MICROSCOPIC DESCRIPTION OF NUCLEAR FISSION

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Nuclear fission represents one of the most enduring challenges in the many-body theory and at almost 80 years old of age it still appears to defy our efforts to obtain a microscopic description. Several major developments have changed radically our prospects of attaining this so far illusory goal: a new theoretical framework – the Density Functional Theory extended to superfluid systems and real-time dynamics; its validation and verification against a large set of experimental data; a non-trivial numerical implementation and the development of complex codes for the largest and fastest supercomputers. The numerical computational challenge of applying this extension of DFT to nuclear systems is still a problem of extreme computational complexity and it requires the use of the most advanced capabilities of leadership class computers, and taking advantage of tens of thousands of GPU accelerators. A single GPU on Titan ORNL performs the same number FLOPs as approximately 160 CPUs.

The simulation of the fission dynamics of ^{240}Pu from the outer saddle of the fission barrier to the scission point in real-time has been now performed and qualitative new features of the fission dynamics and an unparalleled insight into many observables have been achieved: the pre-neutron emission, total kinetic energy of the fission fragments, their charge, mass yields, and the excitation energies. The evolution is found to be much slower than previously expected, and the comparison with experimental data demonstrates an unexpectedly good agreement in the absence of any fitting parameters.