

Mondays 4-5:45 pm and Fridays 3:30-5:15 pm in ISB 231

(+ possible additional times to be determined)

Instructor: Joel Primack – office hours: Thurs 2-3:30 pm or by appointment

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Introduction to the cosmology and particle physics of the early universe and the formation of galaxies and large scale structure, including relativistic cosmology, initial conditions, inflation and grand unified theories, baryogenesis, nucleosynthesis, gravitational collapse, hypotheses regarding the dark matter and consequences for formation of galaxies and large scale structure, and the evolution of galaxies and their contents. Students will be expected to do several homework assignments, and also a term project. (Also offered as Astronomy and Astrophysics 224.)

We will not follow any one textbook, but for your convenience the following books have been ordered at Bay Tree Bookstore (they have used copies for less than the list prices):

Peter Schneider, *Extragalactic Astronomy and Cosmology: An Introduction* (Springer, 2006) \$69.95 (used \$52.50)

Viatcheslav Mukhanov, *Physical Foundations of Cosmology* (Cambridge University Press, 2005) \$80 (used \$60)

Scott Dodelson, *Modern Cosmology* (Academic Press, 2003) \$75.95 (used \$56.95)

E. W. Kolb and Michael Turner, *The Early Universe* (Addison Wesley, 1993) \$59 (used \$44.25)

Other good textbooks at roughly the same level include the following, which can be ordered from Amazon or Barnes & Noble (prices are for the paperback, if available):

Bailin and Love, *Cosmology in Gauge Field Theory and String Theory* (Institute of Physics Publishing, 2004) \$55

Liddle and Lyth, *Cosmological Inflation and Large-Scale Structure* (Cambridge University Press, 2000) \$40

Padmanabhan, *Structure Formation in the Universe* (Cambridge University Press, 1993) \$53

Padmanabhan, *Theoretical Astrophysics Vol. III: Galaxies and Cosmology* (Cambridge University Press, 2003) \$60

Peacock, *Cosmological Physics* (Cambridge University Press, 1999) \$55

Peebles, *Principles of Physical Cosmology* (Princeton UP, 1993) \$36

Ryden, *Introduction to Cosmology* (Addison Wesley, 2002) \$57

I will also hand out some lectures and papers and other selected readings. Lectures and selected readings will be posted at physics.ucsc.edu/~joel/Cosmology224 and general information will be at the webpage for this course <http://physics.ucsc.edu/~joel/224.html>

Topics (not necessarily in order of discussion in class):

I. Standard Modern Cosmology

1. History of dark matter
2. Homogeneous (Friedmann-Robertson-Walker) cosmologies, cosmological thermodynamics
3. Big bang nucleosynthesis; the Boltzmann equation; baryon, neutrino, and WIMP abundances
5. Structure formation: power spectra and evolution of density inhomogeneities; linear theory; nonlinear approximations: spherical collapse, Zel'dovich approximation
6. Cold dark matter theory and variants vs. data: galaxies, clusters, and large scale structure; Press-Schechter, Extended PS; simulations
7. Dark matter halo structure and substructure; halo shapes; angular momentum issues
8. Galaxy evolution, including hydrodynamics (heating and cooling, star formation, and feedback) and effects of active galactic nuclei; simulations and semi-analytic models vs. observations
9. Probes of inhomogeneities in the universe: CMB, clustering, lensing, morphology

II. Early Universe Cosmology

1. Inflation and dark energy/"quintessence"
2. Cosmic microwave background (CMB), effects of various cosmological parameters
3. Particle physics and detection of dark matter candidates: Axions, WIMPs, etc.
4. Phase transitions in the early universe: walls, strings, and monopoles
5. Baryogenesis (creating slightly more matter than antimatter)
6. Toward the Planck epoch

The topics in part II are listed roughly in order of increasing use of speculative particle physics theory. The order of discussion in class and the relative emphasis on each topic will depend on the level of student interest.

Some of these topics will be covered in your term projects rather than my lectures. I'll hand out a list of suggested term projects soon.