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Gamma-Particle Coincidence Studies with Radioactive Beams[1]

ANDREW RATKIEWICZ, Lawrence Livermore National Laboratory

Reactions in normal kinematics, in which a light ion is impinged on a heavier stable or long-lived target, have long been used to probe the internal structure of nuclei and to constrain the properties of the astrophysical processes that synthesized the nuclei from which our universe is composed. The advent of radioactive ion beams (RIBs) brought these studies to radioactive nuclei in inverse kinematics, with a stable light-ion target and a radioactive heavy beam, greatly expanding the reach of the technique. While these reactions offer powerful and well-understood tools for determining nuclear properties, the systems typically used to detect these particles have limited resolution, thus are not capable of discriminating between the population of closely spaced nuclear levels. There are also a number of experimental challenges inherent in these techniques: for instance, many studies employ targets with a carbon matrix, leading to fusion-evaporation backgrounds that can be significant. Additionally, RIB studies are often limited by the beam rate, necessitating thicker targets to maintain luminosity, which leads to kinematic broadening in the target, decreasing the achievable energy resolution. These effects can be mitigated by measuring γ rays in coincidence with particles. Gamma-ray detectors, especially those made of High-Purity Germanium (HPGe) offer dramatically better energy resolution – often more than an order of magnitude – than is achievable with the popularly-used silicon particle detectors. Additionally, measurements of γ rays can provide information about states not directly populated in the reaction studied and can be used to determine the lifetimes of excited states and the character of transitions between them. With the availability of large HPGe detector arrays, a number of particle-γ spectrometers have been built. I will discuss recent measurements with some of these detectors and provide an outlook for future work in the FRIB era.

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