Papers from Italian workers in Parma and Turin show that these peptides have a higher vasodilator activity per unit weight than any other known biological substance. Hypotension is caused by direct peripheral vasodilatation particularly in the musculo-cutaneous circulation. During hypotension sympathetic reflexes increase heart rate, stroke volume and cardiac output.

Bradykinin is believed to play a physiological part in the vasodilatation which accompanies glandular activity and inflammation. Papers from England and the United States discuss the microcirculatory effects of bradykinin. There are a number of papers on kinin formation in pathological states in man, notably pancreatitis, strangulation of the gut and the carcinoid syndrome. Fairly convincing evidence is presented by Drs. Oates and Melmon from the United States to show that adrenaline acts on carcinoid tumour metastases to liberate the enzyme kallikrein into the blood. This acts on kininogen to liberate lysyl-bradykinin which is converted to bradykinin by aminopeptidase in plasma.

Evidence is slowly accumulating that these peptides have a wide range of important pharmacological actions. Although many of them share the property of causing hypotension by bringing about vasodilatation, the title of this book is misleading concerning both the scope of the papers it contains and the diversity of actions of kinins.

C. T. DOLLERY

IN SEARCH OF GAS EQUATIONS

Kinetic Equations of Gases and Plasmas

By Ta-You Wu. (Addison-Wesley Series in Advanced Physics.) Pp. vi+298. (Reading, Mass., and London: Addison-Wesley Publishing Company, 1966.) 94*s*.

IN recent years numerous attempts have been made to develop a kinetic theory of dense gases and plasmas, by applying the ideas of statistical mechanics to non-equilibrium processes. These attempts have had only limited success, partly because they depend on multibody collisions, partly because electrostatic forces (and other intermolecular forces to a lesser extent) decrease relatively slowly with increasing distance, and partly because the velocities of colliding molecules may not be uncorrelated. The first of these implies that the expressions for the various gas coefficients cannot be evaluated explicitly; the second and third imply that these expressions are frequently given in terms of non-convergent expansions.

Professor Wu's book gives an account of such attempts, largely stemming from the work of Bogoliubov (1946). The book's title is significant; it is not about gases and plasmas as such, but about mathematical methods invoked to construct their kinetic equations. Only at one point (page 154) is a comparison with experiment mentioned. This is only partly a result of difficulties in treating multibody collisions. Often the highest achievement of one of the approaches described appears to be that it supplies some measure of justification for a crude simplifying assumption made earlier on general grounds, or gives results consistent with those obtained by another of the approaches.

I found the book alternately exciting and exasperating; exciting in its discussion of basic problems like irreversibility and difficulties of convergence; exasperating in its preoccupation with equations as such, in its reference away to original papers just when one expected the keystone of an argument, and in occasional assumptions of more knowledge than could be derived from the book alone. (There is also a not inconsiderable number of misprints.) The book can fairly be regarded as an interim report. A final version, one feels, should unify the different approaches and lead to a comparison with experiment.

T. G. COWLING

ABSORBING TOPIC

Mössbauer Effect Methodology

Edited by Irwin J. Gruverman. Vol. 2. (Proceedings of the 2nd Symposium, New York City, Jan. 25, 1966.) Pp. viii+191. (New York: Plenum Press, 1966.) $12.50.

Two meetings were held in New York, in January 1965 and January 1966, under the somewhat unattractive title of Symposium on Mössbauer Effect Methodology. Resulting from each of these, a volume of *Proceedings* has appeared, both of which are of substantial value to practitioners in this field. It is interesting to note that both meetings were sponsored by two commercial organizations, the New England Nuclear Corporation and the Technical Measurement Corporation.

The first volume, the subject of an earlier review, largely restricted its attention to experimental procedures and apparatus, while the second is divided into two sections with different objects.

The first section is the one which most readers will find the more useful. It consists of articles concerning the technique of analysing the raw data of Mössbauer experiments in various chemical and physical applications. For example, the analysis of recoilless fraction measurements in terms of lattice dynamics is discussed, together with the possibility of extracting the parameters of the electric field gradient tensor from Mössbauer resonances split by quadrupole interactions. There are also articles on Mössbauer measurements of non-metallic materials in the paramagnetic state and on the determination of local moments in dilute alloys of iron in diamagnetic host metals.

