Aug. 2014

PHY 613, Advanced Theoretical Particle Physics, Fall 2014

Instructors: Profs. R. Essig, P. Meade, and R. Shrock

Meeting Times: Mon. 5-8 pm in Rm. P-129. (The first lecture is on the first day of classes, Aug. 25.)

Prerequisites: The course prerequisites include a working knowledge of quantum field theory and the Standard Model (SM), as covered in the PHY 610, 611, 612 sequence at Stony Brook. If a student has equivalent preparation as part of an M.A. or M.S. degree, this should be acceptable; the student should check with the instructors.

Course materials: The course does not have a formal textbook but the book P. Langacker, *The Standard Model and Beyond* is useful for background.

Grading: The course requirements include homework and a final exam. The grade is based on homework, the final exam, and class participation. This course should help advanced students move into thesis reseach projects and/or broaden their knowlege of particle physics. We strongly encourage interested students to register for this class, rather than auditing it.

Topics: The course will cover topics from the list below:

- Models of quark and charged lepton mass matrices and comparison with data on CKM parameters and flavor physics.
- Neutrino masses and lepton mixing as confirmed physics beyond the original Standard Model (SM), including theory and discussion of data from reactors experiments, solar and atmospheric neutrino experiments, accelerator neutrino oscillation experiments, and astrophysical/cosmological constraints.
- Lattice gauge theory, including results on confinement, spontaneous chiral symmetry breaking, and hadron masses in quantum chromodynamics
- Electroweak symmetry breaking; Higgs mechanism in SM; properties of the 125 GeV Higgs boson discovered by the LHC; searches for possible non-SM properties of this boson; collider phenomenology
- Questions unanswered by the SM and ideas for physics beyond the SM that could answer these questions, e.g., charge quantization, relative sizes of gauge coupling, and values of fermion masses including generational dependence
- Grand unified theories and searches for baryon number violation.
- Effective field theory; application to QCD and physics beyond the SM.
- Hierarchy problem in SM and ideas, including supersymmetry, for avoiding this problem
- Renormalization group, β function, ultraviolet to infrared evolution of asymptotically free gauge theories.

- Dark matter, primordial nucleosynthesis, early universe cosmology

Learning goals: Students will learn modern advanced particle theory at a level that will help them begin Ph.D. thesis research, including a selection of topics from quark masses and mixing, neutrino masses and lepton mixing, quantum chromodynamics, Higgs physics, grand unified theories, dark matter, and other material from cosmology.