Heavy-ion fusion reactions involving Ni and Ca isotopes at sub-barrier energies

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Heavy-ion fusion reactions at low energies are governed by quantum tunneling through the Coulomb barrier. Extensive experimental and theoretical studies have been carried out in order to understand fusion reactions at sub-barrier energies. Sub-barrier fusion cross sections are influenced by couplings of the relative motion of the colliding nuclei to nuclear shape deformations as well as by nucleon transfer channels [1,2]. An enhancement of sub-barrier fusion cross sections, in comparison with the predictions of one-dimensional barrier penetration models, is observed and can be described by coupled-channels calculations. Recently, experimental studies have been extended to deep sub-barrier energies. Hindrance of fusion cross sections [1,3] has been observed in medium-mass systems, in comparison with standard coupled-channels calculations using a Woods-Saxon nuclear potential.

The interplay between nuclear structure and reaction dynamics has been studied for medium-mass systems, in particular for ^{58,64}Ni+^{58,64}Ni, ^{40,48}Ca+^{40,48}Ca and ^{40}Ca+^{58,64}Ni. The ^{40}Ca+^{58,64}Ni [4] fusion reactions have recently been performed at Laboratori Nazionali di Legnaro (LNL), using ^{40}Ca beams from the XTU Tandem accelerator and the LNL electrostatic deflector placed at around 0°. In this contribution, the Ni+Ni, Ca+Ca and Ca+Ni systems will be described in a consistent way. Barrier distributions and logarithmic derivatives of the energy-weighted cross sections have been extracted from accurate fusion data. Coupled-channels calculations have been performed with the CCFULL code, using the Akyüz-Winther nuclear potential, including projectile and target inelastic excitations of the 2^+ and 3^- states and schematically taking into account the positive Q value neutron pair-transfer channels.

A further experimental study is planned at LNL, using ^{58,64}Ni beams from the XTU Tandem accelerator and the LNL PRISMA magnetic spectrometer, to measure directly nucleon transfer cross sections at energies above and around the fusion barrier for ^{40}Ca+^{58,64}Ni. In the future, it would be of high interest to explore the fusion hindrance phenomenon by extending the fusion cross sections to deep sub-barrier energies, below the 1 μb level, which will be a real experimental challenge.

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[4] D. Bourgin *et al.*, *Barrier distributions and signatures of transfer channels in the ^{40}Ca+^{58,64}Ni fusion reactions at energies around and below the Coulomb barrier*, Phys. Rev. C **90**, 044610 (2014).