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978-0-521-36730-1 - Introduction to Plasma Physics: With Space and Laboratory Applications

D. A. Gurnett and A. Bhattacharjee

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## INTRODUCTION TO PLASMA PHYSICS

### With Space and Laboratory Applications

The emphasis of this text is on basic plasma theory, with applications to both space and laboratory plasmas. All mathematical concepts beyond those normally covered in an advanced calculus course are fully explained.

Topics covered include single particle motions, kinetic theory, magnetohydrodynamics, small amplitude waves in both cold and hot plasmas, non-linear phenomena and collisional effects. Applications include planetary magnetospheres and radiation belts, the confinement and stability of plasmas in fusion devices, the propagation of discontinuities and shock waves in the solar wind, and the analysis of various types of plasma waves and instabilities that can occur in planetary magnetospheres and laboratory plasma devices. This book is structured as a text for a one- or two-semester introductory course in plasma physics at the advanced undergraduate or first-year graduate level. It can also serve as a resource book on the basic principles of plasma physics.

DON GURNETT is a pioneer in the study of waves in space plasmas, and has been the author or co-author of over 470 papers in the field of space plasma physics. He is currently a Carver/James A. Van Allen Professor of Physics at the University of Iowa and has received numerous awards for both his teaching and research. In 1994 he received the Iowa Board of Regents Award for Faculty Excellence, and in 1998 was elected a member of the National Academy of Sciences.

AMITAVA BHATTACHARJEE is a leading theoretical plasma physicist and has published over 170 papers on a wide range of subjects spanning fusion, space, and astrophysical plasma physics. He is currently Paul Professor of Space Science at the Institute for the Study of Earth, Oceans, and Space and the Department of Physics at the University of New Hampshire. He is a Fellow of the American Physical Society and the American Association for the Advancement of Science.

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D. A. GURNETT and A. BHATTACHARJEE

*Department of Physics and Astronomy  
The University of Iowa*



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## Preface

This textbook is intended for a full year introductory course in plasma physics at the senior undergraduate or first-year graduate level. It is based on lecture notes from courses taught by the authors for more than three decades in the Department of Physics and Astronomy at the University of Iowa and the Department of Applied Physics at Columbia University. During these years, plasma physics has grown increasingly interdisciplinary, and there is a growing realization that diverse applications in laboratory, space, and astrophysical plasmas can be viewed from a common perspective. Since the students who take a course in plasma physics often have a wide range of interests, typically involving some combination of laboratory, space, and astrophysical plasmas, a special effort has been made to discuss applications from these areas of research. The emphasis of the book is on physical principles, less so on mathematical sophistication. An effort has been made to show all relevant steps in the derivations, and to match the level of presentation to the knowledge of students at the advanced undergraduate and early graduate level. The main requirements for students taking this course are that they have taken an advanced undergraduate course in electricity and magnetism and that they are knowledgeable about using the basic principles of vector calculus, i.e., gradient, divergence and curl, and the various identities involving these vector operators. Although extensive use is made of complex variables, no special background is required in this subject beyond what is covered in an advanced calculus course. Relatively advanced mathematical concepts that are not typically covered in an undergraduate sequence, such as Fourier transforms, Laplace transforms, the Cauchy integral theorem, and the residue theorem, are discussed in sufficient detail that no additional preparation is required. Although this approach has undoubtedly added to the length of the book, we believe that the material covered provides an effective and self-contained textbook for teaching plasma physics. MKS units are used throughout.

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