PHYSICS 621: NUCLEAR PHYSICS

Fall 2008

Witold Nazarewicz, Nucolas Schunck, and guest stars

A. Introduction
1. Nuclear scales (From Big-Bang to galaxy clusters)
2. Roadmap of nuclear science

B. Nuclear Properties
3. Symmetries of the nuclear Hamiltonian
4. Global properties of the atomic nucleus
    a. Binding energy. Mass landscape and separation energies.
    b. Nuclear sizes. Nuclear radius and diffuseness of nuclear surface
    c. Nuclear shapes. Electromagnetic moments
5. Properties of nuclear excited states
    d. Spin, parity of nuclear states.
    e. Isomers
6. Nuclear decay modes
    f. Electromagnetic decay
    g. Beta decay, double-beta decay, and neutrino
    h. Alpha decay
    i. Proton and neutron decay
    j. Spontaneous fission
7. Nuclear reactions, general overview

C. Frontiers in Nuclear Physics
8. The nuclear building blocks
    a. Quark and gluons, QCD
    b. Quark models of hadrons.
    c. Lattice QCD
    d. Internal structure of protons and neutrons
9. Nuclear Hamiltonian
    a. Quark-gluon origin of the nuclear force
    b. Nucleon-nucleon interaction, general properties
    c. Deuteron
    d. Three- and many-nucleon forces
    e. Effective forces in nuclear medium. G-matrix
    f. Phenomenological nucleon-nucleon forces. Pairing.

10. Nuclear structure
    a. Single-particle and collective modes
    b. Models of nuclear structure
        i. The liquid drop model
        ii. Ab initio models for light nuclei
        iii. Nuclear shell model
        iv. Nilsson model and the unified model

v. Self-consistent models for heavy nuclei.
vi. Hartree-Fock-Bogolyubov and Relativistic Mean Field Theory.
vii. Algebraic models of nuclear structure
viii. New vistas: effective field theory

c. Nuclei far from stability. Physics of radioactive beams.
d. Nuclear matter. Nuclear equation of state. Phase transitions.
e. Intersections with other many-body systems

11. Matter at extreme densities.
    a. Relativistic heavy Ion collisions
    b. QCD phase diagram and quark-gluon plasma
    c. Chiral symmetry
    d. Phases of quark-gluon plasma. Color superconductivity.
12. The nuclear physics of the Universe
    a. Nuclear astrophysics
    b. Origin of the elements
    c. Neutrino physics
    d. Supernova
    e. Neutron stars
13. Nucleus as a laboratory of fundamental symmetries
    a. The Standard Model
    b. Symmetry tests in nuclear physics
14. Nuclear physics and society

Recommended textbook:

"Introductory Nuclear Physics",
Samuel S. M. Wong (Wiley-Interscience, 1998/99) Library Catalog
QC776.W66, ISBN: 0471239739

Supplementary texts:

"An Advanced Course in Modern Nuclear Physics", Ed. Arias and Lozano,
(Lecture notes in physics, vol. 581), Springer 2001
ISBN: 3-540-42409-1

"Frontiers in Nuclear Physics", Ed. S. Kuyucak, World Scientific 1999
http://www.wspc.com/books/physics/4136.html

"Nuclear Physics. The Core of Matter, The Fuel of Stars",
National Research Council Report, National Academy Press,
Washington D.C. 1999.
Can be downloaded from http://www.nap.edu/html/nucphys/pdf.html

"2007 NSAC Long Range Plan: The Frontiers of Nuclear Science"
Can be downloaded from
http://www.sc.doe.gov/np/nsac/docs/Nuclear-Science.Low-Res.pdf

"Guidance for Implementation of the 2002 Long Range Plan", NSAC June 2005.
Can be downloaded from
http://www.er.doe.gov/np/nsac/docs/nsac-report-final1_Tribble.pdf

Requirements/grading criteria:

- Attendance
- Answers to the problems
- Final presentation

Any student who feels s/he may need an accommodation based on the impact of a disability should contact me privately to discuss your specific needs. Please contact the Office of Disability Services at 865-974-6087 in Hoskins Library to coordinate reasonable accommodations for students with documented disabilities.