PLASMA  ASTROPHYSICS

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Class Hours: 15:20-18:10, FRI
Place: Room 701, Physics Building

1. Course Description

The course covers plasma phenomena relevant to astrophysics.
The content includes the following chapters (key words are written in the parenthesis):

Chapter 1  Basic concepts and preparation
1-1 What is a plasma?
1-2 History of plasmas
1-3 Examples of plasmas
1-4 Mathematical preparation (vector and tensor analyzes)

Chapter 2  Motion of a single charged particle
2-1 Equation of motion in electro-magnetic fields
2-2 Motion in a uniform and static B field, E=0 (guiding center, magnetic moment)
2-3 Motion in a uniform and static B field, E=0, under external force (external-field drift)
2-4 Motion in a uniform and static B field, non-zero E (electric drift)
2-5 Motion in a non-uniform, static B field (magnetic-gradient drift, magnetic-curvature drift)
2-6 Motion in a slowly varying electro-magnetic fields
   (adiabatic invariants, magnetic mirrors, Fermi acceleration)

Chapter 3  Macroscopic description of plasmas
3-1 Distribution functions and macroscopic equations
   (continuity equation, equation of motion, energy equation, mass and charge conservation)
3-2 Magnetohydrodynamics (frozen-in, magnetic diffusion, magnetic Reynolds number)

Chapter 4  Basic characteristics
4-1 Plasma oscillations
4-2 Debye shielding
Chapter 5      Plasma waves

5-1 Phase velocity and group velocity

5-2 Oscillations without external magnetic field
   (electron plasma oscillations, ion plasma oscillations, Landau damping)

5-3 Magnetohydrodynamic oscillations in an external magnetic field
   (Alfvén waves, magnetosonic waves)

5-4 Classification of small-amplitude waves
   (dispersion relation, dielectric tensor, cut off, absorption,
   wave normals, CMA diagram, ordinary waves, extraordinary waves)

Chapter 6      Instabilities of plasmas

6-1 Magnetohydrodynamic instabilities
   (Rayleigh-Taylor instability, Kelvin-Helmholtz instability, Jeans instability)

6-2 Two-stream instabilities

6-3 Pinch-type instabilities (sausage instability, kink instability, helical instability)

Chapter 7      Plasma basic equations

7-1 Boltzmann equations (Liouville theorem, collision integral, H theorem, Maxwell distribution)

7-2 Fokker-Planck equations (Markovian process, collisional relaxation)

Chapter 8      Collisionless kinetic theory

8-1 Vlasov equation

8-2 Landau damping

2. Text books

None required. Lecture note will be distributed before the subject.

3. References


"Physics of Fully Ionized Gases", L. Spitzer, Jr. 1962, Interscience Publishers, New York,
ISBN 0 470 82723 2
4. Teaching method

This course will go mainly with classroom lectures and problem solving in the form of exercises.

5. Grading

Homework (20%) one problem set per week
Quiz (30%) 1.5 hours on Part I
Final exam (50%) 3 hours

6. Prerequisites

Partial differential equations, vector calculus, elementary kinetic theory of gases, and electromagnetism including Maxwell equations.

7. Related website

http://www.asiaa.sinica.edu.tw/~hirotani/