helium is not an ideal Bose-Einstein gas, since the effect of Van-der-Waals forces is to create some spatial order. This will give a decrease in the density of the levels for the lowest states (proportional to say k^4dk instead of k^2dk as for free particles, where k is the wave-number). It can be shown that such a non-ideal Bose-Einstein gas will have a jump in the specific-heat curve at the point where particles begin entering the lowest energy states. Professor London emphasized a possible analogy of the behavior of helium-II to the superconductivity-electrons in metals and to the diamagnetism observed in many types of solids. He also proposed a theory for the viscosity and heat-conduction of helium-II (bearing an analogy with electrons in a metal) which makes use of free particles obeying a Bose statistics. The work of L. Tisza on these phenomena was discussed; Tisza states that not all the atoms enter the lowest energy state and therefore a few of them have a finite momentum and exert a pressure. Only these few give rise to the viscosity which one observes; the heat-conduction arises from the change in pressure of these excited atoms. Professor Fermi and Professor London proposed several experiments which would throw further light on these problems.

Recent considerations bearing on the method of Giauque and Debye for obtaining temperatures below 1° K by the adiabatic demagnetization of a paramagnetic salt and the property of matter at these temperatures were discussed by Professor J. H. Van Vleck, of Harvard University. The well-known method of liquefying a gas such as helium consists in isothermally compressing (thus lowering the entropy of the system) and then expanding adiabatically (thus lowering the temperature while the entropy stays constant); magnetic cooling is quite similar—the magnet is the "entropy squeezer" and the field is released after establishing thermal insulation (pumping out the heat-transfer gas around the paramagnetic salt).

The experiments of Simon, Kurti and coworkers on $NH_4Fe(SO_4)_2 \cdot 12H_2O$ at temperatures below 1° K was discussed by Dr. M. H. Hebb and Dr. C. F. Squire. The absolute temperature scale was established in these experiments *not* by use of Curie's law relating the magnetic susceptibility with the temperature, but through the thermodynamic relationship $T_{abs} = \Delta Q/\Delta S$. The Curie law, which is valid at temperatures of 1° K, is no longer valid at the temperatures obtained by magnetic cooling because just the interaction forces which produce the cooling effect are responsible for the variation from Curie's law. Professor Van Vleck discussed the theory of these interaction forces—the splitting of electron-energy states by the crystalline electric field and the spin-spin interaction of the paramagnetic ions causing further splitting. Partition-functions and specific heats were calculated for several salts, and agreement with experiment indicates that a representation of the local field acting on the spins of the type proposed by Onsager is better than the classical one of Lorentz. Spin-spin interaction could only be partially solved and agreement with experiments remains only qualitative. The theoretical interpretation of the ferromagnetism (hysteresis effects) found in iron-alum by Simon and Kurti at 0.034 K remains quite unclear.

The theory of paramagnetic relaxation-time and the experiments of Professor Gorter and other Dutch physicists were discussed in great detail. Just as one has absorption and dispersion of the electric vector light, so one can have magnetic absorption and dispersion at about radio frequencies. The oscillators are the electron-spins, which are damped by the spin-spin coupling in about 10^{-9}/sec; the damping-time can be enormously increased by applying an external magnetic field. Under these conditions the spin-spin coupling is too weak to "finance a turn over" of the dipoles, but the spin-lattice interaction can turn them over.

The time required for spin-lattice interaction to establish thermal equilibrium has great significance, since it might be the limiting factor in reaching still lower temperatures than have been attained up to now. According to Van Vleck and Kronig, non-adiabatic coupling between lattice vibrations and electronic motion determines this time. Quantitative calculations are still in a preliminary stage. Relaxation-time between nuclear-spin moments and electron-spins or with the lattice are very long and the cooling to extremely low temperatures by this interaction would require at least a day before equilibrium would be established. Professor Teller discussed the calculation for the time-effect. The matrix-element (perturbation-energy) which gives the transition-probability between the nuclear spin and electron-spin is quite small for paramagnetic salts. Perhaps the interaction with electrons in metals would be sufficient to cut down the relaxation-time considerably.

The theory of superconductivity was briefly discussed by Professor F. London. It must be emphasized that the magnetic behavior is as important as the superconduction. The microscopic picture is not yet clear. From the behavior of liquid helium and that of diamagnetism in solids it is probable that superconductivity is a cooperative phenomenon causing very low level-densities for low energies.

