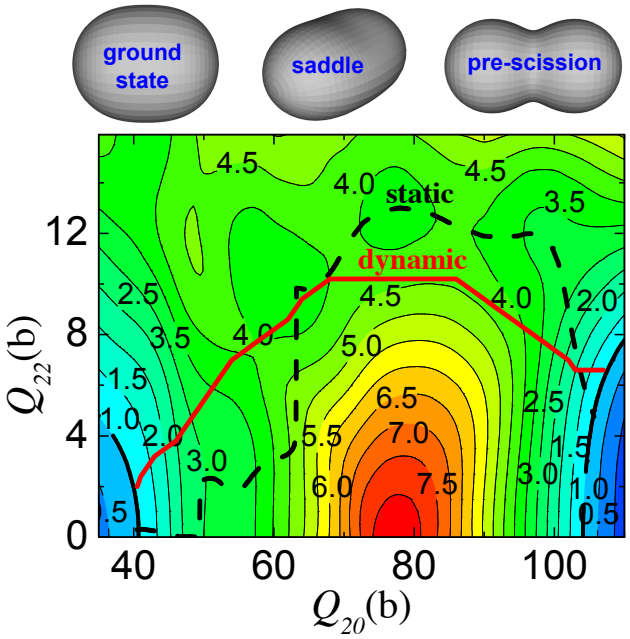
Spontaneous fission lifetimes from the least-action principle

Objectives

- Advanced theoretical methods and high-performance computers may finally unlock the secrets of nuclear fission, a fundamental nuclear decay that is of great relevance to society.
- Spontaneous fission is a magnificent example of a motion during which the nucleus evolves in a multidimensional space of complex shapes, going through regions that are forbidden by classical mechanics.
- Used nuclear Density Functional Theory to investigate the dynamical evolution of the heavy nucleus fermium-264 from its ground state to its symmetric split into two tin-132 nuclei.

Impact

- Enables rigorous data-driven predictive modeling in complex physical systems.
- Provides benchmark for future model developments.
- Develops a predictive framework to describe spontaneous fission of a heavy nucleus
- Employs a dynamic approach based on minimization of the action integral in many dimensions.
- Uses symmetry-free DFT solver HFBODD, optimized for performance under UNEDF/NUCLEI SciDAC projects.



Dynamic and static paths for spontaneous fission of 264Fm in the 2D plane of elongation (Q_{20}) and triaxiality (Q_{22}) obtained by minimizing the collective action integral. It is seen that the fission pathway connects the slightly deformed ground-state of ^{264}Fm with the ^{132}Sn+^{132}Sn pre-scission configuration through the family of elongated triaxial shapes, thus bypassing the axial saddle (inner fission barrier).

Accomplishments

1. Spontaneous fission has been studied microscopically for the first time within a self-consistent model employing realistic collective mass
2. Strong dynamical effects have been predicted due to the interplay between level crossing dynamics and nuclear superfluidity.
3. Approximate treatment of collective mass employed in previous studies results in incorrect fission path.
4. This paper has been chosen by the Editors of Physical Review C for the "Kaleidoscope"

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Reference: Jhilam Sadhukhan et al, Phys. Rev. C 88, 064314 (2013).

Contact: W. Nazarewicz, witek@utk.edu