Kinetic approach to light-nuclei production in intermediate-energy heavy-ion collisions

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We have developed a kinetic approach to the production of light nuclei up to mass number $A \leq 4$ in intermediate-energy heavy-ion collisions by including them as dynamic degrees of freedom [1]. The conversions between nucleons and light nuclei during the collisions are incorporated dynamically via the breakup of light nuclei by a nucleon and their reverse reactions. We have also included the Mott effect on light nuclei [2,3], i.e., a light nucleus will no longer be bound if the phase-space density of its surrounding nucleons is larger than the cutoff parameter $f_A^{\text{cut}} \geq \int f_N\left(\frac{\boldsymbol{P}}{A}+\boldsymbol{p}\right)\rho_A(\boldsymbol{p})d^3\boldsymbol{p}$, where $\rho(\boldsymbol{p})$ denotes the

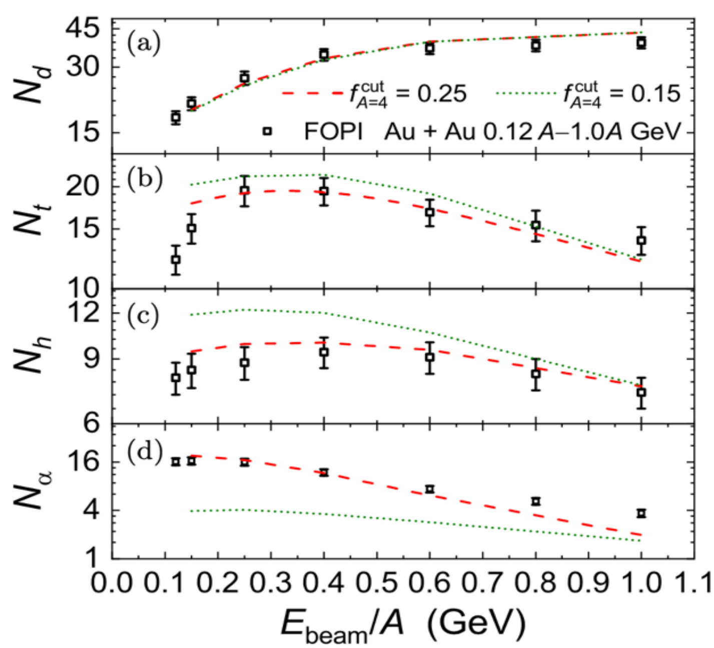

FIG. 1. Incident-energy dependence of light-nuclei yields from kinetic approach with $\boldsymbol{f_{A=2}^{\text{cut}} = 0.11}$, $\boldsymbol{f_{A=3}^{\text{cut}} = 0.16}$, and $\boldsymbol{f_{A=4}^{\text{cut}} = 0.25}$. The results for a smaller $\boldsymbol{f_{A=4}^{\text{cut}} = 0.15}$ are also included for comparison. The experimental data are from the FOPI Collaboration [4,5].

nucleon momentum distribution inside a light nucleus consisting of A nucleons and f_N is the nucleon phase-space distribution in the medium with $\boldsymbol{P}$ being the total momentum of the A nucleons. With this kinetic approach, we have obtained a reasonable description of the measured yields of light nuclei in central Au + Au collisions at energies of 0.25A GeV-1.0A GeV by the FOPI Collaboration [4,5], as shown in Fig. 1. Our study also indicates that the observed enhancement of the alpha-particle yield at low incident energies can be attributed to a weaker Mott effect on the alpha particle, which makes it more difficult to dissolve in nuclear medium, because of its much larger binding energy.

[1] R. Wang, Y.G. Ma, L.W. Chen, C.M. Ko, K.J. Sun, and Z. Zhang, Phys. Rev. C **108**, L031601 (2023).
[2] G. Röpke, L. Münchow, and H. Schulz, Nucl. Phys. **A379**, 536 (1982).
[3] G. Röpke, M. Schmidt, L. Münchow, and H. Schulz, Nucl. Phys. **A399**, 587 (1983).
[4] FOPI Collaboration, Nucl. Phys. **A848**, 366 (2010).
[5] R. Bougault, B. Borderie, A. Chbihi, Q. Fable, J. D. Frankland, E. Galichet, T. Genard, D. Gruyer, M. Henri, M. La Commara, N. Le Neindre, I. Lombardo, O. Lopez, M. Pârlog, P. Pawłowski, G. Verde, E. Vient, and M. Vigilante, Symmetry **13**, 1406 (2021).