The second section of the volume concerns applications of the Mössbauer effect to the study of specific and especially interesting materials, such as meteoric iron minerals, haemoglobin and very thin films of iron.

Applications of the Mössbauer effect are now recorded in an extremely wide range of the journals of chemistry and physics, and the appearance of a further collection of authoritative articles between two covers will please many workers who are having difficulty in coping with the Mössbauer literature explosion.

R. E. MEADS

OBITUARIES

J. Robert Oppenheimer

OPPENHEIMER was one of the most influential physicists in the middle of this century. This influence stemmed from his personality and intellectual breadth, which, when added to his very considerable scientific talents, made him a leader of the scientific community. After his very early work, his interest in physics turned increasingly toward fundamental questions of quantum electrodynamics, positron theory, cosmic ray showers, meson theory, and nuclear processes.

Oppenheimer's education was completed after the events of 1925–26 which are associated with the great names of de Broglie, Heisenberg, Pauli, Schrödinger and Dirac, and therefore he cannot be counted among these major contributors to the basic structure of quantum mechanics. Nevertheless, he very soon acquired a complete mastery of these new tools and was among the first to bring this knowledge and skill back to the United States from Cambridge and Göttingen and Zurich where he had worked. This knowledge and skill, combined with a fascinating personality, made it possible for him to establish the very important school of theoretical physics centered in Berkeley. There, and in Pasadena, California, he had close contacts with experimental physicists. The rest of his scientific career is typified by close collaboration in his own work and the work of his students, between theory and experiment—nuclear physics with Charles Lauritsen, cosmic rays with Millikan and Anderson in Pasadena and with the great school which was being built around E. O. Lawrence in Berkeley.

Oppenheimer's first paper, in 1926, dealt with molecular energy levels, his second with transitions to continuum states in hydrogenic atoms. Then at Göttingen he wrote his famous paper with Born on the approximations involved in the theory of molecules. During the next three years he wrote a series of papers mostly depending on his knowledge of the continuum wave functions, which he appears to have been the first to master. He discussed their normalization, and calculated the absorption coefficient of X-rays near the K-edge, the continuous X-ray spectrum, the elastic and inelastic scattering of electrons including exchange effects, and greatly improved the calculation of stellar opacities. He also developed the theory of cold emission, the first example of barrier penetration (antedating the explanation of radioactive α-decay), and, incidentally, invented the perturbation theory of non-orthogonal states. This was done at Pasadena, where Millikan and Lauritsen were studying the phenomena, and was the first evidence of a feature later to be so prominent in his work, that is his close collaboration with his experimental colleagues.

This early work showed power and facility, but after his year with Pauli in 1928–29 his interests changed, and thereafter were devoted to the more fundamental questions of physics. At Zurich he learned of Heisenberg and Pauli's work on quantum electrodynamics, and in late 1929 he published his paper on resonance scattering of light in which he made a valiant but unsuccessful effort to deal with the self-energy difficulties.

Early in 1930 Oppenheimer showed that the positive particles of the Dirac theory must have the same mass as the electron, and calculated their rate of annihilation in matter. He concluded that the proton must be an independent elementary particle, and have its own antiparticle. He then turned to the problem of the anomalous absorption of ThC″ γ-rays which had been reported by Chao and Tarrant, and with Harvey Hall calculated the relativistic photoeffect. An error led them to the conclusion that the Dirac theory must be wrong for energies greater than mc^2 and was probably responsible for Oppenheimer's failure at that time to believe in the reality of the positron. In 1931 he attempted to linearize the theory of the photon, as Dirac had done for the electron, and pointed out the different structure of the theory for particles of integral and half-integral spins, the difference which later was the basis of Pauli's proof of the connexion between spin and statistics.

