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Theoretical nuclear reaction analysis for the ISOLDE Superconducting Recoil Separator (ISRS)

The ISOLDE Superconducting Recoil Separator (ISRS) [1] is an innovative high-resolution recoil separator aiming to extend the physics program of HIE-ISOLDE by using gamma-particle correlations and decay spectroscopy at the focal plane detector. The objective of the ISRS´s theory group is to predict direct and compound-nuclei production for selected nuclear reactions, aiming to optimize the performance of the spectrometer. The team has analyzed a selection of physics cases entailing reactions induced by 9Li, 30Mg, 68Ni, 132Sn, 185Hg, and 225Ra beams on a CD_2 target at the energy of 10 MeV/u.

A comprehensive analysis has been undertaken to describe various mechanisms such as elastic breakup, nonelastic breakup, compound-nucleus, and pre-equilibrium processes, as well as transfer reactions, for which we have made use of different codes, particularly a modified version of EMPIRE, PACE4, and FRESCO [2-4]. In our analysis, the use of modified EMPIRE which incorporated the post-form distorted wave Born expression of the Ichimura-Austern-Vincent approach (DWBA-IAV) [5-9] for breakup predictions alongside PACE4 allow us to provide an accurate depiction of reaction dynamics and thorough estimates of the energy and angular distributions of the residual nuclei produced in the selected systems.

Furthermore, for the transfer channels, which play a crucial role in nuclear structure and reaction studies, theoretical calculations for the (d,p) and (d,n) reactions in all the selected cases have been performed using the coupled-channels code FRESCO, providing both angular and energy distributions essential for accurate separator design.

The resulting theoretical angular and energy distributions for residual nuclei through various reaction mechanisms are currently being used in beam dynamics simulations. These simulations provide critical input for optimizing the experimental design, thereby advancing future nuclear-reaction analysis with ISRS.

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