1. INTRODUCTION

In this chapter we turn our attention to the kinetic theory of partially ionized plasmas. Such a study of the kinetic theory of plasmas can proceed from two different points of view. On the one hand, a plasma can be regarded as a gas mixture which is described by the hydrodynamic equations and transport properties that are to be calculated according to well-established methods based on the assumption of binary collisions between particles. In this approach the electrons and ions are considered on a more-or-less equal footing with the neutral species in the mixture. Alternatively, in the description of low-pressure, highly ionized plasmas emphasis is characteristically placed on the particular properties of charged particles and on the collective and statistical nature of the Coulombic interactions between these particles.

The present discussion pertains to partially ionized, collision-dominated plasmas which can be satisfactorily described, as in the first approach, by the hydrodynamic equations and the (explicit) consideration of only binary collisions. Our analysis, however, differs significantly from that which applies to mixtures of neutral gases in that we emphasize the simplifications associated with the small mass of the electron and the special nature of charged-particle collisions.

The objective of this chapter is the formulation of a kinetic-theory description of partially ionized plasmas. This formulation will then be applied in the following chapter to the calculation of plasma transport properties. In Sec. 2 we consider the relation between the distribution function and the mass, momentum, and energy fluxes which are central to the study of transport phenomena. The Boltzmann equation for the distribution function is derived in Sec. 3 and the species and global conservation equations are then obtained as integrals of the Boltzmann equation. In Sec. 4 we consider the Fokker-Planck description of collisions between
charged particles. The final two sections emphasize the special role of the electrons in plasma kinetic theory. In Sec. 5 the simplifications which result from the small mass of the electron are applied to the consideration of collisions between electrons and heavy particles. Making use of the preceding sections, we then formulate in Sec. 6 the Cartesian-tensor expansion for the electron distribution function. It is this expansion which is used in Chapter VIII as a basis for the calculation of electron transport properties.