Induced fission in real-time

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Abstract:

Nuclear fission appears to be one of the most difficult problems in quantum many-body physics and is approaching shortly the venerable age of 80 years and it still defies efforts to arrive at a microscopic description. A quantum theory of superconductivity was developed in contrast in less than 50 years. Major progress in developing an extension of the Density Functional Theory to superfluity systems and to real-time phenomena, along with a quite satisfactory understanding of the main properties of the energy density functional of nuclear systems, and with the emergence of great computational developments, allow now a direct attack of the nuclear fission using a realistic description of nuclei. In a first application of these new developments we describe the fissioning dynamics of 240Pu from a configuration in the proximity of the outer fission barrier to full scission and the formation of the fragments within an implementation of density functional theory extended to superfluid systems and real-time dynamics. The fission fragments emerge with properties similar to those determined experimentally, while the fission dynamics appears to be quite complex, with many excited shape and pairing modes. The evolution is found to be much slower than previously expected, and the ultimate role of the collective inertia is found to be negligible in this fully nonadiabatic treatment of nuclear dynamics, where all collective degrees of freedom (CDOF) are included (unlike adiabatic treatments with a small number of CDOF).