

PHYSICS 621: NUCLEAR PHYSICS
Fall 2004

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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
 - a. Spin, parity of nuclear states.
 - b. Isomers
6. Nuclear decay modes
 - a. Electromagnetic decay
 - b. Beta decay, double-beta decay, and neutrino
 - c. Alpha decay
 - d. Proton and neutron decay
 - e. 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 models
 - iv. Nilsson model and the unified model
 - v. Self-consistent models for heavy nuclei.
Hartree-Fock-Bogolyubov and Relativistic Mean Field Theory.
 - vi. Algebraic models of nuclear structure
 - vii. 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>

"Opportunities in Nuclear Science", A Long-Range Plan for the Next
Decade, NSAC, April 2002.

Can be downloaded from http://www.phy.anl.gov/atlas/LRP_5547_FINAL.pdf