C. F. SQUIRE
UNIVERSITY OF PENNSYLVANIA
F. G. BRICKWEDDE
NATIONAL BUREAU OF STANDARDS
E. TELLER
GEORGE WASHINGTON UNIVERSITY
M. A. TUVE
CARNEGIE INSTITUTION OF WASHINGTON

REPORTS

THE BANTING RESEARCH FOUNDATION

THE annual report for 1937–38 of the Banting Research Foundation reveals that its income was, as usual, disbursed in two ways. A substantial part of it was placed at the disposal of Sir Frederick Banting to employ research workers in the Department of Medical Research, University of Toronto, to pursue research work of his election. This is allowing the investigation of twenty-one different problems in the department which Sir Frederick heads. The second, and slightly larger portion of the foundation's income, was widely distributed throughout Canada to twenty-four applicants who submitted problems to the foundation which met with the trustees' approval. These problems are being worked out in various hospitals and university laboratories scattered throughout the country. Analysis of the applications showed that they were granted to provide financial assistance for four different purposes: (1) salaries for full-time work, (2) salaries for part-time work, (3) salaries for helpers or assistants and (4) money for equipment and materials only. Following is a list of these workers whose applications were granted during the past year, the place where the work is being carried out and the general topic with which each problem is concerned.

B. F. Crocker, department of biochemistry, University of Toronto, is making an experimental study of digestion. E. W. McHenry, school of hygiene, University of Toronto, is studying the physiological action of vitamin C. R. W. Begg, department of pathology, Dalhousie University, Halifax, is making an extensive study of the sedimentation of erythrocytes. E. M. Boyd, department of pharmacology, Queen's University, Kingston, is pursuing further studies on the water-balance hormone of the pituitary. Maria Sergeyeva, department of physiology, McGill University, is investigating the nervous and hormone effects on the structure of islet cells. B. Rose, University Medical Clinic, Royal Victoria Hospital, Montreal, is studying the effect of cortin and histaminase on the disappearance of histamine in the adrenalectomized rat. M. J. Miller, University of Saskatchewan, is determining the distribution of human parasites in midwestern Canada. G. L. Bateman, department of physiology, Queen's University, is investigating the occurrence and function of acetylcholine in the placentae of animals. E. A. Ryan, department of biochemistry, University of Toronto, is investigating the physiological significance and chemical structure of a new compound, probably related to the sterols, which is excreted by normal humans. A. D. Odell, department of biochemistry, University of Toronto, is attempting to synthesize the progestational hormone or a possible substitute for it by the chemical degradation of an easily procurable bile acid. C. H. Walton, faculty of medicine, University of Manitoba, is, with Dr. M. Dudley's help, making a thorough pollen survey of Manitoba. K. W. Baldwin, department of anatomy, University of Toronto, is studying with A. W. Ham the fate of alveolar epithelium as the lung passes through various stages of embryonic development. D. W. G. Murray, department of surgery, University of Toronto, is continuing clinical studies regarding the effects of heparin on patients. H. T. Malloy, Royal Victoria Hospital, Montreal, is studying congenital haemolytic jaundice in the rat and man. H. B. Collier, department of biochemistry, University of Toronto, is pursuing researches on the enzymatic synthesis of protein. W. J. Auger, Hospital for Sick Children, Toronto, having devised a superior method for obtaining sputum from children, is studying type I pneumonia. D. L. Selby and R. W. I. Urquhart, both of the department of pathological chemistry, University of Toronto, are continuing their studies of experimental nephrosis, using an ingenious technique which they have recently described. E. E. Kuitunen, school of hygiene, University of Toronto, is making a survey of the distribution and type of intestinal parasites in Toronto children. D. G. MacDonald, school of hygiene, University of Toronto, is studying, in cooperation with Dr. A. A. Fletcher, the action of the B vitamins on intestinal tonus and also the cause of bradycardia, which occurs in B_1 deficiency. B. Schachter, department of biochemistry, University of Toronto, is investigating the nature of a compound in pregnant mare's urine to see if it is an oestrogen derivative. M. M. Hoffman, Dalhousie University, Halifax, is determining the physiological properties of an unidentified ketone in