GRS AS 725 – Gravitational Astrophysics (Fall 1999)

Lectures: Tuesdays & Thursdays, 9:30am – 11:00am (CAS Room 500)
Instructor: Prof. Tereasa Brainerd
Grading: Homework Problem Sets (65%), Final Examination (35%)

The goal of this course will be to explore a number of astrophysical topics in which gravity plays a dominant role. By and large the topics will be dynamical in nature, but we will cover a few specific instances where this is not the case. There is, unfortunately, no single textbook that addresses all of the material (nor even half of the material!) that we will be covering and, hence, there is no required book for the class. Instead, related reading material will come from a number of "classic" books that will be placed on reserve in the library. These will include, but will not be limited to, *Classical Mechanics (2nd Edition)* by Herbert Goldstein, *Galactic Dynamics* by James Binney & Scott Tremaine, and *Gravitation & Cosmology* by Steven Weinberg. From time to time, typed class notes will be used to supplement the texts in the library.

Course Outline

Classical Mechanics:
- generalized coordinates
- Lagrangian & Hamiltonian formalisms
- equations of motion involving central potentials
- the 2-body problem (Kepler's laws; binary stars)
- the restricted 3-body problem

N-body Systems:
- relevant time scales and the process of virialization
- the collisionless Boltzmann equation
- phase space distribution functions
- spherical and triaxial systems (isotropic vs. anisotropic velocity dispersions)
- axisymmetric disk systems
- perturbations to the axisymmetric disk (kinematic spiral arms)
- dynamical evidence for dark matter in the universe
- N-body computer simulations

General Relativity basics:
- the Equivalence principle
- geodesics, metrics, and the "warping" of spacetime
- the field equations

Classical Theoretical Cosmology:
- the Friedmann-Robertson-Walker metric
- equations of motion for the universe
- the unique connection between the dynamics of the universe and its overall geometry
- the power spectrum of density fluctuations and "cold" vs. "hot" dark matter
- "linear" theory and the growth of density fluctuations in an expanding universe
- simple spherical collapse models for galaxy formation

Gravitational Lensing:

- geometry of a lens system and the non-linear nature of the lens equation
- strong vs. weak lensing
- the Einstein radius and conditions for the creation of multiple images and arcs
- geometrical and “Shapiro” time delays in multiply-imaged systems
- using observations of gravitational lensing to locate and map the dark matter in the universe