GLOBAL PROPERTIES OF THE ^{4}He + ^{28}Si REACTION AT 117.4 AND 198.5 MeV

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Mass, kinetic energy and angular distributions have been measured for all fragments with $6 \leq A \leq 30$ in the reaction of 117.4- and 198.5-MeV ^{4}He ions with a ^{28}Si target. Mass identification with a resolution of $\approx$0.3 u was achieved with a channel plate/47μm silicon surface barrier time-of-flight/energy system, followed by surface-barrier detector elements of 500 μm and 2 mm and a 5 mm lithium-drifted silicon detector. This system permitted identification of all fragments with recoil energies $E_R \gtrsim 0.1$ MeV.

The data have been compared with predictions of the internuclear cascade code CLUST[1], which incorporates elementary scattering cross sections for all nucleon, deuteron and alpha-particle collision possibilities. This code, combined with a statistical Fermi breakup mechanism in the decay channel, has proven successful in describing ^{4}He + ^{12}C collisions over a range of intermediate energies[2]. In the present case, a standard statistical decay code (DFF) is used to account for de-excitation of the excited cascade residue[3]. For fragments with $A \lesssim 26$ the calculations reproduce the shapes of the energy spectra rather well at both energies. However, for near-target fragments, the code predicts a much larger contribution from quasi-elastic processes than is observed in the data. As shown in Fig. 1, the fragment angular distributions are described well at angles greater than 30°-40°. However, the code severely underpredicts the data at small angles and overpredicts the yields of near-target fragments near the quasi-elastic recoil angle. This result is consistent with previous studies that show the energy dissipation mechanism in the intranuclear cascade code is not strong enough. This same effect is reflected in the fragment mass distributions, for which the cascade code overpredicts near-target yields and fails to produce sufficient amounts of $A \lesssim 22$ fragments, which can only be produced from reactions involving high excitation energies.

These data also permit an extension of the systematics of average linear momentum transfer, $<p_{\parallel}>$, as the function of target mass[4]. Using these data and predictions of the cascade code to estimate the average number of nucleons emitted prior to statistical decay, values of $<p_{\parallel}>$ can be evaluated for these data. We find $<p_{\parallel}>$ = 460 MeV/c at 117.4 MeV and $<p_{\parallel}>$ = 440 MeV/c at 198.5 MeV. In Fig. 2 we include our value for the ^{4}H + ^{28}Si system with other data for ^{4}He-induced reactions. The important role of the nuclear matter density distribution in energy transfer from projectile to target at intermediate energies is apparent in the monotonic decrease of $<p_{\parallel}>/p_{beam}$ as a function of decreasing target mass.

1. G.J. Mathews et al., Phys. Rev. C **25**, 2181 (1982).

2. A. Gökmen et al., Phys. Rev. C **29**, 1595 (1984).

3. K. Kwiatkowski et al., Phys. Rev. Lett. **50**, 1648 (1983).

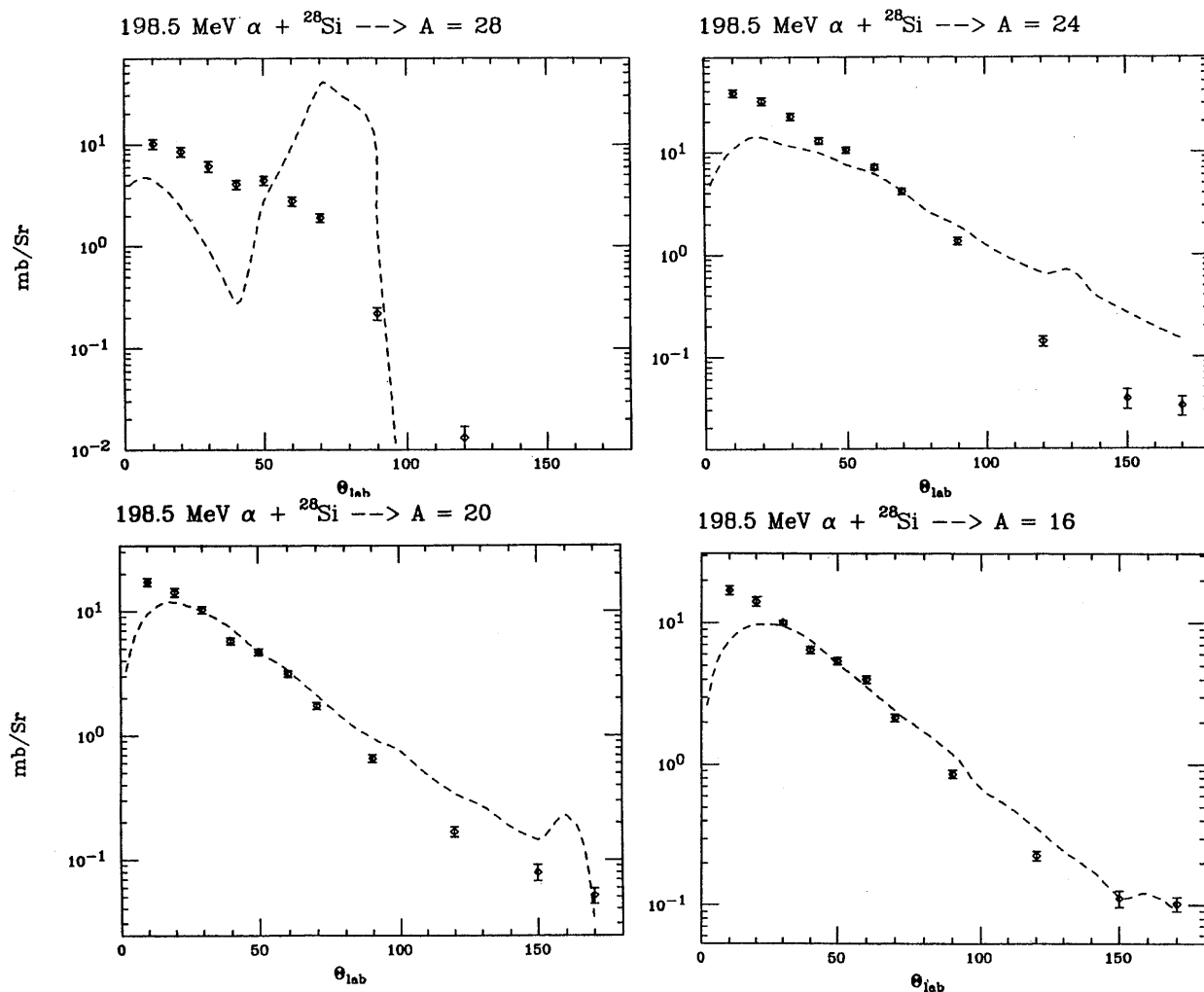4. T. Batsch et al., Phys. Lett. B **189**, 287 (1987).

