Topics

Content: Physics 218A, B, together form an advanced graduate treatment of the physics of unmagnetized (A) and magnetized (B) plasmas. In addition to traditional plasma physics, the course will include relevant material from statistical mechanics, nonlinear dynamics and fluid mechanics. Examples from inertial and magnetic fusion and space/astrophysical plasmas will be utilized. Preparation at the level of the first year graduate courses in physics is assumed.

I) Introduction: Plasmas on a Back-of-Envelope

- a) Gas vs. Plasma – Scales, Debye Length, Screening
- b) Collective Resonances and Waves
- c) Coulomb Collisions and Transport

II) Plasmas Near Thermal Equilibrium

- a) Heuristics of Test Particle Model as case of Fluctuation-Dissipation balance
- b) Collective Modes and Their Description
  - i) Basic Fluid Description – Foundations, Basic modes
  - ii) Liouville Equation → Boltzmann Equation → Vlasov Equation via BBGKY Hierarchy
  - iii) Vlasov Theory of Plasma Waves and Landau Damping, physics of Landau Damping
- c) Analysis of Test Particle Model
  - i) Calculation of Discreteness Emission
  - ii) Emission–Absorption Balance, and Equilibrium Spectrum

III) Collisional Transport Theory

- a) Fokker-Planck Equation, Lenard-Balescu Equation, relation
- b) Rosenbluth Potentials
- c) Chapman-Enskog Expansion and Transport Coefficients

IV) Linear Waves and Instabilities

- a) Wave Energy and Momentum, Conservation Theorems, Negative Energy Waves
- b) Two Stream Instability and Bump-on-Tail Instability
- c) Current Driven Ion-Acoustic Instability and Anomalous Momentum Transfer

V) Quasilinear Theory of Instability Evolution

a) Basic Ideas and Time Scales, Foundations in Hamiltonian Chaos
b) Derivation and Interpretation: Resonant, Non-resonant Diffusion
c) Energy and Momentum Theorems
d) Application to Anomalous Resistivity via Current Driven Ion Acoustic Instability

VI) Non-Linear Wave Particle Interaction

a) Higher Order Quasilinear Thoery — Nonlinear Landau Damping
b) Trapping and Homogenization
c) Phase Space Granulation

VII) Nonlinear Wave–Wave Interaction

a) Langmuir Turbulence, Disparate Scale Interaction, and NLS Collapse Dynamics
b) General Formulation of Wave Interactions, Manly-Rowe Relations
c) Basic Ideas of Wave Turbulence

VIII) Rayleigh–Taylor Instability - A Case Study in Instability Dynamics

a) Brief Overview of I.C.F. Physics Issues
b) Linear Theory of R.-T.; Effects of ablation, density gradients and spherical geometry
c) Nonlinearity in R.-T. Evolution:
    1) Structure Formation - Single Bubble Dynamics
    2) Heuristics of Bubble Competition, Turbulence and Mixing