Comment on "Early Stages of Nucleus-Nucleus Collisions: A Microscopic Calculation of the Initial Number of Degrees of Freedom"

In a recent Letter [1], Cindro, Korolija, Bĕták, and Griffin calculated the initial degree of freedom (n_0) by a microscopic model. The model follows the evolution of the geometrical and phase spaces during the process of the gradual fusion of the target and the projectile. However, their calculated results did not reproduce the dependence on the target mass A_T displayed by the empirical values of n_0 extracted from the data using the exciton model [2]. Observation, namely, shows that these empirical values generally increase with the target mass; most of the calculated n_0 values of Ref. [1] show an inverse trend with A_T. We suggest that this is due to the use, in Ref. [1], of a simple dynamic process of gradual fusion without friction, instead of which we introduce the Vlasov or Boltzmann-Uehling-Uhlenbeck (BUU) dynamics, incorporating friction.

In Ref. [1], the overlap volume between the projectile and target nuclei in the geometrical space is calculated assuming that the relative velocity of the collision partners is not affected significantly by friction. In fact, the affection of friction is still important in the energy range of 10–100 MeV/nucleon nucleus-nucleus collision. The overlap volume in the geometrical space relies not only on available kinetic energy [1] but also on the energy dissipation produced by friction, etc. So we reject their simple dynamical treatment and apply the Vlasov or BUU model which can incorporate friction [3] to deal with this collision process. The Vlasov model mainly includes the mean-field interaction and the BUU includes both mean-field interaction and nucleon-nucleon collision. By using the Vlasov or BUU dynamics the available excitation energy as a function of the collision time t is obtained. Clearly, all kinematical variables in the momentum phase space (except Fermi momentum P_F), will also depend on t. We take the maximum value of $n_0(t)$ as n_0 [1].

In the present calculation, n_0 is insensitive to nuclear equation of state and in-medium nucleon-nucleon cross section. The time evolution of $n_0(t)$ is almost the same at early stages of collision, it reaches the same maximum (n_0) later. After that for Vlasov dynamics $n_0(t)$ decreases to the value of zero quickly; however, for BUU dynamics it continues to maintain the maximum value (n_0) or decreases to a certain value slowly, depending on the reaction system. In the following calculation, we adopt Vlasov dynamics.

Figure 1 shows A_T dependence of n_0. The solid and unfilled symbols represent the empirical values extracted from the data and the calculated n_0, respectively. Obviously, our results predict the trend of n_0 with A_T and reproduce well the empirical values. It seems that the correct trend of n_0 with A_T stems from

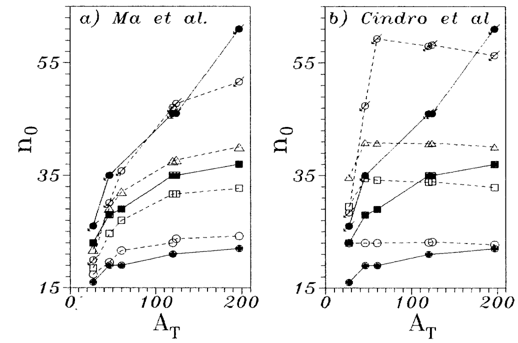

FIG. 1. Dependence of n_0 on A_T. The solid symbols show the empirical values from Ref. [2] and the unfilled symbols show the calculated results. The circles, squares, triangles, and circles with an arrow represent ^{16}O(403 MeV), ^{32}S(504 MeV), ^{32}S(679 MeV), and ^{58}Ni(876 MeV) induced reactions, respectively. Note that the empirical values are the same for ^{32}S(504 MeV) and ^{32}S(679 MeV) induced reactions (shown by the solid squares). (a) Our calculations. (b) Cindro's calculations [1].

Vlasov or BUU dynamics. In addition, other features related to n_0 can be obtained rather well since better results of n_0 than Ref. [1] have been obtained. As one of the examples, we get the linear dependence of the excitation energy per n_0 on the available energy, i.e., $E^*/n_0 = 0.27(\frac{E_{\mathrm{c.m.}}-V_{\mathrm{CB}}}{A_P}) + 9.65$ (all energies in MeV; V_{CB} represents the projectile-target Coulomb barrier). For given colliding systems we can estimate correctly the values of n_0 from the above equation and reproduce well the empirical extracted values [4, 5].

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