ASTR 426: GALAXIES AND COSMOLOGY

Duncan Farrah
Fall 2024
Syllabus

Practical Details

- Instructor: Prof. Duncan Farrah
- Office: WAT 401
- Format: In person
- Times: TR 12:00 - 13:15, WAT 415
- Office Hours: Scheduled as needed.
- TA: Finn Giddings

Grading

- 60% - weekly to biweekly problem sets
- 40% - semester presentations

These contributions may be adjusted as the semester progresses, solely at the instructors discretion.

Semester Presentations

Students should self-organize into groups of 3 (at most two groups of two are allowed, depending on total class number) to give presentations to the rest of the class on assigned topics, in dedicated classes late in the semester. The groups should choose a topic by the end of week 2. Topics are first-come, first served. The complete list of topics is:

1. Potentials and orbits for axisymmetric galaxies
2. The Oort Constants
3. The Tully-Fisher relation
4. The origin of jets from AGN
5. Growing the first supermassive black holes: super-Eddington accretion vs Direct Collapse.
6. Science with the Roman Space Telescope

7. The Sunyaev-Zeldovich effect
8. From Parallax to Type 1a's: the cosmological distance ladder
9. The origin of anisotropies in the cosmic microwave background
10. A history of the Hubble constant: 1930 to 2020
11. Baryon Acoustic Oscillations

Synopsis

Studying galaxies from a physical perspective employs a wide variety of methods. Understanding the structure and dynamics of individual galaxies utilizes diverse techniques. Moreover, understanding the broader history of galaxy assembly over cosmic time is now recognized as an invaluable tool in efforts to understand the evolution of both the total mass density and expansion history of the Universe.

Turning to Cosmology: current research in Cosmology embodies a unique dissonance. On one hand, an oft-quoted phrase is that we are in a 'precision' cosmology era, where observations seek to refine measurements of key cosmological parameters. On the other, there are hints from observations and theory that we may be on the verge of a revolution in our understanding of our place in the Universe. Moreover, cosmological research offers the potential for important advances in our understanding of particle physics and the structure of matter.

This course will start from first principles to both build our modern theoretical picture of galaxy structure and dynamics, and to give students a quantitative understanding of the currently popular cosmological world model and the evidence behind it.

Learning Objectives

- Outline the observed structural parameters of galaxies, their components, and key points in their evolutionary histories.
- Explain the core motivations behind the theoretical description of galaxy dynamics, including the treatment of stars as a collisionless gas in a bound system.
- Use the formalism of a distribution function in a phase space to extract structural parameters and stellar orbits for different classifications of galaxy.
- Apply basic physical principles to understand the origin of active galaxies, including the triggers behind high rates of star formation, and the evolution of black hole powered jets.
- Outline the key observational evidence behind the modern picture of the Big Bang, the formation of galaxies and large-scale structures, and accelerating expansion.
- Explain the motivations behind the idea of inflation.
- Use the Friedmann-Lemaitre-Robertson-Walker equations to describe the dynamics of an expanding Universe

Course Text

None. I will aim to provide you with "near book level" notes by the end of the course, and will point you to other (free) resources during the course. If you are keen to buy a book then come talk to me and I'll point you at some good ones.

Special Accommodations

There are two resources available for students who may require special accommodations; the KOKUA Program, and the Counseling and Student Development Center.

The KOKUA program (http://hawaii.edu/kokua/) is the UH Mānoa office for students with disabilities. They serve undergraduate, graduate and professional students with learning, physical, psychiatric and other documented disabilities. Students with special needs or circumstances who have not already done so should contact the KOKUA program as soon as possible. Students who have accommodations from the KOKUA program should contact Dr. Farrah as soon as possible. In general, if you are a student with special needs or circumstances, if you have emergency medical information to share, or if you need special arrangements in case the building must be evacuated, please make an appointment to see Dr. Farrah as soon as possible during office hours. All discussions will be treated with the strictest confidence.

The Counseling and Student Development Center (http://www.manoa.hawaii.edu/counseling/, (808) 956-7927) offers counseling services to students no matter what is troubling them. These services include individual counseling, group counseling, couples therapy, and career counseling. If you are feeling stressed or overwhelmed, or struggling to deal with events in your personal or family life, then the CSDC is here to help. Feeling stressed and overwhelmed when you first come to university, or even after having been here for a few years, is common, and there are people and resources to help you through. Steps can also be taken to help minimize the impact of life events on academic performance. Counseling sessions are treated in the strictest confidence. If you wish, you can also discuss anything along these lines with Prof. Farrah, again in strict confidence.

Discrimination and Harassment

The diversity of students and staff that contribute to this class is a core strength that is critical to its educational mission. Every member of the class is expected to contribute to an inclusive and respectful culture. Dimensions of diversity can include sex, race, age, national origin, ethnicity, gender identity and expression, intellectual and physical ability, sexual orientation, income, faith and non-faith perspectives, socio-economic status, political ideology, education, primary language, family status, military experience, cognitive style, and communication style. The individual intersection of these experiences and characteristics build to form a valuable and positive educational environment.

If there are aspects of the design, instruction, and/or experiences within this course that result in barriers to your inclusion or accurate assessment of achievement, please notify Dr. Farrah as soon as possible. Any student who believes they have been subject to discrimination or harassment on any of these grounds should contact the relevant university body. A complete listing is available at: http://manoa.hawaii.edu/dps/support.html. They may also contact Dr Farrah.

A Special Note on Title IX

Title IX of the Education Amendments (1972) prohibits discrimination on the basis of sex in any educational program or activity that receives federal financial assistance (20 U.S.C. § 1681(a)). Title IX prohibits sexual harassment. This includes sexual assault, sexual violence, relationship (domestic /dating) violence, stalking or other sexual misconduct. Further details can be found at: https://manoa.hawaii.edu/titleix/

The Violence Against Women (VAWA) Reauthorization Act (2013), also prohibits sexual assault, domestic violence, dating violence, and stalking. This federal legislation is sometimes referred to as the Campus Sexual Violence Elimination (SaVE) Act.

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. The University of Hawaii is required by Federal Law to handle such assault cases.

If you or someone you know has been harassed or assaulted, then please contact the UH Title IX coordinator, via: https://manoa.hawaii.edu/titleix/

Some external resources on Title IX (their inclusion here is not intended as any form of formal endorsement):

http://knowyourix.org/

http://endrapeoncampus.org/

http://survjustice.org/

http://clerycenter.org/

https://www.notalone.gov/