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Fission dynamics from saddle to scission and beyond

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Nuclear fission, one of the oldest if not the oldest challenge to theoretical many-body physics in literature, is still awaiting a fully quantum microscopic description with a robust predictive power. Since its experimental discovery in 1939 only a few theoretical results have been firmly established in the quantum theory of fission, while many phenomenological and microscopic models, based on untested assumptions have been suggested. The evolution of the compound nucleus from the moment the neutron is absorbed until the saddle is reached was left basically in the dark by theory, and most of the attention was concentrated on the evolution of the nucleus from the saddle-to-scission, where fission fragment properties are defined. The main assumption was that this process is slow and moreover adiabatic, an assumption which allowed the separation of the degrees of freedom into collective and intrinsic. Being slow does not imply adiabaticity however. In a new time-dependent energy density formalism, free of any restrictions and assumptions, we demonstrate that the fission dynamics from saddle-to-scission is slow and even overdamped, but the intrinsic system gains a lot of entropy, and the energy gained from the collective degrees of freedom is never relinquished. The fission dynamics from the saddle-to-scission is much slower than the adiabatic assumption would imply, the collective flow energy never exceeding 1-2 MeV and the rest of the difference between the potential energy at the saddle and at the scission point is almost entirely converted into intrinsic energy or heat. This finding requires a complete retooling of most theoretical and phenomenological approaches, as the introduction of a potential energy surface and inertia tensor is completely illegitimate, the role of collective inertia is negligible. Agreement with experiment is surprisingly good, in spite of the fact that no parameters have been fitted and the results are rather stable with parameter changes.

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