Preface

This book is an outgrowth of a series of courses developed over the past eight years in the department of Mechanical Engineering at Stanford University. These courses were introduced to instruct beginning graduate students in the general features of collision-dominated partially ionized gases and in the description of the flow of such gases in the presence of electric and magnetic fields. In the book, as in the courses, emphasis is placed on developing the fundamental concepts and tools of the subject and on discussing certain basic applications for illustrative purposes. We hope to bring the student to the point where he understands and is able to make many of the kinds of approximate calculations workers in the subject are faced with and where he is prepared to read and understand related material in more advanced books and in the research journals. The exercises, and to some extent also the selection of textual material, tend to reflect our own research involvement in problems related to magnetohydrodynamic energy conversion.

In Chapter I, which outlines the development of the material in the book, we discuss in general terms the relation between the description of collisional and radiative processes at a microscopic level and the calculation of the properties and behavior of gases at a macroscopic level. Chapter II is largely concerned with showing how this connection is actually accomplished, beginning with the concept of the cross section as the basic quantitative measure for the description of a microscopic process. The objective of Chapter II is to develop, in as direct a way as seems reasonable, the main ideas and results pertaining to collision-dominated partially ionized gases so as to provide the reader with a working knowledge of the subject. It is our purpose to focus primarily on those aspects of gases peculiar to their ionization and, therefore, for example, rotational and vibrational processes are not treated in detail.

Chapter III deals with some of the basic properties such as charge neutrality exhibited on a macroscopic level by a nonflowing partially ionized gas, or plasma, in the absence of a magnetic field. A discussion of electrostatic probes and of electromagnetic wave propagation serves to illustrate some of the features of the behavior of plasmas. Chapter IV treats first the microscopic motion of charged particles subjected to electric and magnetic fields and then proceeds with a discussion of the magnetohydrodynamic equations of motion for an electrically conducting gas. The topics
of Hartmann flow, MHD power generation, and the two-temperature ionization instability, are discussed as examples of the application of these equations. In Chapters V and VI we present an introductory discussion to show how many of the microscopic concepts concerning collisions and radiation presented in Chapter II can be developed in a more or less approximate fashion from the basic laws of classical physics. Chapters VII and VIII are concerned with the application of formal kinetic theory, as based on the Boltzmann equation, to the calculation of the transport properties for partially ionized gases. Chapter IX deals with problems of ionizational nonequilibrium.

It is a pleasure for us to acknowledge the support of our friend and colleague Robert H. Eustis, whose initiation and leadership of the high-temperature gas dynamics program at Stanford has made this work possible. Though too numerous to mention individually, we would like to acknowledge also the important role our students have had in shaping the contents and contributing to the material of this book.

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