By 1931 Oppenheimer's school of theoretical physics in Berkeley was growing; after this time most of his papers were published in collaboration with his students. In 1932 Carlson and Oppenheimer, in an effort to understand the great penetration of cosmic rays, studied the ionization losses of relativistic electrons and Pauli neutrinos, and were unable to account for the penetrating component. In 1933, after the discovery of the positron by Anderson, Oppenheimer and Plesset gave the first correct description of the mechanism of pair production by γ's, and showed that the theory quantitatively explained the excess absorption of ThC″ γ-rays in heavy elements. They pointed out, however, that the theory would predict large deviations from the mass absorption law for cosmic rays (assuming, as they did, that the sea level cosmic rays were mostly electrons and positrons), and concluded that, while it was applicable in the range of radioactive decay energies, it must fail at energies greater than 137 mc^2. A fundamental barrier to Oppenheimer's success in making progress with the difficulties of quantum electrodynamics must have been this belief in the incorrectness of the theory, a belief which he continually stresses. His appreciation of experimental results and his close association with the experimentalists, a strength in other aspects of his work, in this may have been a weakness.

Later in 1933, in a paper with Furry, Oppenheimer formulated the Dirac theory as a field theory, essentially in its modern form. The charge renormalization and the vacuum polarization effects were pointed out, although the problem of gauge invariance remained as a difficulty. The vacuum polarization effects were declared to be observable, with a warning that other radiative corrections existed for electrons. During 1934 and 1935 he worked on critiques of this and other aspects of electrodynamics. In June 1936, he first discussed the theory of electron–positron showers, and an elegant treatment of this important problem was given at the end of the year by Carlson and Oppenheimer and then by Snyder, one of his students. Oppenheimer concluded that the success of the shower theory proved the validity of electron theory, and required the existence of a new type of particle in cosmic rays. In June 1937, immediately after the discovery of the meson by Anderson and Neddemeyer and Street and Stevenson, he wrote, with Serber, pointing out the probable connexion of the cosmic ray meson with the particle suggested by Yukawa, concluding that it was not a primary cosmic ray, but was ejected from nuclei in the upper atmosphere, and explaining the showers at sea level and below as being produced by knock-on electrons. Another suggestion which was originally in this paper, that the finite lifetime of the meson would lead to anomalous atmospheric absorption, was eliminated on Millikan's insistence of the validity of the mass-absorption law.

Earlier, Oppenheimer had become involved in the work in nuclear physics being done by the rapidly growing schools of Lawrence in Berkeley and Lauritsen in Pasadena. His first paper on this subject, in December 1932, accounted for the results of Henderson on the energy variation of the nuclear reaction produced by bombarding lithium by protons. In 1935, with Phillips, he calculated the yield of protons in deuteron reactions, the "Oppenheimer–Phillips process", which explained the experimental results of Lawrence, McMillan and Thornton. A series of papers on reactions in light elements discussed observations of the Lauritsen group. In one of them the first evidence for the operation of an isotopic spin selection rule was pointed out.

Oppenheimer's connexions at Pasadena with the staff of the Mount Wilson Observatory led to an interest in astrophysics, to papers on neutron stars in 1938 and 1939, and to his well known work with Snyder on gravitational contraction in 1939.

The years 1940 and 1941 saw intensive work on meson theory, including attempts to deal with the strong coupling problem by including inertial and radiative reaction damping effects. In 1941, in a paper with Schwinger, he applied Wentzel's strong coupling theory to pseudoscalar mesons, and predicted the existence of nucleon isobars with an excitation energy slightly less than the rest energy of the meson. These efforts were interrupted by the war. The papers Oppenheimer published immediately after the war represented a continuation of this line. One, with Bethe, discussed radiation damping, and another, with Lewis and Wouthuysen, the multiple production of mesons.

The discovery of fission changed the lives of a whole generation of physicists. Oppenheimer's understanding of both theory and experiment, and his close relations with both, made him a very suitable head for the famous Los Alamos Laboratory which made the atomic bomb. Those connected with this laboratory in the war-time years will never forget the spirit and verve which infused the whole enterprise and Robert Oppenheimer who was the leader and source of this inspiration.

I. I. Rabi
Robert Serber