Hydrodynamics and Magnetohydrodynamics

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Abstract

Hydrodynamics is an incredibly successful framework to describe the dynamics of matter from scales as small as those of colliding elementary particles, up to the largest scales in the universe. This course will provide an introduction to the mathematical and physical properties of hydrodynamics and its extension to magnetized fluids, i.e. magnetohydrodynamics or MHD. Starting from an initial kinetic-theory description, the equations of hydrodynamics will be derived and their most important properties will be discussed. The course will also discuss the nonlinear nature of the hydrodynamics equations and the occurrence of nonlinear waves such as shocks and rarefaction waves. The final part of the course will deal with neutrally charged and magnetized plasmas and discuss the basic features of ideal magnetohydrodynamics and the associated nonlinear waves. A series of exercises will parallel the course. The content of the lectures can be found in a series of books [1, 2, 3].
Syllabus and plan of the lectures


3. The zero-order approximation: perfect fluids, The first-order approximation: non-perfect fluids, Relativistic kinetic theory.


5. Equations of state, Kinematic properties of fluids, Evolution laws of the kinematic quantities, Mass current and energy-momentum of perfect fluids.


8. Conservative formulation, Linear and nonlinear behaviour, Characteristic equations for linear systems, Characteristic curves and caustics.


12. Plasma orbit theory, magnetic mirrors, Debye shielding, plasma parameter.


15. Magnetohydrodynamic instabilities.
References

