TOPICS

Content: Physics 218 A, 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 Basic Waves, Wave Energy and Momentum Theorem
- c.) Coulomb Collisions and Transport

II.) Plasmas Near Thermal Equilibrium

- a.) Heuristics of Test Particle Model as case of Fluctuation-Dissipation Theorem Balance
- b.) Collective Modes and Their Description
  - i.) Liouville Equation → Boltzmann Equation → Vlasov Equation via BBGKY Hierarchy
  - ii.) Vlasov Theory of Plasma Waves and Landau Damping
- c.) Analysis of Test Particle Model
  - i.) Calculation of Discreteness Emission
  - ii.) Emission-Absorption Balance and Equilibrium Spectrum

III.) Collision Theory

- a.) Lenard-Balescu Equation, basic concepts and applications
- b.) Landau Collision Integral: Basic Concepts, Rosenbluth Potentials
- c.) Chapman-Enskog Expansion and Transport Coefficients

IV.) Linear Instabilities

- a.) 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 Bump-on-Tail and Anomalous Resistivity via Current Driven Ion Acoustic Instability
e.) Discussion of Traveling Wave Tube QL Experiment

VI.) Nonlinear Waves and Wave-Wave Interaction

a.) Langmuir Turbulence, Disparate Scale Interaction
b.) Laser-Plasma Processes, Parametrics, SBS, SRS
c.) General Formulation of Wave Interactions, Manly-Rowe Relations
d.) Basic Ideas of Wave Turbulence
e.) Simple Ideas of Collisionless Shocks

VII.) Rayleigh-Taylor Instability - A Case Study in Instability Dynamics

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

VIII.) Non-Linear Wave Particle Interaction

a.) Nonlinear Landau Damping, Higher Order QLT
b.) Wave Trapping
c.) Phase Space Granulations