Fission and fusion at the end of the periodic system.

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We study in a unified macroscopic-microscopic nuclear-structure model fission and fusion in the heavy-element region.

We calculate fission barriers for about 3000 nuclei with $A > 190$. The calculations are done in a 5D space with several million distinct deformations. We have shown that the model reproduces known barriers from Se to Cf with an average error less than 1 MeV while improving an earlier fit of nuclear masses. We therefore feel we can reliably model barriers for neutron-rich nuclei and determine in detail how the stability to fission evolves as one moves away from the line of beta stability. We present new results on fission barriers for neutron-rich nuclei affecting the end of the r-process.

The 5D potential-energy surfaces describe simultaneously fission and fusion valleys and the ridges between these. We show that the shapes of the composite system corresponding to the fusion channel in the 5D potential-energy surface in many cases have mass asymmetries closely corresponding to the projectile and target combinations which have been observed to lead to successful cold-fusion reactions. In addition the shapes of the partially-merged fragments often correspond closely to the shapes of the target and projectile at the top of the fusion barrier.

Another implementation of our model allows the calculation of the interaction energy between two arbitrarily oriented deformed heavy ions. Our model allows the calculation of the macroscopic interaction energy as a function of relative distance and orientation for deformed targets and projectiles as well as their macroscopic self-energies and shell corrections. We show that before touching the shell correction is not significantly affected by any interaction term between the target and projectile. Our model therefore gives the total macroscopic-microscopic potential energy of the target-projectile system. We use this model to obtain more realistic "fusion barriers" than are given by standard "Coulomb barriers" which are usually just given by the maximum of the Coulomb interaction energy between spherical targets and projectiles, where the nuclear radii are modeled phenomenologically. We discuss how the more realistic shape configurations we obtain at the fusion barrier compare to the fusion channel shapes calculated from the 5D potential-energy surfaces of the composite systems.