As observed in Fig. 2, the model qualitatively reproduces the trends observed in the data for Z = 3−5 fragments. For heavier fragments the preference for the growth of neutron-deficient ejectiles in the high-energy tails of the spectra is much less pronounced. This may in part be due to the fact that with increasing atomic number the ratio of equilibrated to nonequilibrated IMFs increases,[3] thus favoring $N \geq Z$ fragments.

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LIGHT PARTICLE CORRELATION FUNCTIONS FOR THE ^{3}He + Ag REACTION AT 200 MeV

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For collisions at non-relativistic energies, particle-particle correlation functions,[1] gated on the energy of the detected particles, indicate that the space-time extent of the initial source which produces the most energetic particles generally increases with the size of the projectile.[2] The most dramatic sensitivity to the space-time evolution of such reactions might, therefore, be expected for light-ion-induced reactions on heavy targets, reflecting the evolution from an initial configuration involving the projectile and a few target nucleons to the equilibrated target-like residue. Here we present measurements of light-ion-induced reactions that illustrate effects which influence the correlation functions of very energetic particles emitted during these early stages−−effects which are averaged away in energy averaged correlation function data.

The experiment was performed at the Indiana University Cyclotron Facility. A natural 1.05 mg/cm^2 Ag target was bombarded by 200 MeV ^{3}He ions. Coincident light particles were detected with a high resolution hodoscope consisting of 13 closely packed telescopes. Four of these telescopes were each comprised of four silicon detectors (75 μm, 100 μm, 5 mm, and 5 mm thick). The other nine telescopes were each comprised of two silicon detectors (200 μm and 5 mm thick) and a 10 cm thick NaI(Tl) detector. Two single-wire gas counters were placed in front of each telescope to provide x and y position information. Measurements were performed with the hodoscope centered at $\theta_A = 42°$, where nonequilibrium processes dominate, and 109°, where equilibrium emission becomes dominant.

We define the experimental correlation function R(q) in terms of the measured coincidence yield $Y_{12}(\vec{p}_1,\vec{p}_2)$ and the singles yield $Y_1(\vec{p}_1)$ and $Y_2(\vec{p}_2)$:

$$\sum Y_{12}(\vec{p}_1,\vec{p}_2) = C[1 + R(q)] + Y_1(\vec{p}_1)Y_2(\vec{p}_2). \tag{1}$$

Here, $\vec{p}_1$ and $\vec{p}_2$ are the momenta of the two particles in the laboratory and q is the relative momentum between the two particles. The normalization constant C in Eq. (1) is chosen so that R(q) vanishes at large relative momenta where final state interactions between the two particles become negligible.

Figure 1 shows two-proton correlation functions for energy gates containing different portions of equilibrium and nonequilibrium emission. The correlation functions exhibit minima at q = 0 MeV/c and maxima at q = 20 MeV/c due to the attractive singlet S-wave final state interaction. For low energy protons ($E_p = 12 - 16$ MeV at $\theta_A = 42°$

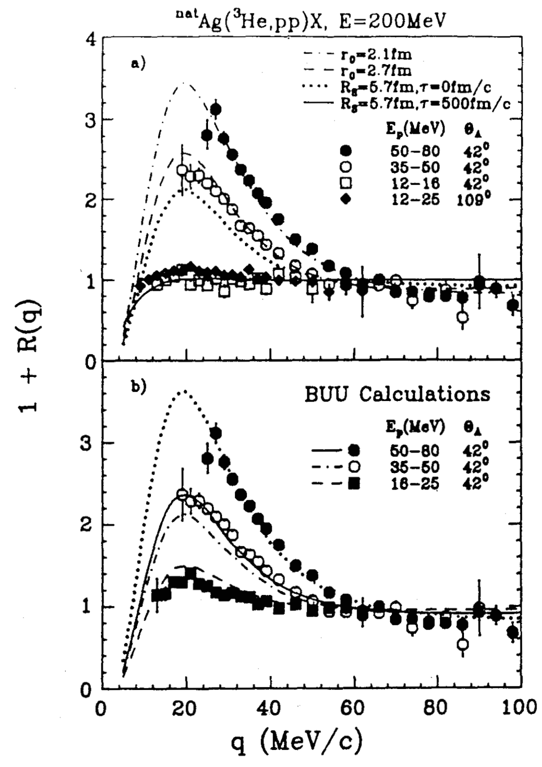

Figure 1. Part a: p−p correlation functions measured for the ^{3}He + Ag reactions at 200 MeV. The energy gates and angular position of the center of the hodoscope are indicated in the figure. The curves are discussed in the text. Part b: Comparison of experimental p−p correlation functions with predictions from the BUU theory for the ^{3}He + Ag reaction at 200 MeV.

and $E_p = 12-25$ MeV at $\theta_A = 109°$) the maxima are strongly attenuated, qualitatively consistent with an evaporative emission mechanism. The maxima increase with the kinetic energy of the emitted particles, reaching values for the highest energy gate (E_p = 50-80 MeV) which are much larger than those observed in previous medium energy experiments,[3] indicating rapid emission from a small source.

