CALCULATIONS OF ISOTOPIC IMF YIELDS IN THE ^{4}He + ^{116,124}Sn REACTION

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The effect of target N/Z ratio on the properties of intermediate-mass fragment (IMF) ejectiles has been investigated in the reaction of E/A≈50 MeV ^{4}He ions with targets of ^{116}Sn and ^{124}Sn. Both equilibrium-like and nonequilibrium sources have been studied by performing measurements at extreme backward and forward angles.

The data demonstrate the influence of target composition on both the charge and isotopic distributions of the fragments. Elemental cross sections from the ^{4}He + ^{116}Sn system are distinctly enhanced relative to ^{4}He + ^{124}Sn. For nonequilibrium emission, both targets produce similar yields for light IMFs; however, the ratio of the elemental cross sections from ^{116}Sn to those from ^{124}Sn becomes increasingly larger as a function of increasing fragment charge.

The backward-angle emission of IMFs can be interpreted in terms of statistical emission from a compound nucleus.[1] In order to examine the influence of neutron binding energies and angular momentum on the ^{116,124}Sn charge distributions, we have performed calculations with the evaporation code BUSCO.[2] These results are shown in Fig. 1. Using a value of L=19$\hbar$ and the maximum available excitation energy, the cross sections for the ^{116}Sn target are relatively well reproduced. For the ^{124}Sn target the calculation successfully predicts the lower IMF cross sections relative to ^{116}Sn, but is much less successful in describing the heaviest fragment yields. In both cases the slope of the calculation is steeper than the data. By increasing the input angular momentum to L=22$\hbar$, a somewhat better fit to the ^{124}Sn data is obtained, both in magnitude and slope. A possible explanation for this result is that the L-wave distribution for the average emitting system formed in the ^{4}He + ^{116}Sn reaction may sample a higher range of angular momentum values than in ^{4}He + ^{116}Sn reactions, a result consistent with the increased decay widths for neutron emission from the neutron-excess system. Nonetheless, the BUSCO calculation underpredicts heavy fragment yields, especially for the neutron-excess targets. This suggests that calculations of Γ_n/Γ_{IMF} in this code may need some modification.

While the backward angle emission of IMFs can be understood relatively well in terms of the decay of a compound nucleus, the mechanism of nonequilibrium production is still poorly understood. For these ejectiles the important question of the time scales complicates the theoretical interpretation of the data. The accreting source model[3] is based on the assumption of local statistical emission from an excited subsystem of the nucleus created by the fusion of the projectile with some number of target nucleons. This source simultaneously emits fragments and cools by accreting nucleons from the remainder of the target. In our calculations we have assumed an initial source size of eight nucleons, an accretion rate of 2 nucleons/fm/c, and an exit-channel Coulomb barrier of 0.9 times the touching-spheres value. The Fermi energy of 24 MeV and normalization coefficients were

