Physics 444 Introduction to Cosmology

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Overview: Cosmology is the study of the origin and evolution of the Universe. As such, it is a big (and exciting) topic, employing a wide range of physics, both theoretical and experimental. Cosmology has deep ties both to astrophysics, as many cosmologically important observations of celestial objects must be interpreted through the prism of astrophysics, and to fundamental physics, since the form our Universe displays is determined by gravitation, particle physics, nuclear physics, and thermodynamics. These various physical processes have come together into a simple "concordance (or standard) model" of cosmology which makes detailed predictions of a wide range of observable phenomena. Yet problems remain, some quite challenging, which keeps research in cosmological areas vibrant and stimulating.

This is an thrilling time in cosmology. Technological advances over the past decade have made possible an array of observations which strongly constrains the properties of the Universe. The discovery that the expansion of the Universe is accelerating presents a great challenge to high-energy physicists to explain the source and nature of the mysterious "dark energy" which is likely driving this expansion. The Sloan Digital Sky Survey has observed more than a quarter of the sky, detecting nearly 200 million celestial objects and measuring spectra of more than 675,000 galaxies, 90,000 quasars, and 185,000 stars. Wide-coverage gravitational lensing surveys are probing the distribution of mass in the Universe. And last, but not least, measurements of the Cosmic Microwave Background, notably the results from the WMAP satellite, have yielded values for cosmological parameters with an accuracy of several percent. After spending decades in what cynics called "an attempt to measure two numbers" (the Hubble constant and the deceleration constant), we are now in the age of "precision cosmology".

In this class we will develop an understanding of the standard model and show how much of the deluge of observational data are consistent with that model. We will also examine lingering trouble spots (some possibly quite significant) and explore how cosmology can be used as a tool for probing fundamental physics and astrophysics.

Lectures: Tuesday and Friday, 3rd period (12:00 - 1:20 PM for Busch Campus), Hill 009.

Home page: http://www.physics.rutgers.edu/ugrad/444/

Text: *Introduction to Cosmology*, B. Ryden, 2003, Addison Wesley. This book is a good, unfortunately not quite up-to-date undergraduate cosmology text. It includes material on the accelerating universe, but not the results from WMAP.

The text has an annotated bibliography giving other useful references. I would rank Peacock's book as "advanced" rather than "intermediate." I have placed the text and Harrison's *Cosmology: The Science of the Universe* on reserve in the Physics Library. Two other potentially useful books are:
Modern Cosmology, S. Dodelson, 2003, Academic Press. An excellent book with a focus on the microwave background. Graduate level.

First Principles of Cosmology, E. V. Linder, 1997, Prentice Hall. Is a nice, concise undergraduate-level overview of some major areas of cosmology, with an emphasis on nucleosynthesis, the microwave background, and large-scale structure.

Office hours: Wednesday: 3:30 - 4:30 Also feel free to contact me by email or phone to set up a time to drop by my office.

Homework and Grades: Your grade will be based on about seven problems sets (70%) and about two larger numerical assignments (30%). The problem sets will be handed out one week and due the next. You will have more time for the larger assignments. Sets handed in after I have posted solutions cannot receive credit.

Students with Disabilities: If you have a disability, you are urged to speak to me early in the semester to make the necessary arrangements to support a successful learning experience. Students with disabilities should consult the webpage:
http://www.physics.rutgers.edu/ugrad/disabilities.html.

Class Calendar:

Date	Topic	Chap
Tu Sept 2	Introduction to Cosmology	1
Fr Sept 5	Fundamental Observations	2
Tu Sept 9	″ ″	2
Fr Sept 12	Gravity and Curvature	3
Tu Sept 16	″ ″	3
Fr Sept 19	Cosmic Dynamics	4
Tu Sept 23	″ ″	4
Fr Sept 26	Dynamics and Simple Universes	4 & 5
Tu Sept 30	Single-Component Universes	5
Fr Oct 3	Single- and Multiple-Component Universes	5 & 6
Tu Oct 7	Multiple-Component Universes	6
Fr Oct 10	NO CLASS	
Tu Oct 14	. . . and the Benchmark Model	6
Fr Oct 17	Measuring Cosmological Parameters	7
Tu Oct 21	″ ″	7
Fr Oct 24	″ ″	7
Tu Oct 28	Dark Matter	8
Fr Oct 31	″ ″	8
Tu Nov 4	Cosmic Microwave Background	9
Fr Nov 7	″ ″	9
Tu Nov 11	″ ″	9
Fr Nov 14	Nucleosynthesis	10
Tu Nov 18	Nucleosynthesis and Baryogenesis	10
Fr Nov 21	Inflation and the Very Early Universe	11
Tu Nov 25	**No Class** CHANGE IN CLASS DAY	
We Nov 26	Inflation and the Very Early Universe	11
Fr Nov 28	**No Class** (Thanksgiving)	
Tu Dec 2	Formation of Structure	12
Fr Dec 5	″ ″	12
Tu Dec 9	″ ″	12