For illustration, the solid and dotted curves in Fig. 1 show correlation functions calculated assuming surface emission from a Ag target-like residue[1,4] ($R_s = 5.7$ fm). The correlation functions for low energy protons can be reproduced with lifetimes of $\tau \approx 300 - 3000$ fm/c; the solid curve shows a calculation for $\tau = 500$ fm/c. While larger maxima at q = 20 MeV/c are predicted for smaller τ, even the assumption of a vanishing source lifetime (dotted curve) underpredicts the correlation functions measured for the two highest energy gates where preequilibrium emission dominates. The dashed and dot-dashed curves show calculations for Gaussian sources of negligible lifetime. The calculations illustrate that the correlation functions for the most energetic protons are consistent with instantaneous emission from a system significantly smaller than the target nucleus.

In order to determine whether such strong correlations could be reproduced by microscopic dynamical calculations, we have calculated correlation functions using Wigner transforms which satisfy the Boltzmann-Uehling-Uhlenbeck (BUU) transport equation.[5] In our calculations we assumed a free nucleon-nucleon cross section and an equation of state with a compressibility coefficient K = 240 MeV. Nucleon emission was calculated during a time interval of $\Delta t_e = 140$ fm/c after the initial contact of the colliding nuclei.

The solid, dashed and dot-dashed curves in Fig. 1 show the correlation functions from the BUU calculations. For nonequilibrium emission at low ($E_p = 16-25$ MeV) and intermediate $E_p = 35-50$ MeV) energies, the calculations are in reasonable agreement with the data. For the most energetic protons ($E_p = 50-80$ MeV), however, the calculations underpredict the observed correlations, a discrepancy not observed in previous comparisons of heavy-ion-induced reactions.

Large correlation functions are observed for other pairs of particles which cannot arise from projectile breakup. For example, the correlation function in Fig. 2 for nonequilibrium deuterons and α particles emitted at $\theta_A = 42°$ displays large peaks near q $\approx$ 80 MeV/c, due to overlapping resonances centered at 4.31 and 5.65 MeV. These correlation functions are reproduced by calculations which assume instantaneous emission from a Gaussian source of radius parameter $r_0 \approx 2.7$ fm (depicted by the dashed line in Fig. 1) to the two proton correlation function at E_p = 35–50 MeV assuming the statistical spin weighting factor, $\alpha = 1/4$.

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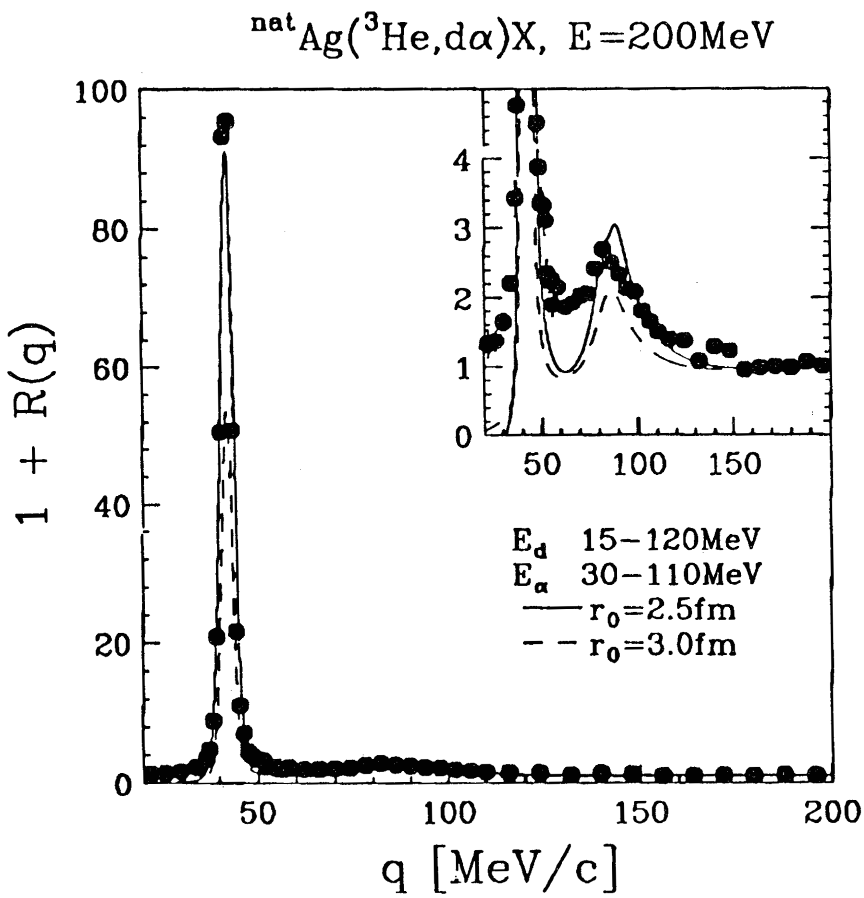

Figure 2. d−α correlation functions measured for the ^{3}He + Ag reaction at 200 MeV. The energy gates and angular position of the center of the hodoscope are indicated in the figure. The curves are discussed in the text.