Nuclear Physics

Lectures: 3x45 min/week
Classroom practices: 1x45 min/week
ECTS: 5
Assessments:

Oral examination at the end of the semester in the period of exams

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Leader of classroom practices: Máté Halász, PhD student (halasz.m@gmail.com)

Syllabus

1. Manipulating electrically charged particles. Thomson experiment, q/m. Mass spectroscopy and atomic mass unit. Mass-doublet method. Spatial resolution, de Broglie formula. Electrostatic accelerators: Cockroft-Walton, Van de Graaf, Tandem Van de Graaf. Resonance accelerators: linear accelerator, cyclotron, synchrotron. LHC.
2. Size of the nucleus, Rutherford's experiment. Hofstädter experiments. Discovery of the neutron and the composition of the nucleus. Angular momentum and parity. Electric and magnetic moments, NMR, MRI. Excited states and levels schemes
3. Stability of the nucleus, nuclear mass, mass defect. Weizsäcker's semi-empirical binding energy formula. Types and main characteristics of radioactive decays. Exponential decay law, decay chains. (Radioactive dating.)
4. Basic theory of beta decays. Fermi's Golden Rule, Fermi theory of beta-decay, allowed and forbidden transitions. Fermi and Gamow-Teller transitions.
5. Parity violation. The story of the neutrino. Anti-neutrino and neutrino detection (Reines Cowan, and Davis experiments). Solar neutrino puzzle and the neutrino oscillation.
6. Basic theory of alpha decays. Transition coefficients and alpha spectroscopy factor. Basic theory of gamma-decays. Classification of decay modes: „electric" and „magnetic" transitions. Selection rules. Probabilities of gamma-transitions and Weisskopf-units.
7. (National Day Oct. 23.)
8. Sum rules. Measurements of gamma-decay probabilities.
   Nuclear models: Fermi-gas
9. Shell-model. Experimental hints, magic numbers. Definition of shells, harmonic oscillator. Spin-orbit interaction. Successes and failures of the shell model: excited states, Schmidt-lines, nuclear quadrupole moment.
10. Basics of collective model. Rainwater approximation. Vibrations and rotations. High spin states and back bending.
11. Nuclear forces. Learning from the deuteron. Basic ideas of Yukawa theory. Charge independency and isospin.
12. Nuclear reactions. Kinematics. Elastic scattering of neutrons. Microscopic and macroscopic cross sections and their two additivities. Differential cross-sections. Excitation functions. Reaction mechanisms, types of direct reactions, characteristics of compound nucleus reactions. Resonances.
13. Mechanism and characteristics of nuclear fission. Nuclear chain reaction
14. Moderator. Four-factor formula. Under-moderated and over-moderated reactors. Basics of nuclear safety. Basics of nuclear reactor operation and reactor types. History of nuclear energy. Exponential experiment