Physics 431: Particle and Nuclear Physics Spring, 20

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Prerequisites: PHY 308 (quantum physics); it is also assumed that students have taken r courses including PHY 251 (modern physics).

Course requirements: homework, midterm, and final exam

First meeting time/place: Tue. Jan. 24, 2017, 8:30 AM, Room TBA; office hr. TBA

The main textbook is D. Griffiths, *Introduction to Elementary Particles* (2010). Another book is C. Quigg, *Gauge Theories of the Strong, Electromagnetic, and Weak Interactions* also use information from various websites.

This is a senior-level undergraduate course on particle and nuclear physics covering topic following list:

- Basic properties and interactions of elementary particles
- Early history of discoveries of elementary particles and connection with nuclear phy
- Relativistic kinematics, calculation of scattering cross sections and decay rates
- Dirac equation, gamma matrices
- Introduction to quantum field theory, Lagrangians, and use of Feynman diagrams f calculations
- Accelerators and particle detectors
- Symmetries, groups, and conservation laws; SU(2) and spin; chiral and vectorial "fl
- Concept of gauge invariance, gauge interactions; abelian (QED) and non-abelian (Y
- Electromagnetic interactions and properties of elementary particles
- Weak interactions and beta decay, Fermi current-current theory and applications to
- Construction of a unified electroweak SU(2) $\times$ U(1)$_Y$ gauge theory; role of spontan breaking; vector boson masses and couplings; observation of W and Z; Higgs mech observation; other tests, including muon $g-2$
- Fermion couplings and masses; Cabibbo-Kobayashi-Maskawa quark mixing matrix; Glashow-Iliopoulos-Maiani mechanism; $K^0 - \bar{K}^0$ mixing, $B^0 - \bar{B}^0$, and $D_0 - \bar{D}_0$ m $K_L \to \mu^+\mu^-$, CP violation
- Quantum chromodynamics with SU(3) color gauge group, including early indicatio inelastic scattering and asymptotic freedom, quarkonium, heavy quarks c, b, t; jets, chiral symmetry breaking; residual strong interactions between hadrons; scattering.
- Properties of nuclei as bound states of nucleons: masses, radii, stability considerati decays; β, γ, α decays; nuclear reactions; models for nuclei; fission and nuclear pow nuclei.
- Neutrino masses and lepton mixing as evidence of physics beyond the SM; types of terms, models of neutrino masses, searches for neutrino masses in nuclear and parti neutrinoless double beta decay, theory and experiments on solar and atmospheric n accelerator neutrino experiments, reactor antineutrino experiments