Dynamical probe of the pseudo Jahn-Teller effect in one-dimensional confined fermions

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We investigate the real-time dynamics of a quenched quantum impurity immersed in a one-dimensional ultracold Fermi gas, focusing on the breakdown of the adiabatic Born-Oppenheimer approximation due to non-adiabatic effects. Despite a sizable impurity-bath mass imbalance, increasing interactions induce strong non-adiabatic couplings, disrupting adiabatic motion and enabling population transfer between the adiabatic potential energy curves. These transitions are governed by conical intersections arising from the pseudo Jahn-Teller effect, dynamically shaping the impurity's motion through the bath. Using *ab initio* simulations via the Multi-Layer Multi-Configuration Time-Dependent Hartree method and a multi-channel Born-Oppenheimer framework, we track the impurity's evolution and directly prove the dynamical manifestation of the pseudo Jahn-Teller effect. We analyze two key scenarios: (i) a small initial shift, where a single avoided crossing drives transitions, and (ii) a large shift, where multiple avoided crossings lead to enhanced non-adiabaticity, self-trapping, and energy redistribution. Our findings establish ultracold fermionic few-body systems as tunable platforms for studying non-adiabatic quantum dynamics, opening new avenues for controlled impurity transport in strongly correlated environments.