Galactic Dynamics and Magnetohydrodynamics

I.) ***Basics of Stellar Dynamics***

- a.) Overview of Galaxy Phenomenlogoy
- b.) Stellar Dynamics - the Galaxy as a Collisionless, Self-Gravitating N-body System
  - i.) Nature of Stellar Interactions
  - ii.) Vlasov Equation for Stellar Dynamics: Origin and Meaning
  - iii.) Jeans Theorem and Implications
- c.) Characteristic Equations: Stellar Orbits
  - i.) orbits in axisymmetric potentials, epicycles and epicyclic frequency, implications for collective effects
  - ii.) the Third Invariant: meaning and implication
  - iii.) planar non-axisymmetric potentials: weak bars, Lindblad resonance, co-rotation resonance, trapping
- d.) Jeans Equations - Moments of the Vlasov Equation
- e.) Applications of the Jeans Equations
- f.) Some Simple Models of Galactic Equilibria
- g.) Virial Theorems for Stellar Dynamics: Derivation, Significance, Applications
- h.) Lynden-Bell Theory of Violent Relaxation

II.) ***Collective Dynamics, Disk "Pattern Formation" and the Origins of Spiral Structure***

- a.) Fluid and Kinetic Theory of the Jeans Instability
- b.) Energy Principles for Spherical Systems (Eddington, Antonov, Antonov-Lebovitz)
- c.) Gas Dynamics of Disks
  - 1.) Toomre Criterion $(m = 0)$ for thin disk
  - 2.) Basics of Spiral Wave $(m \neq 0)$ Structure and Dynamics
  - 3.) Wave Energy and Momentum - Variational Theory and Applications
  - 4.) Lindblad Resonance and Spiral Wave Scattering
  - 5.) Waser and Swing Amplification Mechanisms
  - 6.) Shearing Sheet vs Modal Approach
- d.) Stellar Dynamics of Disks
  - 1.) Vlasov Theory of Toomre Stability
  - 2.) Vlasov Theory of Spiral Waves

III.) ***Kinetics of Stellar System Interactions***

a.) Dynamical Friction
b.) Encounters and Mergers
c.) Fokker-Planck Theory of Stellar System Interactions
d.) Evolution of Spherical Systems

IV.) ***Galactic Magnetohydrodynamics***

a.) Basics of MHD: Equations, Freezing-in Law, Virial Theorem
b.) Phenomenology of Galactic Magnetic Fields
c.) Galactic Disk Modes in MHD Description
d.) Cosmic Rays in the ISM and Galaxy
e.) Parker instability of the Galactic Magnetic Field
f.) Basic Concepts in Dynamo Theory
g.) Theories of the Galactic Dynamo