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PRINCIPLES OF MAGNETOHYDRODYNAMICS With Applications to Laboratory and Astrophysical Plasmas J. P. (HANS) GOEDBLOED FOM-Institute for Plasma Physics 'Rijnhuizen', and Astronomical Institute, Utrecht University STEFAAN POEDTS Centre for Plasma-Astrophysics, Katholieke Universiteit Leuven CAMBRIDGE UNIVERSITY PRESS

PRINCIPLES OF MAGNETOHYDRODYNAMICS

Magnetohydrodynamics is the study of the magnetic properties and behaviour of electrically conducting fluids. Examples of such magneto-fluids include plasmas, liquid metals, salt water, and electrolytes. The word "magnetohydrodynamics" is derived from magneto- meaning magnetic field, hydro- meaning water, and dynamics meaning movement. The field of MHD was initiated by Hannes Alfvén, for which he received the Nobel Prize in Physics in 1970. The fundamental concept behind MHD is that ...

Magnetohydrodynamics - Wikipedia

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Senior undergraduate and graduate textbook on key area in plasma physics and astrophysics.

Following on from the companion volume Principles of Magnetohydrodynamics, this textbook analyzes the applications of plasma physics to thermonuclear fusion and plasma astrophysics from the single viewpoint of MHD. This approach turns out to be ever more powerful when applied to streaming plasmas (the vast majority of visible matter in the Universe), toroidal plasmas (the most promising approach to fusion energy), and nonlinear dynamics (where it all comes together with modern computational techniques and extreme transonic and relativistic plasma flows). The textbook interweaves theory and explicit calculations of waves and instabilities of streaming plasmas in complex magnetic geometries. It is ideally suited to advanced undergraduate and graduate courses in plasma physics and astrophysics.

This text focuses on conservation laws in magnetohydrodynamics, gasdynamics and hydrodynamics. A grasp of new conservation laws is essential in fusion and space plasmas, as well as in geophysical fluid dynamics; they can be used to test numerical codes, or to reveal new aspects of the underlying physics, e.g., by identifying the time history of the fluid elements as an important key to understanding fluid vorticity or in investigating the stability of steady flows. The ten Galilean Lie point symmetries of the fundamental action discussed in this book give rise to the conservation of energy, momentum, angular momentum and center of mass conservation laws via Noether’s first theorem. The advected invariants are related to fluid relabeling symmetries – so-called diffeomorphisms associated with the Lagrangian map – and are obtained by applying the Euler-Poincare approach to Noether’s second theorem. The book discusses several variants of helicity including kinetic helicity, cross helicity, magnetic helicity, Ertels’ theorem and potential vorticity, the Hollman invariant, and the Godbillon Vey invariant. The book develops the non-canonical Hamiltonian approach to MHD using the non-canonical Poisson bracket, while also refining the multisymplectic approach to ideal MHD and obtaining novel nonlocal conservation laws. It also briefly discusses Anco and Bluman’s direct method for deriving conservation laws. A range of examples is used to illustrate topological invariants in MHD and fluid dynamics, including the Hopf invariant, the Calugareanu invariant, the Taylor magnetic helicity reconnection hypothesis for magnetic fields in highly conducting plasmas, and the magnetic helicity of Alfvén simple waves, MHD topological solitons, and the Parker Archimedean spiral magnetic field. The Lagrangian map is used to obtain a class of solutions for incompressible MHD. The Aharonov-Bohm interpretation of magnetic helicity and cross helicity is discussed. In closing, examples of magnetosonic N-waves are used to illustrate the role of the wave number and group velocity concepts for MHD waves. This self-contained and pedagogical guide to the fundamentals will benefit postgraduate-level newcomers and seasoned researchers alike.

This book is an introductory text on magnetohydrodynamics (MHD) - the study of the interaction of magnetic fields and conducting fluids.

Develops a fresh mathematical approach to coronal seismology, explaining oscillatory phenomena by drawing upon original research and complex modelling techniques.

Advanced undergraduate/beginning graduate text on space and laboratory plasma physics.

This unified introduction provides the tools and techniques needed to analyze plasmas and connects plasma phenomena to other fields of study. Combining mathematical rigor with qualitative explanations, and linking theory to practice with example problems, this is a perfect textbook for senior undergraduate and graduate students taking one-semester introductory plasma physics courses. For the first time, material is presented in the context of unifying principles, illustrated using organizational charts, and structured in a successive progression from single particle motion, to kinetic theory and average values, through to collective phenomena of waves in plasma. This provides students with a stronger understanding of the topics covered, their interconnections, and when different types of plasma models are applicable. Furthermore, mathematical derivations are rigorous, yet concise, so physical understanding is not lost in lengthy mathematical treatments. Worked examples illustrate practical applications of theory and students can test their new knowledge with 90 end-of-chapter problems.

This book is an introduction to contemporary plasma physics that discusses the most relevant recent advances in the field and covers a careful choice of applications to various branches of astrophysics and space science. The purpose of the book is to allow the student to master the basic concepts of plasma physics and to bring him or her up to date in a number of relevant areas of current research. Topics covered include orbit theory, kinetic theory, fluid models, magnetohydrodynamics, MHD turbulence, instabilities, discontinuities, and magnetic reconnection. Some prior knowledge of classical physics is required, in particular fluid mechanics, statistical physics, and electrodynamics. The mathematical developments are self-contained and explicitly detailed in the text. A number of exercises are provided at the end of each chapter, together with suggestions and solutions.

Comprehensive, self-contained, and clearly written, this book describes the macroscopic equilibrium and stability of high temperature plasmas.