PHYS 622 (Spring 2017)
Astrophysics II: Galaxies and Cosmology
Tues & Thurs, 2:30-3:45 pm, HBH 453

Instructor: Mustafa A. Amin
email: mustafa.a.amin@rice.edu
office: HBH 364
office hrs: Thurs 4:00-5:00 pm (or by appointment)
Ph: (832) 938-5826

Course Description: This course is an introduction to modern cosmology and aspects of galaxies. On the cosmological front, you will learn about the standard cosmological model: inflation followed by a radiation, a dark-matter and finally a cosmological constant dominated universe. You will learn about (1) the interplay between the contents of the universe and its space-time dynamics, (2) about how different particle species emerge from the thermal soup after the big bang and (3) the evolution of structure in our universe: from tiny quantum fluctuations during our universe's infancy to correlated distribution of galaxies we see in the sky today. In second half of the course we will discuss galaxies in detail including our own host galaxy. We will emphasize the kinematics and dynamics of galaxies, their classifications as well as important scaling relations between observables. Throughout the course, we will emphasize the the interplay between different areas of physics in an astrophysical/cosmological setting and how our current theoretical understanding of galaxies and cosmology is firmly rooted in observations.

Learning Objectives:
By the end of the course, you (the student) should be able to to do the following:

- Describe and calculate the dynamics of the homogeneous universe, understand how the dynamics relates to its contents as well as observational probes of these dynamics.
- Be familiar with the thermal history of our universe and be able to calculate how different species of particles emerge from the thermal soup in the early universe.
- Calculate the evolution of density perturbations in our universe; from initial conditions during inflation to the present day and understand corresponding observations.
- Describe properties of our host galaxy including its morphology and kinematics.
- Understand galaxy classifications and be familiar with scaling relations between different observables of galaxies.
- Make order of magnitude estimates, apply concepts from many different areas of physics and perform detailed calculations of astrophysical/cosmological observables with an understanding of the approximations involved.

Prerequisites: A good base in electromagnetism, classical mechanics, statistical mechanics, special relativity, quantum mechanics, and of course prior exposure to astrophysics in general will be helpful. I will introduce relevant ideas as needed for (aspects of) general relativity, familiarity with GR will make your life easier. I will assume familiarity with systems of ordinary differential equations, multivariable calculus, Fourier analysis and linear algebra. Formally, for undergraduate students at Rice the prerequisites include (ASTR 350 OR ASTR 360) and (PHYS 301 and PHYS 302).

Class Website: All course materials including problem sets, links to relevant websites, supplementary material, class updates and announcements will be posted on the ASTR 452 Canvas page. It is your responsibility to check Canvas regularly for the most recent information concerning the class.

Main Text(s): I will provide hand written class notes after class. For the cosmology section, you should refer to the cosmology notes by D. Baumann which be available on Canvas. For the galaxies part, I recommend the book by Peter Schneider. The book by Schneider is recommended, but not required for you to buy.

- *Class Notes*: My hand written notes for the class will be provided after each class.
- *Cosmology Lecture Notes* by Baumann (U. of Amsterdam): We will mostly follow Baumann's notes for the cosmology part of this course, with some omissions and additions. At the minimum, you should read these notes and class notes.
- *Extragalactic Astronomy and Cosmology* by Peter Schneider: We will use this book for the galaxies part of the course. It has a good balance of relevant observational details along with the theory. It is also a gentler, less mathematical treatment for the cosmology part of the course.

Additional Resources:

- *Cosmology* by Steven Weinberg: If you want rigor, this is the place to go to. The presentation is "clean". It has most of the interesting things you can do "by hand" in cosmology. It might not be easy on the first reading but I recommend referring to it if you are confused elsewhere.
- *Physical Cosmology* by Mukhanov: I like the treatment of hydrodynamical perturbations in this book. It also has some more advanced topics relevant for the very early universe.
- *Spacetime and Geometry: An Introduction to General Relativity* by Carroll. This is an excellent textbook for GR at the graduate level.
- *Physical Cosmology* by Scott Dodelson: This is a detailed, graduate level text. It is particularly good in its detailed treatment of the cosmic microwave background.
- *An Introduction to Modern Astrophysics* by Carroll & Ostlie. Less advanced than the course, but comprehensive.

Caution: Notation varies across texts! Baumann and Mukhanov use the "mostly minus" $+---$ metric convention while Weinberg, Dodelson and Carroll use the "mostly plus" $-+++$ metric convention.

Exams and Problem Sets:
Problem sets every 1 - 2 weeks
2 Oral Exams (a Midterm and a Final)

Grading Policies: Homeworks will account for 60% of the grade and the two exam will account 20% each of the total grade. Late Homeworks are annoying. For unexcused tardiness, there will be a 20% reduction/per day in credit, with no credit 2 days after the homework is due. If illness or other circumstances beyond your control lead to a delay in submission, please contact me as soon as possible (preferably before the deadline). The final grade for the course will include some discretion based on class participation/interactions etc. Attendance is not mandatory, but highly recommended.

Collaboration and Help: For a better understanding of the material you are strongly encouraged to talk to other students, postdocs and faculty (including me!). For the problem sets, you should work on each problem independently first ($\geq$ 1 hr). When needed, get help about the general idea of how to do the problem but not the details of the entire calculation. If you collaborate/get help from others, they should be acknowledged in the problem sets along with details of what you collaborated/got help on. The write-up should always be done independently. Do not look up solutions online or from previous years. The Honor Code applies. You can review Rice's Honor Council documentation online at: honor.rice.edu/index.cfm

Special Needs: If you have a documented disability that requires special consideration for this class then please contact the me as soon as possible to discuss your needs. Students with disabilities should also contact the Disability Support Services Office in the Ley Student Center (dss.rice.edu).

Note: I reserve the right to change the contents and policies in this syllabus during the semester to suit the needs of the class.