

Preface

In this monograph, theories of nonequilibrium statistical mechanics of simple molecules are presented in density ranging from dilute gases to moderately dense gases to liquids. Both single and multiple components are considered for nonrelativistic and relativistic kinetic theories. The nonrelativistic kinetic theories are in classical formalism. In the case of relativistic kinetic theories, classical gases are treated with a relativistic Boltzmann equation, whereas radiation (photons) and matter are treated by means of quantum mechanical kinetic equation—covariant Boltzmann–Nordheim–Uehling–Uhlenbeck kinetic equations for a mixture of photons and material gases. The nonrelativistic theories are presented in Volume 1 and the relativistic theories in Volume 2. The kinetic equations are postulates and hence their predictions are to be verified *a posteriori* against experiments. The laws of thermodynamics serve as the required benchmark for *a posteriori* verification for the present kinetic theories. The postulational kinetic theories presented are formulated for nonequilibrium ensembles of fluids which obey irreversible time-reversal-invariance-breaking kinetic equations modeled after the Boltzmann kinetic equation. Being time-reversal symmetry breaking and hence irreversible, the kinetic equations employed are capable of providing molecular theoretic foundations for irreversible transport processes. The thermodynamic theory of irreversible processes obtained therewith is in full conformation with the laws of thermodynamics as we know of from the phenomenological theories of thermodynamics by S. Carnot, R. Clausius, and W. Thomson (Kelvin) and of J.W. Gibbs. Therefore the consequences of the present kinetic theory for the thermodynamics of irreversible processes and the accompanying hydrodynamics (more precisely, generalized hydrodynamics), may be said to be thermodynamically consistent.

The germ of the present line of work was conceived by the author's realization that the celebrated Boltzmann equation is not derivable, but should be regarded as a postulate for a time-reversal symmetry breaking evolution equation for singlet distribution functions of dilute monatomic gas molecules in the phase space and that it should be also regarded as a phase-space evolution equation of a particular form for an ensemble of uncorrelated molecules. This strand of thought that initially

was put forth in the papers [Ann. Phys. (NY) **118**, 187, 230 (1979); **120**, 423 (1979)] by the present author, however, has taken considerably roundabout ways to come to the present form that the Boltzmann equation should be regarded as a kinetic equation for a simplest possible dynamical ensemble of the many-particle systems consisting of a very dilute monatomic gas. It, in fact, is not derivable from the mechanical laws of motion alone since it requires *extra-mechanical* principles, for example, the probability theory. In this work we, therefore, abandon the pretension that the irreversible kinetic equations are somehow derived from the mechanical principles. This roundabout journey has taken many years, which took a more concrete form with the works underlying the monograph by this author entitled *Kinetic Theory and Irreversible Thermodynamics* published by John Wiley & Sons in 1992 and continued in its sequel, the monograph entitled *Nonequilibrium Statistical Mechanics* (Kluwer 1998) where the idea of the role of ensemble was broached along the line presented in one of my papers [J. Chem. Phys. **107**, 222, (1997)]. In the intervening years there have been made a number of developments and minor corrections in the course of thoughts and applications of the theories developed from the thoughts in the aforementioned monographs. Although there still remains a great deal of further work to be done, it is felt that it is an opportune time to gather materials studied and present a synthesis of them as best as possible in a coherent form. The present monograph is a product of such a sentiment on the part of this author. It is hoped that this work would be useful to readers interested in the subject matter. In the course of this work the author has experienced numerous physical travails, which I could not have overcome without the dedicated cares of numerous physicians and cardiac surgeons at the Royal Victoria Hospital, McGill University, who rescued me from the brink of the abyss of life, and last but not least, of the cares and devoted love of my wife Hui Young. That was about three years ago to this day. Without them this work would not have been possible. I would like to thank them all and, especially, for the encouragement of my wife for this work. I would also like to thank my former students and associates who shared the joys as well as labors with me during the journey along the course of this work. The thoughts of their camaraderie will be cherished. I would also gratefully acknowledge the valuable help from my son David for drawing figures despite his busy schedule.

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