3-D unrestricted TDHF fusion studies of neutron-rich nuclei using the full Skyrme interaction

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We utilize the Time-Dependent Hartree-Fock (TDHF) method to calculate heavy-ion fusion cross sections for stable and neutron-rich nuclei. The calculations involve modern Skyrme forces and are carried out on a large 3-D Cartesian lattice using the Basis-Spline collocation method. We present TDHF studies without any spatial symmetry restrictions or time-reversal invariance assumptions. This introduces many additional terms into the Skyrme energy functional, including spin-currents and tensors.

One of the appealing features of TDHF is that one can follow the time-evolution of the nuclear density distributions during fusion, involving neck formation, surface vibrations and rotations of the system. Computer animations for several light systems will be presented.

We study both stable and neutron-rich systems ($^{16}O +^{16} O$ and $^{16}O +^{24} O$) to understand the effects of the time-odd parts of the Skyrme interaction on heavy-ion fusion using some of the more recent parameterizations of the Skyrme force (SLy4 and SLy5). In particular, we study the impact parameter dependence of fusion at a fixed bombarding energy, and we determine the total fusion cross section. We also investigate the threshold energy for fusion.

In the second part of the talk, we study fusion reactions of systems involving a spherical projectile and a deformed target nucleus. The computations involve two separate steps: first, a TDHF calculation for a given initial orientation of the deformed nucleus, and secondly a semiclassical time-dependent Coulomb excitation calculation to determine the relative orientation probability of the deformed nucleus near the distance of closest approach. Results will be presented for the light systems $^{16}O +^{22} Ne$ and $^{16}O +^{34} Ne$. We demonstrate that in heavier systems (e.g.$^{64}Ni +^{162} Dy$) the alignment due to multiple E2 and E4 Coulomb excitation is substantial and must be taken into account when calculating fusion cross sections with TDHF.

In the future, we plan to carry out fusion calculations for heavy systems by implementing our TDHF code on massively parallel supercomputers.

References

[1] A.S. Umar and V.E. Oberacker, Eur. Phys. J. A **24** 2005

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