PHYS 431/531
Galactic Astrophysics
Fall 2021

Instructor:	Prof. S. McMillan (Disque 815, x2709)
Time and place:	TuTh 5:00–6:20, Disque 919, or `https://drexel.zoom.us/my/slm23`
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Course Overview

Galaxies are among the most spectacular objects in the night sky. These huge collections of stars, gas, dust, and dark matter trace out the structure of the universe on the largest scales, and each represents a complex and dynamic "ecosystem" in which stars form, evolve, and interact with their environment. The goal of this course is to present an introduction to the processes responsible for the formation, structure, evolution, and present-day appearance of the Milky Way and other galaxies. Using the Milky Way as a guide, we will develop analytical and numerical tools to help us understand of the properties of galaxies near and far. For the most part, these tools will be based on familiar concepts in classical mechanics and thermodynamics.

Course Outline

The course material will include the following topics:

- **Stars and Stellar Evolution [1 week]**
  - review of stellar properties
  - review of stellar evolution
  - the stellar mass spectrum
- **Star formation and the Interstellar Medium [2 weeks]**
  - properties of interstellar matter
  - molecular clouds and cloud complexes
  - Jeans instability
  - competitive accretion and radiation processes
- **Galactic Structure and Dynamics [4 weeks]**
  - kinematics of the disk, bulge, and halo
  - motion in a general potential field
  - the 2-body problem
  - the many-body problem: the virial theorem
  - relaxation: collisional and collisionless systems
  - globular clusters and the Galactic spheroid
  - 21 cm observations and the Galactic disk
  - the Galactic rotation curve and dark halo
  - the Galactic nucleus and central black hole
  - dynamical friction

- **Galaxy Formation and Evolution [3 weeks]**
  - the Hubble sequence
  - quantifying galaxy properties
  - cosmological context
  - growth of structure in the universe
  - galaxy interactions and star formation
  - galaxy mergers and growth
  - supermassive black holes in galaxies

Learning Outcomes

On completing this course, students should be able to

- explain in general terms how cosmic distances are measured,
- outline the key features of stellar evolution, and explain how stellar properties are used to probe galactic structure and history,
- discuss the process of star formation and how it couples to the interstellar medium,
- describe the large-scale structure of the Milky Way Galaxy,
- explain the dynamical and compositional differences between the disk, bulge, and halo of our galaxy.
- explain how galaxies form and evolve in a dynamic universe,
- describe how mergers of galaxies are coupled to the formation of black holes and stars.

Textbooks

The principal text for this course is *Galaxies in the Universe*, second edition, by Linda Sparke and Jay Gallagher (Cambridge University Press, 2007). This advanced undergraduate text provides excellent discussions of galaxy properties and current research, as well as providing good introductions to many of the theoretical issues involved. However, the scope and level of this course mean that we may supplement this text at times with the following:

- *Galactic Dynamics*, second edition, by James Binney and Scott Tremaine (Princeton University Press, 2008). The definitive graduate-level theoretical text in the field. An excellent reference, with many technical details and important theoretical insights, but a little inaccessible for an introductory course.

Selected material may be drawn from these texts, and will be distributed in class as needed. All handout material should be regarded as required reading.

Evaluation

The final grade for the course will be based on

1. a mid-term examination (30% of the total), tentatively scheduled for Tuesday, October 26 (week 6),

2. a final examination (30%), to be held during finals week, and

3. approximately 6 homework assignments completed during the quarter (40%).

The homeworks will be similar but not identical for the undergraduate and the graduate versions of the course, with some additional problems intended for graduate students only. Some of the homeworks may include computing assignments, in which you will be expected to write a program (in the language of your choice) to solve a physical problem. Assignments will be due one week after they are distributed. Late homeworks will receive reduced credit, at a rate of roughly -10% per week late. Homeworks turned in after they are discussed in class (about 2 weeks after they are due) or after the final examination will receive zero credit.

Drexel Learning Priorities

- Information Literacy - Possess the skills and knowledge to access, evaluate and use information effectively, competently and creatively.
- Technology Use - Make appropriate use of technologies to communicate, collaborate, solve problems, make decisions, and conduct research, as well as foster creativity and life-long learning.
- Professional Practice - Apply knowledge and skills gained from a program of study to the achievement of goals in a work, clinical, or other professional setting.

University Policies

Please refer to Drexel's academic dishonesty policy:

`http://drexel.edu/provost/policies/academic_dishonesty/`

and disability and course-drop policies:

`http://drexel.edu/oed/disabilityResources/overview/`
`http://www.drexel.edu/provost/policies/course_drop/`