Physics 224 **Origin and Evolution of the Universe** Spring 2014

Tuesday-Thursday 12:00-1:45 pm in ISB 231

Instructor: Joel Primack – office hours: Thurs 2:00-3:00 pm or by appointment
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Catalog Description: Introduction to the particle physics and cosmology of the very early universe: 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. Offered in alternate academic years.

Students will be expected to do several homework assignments, and also a term project to be presented orally at the end of the course. Lectures and homework will be posted at physics.ucsc.edu/~joel/Phys224 . We will not follow any one textbook, but I particularly recommend Abraham Loeb, *How Did the First Stars and Galaxies Form?* (Princeton University Press, 2010) and Scott Dodelson, *Modern Cosmology* (Academic Press, 2003), which I have asked Bay Tree Bookstore to order.

Here's a list of other good books, most of which you can get online cheaply:

E. W. Kolb and Michael Turner, *The Early Universe* (Addison Wesley, 1993)

Edward Harrison, *Cosmology: The Science of the Universe* (Cambridge, 2000)

A. Liddle, *An Introduction to Modern Cosmology* (Wiley, 2003) (elementary)

V. F. Mukhanov, *Physical Foundations of Cosmology* (Cambridge University Press, 2005) (advanced)

T. Padmanabban, *Structure Formation in the Universe* (Cambridge University Press, 1993) (includes some detailed derivations)

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

J. Peacock, *Cosmological Physics* (Cambridge University Press, 1999)

P. J. E. Peebles, *Principles of Physical Cosmology* (Princeton UP, 1993)

B. Ryden, *Introduction to Cosmology* (Addison Wesley, 2002) (pretty elementary)

P. Schneider, *Extragalactic Astronomy and Cosmology: An Introduction* (Springer, 2010)

Steve Weinberg, *Cosmology* (Oxford UP, 2008) (magisterial)

Topics (more or less in order of discussion in class, depending on student interests):

1. Historical introduction: history of dark matter; general relativity and cosmology

2. Homogeneous (Friedmann-Robertson-Walker) cosmologies, cosmological thermodynamics

3. Big bang nucleosynthesis; the Boltzmann equation; baryon, neutrino, and WIMP abundances; Dark matter candidates particle physics and detection: WIMPs, axions, sterile neutrinos, etc.

4. Structure formation: power spectra and evolution of density inhomogeneities; linear theory; nonlinear approximations: spherical collapse, Zel'dovich approximation

5. Cold dark matter theory and variants vs. data: galaxies, clusters, and large scale structure; Press-Schecter, Extended PS; cosmological simulations

6. Dark matter halo structure and substructure; halo shapes; angular momentum issues

7. Galaxy evolution, including hydrodynamics (heating and cooling, star formation, and feedback) and effects of active galactic nuclei; galaxy simulations and semi-analytic models vs. observations

8. Probes of inhomogeneities in the universe: Cosmic microwave background (CMB), clustering, lensing

9. Phase transitions in the early universe: walls, strings, and monopoles; Inflation and dark energy; Baryogenesis (creating slightly more matter than antimatter)

10. Student presentations