



LAWRENCE  
LIVERMORE  
NATIONAL  
LABORATORY

# New Discoveries Bring us Closer to a Predictive Theory of Fission

W. Younes

August 29, 2011

## **Disclaimer**

---

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL fission theorists Younes et al. have taken an important step in quantifying a part of the fission process known as scission: the point at which one fissioning nucleus becomes two fission fragments. In doing so, they are now determining how the total energy released during fission is partitioned to individual fission fragments. Coupled with HPC, these calculations represent a key first step in understanding the properties of fission fragments (Fig. 1) and their impact on program metrics, and ultimately lead to a predictive theory of fission.

A predictive and comprehensive theory of nuclear fission is critical to applications such as nuclear materials detection, nuclear energy, and stockpile stewardship\*, but has proven a daunting challenge since the discovery of fission in the 1930's. The recent work of Younes et al. on the fundamental nature of scission\*\* uses a concept analogous to that of "Localized Molecular Orbitals" in molecular physics and quantum chemistry to solve the longstanding question of how to follow continuously the evolution of one quantum system (the fissioning nucleus) into two sub-systems (the fragments).

\* Report from DOE/NNSA-sponsored workshop on "Scientific Grand Challenges for National Security: The Role of Computing at the Extreme Scale", Washington D.C. (2009). [http://science.energy.gov/~media/ascr/pdf/program-documents/docs/Nnsa\\_grand\\_challenges\\_report.pdf](http://science.energy.gov/~media/ascr/pdf/program-documents/docs/Nnsa_grand_challenges_report.pdf)

\*\* W. Younes and D. Gogny, accepted for publication in Physical Review Letters (2011).

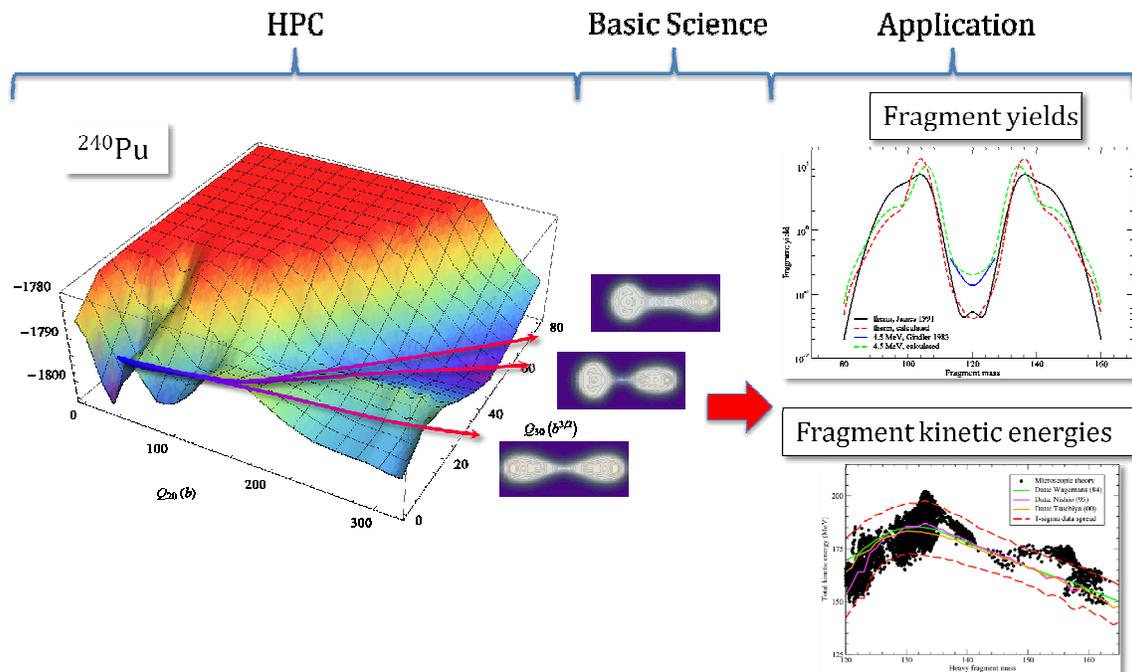


Fig 1. Illustration of combined efforts in HPC to model the evolution of the fissioning nucleus and in the basic science of scission to produce critical input for the programs, such as fragment yields and kinetic energies.