ASTR 3500: Galaxies and Cosmology (fall)

Calendar description: This course deals with an extremely broad area of astrophysics covering seven or eight orders of magnitude in length scale. Topics in galactic dynamics include the kinematic properties of nearby stars, galactic rotation, spiral structure. The formation of the Milky Way is discussed in the context of general galaxy formation. Extragalactic topics include the classification of galaxies, galactic formation and evolution, galaxy clusters, large scale structure of the universe, and modern cosmology including observational tests of various cosmological models.

Contents

Overview

This is the only course in the programme dedicated to topics in extragalactic astronomy and cosmology. The subject is so vast and growing so rapidly that it would be easy to turn this course into a survey course, particularly in the area of cosmology. Instead, it is hoped that the instructor will pick and choose a representative sample of topics from both galaxy formation and structure and cosmology and concentrate on those, without trying to cover all subjects thoroughly.

This course is cycled with ASTR 3400 (Interstellar Matter and Stellar Evolution).

Prerequisites

ASTR 2400 Properties of Stars

Students bring from ASTR 2400 a good familiarity with stellar properties (*e.g.*spectral types), stellar evolution (*e.g.*the Main Sequence lifetime of stars of various spectral

types), stellar clusters, orbital motion, and blackbody radiation.

The level of calculus and physics (including thermodynamics) required by the student is no more than at the first-year level.

Dependent courses

none

Student Outcomes

The overall aim of ASTR 3500 is to provide students with an understanding of the physics governing the formation of galaxies, as well as what drives the internal structure of various galaxy types. The student should also gain an appreciation of current ideas on how the universe came into being, and that the area of cosmology is as active and controversial today as it has always been.

Typical problems and questions a student completing ASTR 3500 should be able to answer include:

1. What is the structure and size of the Galaxy, and how do we know?
2. How is a galaxy rotation curve measured and what does it tell us?
3. Compare and contrast the various galaxy Hubble types.
4. Describe the current theories of galaxy formation and the evidence in support of them.
5. Describe the extragalactic distance scale ladder.
6. Describe properties of galaxy clusters and explain how we determine them.
7. Describe the standard Big Bang model and the evidence for it.
8. Explain the process of Big Bang nucleosynthesis of lighter elements.
9. Explain what inflation is and the evidence we have that the universe is in an accelerating phase.

Curriculum

1. the Milky Way galaxy
    - morphology
    - kinematics
2. the nature of galaxies

- the Hubble sequence
- spirals and elliptical
- spiral structure

3. galactic formation and evolution
4. the structure of the universe
   - the extragalactic distance scale
   - expansion of the universe
   - clusters of galaxies
5. active galaxies
   - observations
   - unified model
6. cosmology
   - Newtonian cosmology
   - simplified relativistic treatment
   - the accelerating universe
   - cosmic microwave background
   - cosmological tests
7. the early universe
   - the four eras
   - cosmic nucleosynthesis
   - inflation as a solution to the shortcomings of the standard Big Bang model

Suggested texts

1. *An Introduction to Modern Astrophysics* by Carroll and Ostlie (ISBN) has traditionally been used for this course and follows the curriculum well. The relevant chapters are 24–30, inclusive. This text is practical only if it is adopted for the other advanced courses in ASTR as well, but is inappropriate for this course alone as its scope is far beyond what this course needs.

2. *Galaxies in the Universe* by Sparke and Gallagher (ISBN 978-0-521-67186-6) may be more concise and relevant than Carroll and Ostlie and is the recommended text by the Curriculum Committee.

3. *Extragalactic Astronomy and Cosmology* by Schneider (ISBN 3-540-33174-3) is concise and up-to-date.

Notes to the instructor

1. Ryden's *Introduction to Cosmology* is a useful textbook for instructors needing a cosmology refresher.

2. If Carroll and Ostlie is to be used for this course, it is highly recommended that the instructor consult with other instructors of advanced ASTR courses to see if they will also be using this text. If not, asking the student to purchase this very expensive and expansive text for this course alone is discouraged.