Entrance Channel Effects on the Fusion Dynamics with Exotic Beams

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The reaction path followed by Heavy Ion Collisions with neutron-rich (or exotic) nuclear beams at low energies is investigated in a transport theory based on a microscopic stochastic mean field approach, where two parametrizations for the density dependence of symmetry energy (Asy-soft and Asy-stiff) are implemented [1]. The goal of this analysis is to pin down specific observables which are sensitive to the symmetry energy in the entrance channel, to learn about its poorly known density behavior. We focus on the interplay between reaction mechanisms, fusion vs. break-up (fast-fission, deep-inelastic), that in neutron-rich systems is expected to be influenced by the symmetry energy term at densities around the normal value [2]. Fusion probabilities for reactions induced by ^{132}Sn on ^{64,58}Ni targets at 10AMeV are evaluated by the evolution of the phase-space quadrupole collective modes [3]. Larger fusion cross sections are obtained for the more n-rich composite system, and, for a given reaction, with a soft symmetry term (i.e. a rather flat behaviour of the symmetry energy around normal density). Fusion vs. break-up probabilities are influenced by the neutron repulsion during the approaching phase, where densities just above the normal value are observed.

The break-up events appear also sensitive to the stiffness of the symmetry energy. Owing to the lower symmetry repulsion at low densities in the linear (stiff) choice, the neutron-rich neck connecting the two partners can survive a longer time producing very deformed final fragments, eventually leading to ternary/quaternary fragmentation events. ^{197}Au + ^{197}Au collisions at 15 AMeV are simulated to investigate the main modes of re-separation of a heavy nuclear system and their sensitivity to the symmetry energy. For this system a rather fast break-up into three or four massive fragments have been experimentally revealed [4,7], allowing for a comparison between data and theoretical predictions. In the ternary partitioning case, either the projectile-like fragment (PLF) or target fragment (TLF) breaks up collinearly with PLF-TLF separation axis, a fact that excludes purely statistical fission in ternary events. The analysis of this mechanism will give independent information on the symmetry term around saturation value.

In addition, we investigate the collective charge equilibration mechanism, the Dynamical Dipole Resonance, DDR [1], in fusion and breakup events induced by ^{132}Sn + ^{64,58}Ni collisions at 10 AMeV. The strength of the corresponding radiative emission depends on the stiffness of the symmetry term just below saturation and presents clear angular anisotropies [5,6]. We also investigate the effect of the mass asymmetry in the entrance channel for systems with the same overall isospin content and similar initial charge asymmetry [3]. As expected, we find reduced fusion probabilities for the more mass-symmetric case, while the DDR strength appears not much affected. This is a nice confirmation of the prompt nature of such collective isovector mode. The prompt dipole radiation also represents a nice cooling mechanism during the fusion path. It is a way to pass from a warm to a cold fusion in the heavy elements synthesis. Two different N/Z entrance channel are valued by the ^{40,48}Ca + ^{152}Sm reactions at about 11AMeV beam energy, leading to the same fissile ^{192}Pb compound nucleus. Interesting perspectives are opening for new experiments on low energy collisions with exotic beams.

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