Activity report of Sakir Ayik while he was visiting GANIL with FUSTIPEN support

The self-consistent mean-field theory, also known as TDHF, by employing Skyrme-type effective interactions, has been very successful for describing nuclear collision dynamics at bombarding energies below binding energy per nucleon. At low energies, two-body dissipation mechanism is not important due to very effective Pauli blocking. Consequently, in the mean field theory collective energy is converted into intrinsic degrees of freedom via interaction of nucleons with the self-consistent mean-field, so called one-body dissipation. The one-body dissipation mechanism plays a dominant role in low energy nuclear dynamics including deep-inelastic heavy-ion collisions, heavy-ion fusion reaction as well as nuclear fission. One important limitation of the mean-field theory is related to the dynamical fluctuations of collective motion. In the mean-field description, while the single-particle motion is treated in a quantal framework, collective motion is treated almost in a classical approximation. Therefore, TDHF severely underestimated fluctuations in collective motion. However, it is well known that no dissipation takes place without fluctuations. Therefore one of the fundamental questions is how to improve the mean-field theory by incorporating the one-body fluctuation mechanism. In a recent work, based on an appealing idea of Esbensen et al., we proposed a stochastic mean-field approach (SMF) by incorporating quantal zero point and thermal and density fluctuations in the initial state [1]. In the standard mean-field approach, the evolution starts from well defined initial state and leads to a definite final state. On the other hand in the SMF approach the initial state is specified by a suitable distribution which can be simulated stochastically to produce an ensemble of final states. For small amplitude fluctuations, this approach gives a result for dispersion of one-body observables that is identical to the formula obtained through a variational approach [2]. In a recent work, by a suitable definition of relative distance, relative momentum and mass-asymmetry variables in low energy heavy-ion collisions, from the SMF approach we deduced transport coefficients associated with these macroscopic variables [3]. These transport coefficients have similar form with those are familiar from the phenomenological nucleon exchange model. In earlier work, we calculated these transport coefficients in central collisions of heavy ions [4-5]. We are currently calculating transport coefficients for nucleon exchange and relative momentum in off-central heavy-ion collisions employing a 3D TDHF code. During my visit at GANIL, we carried out discussions on the ongoing collaboration on this topic. Also, I presented a talk titled “Stochastic Mean-Field Approach for Heavy-Ion Collisions”.

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