Syllabus for Particle Astrophysics and Cosmology.
Spring Term 2013
M.W.F. 11:00 → 11:50. 300 OEH.

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This class is tailored to the wide audience of graduate students as a detailed survey of the interplay between astrophysics, particle and nuclear physics and cosmology. A familiarity with quantum mechanics, electromagnetism and statistical mechanics is assumed. Topics covered: Early Universe cosmology, thermal history, Big Bang Nucleosynthesis. Dark Matter and Dark energy cosmic microwave background and structure formation. Particle physics in stars: supernovae, neutron stars and white dwarfs.

Content:

1) **The expanding Universe:** The Hubble expansion, Newtonian description and Friedmann equations. A brief excursion into General Relativity, metrics, geodesics, curvature and Einstein equations. Gravitational Lensing as a probe of Dark Matter. Friedmann equations revisited: sources of energy and momentum. Covariant conservation laws. Observed energy densitities, the age of the Universe, deceleration, acceleration and a cosmological constant. Dark Energy and Dark Matter.

2) **Particles and fields: the standard model of particle physics:** the building blocks. Fermions and Bosons: spin and statistics. Quarks, leptons and vector bosons. Interactions: cross sections. Symmetries: CP, T and CPT, C and P and CP violation: baryon asymmetry. Statistical Mechanics + Particle Physics = thermal history of the Universe. Big Bang Nucleosynthesis. Scalar fields and inflation a brief exploration. Cosmic neutrinos.

3) Structure formation: Fluid perturbations: pitting gravity against pressure: Jeans instability, including expansion. Growth of structure: Cold, Warm and Hot dark matter. Particle physics candidates. Free streaming and power spectra. Where did fluctuations come from?: inflation and the seeds of galaxies: a brief report. Cosmic microwave background: peaks and valleys tell a tale: COBE, WMAP and the inflationary smoking gun.

3) **Particle Physics and Stellar Evolution:** A crash course in stellar evolution. Hydrogen burning: the p-p chain, neutrinos from the sun don't sum!!. Neutrino oscillations and the MSW effect: new physics beyond the standard model. On to Helium burning, carbon, oxygen, electron degeneracy: white dwarfs, SNIa supernovae as ``standard candles''. Up along the binding energy curve: iron is hard core but not hard enough, core collapse SNII. Neutrinos fly away, SN1987 A: a good catch!. Neutron Stars and Black Holes.

BOOKS SUGGESTED:

I will mainly follow the excellent books: Particle Astrophysics by Donald Perkins, and Cosmology and Particle Astrophysics, by L. Bergstrom and Ariel Goobar, The former one is a somewhat more elementary and perhaps more pedagogical survey, the latter gives a more thorough description of GR + Particle Physics.