MICROSCOPIC APPROACH TO HEAVY-ION FUSION

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Fusion reactions between heavy-ions are strongly affected by nuclear structures and competing mechanisms. For instance, the nucleus-nucleus potential is modified by neutron skins. Dynamical effects, such as couplings to collective vibrations and transfer channels, are also known to play a crucial role in fusion. For heavy systems, the quasi-fission mechanism competes strongly with fusion.

Microscopic approaches such as the time-dependent Hartree-Fock (TDHF) theory are ideal to study these effects. In particular, TDHF treats static and dynamic properties on the same footing, allowing for a description of the interplay between structures and reactions. In addition to describe collective effects (e.g., neutron skins and vibrations), TDHF incorporates single-particle degrees of freedom which are crucial to account for effects of transfer as well as of the Pauli principle. A major asset of TDHF is that it does not require other parameters than those of the effective interaction.

Applications of TDHF to fusion dynamics will be presented. First, it will be shown that the Pauli Exclusion Principle naturally increases the potential inside the barrier, providing a possible explanation for the long-standing problem of deep sub-barrier fusion hindrance. Then, fusion with exotic nuclei will be studied to investigate the effect of neutron skins. Surprisingly, it will be shown that the dynamics washes out these static effects due to vibrational couplings and transfer. Finally, properties of the quasi-fission process, which hinders fusion in heavy systems, will be studied. In particular, it will be shown that the quasi-fission dynamics is strongly affected by magic shells.