Recent advances and challenges in the description of nuclear reactions at the limit of stability.

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ECT* - Villa Tambosi - Trento

Scientific Programme

SCOPE

Nuclei are quantum many-body systems consisting of protons and neutrons strongly bound together. Understanding the properties of such complex systems in terms of their constituent particles and the interaction between them is a true challenge, as the dimension of the nuclear many-body problem is overwhelming. Nuclei are exceedingly difficult to describe; they contain too many nucleons to allow for an exact treatment and far too few to disregard finite-size effects.

Our current understanding of the nuclear properties stems to a large extent from the information obtained through nuclear reactions. This includes elastic/inelastic scattering, breakup, transfer reactions, knockout and quasi-free scattering (p,pN), charge exchange,... In the past few decades, the development of Radioactive-Ion Beam (RIB) facilities has enabled the study of nuclei far from stability. A strong effort has been devoted to understand the structure and decay modes associated with the exotic properties of these systems. In this context, the advances in nuclear-reaction theory have played a fundamental role in exploring the edges of the nuclear landscape.

The theoretical description of nuclear reactions need to incorporate the relevant degrees of freedom which are probed in specific processes. In addition to developing more elaborate theoretical frameworks to capture the essence of the different reactions, the nuclear-structure inputs need to properly combine single-particle and collective aspects of nuclei. Therefore, it is important to highlight the connection between reaction observables and the underlying nuclear-structure properties.

Recent advances at the leading experimental facilities walk towards the production and study of heavier and more exotic nuclei along the driplines. The analysis of the increasingly large amounts of nuclear data demands new theoretical developments. A strong interaction between experimental collaborations and theoretical groups is needed. Theoreticians and experimentalists should discuss together what information can be extracted and which is the best way to analyze future measurements. To reach this goal, it will be interesting to propose new observables which may improve our knowledge of nuclear structure or even to open the possibility to study aspects not reachable before. These new measurements should be discussed in terms of the experimental feasibility and the possibility of an accurate theoretical analysis.

To this end, we plan to gather experts from experimental and theoretical nuclear physics, who will guide and foster the aforementioned discussions. We expect this workshop will lead to new theoretical developments in nuclear-reaction theory in tight connection with the evolution of the RIB facilities.

GOALS

The workshop aims at discussing the most recent advances and future developments in nuclear reaction models. In particular, we will put an emphasis on the description and interpretation of different types of direct reactions: elastic/inelastic scattering, breakup, quasi-free (p,pN) processes, charge-exchange, ...

We intend to gather experts in structure and reaction theories, to discuss about the state of the art of nuclear models and foresee possible developments. Additionally, several key representatives from leading experimental facilities will provide an overview of the ongoing and planned experiments.

We will focus on:
few-body reaction models;
eikonal and semiclassical models;
coupled-channels (with and without inclusion of the continuum);
nuclear reactions from ab-initio calculations;
theoretical support to experiments.

By bringing together various communities in low-energy nuclear physics, the primary goal of this workshop is to foster discussions between different fields on the future of nuclear theory in Europe and abroad. The inputs of experimentalists in this discussion will provide the key issues for experimental facilities in Europe and their need for theoretical support in the analysis of their measurements. This workshop will thus help us reach focussed goals of TheoS, the theory JRA within ENSAR2.

OUTLINE

The workshop will be organized in sessions of short talks with ample time for discussion (e.g. 30'+15') on the following topics:
elastic scattering;
elastic and non-elastic breakup;
knock-out and quasi-free (p,pN) reactions;
transfer reactions;
charge-exchange reactions (including double-charge exchange);
interface between nuclear structure and reaction models.

In addition to the presentation sessions, we will organize two or three discussion sessions to foster the exchange between the different communities represented in this workshop. Among the important aspects that will be discussed during these sessions, an effort will be made to suggest relevant physics cases for key experiments. Also, coherent procedures to construct a rigorous connection between structure, reaction models and experimental observables will be identified and discussed, and some practical illustrative cases will be proposed.