Nuclear structure theory: density functional methods in nuclear physics (2 CFU – 10 hours)

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Nuclear structure theory will be discussed with emphasis on the connection with experiments. The course also has an interdisciplinary aspect in that it highlights common aspects of nuclear structure, condensed matter theory, and nuclear astrophysics. After an overview of the current status of nuclear theory, the bulk of the program focuses on nuclear density functional methods and applications. The course plan can be, to some extent, changed by agreement with students.

- The nuclear many-body problem: a survey of the present theoretical approaches.
- Nuclear structure models with emphasis on Density Functional Theory (DFT).
- DFT: the original Hohenberg-Kohn theorem; transferring DFT from electronic systems to nuclei; basics on Skyrme, Gogny and relativistic functionals.
- Applications of static DFT: ground-state properties (masses, radii).
- Nuclear intrinsic deformation, vibrational and rotational spectra, electromagnetic transitions.
- Time-dependent DFT and nuclear giant resonances.
- The nuclear equation of state and applications to compact objects (neutron stars).
- Optional topics: nuclear superfluidity, charge-exchange nuclear transitions.

Nuclear structure studied with stable and radioactive beams (2 CFU-10 hours)

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Lectures will concern the study of modern aspects of the structure of nuclei in the ground state and excited
states. Nuclear Structure properties will be discussed from a phenomenological/experimental point of view,
mostly in connection with the present use of accelerated beams of stable and radioactive heavy ions. The
Course program could be changed by agreement with the students.
Tentative program:

- Production techniques for exotic beams: ISOL and in-FLIGHT methods.
  Examples of facilities and dedicated setups.
- High precision Mass measurements with traps and storage rings.
- Beta decay studies.
- Collective modes of vibration: Giant Resonances (optional).

Nuclear Structure and reaction dynamics with radioactive beams (4 CFU-24 hours)

This course takes place in Padua

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- Brief introduction to radioactive ion beams production techniques.
- Nuclear structure studies with ISOL beams.
- Nuclear structure studies with fragmentation beams.
- Experimental problems in reactions with radioactive beams.
- Reaction kinematics
- Resonance elastic scattering: Inverse kinematics thick target method
- Effects of “exotic” nuclear structure on reaction dynamics: elastic scattering, break-up and fusion
- Theoretical models of nuclear reactions
- Design of an experiment with radioactive ion beams.