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A comprehensive physics program for the ISRS recoil separator at ISOLDE

The ISOLDE Superconducting Recoil Separator (ISRS) [1-2] represents a major step forward in extending the experimental capabilities of HIE-ISOLDE for precision studies of exotic nuclei. Designed as a next-generation, high-resolution recoil separator, the ISRS will enable a broad physics program with unprecedented resolving power. In parallel with its technical development, the ISRS physics program has been established to provide realistic reaction modeling and to guide the optimization of the spectrometer design and its future experimental campaigns.

Our theoretical effort integrates a multi-code framework encompassing direct, transfer, breakup, and compound-nucleus processes. Using nuclear reaction codes such as the updated version of EMPIRE [3-4], PACE4 [5], and FRESCO [6], we have systematically analyzed various mechanisms, including breakup, fusion-evaporation, and (d,p)/(d,n) transfer reactions, induced by radioactive ion beams spanning a broad mass range, from ^{9}Li to ^{224}Ra, on CD_2 targets at 10 MeV/u. This program has yielded detailed angular and energy distributions of residual nuclei, which have been implemented in ISRS beam-dynamics simulations to refine acceptance and optics.

Building on this foundation, the next phase of the ISRS theoretical program focuses on multinucleon transfer (MNT), expanding toward Coulomb excitation and breakup-fusion mechanisms to map the interplay between nuclear structure and reaction dynamics in heavy and weakly bound systems. These developments are crucial for predicting rare-isotope yields and optimizing separator performance for future experiments. Ultimately, the rigorous integration of these studies into the ISRS framework strengthens the predictive connection between reaction theory, beam dynamics, and experimental design.

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Abstract

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