AS 413 – Extragalactic Astrophysics & Cosmology
Fall 2018, TR 11:00 am – 12:15 pm, CAS Room 502
`http://firedrake.bu.edu/AS413/AS413.html`

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Office Hours: Mon. 9:00am–10:30pm, Weds. 3:30pm–5:00pm, and by appointment

This course serves as an introduction to advanced topics in extragalactic astronomy (astronomy outside of the Milky Way) and cosmology (the study of the universe as a whole). Galaxies are the fundamental building blocks of the universe; i.e., they are the basic bricks out of which the structure of the universe is assembled. Therefore, it is natural to combine studies of the present-day properties of galaxies, as well as theories of their formation and evolution, with studies of cosmology in order to gain an understanding of how the universe came to be as we currently observe it. Particular emphasis will be placed on the use of modern extragalactic observations to constrain theories of the origin and nature of the universe. In addition to topics which are well–understood, we will also discuss a number of the current unanswered questions in modern cosmology and how the answers to these questions may ultimately shape our theories of the origin and evolution of the universe.

Pre–requisites and Expectations:

AS413 is intended primarily for junior and senior concentrators in Astronomy, Astronomy & Physics, and Geophysics & Planetary Sciences. Students are expected to have completed the astronomy, physics, and mathematics requirements of their respective programs through the sophomore year. The formal pre–requisite classes are **AS312** and **PY355**. Students are expected to have a good working knowledge of the material in these courses and to be able **to apply** that knowledge to this class, particularly when it comes to solving problems. In the latter half of the course there will be a fair amount of differential and integral calculus required to solve the problems, and students will be expected to perform these calculations without having been shown examples of the necessary mathematical techniques in an AS413 lecture. **Please note that, unless a problem specifically states otherwise, tables of integrals and symbolic integrators MAY NOT be used to solve homework problems. Also, in order to receive full credit for a solution, students must always show ALL of their work, and each line of a solution must follow logically from the line above.** Students who have not fulfilled the pre–requisites by completion of AS312 and PY355 may not enroll in AS413. Students who have earned grades lower than “C” in either one of these courses are cautioned that they are likely to find AS413 quite challenging and should expect to devote considerable time outside of class to complete the homework assignments and to prepare for the examinations.

†My office is not accessible by elevator. If you have a physical challenge that prevents you from climbing a flight of stairs, just let me know and I'll be happy to meet up in person in a different location that does not require climbing stairs.

††I read email all day long during the week, and often check it several times a day on weekends. However, students should not depend on a reply to an email from me at any time other than during normal business hours (9:00 am to 5:00 pm), Monday through Friday.

Academic Conduct:

Students are expected to know and understand the Academic Conduct Code. A copy of the Academic Conduct Code, is posted at `http://www.bu.edu/academics/resources/academic-conduct-code/` . Cases of suspected academic misconduct (e.g., plagiarism or cheating on examinations will be referred to the CAS Dean's office.

Textbook:

The textbook recommended for the course is *Extragalactic Astronomy & Cosmology, An Introduction (2nd Edition)* by Peter Schneider. Copies of this book are available at the BU bookstore.

Grading:

The course grades will be determined by weighting scores as follows:

Homework Problem Sets (due approximately weekly, lowest 2 scores dropped) – 35%
Midterm Exams (Oct. 4 & Nov. 15, 17.5% each) – 35%
Final Exam – 30%

Homework:

Problem sets to be done as homework will be assigned roughly once a week. Homework must be handed in **at the start of class** on the date which it is due. Late homework will not be accepted. Although students are encouraged to discuss potential solutions to the homework problems amongst themselves, each student must hand in her or his own original solution (i.e., students who simply copy another's solution will receive a grade of zero for that problem). Illegible solutions will receive a grade of zero. All solutions must be written in (graphite) pencil, blue ink, or black ink. Solutions written in red ink or colored pencil will receive a grade of zero. **Solutions for each problem must be written on separate pieces of paper, and on only one side of the paper. When a long solution is necessary for a particular problem, multiple one–sided pages must be used. All pages must be stapled together prior to handing in the solutions.** Solutions which violate these requirements will receive a grade of zero.

Examinations:

All examinations will be closed book. The two midterm examinations will be held in class at the regular class meeting time, they will be 75 minutes in duration, and they **MUST** be taken in class on the dates scheduled. If you discover that you are too ill to take a midterm exam with the class, you must notify me by telephone or email **prior to** the start of the examination. If you do not do this, you will receive a grade of zero for the examination and will not be given a makeup exam. **All makeup midterm exams will be 75 minute ORAL examinations, to be taken in my office by appointment and they must be completed within 1 week of the missed exam. The final examination will be held at the time scheduled by the university The date and time of the final examination cannot be altered for any reason.**

Grading Rubric

100% - perfect solution

95% - very minor mathematical errors or the solution is slightly incomplete

80% - problem is set up correctly, the right approach to the solution is demonstrated, but the solution has mathematical errors or is somewhat incomplete

65% - solution demonstrates some understanding of the problem and the path to the solution, but with significant limitations or errors (mathematical or conceptual)

50% - solution demonstrates weak understanding of the problem with little demonstration of the path to the solution

35% - solution demonstrates only minimal understanding of the problem and its solution

0% - solution demonstrates no understanding of the problem, or is left blank

Course Outline

Physical cosmology; Meaningless questions; Olbers' Paradox; Hubble's Law; the Cosmological Principle

Normal Galaxies: Morphological classification; Physical properties; Stellar content; Interstellar media; Integrated light profiles; Luminosity function; Masses and mass distribution; Spiral arms

The Expanding Universe: Redshifts; the distance ladder; Cosmic Microwave Background Radiation; Predictions of the Hot Big Bang and observational support

The Lumpy Universe vs. the Cosmological Principle: Groups, clusters, and superclusters of galaxies; "walls" and "voids"; density-morphology relation for galaxies; the autocorrelation function

Clues toward the History of Galaxy Formation: the universe as a time machine; Galaxy counts and the "faint blue excess" population; Redshift distribution of galaxies; Epoch of galaxy formation; Role of mergers in determining galaxy morphology; High versus low redshift clusters; Biased galaxy formation

Peculiar Galaxies: Interacting systems; Active galaxies; Quasars

General Relativity Basics: the Equivalence Principle; Curved space-time; Gravitational lenses; Robertson-Walker metric; Newtonian and relativistic cosmology

Cosmological Models: the density parameter, Ω; Einstein-de Sitter universe; Friedmann-Le Maître universe; horizons; lookback times; ages; distances in cosmology; Dark Energy

Big Bang Cosmology: Radiation and matter dominated eras; Primordial nucleosynthesis; Small-scale anisotropies in the CMBR and the formation of galaxies

The nature of the ubiquitous dark matter and the role of computer simulations in constraining structure formation theories