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Reaction dynamics near the barrier[1]

W. LOVELAND, Oregon State University

The availability of modest intensity (10^3-10^7 p/s) radioactive nuclear beams has had a significant impact on the study of nuclear reactions near the interaction barrier. The role of isospin in capture reactions is a case in point. Using heavy elements as a laboratory to explore these effects, we note that the cross section for producing an evaporation residue is

$$\sigma_{EVR}(E_{c.m.}) = \sum_{J=0}^{J_{max}} \sigma_{CN}(E_{c.m.}, J) W_{sur}(E_{c.m.}, J)$$

where σ_{CN} is the complete fusion cross section and W_{sur} is the survival probability of the completely fused system. The complete fusion cross section can be written as,

$$\sigma_{CN}(E_{c.m.}) = \sum_{J=0}^{J_{max}} \sigma_{capture}(E_{c.m.}) P_{CN}(E_{c.m.}, J)$$

where $\sigma_{capture}(E_{c.m.},J)$ is the "capture" cross section at center-of mass energy $E_{c.m.}$ and spin J and P_{CN} is the probability that the projectile-target system will evolve inside the fission saddle point to form a completely fused system rather than re-separating (quasi-fission). The systematics of the isospin dependence of the capture cross sections has been developed and the deduced interaction barriers for all known studies of capture cross sections with radioactive beams are in good agreement with recent predictions of an improved QMD model and semi-empirical models. The deduced barriers for these n-rich systems are lower than one would expect from the Bass or proximity potentials. In addition to the barrier lowering, there is an enhanced sub-barrier cross section in these n-rich systems that is of advantage in the synthesis of new heavy nuclei. Recent studies of the "inverse fission" of uranium (^{124,132}Sn + ^{100}Mo) have yielded unexpectedly low upper limits for this process due apparently to low values of the fusion probability, P_{CN}. The fusion of halo nuclei, like ^{11}Li with heavy nuclei, like ^{208}Pb, promises to give new information about these and related nuclei and has led/may lead to unusual reaction mechanisms.

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