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REVIEWS

Mathematical Methods in Kinetic Theory. By CARLO CERCIGNANI. Plenum Press, 1969. 227 pp. $15.00.

The Mathematical Theory of Non-Uniform Gases. By SYDNEY CHAPMAN and T. G. COWLING. (Third edition.) Cambridge University Press, 1970. 423 pp. £5.00 or $16.00.

Microscopic Thermodynamics. By FELIX J. PIERCE. International Textbook Co., 1968. 492 pp. $11.95.

When the density of a gas becomes so low that the mean free path is no longer negligibly small compared with a length characteristic of the flow geometry, the results obtained in continuum fluid dynamics require corrections which become more and more important as the degree of rarefaction increases. When the rarefaction becomes sufficiently great, continuum dynamics must be replaced by the kinetic theory of gases, and the Navier–Stokes equations by the Boltzmann equation of transport. The latter is a complicated non-linear integrodifferential equation whose solution for practical problems is feasible only through the use of suitable methods of approximation.

It was one of the great triumphs of mathematical physics when Chapman and Enskog in the early years of this century found a practicable way of solving the Boltzmann equation which led to numerical values for the transport coefficients. In recent years, flows of gases of arbitrary rarefaction have become problems of practical interest to aerodynamicists and, consequently, solving the Boltzmann equation is no longer a purely academic problem. On the other hand, the structure of the Boltzmann equation is such that special adaptations of the classical methods of mathematical physics have had to be developed to deal with kinetic theory problems. The book by Cercignani gives an excellent modern account of some of these techniques. It does not claim to be a comprehensive treatise, and the choice of topics and emphasis reflects the author's own interest in this subject, to which he has made many contributions. The first five chapters give a good introductory account, happily balancing mathematical and physical arguments, of the basic ideas and concepts. This is followed by a heavily mathematical chapter which deals with existence and uniqueness questions. The rest of the book deals mainly with analytical methods of solution of so-called model equations, in which the full Boltzmann collision integral is replaced by a simplified expression. The emphasis is on the use of the method of separation of variables to obtain solutions of a number of problems of interest, in particular those of flow in bounded regions where the effect of boundary conditions is important. Quantum phenomena are not considered.

The book by Chapman and Cowling is the third edition of the classic account of the Chapman–Enskog theory, first published in 1939. A number of revisions have been made to take account of recent work, but the book inevitably has an old-fashioned flavour now. This is not diminished by the retention of its special

notation for vectors and tensors which does not seen to have found favour elsewhere. In its own day *The Mathematical Theory of Non-Uniform Gases* was the definitive treatise on the kinetic theory of gases. Nowadays it is only a very detailed presentation of one aspect of the subject, but it is still a fascinating account of a major chapter in physical theory.

The book by Pierce gives an elementary account of kinetic theory and statistical mechanics for engineering students at American universities. It is a workmanlike, somewhat pedestrian, treatment. I am surprised that it is still possible to dispense almost completely with vector notation in a work of this kind.

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