UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Elements of Plasma Physics

2122-3-E3001Q076

Aims

The course aims at teaching the students the first fundamental elements of plasma physics.

Contents

Definition of plasma and some basic parameters; single particle description and motion of a charged particle in a plasma; the plasma as a charged fluid; magnetohydrodynamic equilibria and plasma confinement; elements of plasma waves.

Detailed program

1) Definition of plasma and some basic parameters

Definition of plasma and some basic parameters: ionization stage and Saha equation, quasi-neutrality, Debye screening, plasma frequency, distribution function and temperature.

2) Single particle description: motion of a charged particle in a plasma

Motion of a charged particle in an electric and magnetic fields and drift velocities.

Motion in non uniform magnetic fields: drifts due to the gradient of the magnetic field and due to line curvature.

Motion in time dependent fields: polarization drift.

General relation between periodic motions and adiabatic invariants: the case of the simple pendulum.

Applications of adiabatic invariants to plasmas: gyromotion and magnetic moment. Mirror machines.

Second and third adiabatic invariants and their applications.

3) The plasma as a charged fluid

Derivation of the equations that describe the plasma as a charged fluid: equations for the conservation of mass and momentum. Diamagnetic drift.

Single fluid equations and magnetohydrodynamics (MHD).

4) Magnetohydrodynamics equilibria and plasma confinement

MHD equilibrium equations and their general properties: current and magnetic flux surfaces; magnetic pressure and tension.

Some magnetic equilibrium configurations, their properties and limitations: z-pinch, theta-pinch, screw-pinch.

Equilibrium and force balance in toroidal configurations.

Brief introduction to MHD instabilities.

5) Elements of plasma waves

Summary of some basic properties of waves: Fourier representation, phase and group velocity, dispersion relation, uncertainty principle.

Two fluid description of electrostatic and electromagnetic waves in uniform and non magnetized plasmas.

Alfvén waves in the MHD framework for uniform plasmas.

Brief description of some experimental aspects of the propagation of waves in plasmas.

Prerequisites

Mathematics and Physics courses of the first two years of the Bachelor's Degree in Physics

Teaching form

Frontal lectures and homework assignment.

Textbook and teaching resource

F.F. Chen, Introduction to Plasma Physics and Controlled Fusion, 2nd ed. Vol.1, Plenum Press NY

Paul M. Bellan, “Fundamentals of plasma physics”, ed. Cambridge University Press, 2006

J.P. Freidberg, “Plasma physics and fusion energy”, ed. Cambridge University Press, 2007

G. Pucella e S. E. Segre, “Fisica dei plasmi”, ed. Zanichelli, 2009

Semester

I semester

Assessment method

Oral exam with homework assessment

1) Homework assessment

The student will be assigned homework during lectures. The student must present his own solution of the homework at the oral exam. The student can ask the teacher for clarifications on his assignments before the exam.

2) Oral exam

The structure of the oral exam is as follows. The student can choose three topics of the course he would like to discuss in detail at the exam. Each topic shall belong to a different course chapter. Out of those three topics, during the exam the examiner will choose at least one, which the student must be able to discuss in all its details, including the demonstrations that have been presented during the lectures. The next questions will instead be more

general and on some of the other topics discussed during the lectures. The student is not expected to know these other topics in all their details, but must still be able to discuss the most important results and their implications. This more general part will start from the discussion of the solution of the assignments done by the student.

Office hours

By appointment via email