Figure 1. Angular distributions for $A = 16$, 20, 24, and 28 fragments from 198.5-MeV ^{4}He + ^{28}Si reaction. Dashed lines are predictions of intranuclear cascade code CLUST[1].
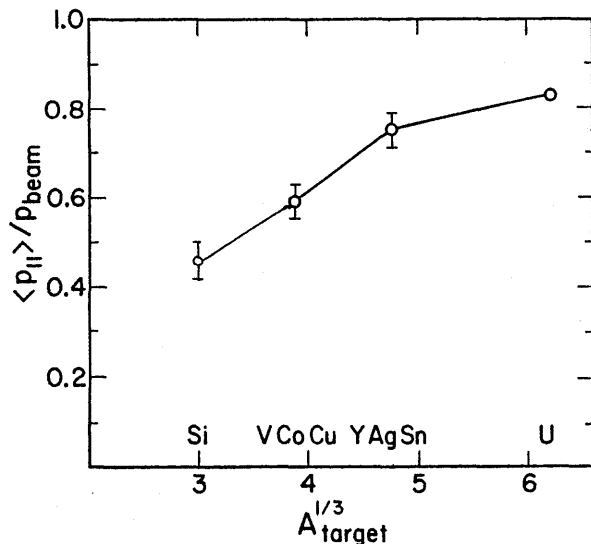
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Figure 2. Average linear momentum transfer for $E/A = 35$ MeV ^{4}He ions as a function of target mass. Data for heavier systems taken from Ref. 4.

STUDIES OF COMPLEX FRAGMENT EMISSION IN REACTIONS
OF E/A = 50 MeV ^{4}He IONS WITH ^{nat}Ag AND ^{197}Au

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Intermediate-mass-fragment yields (IMF: $3 \leq Z \lesssim 15$) have been measured for the $E/A = 50$ MeV ^{4}He $+$ ^{nat}Ag and ^{197}Au reactions. Fragment charges were identified with an axial gas-ionization chamber/silicon semiconductor surface barrier ΔE-E telescope. At selected angles discrete nuclide identification was also obtained with resolution $\Delta A \lesssim 0.5\ \mu$ by using beam rf and silicon detector timing signals for time-of-flight/energy determination.

The energy spectra, angular distributions and cross sections for each Z are found to resemble earlier data for the 200-MeV ^{3}He $+$ ^{nat}Ag system[1]. IMFs from the latter system were well-described by isotropic emission from a two-source model: one involving statistical decay of a fully equilibrated source and the other originating from a fast precompound-like mechanism. For the equilibrated source (EQ) the model of Moretto[2] is employed; the non-equilibrium (NEQ) source is described by a Maxwellian function with surface emission. Each source is characterized by a velocity v, temperature T and Coulomb barrier fraction k; in addition, the statistical fit requires determination of an amplification parameter, p. Because of the distinctly precompound character of the forward-emitted fragments, an angular fitting function, $W(\theta) \propto e^{-a\theta}$, was included in the fit. This addition served to improve the quality of the fits markedly and also provided a more systematic set of fitting parameters, especially with regard to the Coulomb barrier fractions. These results are shown in Fig. 1 where spectra from boron fragments at several representative angles are