Preface

Plasma is a unique state of matter, different from solids, liquids, and vapors. It is a gas where an important fraction of the atoms is ionized, so that the electrons and ions are separate, free, and consists of approximately equal numbers of positively charged ions and negatively charged electrons. The characteristics of plasmas are significantly different from those of ordinary neutral gases so that plasmas are considered a distinct "fourth state of matter." For example, because plasmas are made up of electrically charged particles, they are strongly influenced by electric and magnetic fields, while neutral gases are not. An example of such influence is the trapping of energetic charged particles along geomagnetic field lines to form the Van Allen radiation belts.

Plasma physics is the study of charged particles and fluids interacting with self-consistent electric and magnetic fields. It is a basic research discipline that has many different areas of application—space and astrophysics, controlled fusion, accelerator physics, and beam storage, to name a few.

In addition to externally imposed fields, such as the Earth's magnetic field or the interplanetary magnetic field, plasma is acted upon by electric and magnetic fields created within the plasma itself through localized charge concentrations and electric currents that result from the differential motion of the ions and electrons. The forces exerted by these fields on the charged particles that make up the plasma act over long distances and impart to the particles' behavior a coherent, collective quality that neutral gases do not display. Despite the existence of localized charge concentrations and electric potentials, plasma is electrically "quasi-neutral," because, in aggregate, there are approximately equal numbers of positively and negatively charged particles distributed so that their charges cancel.

Plasma science has, in turn, spawned new avenues of basic science. Most notably, plasma physicists were among the first to open up and develop the new and profound science of chaos and nonlinear dynamics. Plasma physicists have also contributed greatly to studies of turbulence, which is important for safe air travel. Basic plasma science continues to be a vibrant research area. Recent new discoveries have occurred in understanding extremely cold plasmas, which condense to

crystalline states, the study of high-intensity laser interactions, new highly efficient lighting systems, and plasma-surface interactions important for computer manufacturing.

Understanding the complex behavior of confined plasmas has led researchers to formulate the fundamental equations of plasma physics. This foundational work and understanding of plasmas have led to important advances in fields as diverse as computers, lighting, waste handling, space physics, switches and relays, and lasers. Because plasmas are conductive, respond to electric and magnetic fields, and can be efficient sources of radiation, they are used in a large number of applications where such control is needed or when special sources of energy or radiation are required.

The book is intended only as an introduction to plasma physics course and includes what I take to be the critical concepts needed for a foundation for further study. A solid undergraduate background in classical physics and electromagnetic theory including Maxwell's equations and mathematical familiarity with partial differential equations and complex analysis are prerequisites.

In summary, it is clear that this book is not intended to transform its users into experts on plasma physics. Rather, it is intended to provide a simple, coherent, introduction to workers with diverse backgrounds in physics and related sciences.

Albuquerque, NM Bahman Zohuri

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Zohuri, B.

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