Nuclear structure and nuclear reactions

Nuclear structure (Milano)

Lectures will concern the study of modern aspects of the structure of nuclei in the ground state and excited states.
The course is divided in two parts, experimental and theoretical (respectively).

Theory (Gianluca Colò, 10 hours)
Modern theoretical approaches to nuclear structure

A few aspects of the structure of both stable and radioactive nuclei will be covered. Some topics can be decided according to the background and interests of the students. Emphasis will be put on methods based on Density Functional Theory, to consistency between the description of finite nuclei and uniform nuclear matter, and to possible interdisciplinary applications.
Tentative program:

- Introduction and formalism. Methods based on Density Functional Theory vs. other methods (3 hours)
- Applications to the nuclear ground states: binding energies, radii, superfluidity (3 hours)
- Applications to nuclear excited states: vibrational excitations in stable and radioactive nuclei (3 hours)
- Theoretical challenges (1 hour)

Experiment (Silvia Leoni**,** 10 hours**)**
Nuclear Structure studied with Stable and radioactive beams

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.
Tentative program:

- Production techniques for exotic beams (1 hours)
- High precision Mass measurements with traps and storage rings (3 hours)
- Collective modes of vibration: Giant Resonances (3 hours)
- Collective modes of rotation at finite temperature (2 hours)
- Lifetime measurements of excited states by gamma spectroscopy (1 hours)
- Additional topic: β−decay studies

Nuclear Reactions with Heavy Ions (Padova)

Lectures will concern the study of nuclear reactions with heavy ions in the energy interval around the Coulomb barrier. At these energies, nuclear reactions are dominated by fusion and transfer processes, and are strongly influenced by the structure of the interacting nuclear systems.
The course is divided in two parts, experimental and theoretical (respectively).

Experiment (Fernando Scarlassara, 10 hours**)**
Experimental study of transfer and fusion reactions

State-of-the art experimental techniques and perspectives with unstable beams will be discussed together with recent, important results obtained at Legnaro National Laboratory. Particular emphasis will be given to experimental problems related to the measurements of observables such as energy, mass, atomic number and cross sections for reactions with heavy ions.
Tentative program:
Binary reactions: quasi-elastic and transfer

- Introduction and experimental aspects 2 hours
- Results on pair transfer 2 hours

Fusion reaction, in particular below barrier

- "Historical" introduction and experimental aspects 2 hours
- Fusion in "coupled channels" 2 hours
- Deep sub-barrier fusion: the new frontier 2 hours

Theory (Andrea Vitturi**,** 10 hours**)**
Theoretical models for heavy ion reactions around the Coulomb barrier

The theoretical models used to describe the different processes involving heavy ion interactions at energies around the Coulomb barrier will be discussed. In particular, microscopic models will be developed, with the aim of having links between structure aspects and dynamical aspects.

Tentative program:
The semiclassical description of processes involving heavy ions 2 hours
Models for two-body reactions: quasi-elastic and transfer

- inelastic Coulomb excitation: microscopic approaches 2 hours
- pairi transfer and pairing interaction 2 hours

Fusion reactions (in particolar, below the potential barrier)

- coupled channel model 2 hours
- fusion processes involving weakly bound systems 2 hours