April 2013

Physics 403 – Nuclear and Particle Physics (3)
Course Outline

Prerequisite for PHYS 403: PHYS 212 and PHYS 405. Primarily serves as an upper division elective for physics majors.

Learning Objectives and Criteria:
Upon completion of the course the student is expected to:

1. Know and apply principle and concepts within the Standard Model of particle physics:
    a. Know the properties of three of the fundamental forces that dominate elementary particle and nuclear processes: strong nuclear, weak nuclear, and electromagnetic forces.
    b. Know the general classes of elementary particles (gauge bosons, quarks, leptons, baryons, and mesons) and their properties (mass, spin, parity, charge, etc.).
    c. Know and understand the quark model as well as hadronic organization schemes such as the baryon decuplet, baryon octet, meson nonet, and the historical eightfold way etc.
    d. Apply conservation laws (charge, baryon number, lepton number, energy, etc.) to various reactions and, by inspection, be able to estimate the relative rates and fundamental forces that drive the reactions.
    e. The ability to describe the importance of the CPT invariance and give specific instances how these symmetries are broken.
2. Develop a working knowledge of nuclear physics:
    a. The ability to describe, quantum mechanically, the process of two-nucleon interactions and how they lead to the singlet and triplet state of the deuteron.
    b. Understand the role of isospin in the nucleus.
    c. Extend this understanding to the Clebsch-Gordon decomposition of isospin and to the predictions of the relative production rates of simple hadronic processes.
    d. Knowledge of the role of the spin and magnetic moments in the binding of the nucleus.
3. Know relativistic kinematics and how they are applied to nuclear and elementary particle reactions. In particular how to apply energy and momentum conservation and how to exploit frame-invariant properties.
4. Apply Feynman calculus and Fermi's Golden Rule to decay and scattering processes in both toy and basic electromagnetic processes.

Text and References:
D.J. Griffiths, Introduction to Elementary Particles, 2nd edition, 2008.

Content and Method:
Method: Physics 403 is offered in a traditional lecture format. The course is intended as a mathematical, quantitative study of elementary particle and nuclear physics. It has 3 lectures per week.

Content: Physics 403 will adhere to the following topics:

1. The Standard Model of particle physics:
    a. The classification of particles and their interactions via the nuclear and electromagnetic forces.
    b. The quark structure of hadrons and their group representation schemes.
    c. The basic conservation and symmetry laws of nature and their applications to nuclear and elementary particle reactions.
    d. The CPT theorem and its impact on elementary particle processes and the current theories of nuclear structure.
2. An introduction to the Feynman calculus and Fermi's Golden Rule in the context of decays and scattering.
3. The two-nucleon problem, the deuteron, nuclear scattering and the nuclear force.
4. Nuclear spins, magnetic moments, quadrupole moments and their relationship to nuclear stability.

Methods of Assessment:

The student's progress and success in the course are evaluated on the basis of their work on homework assignments and examinations.