Preface

A nonneutral plasma is a many-body collection of charged particles in which there is not overall charge neutrality. Such systems are characterized by intense self-electric fields, and in high-current configurations by intense self-magnetic fields. Nonneutral plasmas, like electrically neutral plasmas, exhibit a broad range of collective properties, such as plasma waves, instabilities, and Debye shielding. Moreover, the intense self fields in nonneutral plasmas can have a large influence on detailed plasma behavior, including stability and transport properties.

Since the monograph *Theory of Nonneutral Plasmas* (Benjamin, Reading, Massachusetts) first appeared in 1974, this important area of physics research has developed into a diverse and sophisticated subfield of pure and applied plasma physics. For example, interest in the physics of nonneutral plasmas has increased substantially in such diverse areas as: investigations of basic equilibrium, stability and transport properties; high-intensity accelerators for high energy and nuclear physics applications; phase transitions in strongly coupled, two- and three-dimensional nonneutral plasmas; coherent electromagnetic wave generation by free electrons interacting with applied magnetic field structures; astrophysical studies of large-scale isolated nonneutral plasma regions in the magnetospheres of rotating, magnetized neutron stars; and the development of positron and antiproton sources for antihydrogen production.

In addition to developing a basic physics understanding of many-body charged-particle systems in which there is not overall charge neutrality, there are many practical applications of nonneutral plasmas. These include: the development of precision atomic clocks;

investigations of nonlinear vortex dyamics and turbulence in nearly-inviscid two-dimensional fluid flow; coherent electromagnetic wave generation by energetic electrons, as occurs in magnetrons, free electron lasers, and cyclotron masers; the development of high-intensity accelerators, such as the periodic focusing induction linac accelerators for space-charge-dominated heavy ion beams; the stability of intense nonneutral electron and ion flow in high-voltage diodes; and the stability and transport of intense charged particle beams propagating through background plasma or through the atmosphere, to mention a few examples.

Physics of Nonneutral Plasmas has been prepared as a graduate-level text which covers a broad range of topics related to the fundamental properties and applications of nonneutral plasmas. The subject matter is treated systematically from first principles using a unified theoretical approach, and the emphasis is on the development of basic concepts that illustrate the underlying physical processes, which are often similar in different application areas. The statistical models used to describe the properties of nonneutral plasma are based on the fluid-Maxwell equations, the Vlasov-Maxwell equations, or the Klimontovich-Maxwell equations, as appropriate to the application under consideration.

Physics of Nonneutral Plasmas includes 138 problems, 143 figures and illustrations, and the results from several classic experiments illustrating fundamental processes in nonneutral plasmas. In view of the book's emphasis on basic physics principles, and the thorough presentation format, it is intended to have a broad and lasting appeal to graduate students and researchers in this rapidly developing field of physics research.

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