Topics


i.) Nonlinear Oscillators
   a.) Ponderomotive Force
   b.) Parametric Instability
   c.) Poincare-Lindstet Perturbation Theory for Nonlinear Oscillators
   d.) Driven Nonlinear Oscillators and Mode Jumping
   e.) Van-der-Pol Oscillator

ii.) Canonical Formalism
   a.) Hamilton-Jacobi Theory, Principle Maupertuis, Applications to Eikonal Theory
   b.) Changing Variables in Hamiltonian Mechanics → Canonical Transformations (Review)
   c.) Underlying Theory → Poincare-Cartan Invariant, Symplectic Systems
   d.) Action-Angle Variables → Symmetry and Canonical Structure
   e.) Using the Formalism → Adiabatic Invariants, Applications to Charged Particle Motion
   f.) Adiabatic Theory for Waves, Quasi-Particle Formulation

ii.) Overview of Hamiltonian Chaos
   a.) Hamiltonian Maps, Systems → Integrability
   b.) Perturbation Theory and Small Denominators
   c.) KAM Theorem, Fate of Resonant Tori
   d.) Standard Map and Stochasticity, Lyapunov Exponent
   e.) Island Overlap, Chirikov Criterion

B.) Kinetic Theory and Hydrodynamics (From Liouville to Boltzmann to Navier-Stokes)

i.) Boltzmann Equation
   a.) Concepts of Entropy: Kolmogorov, Information Theory, Thermodynamic
   b.) From Liouville → Boltzmann: BBGKY Hierarchy and its truncation
   c.) Boltzmann Equation and Collision Operator
   d.) H-Theorem: Proof and Meaning
   e.) Dynamical Foundations of Principle of Molecular Chaos (Time Allowing)
   f.) Resolution of H-Theorem and Recurrence

ii.) Linear Response Theory and Transport
   a.) Transport as a Linear Response Problem → Onsager Matrix and Symmetry
   b.) From Boltzmann → Euler and Navier-Stokes: Deriving Fluid Equations from Kinetic
   e.) Basic Ideas of Fluctuations, Response, Correlation
   d.) Off-diagonal Effects: Chemotaxis, Pinches
   e.) Calculating Transport Coefficients → Chapman-Enskog Expansion
   f.) Fluctuation-Dissipation Theorem

iii.) Introduction to Hydrodynamics
   a.) Fundamentals of Hydrodynamics
   b.) Hydrodynamic Modes
   c.) Introduction to Instabilities