Some recent topics in classical kinetic theory of gases

Kazuo Aoki
Department of Mechanical Engineering and Science
Kyoto University, Kyoto 615-8540, Japan

Kinetic theory of gases is a classical subject in non-equilibrium statistical physics. Nowadays, however, gases in non-equilibrium state play important roles in many fields, such as micro fluid dynamics and vacuum technology. Kinetic theory of gases is a principal tool to deal with the behavior of such non-equilibrium gases, since it is beyond the applicability of ordinary fluid dynamics. In this lecture, we first give a brief introduction to kinetic theory of gases. Then, its application to some basic problems is discussed. More specifically, the lecture consists of the following.

1. The concepts of the velocity distribution function and macroscopic variables are introduced, and the fundamental equation, the celebrated Boltzmann equation, as well as its fundamental properties will be explained very briefly.
2. The approach to the equilibrium state of a gas confined in a vessel kept at a uniform temperature is considered on the basis of kinetic theory, with special interest in the rate of approach. It is known that the approach is exponentially fast in time for a gas with intermolecular collisions. For a collision-less gas, however, it is likely that the approach is slow and algebraic in time (i.e., some inverse power of time). Some pieces of numerical evidence will be given both collisional and collision-less cases.
3. The Crookes radiometer (the light mill) is considered, and its model problem is investigated numerically using kinetic theory. To be more specific, we consider a plate with one side heated, placed in a rarefied gas in a container and investigate the steady gas flow induced around the plate as well as the force acting on it. This study clarifies importance of the edges of the plate for the force acting on a vane of the Crookes radiometer. The singularity of the solution caused by the edges is also discussed.