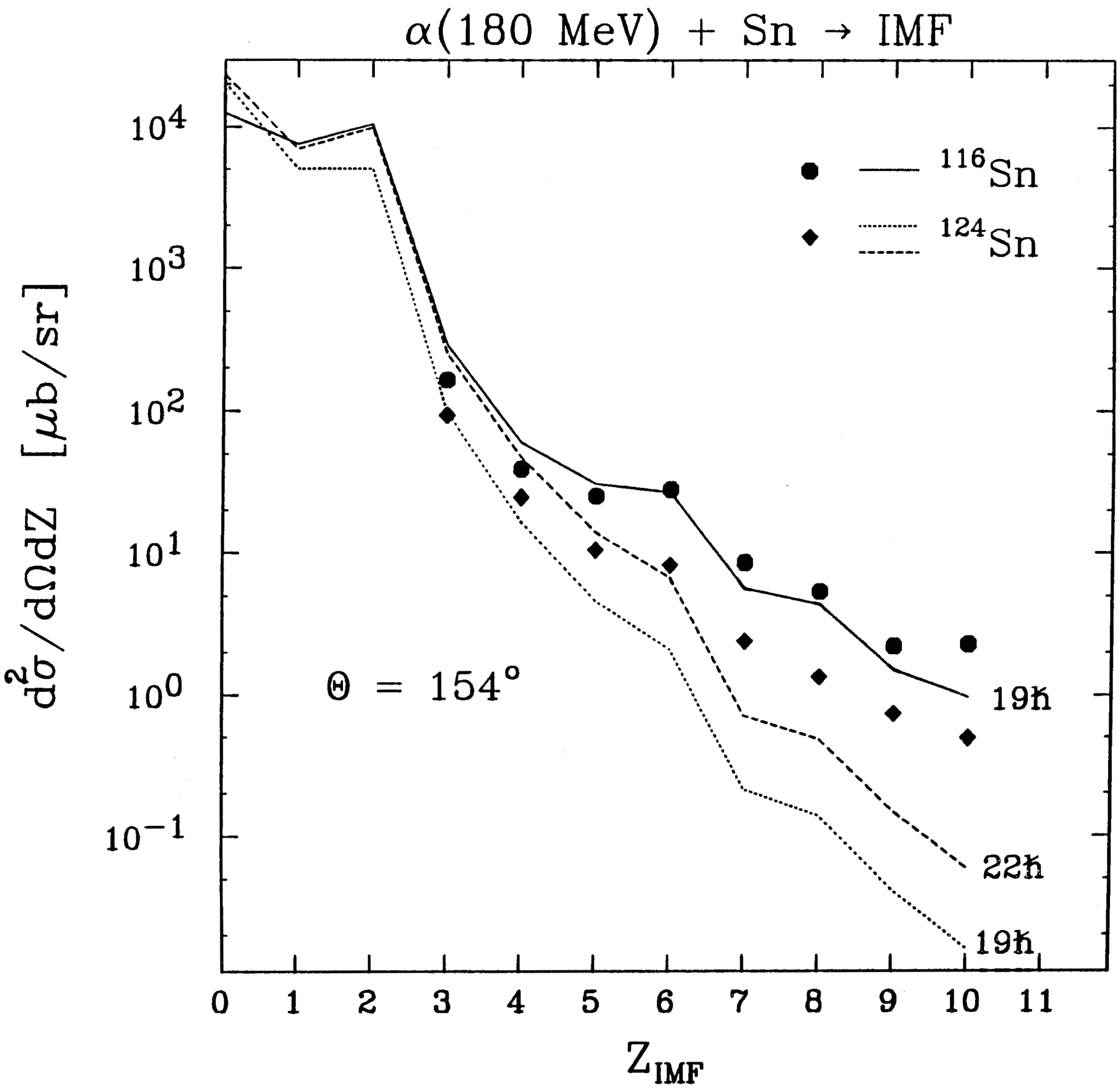

Figure 1. Charge distributions for IMFs emitted at 154° for 180 MeV ^{4}He+^{116,124}Sn reactions, compared with BUSCO[2] calculations. Calculations are performed for L=19$\hbar$ for both systems and L=22$\hbar$ for ^{124}Sn .

fixed by requiring a fit to the charge distributions.

The isotopic yield results are shown in Fig. 2. We observe general agreement with the data, including ^{7}Be. The ratios $\sigma(^{116}\mathrm{Sn})/\sigma(^{124}\mathrm{Sn})$ are also reasonably well reproduced by the calculations. Emission temperatures calculated with the model are lower for heavier fragments and somewhat higher in the case of the ^{124}Sn target.

