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New Discoveries Bring us Closer to a Predictive Theory of Fission

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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

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

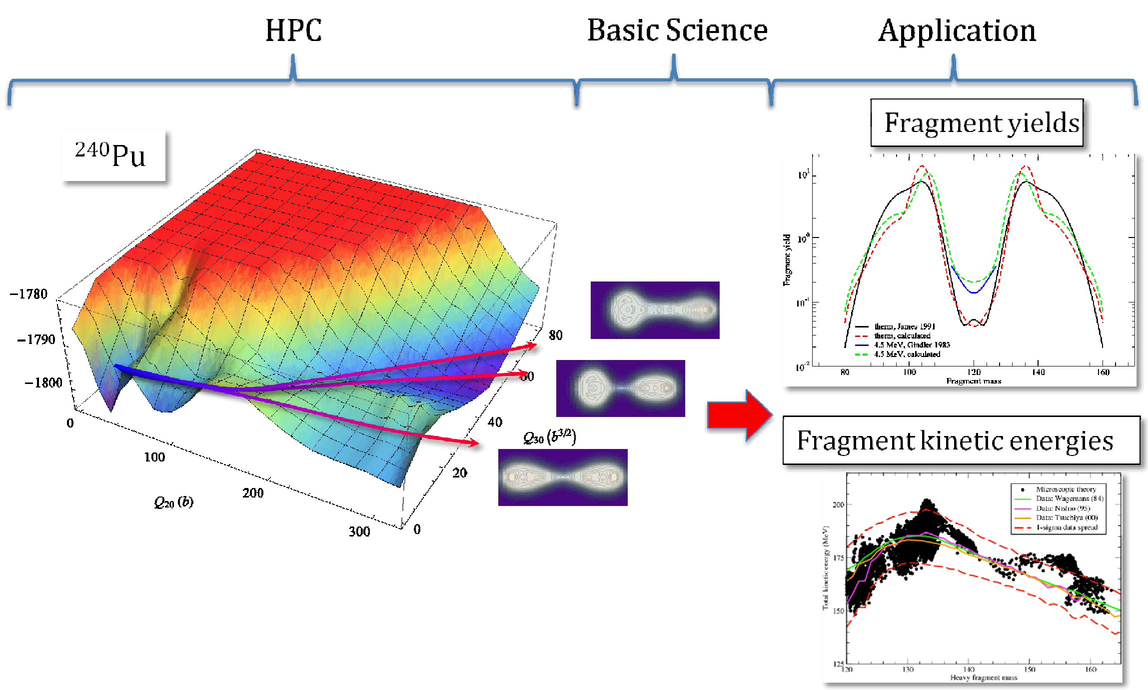

Fig 1. Illustration of combined efforts in HPC to model the evolution of the fissioning nucleus and in the basic science of scission to produce critical input for the programs, such as fragment yields and kinetic energies.