GRS AS 725 – Gravitational Astrophysics (Spring 2008)

Lectures: Mondays & Wednesdays, 9:30 am – 11:00 am (CAS Room 502)
Instructor: Prof. Tereasa Brainerd (CAS Room 515, brainerd@bu.edu, 353–6646)
Office Hours: Tues. 2:30–3:30, Wed. 2:00–3:00, Thurs. 12:00–1:00, or by appointment
Grading: Homework (50%), Midterm Examination (20%), Final Examination (30%)

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 which addresses all of the material (nor even half of the material!) that we will be covering. Instead, related reading material will come from a number of "classic" books that will be placed on reserve in the library. These books 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. I also recommend that you purchase a copy of Binney & Tremaine's book *Galactic Dynamics* since we will be making quite a bit of use of it, and it's a standard book that's good to have on your bookshelf for future reference.

Homework:

Problem sets to be done as homework will be assigned roughly every other week. Homework must be handed in **AT THE START OF CLASS** on the date which it is due. Late homework will not be accepted. Although you are encouraged to discuss potential solutions to the homework problems amongst yourselves, you must hand in your own original solution (i.e., do not simply copy another's solution or you will receive a grade of zero). In order to be graded, solutions must be **LEGIBLE**; illegible solutions will not be graded and will receive a score of zero. To receive full credit for a problem you must **SHOW** all of your work; correct final answers which do not clearly follow from correct, complete solutions will receive scores of zero.

Examinations:

All examinations will be closed book. The midterm examination will be held in class at the regular class meeting time, it will be will be 90 minutes in duration, and it **MUST** be taken in class on the date scheduled. (Actual date of the midterm exam TBA.) The final examination will be 120 minutes in duration and will be held during the University's final exam period. If you discover that you are too ill to take an exam with the class, you must notify me by telephone or email **prior to** the start of the examination **AND** you must obtain a written note from a licensed physician testifying to the fact that you are too ill to take the examination. If you do not do this, you will receive a grade of zero for the examination and will not be given a makeup exam. **All makeup exams will be oral examinations, to be taken in my office by appointment, and they must be completed within 1 week of the missed exam.**

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
- dynamical and hydrodynamical mass estimators
- N–body computer simulations

General Relativity Basics:

- the Equivalence Principle
- geodesics, metrics, and the "warping" of spacetime
- the field equations
- "Shapiro" time delay

Gravitational Lensing:

- geometry of a lens system and the non-linear nature of the lens equation
- strong versus weak lensing
- the Einstein radius and conditions for the creation of multiple images and arcs
- geometrical and Shapiro time delays in multiply–imaged systems
- practical applications of gravitational lensing

Classical Theoretical Cosmology:

- the Friedmann–Robertson–Walker metric
- equations of motion for the universe
- the connection between the dynamics of the universe and its geometry in simple universes
- simple spherical collapse models for galaxy formation