

Extragalactic Astrophysics: Course Syllabus

Course Information

Course Number: PHYS4392
Course Title: Extragalactic Astrophysics
Semester: Spring 2020

Professor and TA Contact Information

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Course Pre-requisites, Co-requisites, and/or Other Restrictions

Prerequisites: MATH 2419 (Calculus II) or MATH 2414 (Integral Calculus) or equivalent. Familiarity with basic mathematics including algebra, geometry, trigonometry and basic integral and differential calculus is assumed.

Course Description

This course gives an introduction to **extragalactic astrophysics**, and applying basic principles of physics to astronomical observations of objects and phenomena primarily outside our Milky Way.

Preliminary list of topics:

(I) Basics of astronomy, astrophysics and cosmology

- Overview of the cosmological model: the expanding Universe and Λ CDM paradigm; observational probes of cosmology; homogeneity and isotropy

- Our place in the Universe: the Milky Way Galaxy and Local Group
- The distance ladder: determining distances in our Galaxy and on extragalactic scales

(II) The zoo of galaxies in the Universe

- The constituents of galaxies: dark matter, gas and stars
- Elliptical galaxies, Spiral galaxies, Dwarf galaxies
- Computer simulations and theory of galaxy formation
- Searching for the most distant galaxies in the Universe

(III) Galaxy clusters

- The constituents, observations and physics of galaxy clusters
- Galaxy clusters as cosmological probes

(IV) Gravitational lensing

- An overview of strong and weak gravitational lensing theory and observations
- Production of multiple, magnified, images of distant sources – the lens equation; analytic solution of lens equation for strong lensing by point masses and by simple models of galaxies and clusters
- Gravitational lensing as a natural telescope
- How to map dark matter: theory and practical application of weak lensing by galaxy clusters

(V) Exotic objects: physics and observations

- Black holes: their formation, physics and observational evidence
- Active galactic nuclei: e.g. radio galaxies, quasars
- Gravitational waves as a window on compact objects: observed systems; theoretical expectations; current and future detectors

(VI) The Cosmic Microwave background

(VII) Future astrophysics: probing cosmic dawn using the 21cm emission from redshifted hydrogen

The course will also provide an introduction to the critical reading of scientific papers, and give experience of team work, and preparing a short report and presentation on a mini literature review or mini research project.

A broad range of choice of topics for the literature review or research project will be suggested in class, or can be agreed on from student suggestions.

Student Learning Objectives/Outcomes

The primary objectives of the course are for the student to:

Gain insight into the physics underlying astrophysical phenomena and objects.

Become familiar with basic principles and tools of astronomy.

Obtain a basic knowledge of cosmology, the framework of the Universe.

Related to this, understand how the composition and dynamics of the universe are derived from astronomical observations.

Be aware of our place in the universe, the main properties of our Milky Way Galaxy and of our local group of galaxies.

Explore the zoo of galaxies in the universe – the constituents of galaxies and broad properties of different types of galaxies and their underlying stellar populations. Understand how dark matter is revealed and weighed in galaxies, e.g. using gravitational lensing.

Become familiar with the multi-wavelength properties of galaxies and galaxy clusters, and how we study galaxy clusters and use them as cosmological tools.

Learn the basics of gravitational lensing by massive objects in the Universe. Be able to solve the lens equation (in this case a quadratic equation) for point masses and other simple lenses, to show that multiple images or Einstein rings can be produced. Develop a basic understanding of weak lensing, in order to determine the quantitative appearance of weakly lensed galaxies compared with their unlensed appearance. Qualitatively appreciate one mechanism for analyzing these weakly lensed galaxies to produce maps of mass for galaxy cluster lenses.

Learn how we find and study distant galaxy populations, the most distant galaxies in the universe representing progenitors of our Galaxy and the galaxies that we see locally.

Understand the basic physical properties of black holes, quasars and other exotic objects, and the observational constraints on their physics.

Develop a basic understanding of the production and detection of gravitational waves from binary compact objects. Become familiar with the current status of observations by gravitational wave detectors, and future plans.

Become familiar with the main physical processes giving rise to the Cosmic Microwave Background (CMB), understand the quantitative representation of the temperature fluctuations on different scales, and the key information contained in CMB data about the early and late Universe.

Understand how we will use new windows on the universe (i) 21cm emission; (ii) gravitational waves.

Additional learning objectives are to:

Develop skills in critically reading scientific papers.

Develop research and team work skills by carrying out a short review or research project. Develop communication skills by writing a short report and giving a presentation and a summary of your findings.

Required Textbooks and Materials

There are no mandatory textbooks for the course. Two textbooks that may be very helpful are:

“Extragalactic Astronomy and Cosmology” by Peter Schneider

“An Introduction to Modern Astrophysics” by Bradley Carroll & Dale Ostlie

Suggested Course Materials

Other resources are discussed in the first class, and outlined on the first set of notes on eLearning. Further resources are discussed as class progresses.

Assignments & Academic Calendar

Class announcements will be sent out on eLearning that is available on the UTD home page. Your UTD user NET ID and password will give you access to this. You are expected to check this site at least twice a week. Assignments will be posted on eLearning.

Grading Policy

Grades will follow the usual UTD scale. The contribution of each component of the course to the final grade is as follows:

Homework assignments: 15%

Mini research project/review individual report and group presentation: 35%

Midterm exam: 10% (Date and location TBD)

Final exam: 35% (Date and location TBD)

Class participation: 5%

Course & Instructor Policies

Class attendance and participation is expected, and 5% will be allocated to class participation (including quizzes). The class will start promptly at 10:00 and end shortly before 11:15.

Comet Creed

This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

“As a Comet, I pledge honesty, integrity, and service in all that I do.”

UT Dallas Syllabus Policies and Procedures

The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus. Please go to <http://go.utdallas.edu/syllabus-policies> for these policies.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.