Time-Dependent Hartree-Fock Theory and Its Extensions for the Superheavy Element Synthesis

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In this contribution, recent extensions and applications of the TDHF approach for the superheavy element (SHE) synthesis will be discussed. (See, e.g., [1] for a recent review of TDHF.)

Quasifission is the predominant process that prevents the compound-nucleus (CN) formation in SHE synthesis. To understand the mechanism of quasifission is thus a crucial step towards the synthesis of the yet-unknown elements, 119, 120, and beyond. Here, we report results of systematic TDHF calculations for various projectile-target combinations ($Z_{\mathrm{CN}} = 118$, 119 and 120) at a range of incident energies. Equilibration dynamics (mass/charge/energy) in quasifission will be discussed.

Although TDHF is capable of describing the quasifission process in reactions for SHE synthesis, the CN formation after capture due to the thermal fluctuation of nuclear shapes is out of reach of the TDHF description. To evaluate the evaporation-residue formation probability, we have developed [2] a novel approach that combines TDHF with a Langevin model (fusion-by-diffusion model [3, 4]). In the latter approach, the entrance-channel dynamics are described microscopically within TDHF, which provides the initial condition for the diffusion process over the inner barrier. Implications of the TDHF+Langevin approach when applied to hot fusion reactions to synthesize the element 120 (i.e., ^{48}Ca+^{254,257}Fm, ^{51}V+^{249}Bk, and ^{54}Cr+^{248}Cm) [2] will be discussed.

Last but not least, the search for an alternative mechanism of SHE productions rather than fusion is of great importance. A seminal work by Zagrebaev and Greiner [5] initiated a revival of interest, where it has been demonstrated that multinucleon transfer (MNT) processes in deep-inelastic collisions of actinide nuclei (e.g., ^{238}U+^{248}Cm) may be useful to produce new SHEs. To explore this possibility, we have combined TDHF and TDRPA [6], where the latter incorporates fluctuations and correlations beyond TDHF, together with recent experimental data taken at the Texas A&M Cyclotron Institute. The possibility of SHE productions via MNT processes will be discussed.

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