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Abstract

The observation of phenomena in nature led to the recognition of physical quantities that evolve in time, but also to the development of laws that describe their change over time. Gradually, the study of the composition of matter led to the recognition that a (macroscopic) physical system consists of microscopic molecular structures that are constantly in motion. The study of the macrocosm led to the foundation of thermodynamics in equilibrium and kinetic theories out of equilibrium, such as hydrodynamics. At the same time, statistical theories were developed that reproduce the macroscopic phenomena based on the molecular motion. Statistical Mechanics of equilibrium reproduces thermodynamics and kinetic (statistical) theories reproduce (macroscopic) kinetic theories. For example, in dilute systems, the Boltzmann kinetic equation reproduces hydrodynamics. For non-equilibrium systems there is no general kinetic theory due to the many ways in which the kinetic states of matter arise and correspondingly the statistical theories are formulated according to the physical system they describe. In this book, the phenomenological theories of thermodynamics and hydrodynamics are presented first, the stochastic processes that describe the statistical evolution of physical quantities over time and characterize physical and chemical systems follow. Subsequently, based on classical mechanics and the use of the Liouville equation, the derivation of kinetic equations for the velocity distributions is presented. In the limit of weak interactions the Boltzmann kinetic equation is obtained and its properties are studied. Then, transport properties are calculated based on the intermolecular interactions. Next, the statistical study of the linear response of a system to the action of external fields is presented. In the last chapter, since thermodynamics has not been generalized to all physical systems, some cases of generalization of local thermodynamics in non-equilibrium conditions are presented for special systems that display various applications.

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