Physics 218A **PLASMA PHYSICS** **Fall 2009**

TOPICS

Content: Physics 218 A, B, together, form an advanced graduate treatment of the basic 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.) Plasmas at Thermal Equilibrium

- a.) Basic Space-Time Scales
- b.) Fluctuation-Dissipation Theorem for Thermal Equilibrium: Noise vs. Damped Modes
- c.) Collective Modes of Plasma
  - i.) Basic Fluid Description
  - ii.) Heuristics of Vlasov Equation, Kelvin's Theorem for Phase Space
  - iii.) Vlasov Theory of Plasma Waves and Landau Damping
- d.) Test Particle Model for Noise at Thermal Equilibrium
- e.) Fluctuation Spectrum at Equilibrium: Emission-Absorption Balance

II.) Plasma Relaxation Near Thermal Equilibrium

- a.) Basics of Relaxation and Transport, Chapman-Enskog Theory
- b.) From Test Particle Model to Lenard-Balescu Equation; Relaxation in Lenard-Balescu Theory
- c.) Fokker-Planck Theory for Collisional Relaxation; Relation to Lenard-Balescu Theory
- d.) Rosenbluth Potentials and Calculating Transport and Relaxation

III.) Introduction to Non-Equilibrium Plasma Dynamics

- a.) Wave Energy and Momentum, Conservation Theorems; Active Media and Negative Energy Waves
- b.) Basic Instabilities: Two Stream, Bump-on-Tail, Current Driven Ion-Acoustic
- c.) Quasi-Linear Theory of Instability Evolution and Relaxation
  - i.) Basic Ideas and Time Scales; Origins of Irreversibility
  - ii.) Derivation and Interpretation; Resonant, Non-Resonant Diffusion
  - iii.) Energy and Momentum Conservation Theorems
  - iv.) Quasilinear Theory of:
    - a.) Bump-on-Tail $\rightarrow$ Plateau Formation
    - b.) C.D.I.A. $\rightarrow$ anomalous resistivity
- d.) Particle Trapping in Nonlinear Waves; BGK Modes
- e.) Basics of Shocks, Ion-Acoustic Solitons and Collisionless Shocks
- f.) Phase Space Density Holes and Double Layers
- g.) Langmuir Turbulence $\rightarrow$ Wave Kinetic Description and Envelope Theory Formulation