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TRABZO: a novel combined model for heavy-ion fusion/capture accounting for zero-point shape oscillations and dissipative effects

The fusion/capture cross sections (CSs) of complex nuclei are often described in the literature within two approaches: i) the coupled channels model accounting for structure of the colliding nuclei [1,2] and ii) trajectory models with friction and thermal fluctuations (dissipative effects) [3,4]. The first approach does not account for friction whereas the second one is not able to deal with sub-barrier CSs. In the present work, we have developed an algorithm for calculating the capture CSs of collision of spherical nuclei accounting for both zero-point oscillations (ZPO) of the nuclear shapes (structure effects) [5] and for dissipative effects; i.e., in a sense we have combined the above two approaches. The bare nucleus-nucleus potential is evaluated using the semi-microscopic double-folding model with M3Y-Paris nucleon-nucleon forces [6]. The nucleon densities are taken from the IAEA database [7]. For each collision partner several deformations of quadrupole and octupole type are accounted for with the probabilities corresponding to the harmonic oscillator at the ground state. In these calculations, the multipole expansion of the densities with the subsequent Fourier transforms of the multipole components and of the nucleon-nucleon forces is applied. The dissipative effects enter into our combined approach within the surface friction model well known in the literature [3]. The final fate of a trajectory is decided by means of quantum transmission coefficients. There are two fitting parameters in the model, τ and K_R. Parameter τ reflects to what extent ZPO survives when the reagents approach each other. Parameter K_R is the friction strength for radial motion. The calculated CSs and barrier distribution are found in good agreement with the precision experimental data at reasonable values of τ and K_R. Calculations show that the CSs are mostly sensitive to τ at low (sub-barrier) collision energies whereas the value of K_R is important at the above barrier energies. We hope the model can be upgraded and applied for describing the CSs in other reactions.

Keywords: heavy ions fusion; cross section; Coulomb barrier distribution; zero-point oscillations; surface friction.

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