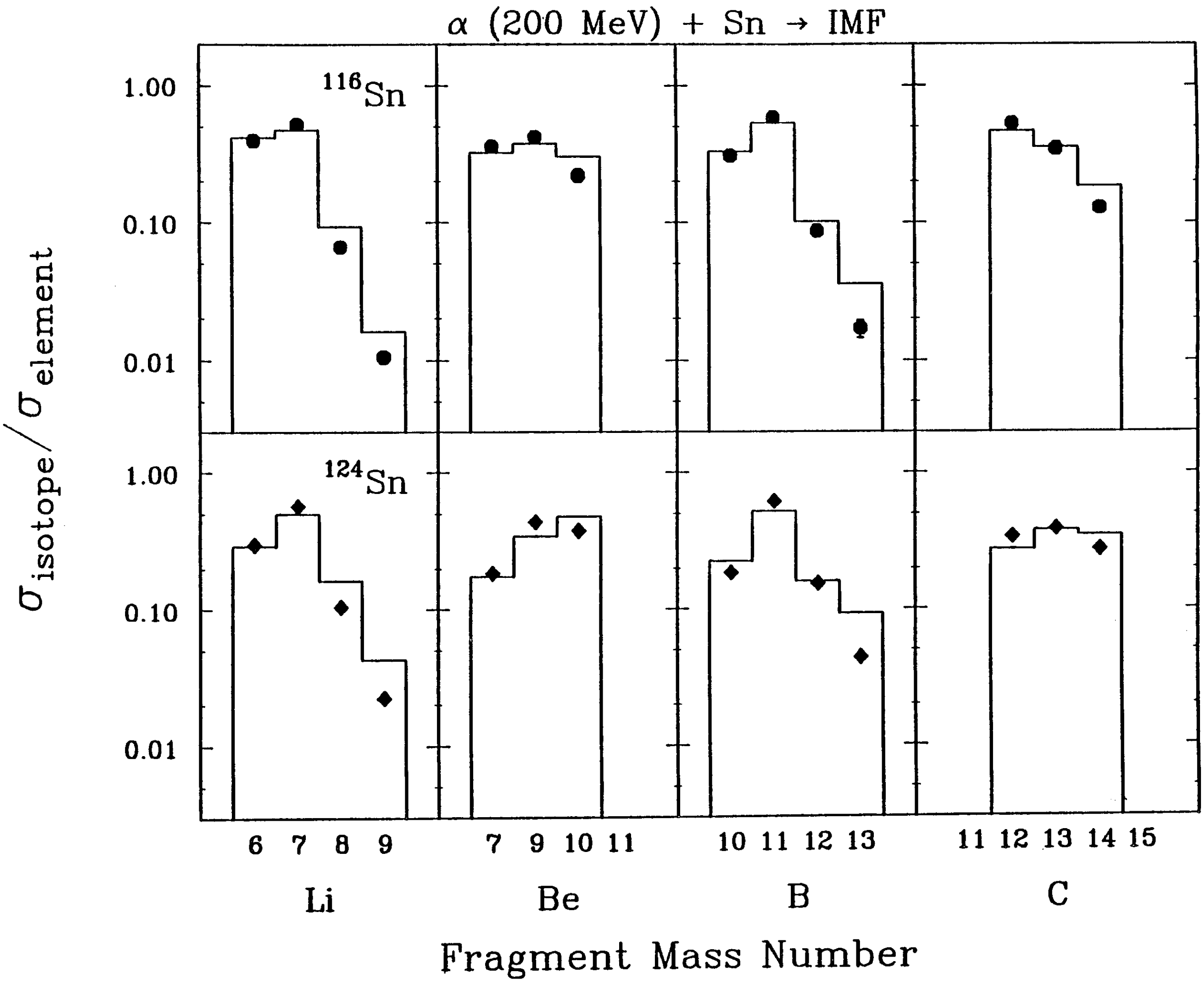

Figure 2. Isotopic ratios for Li, Be, B and C fragments, for ^{116}Sn (upper) and ^{124}Sn (lower) targets. The solid line is the prediction of the accreting source model.[3]

Whereas the calculation reproduces the total cross sections well, it fails to reproduce the angular distributions. The predicted angular distributions are much flatter than the experimental ones. Also, the slopes of the energy spectra for the lighter fragments are too steep. For the heavier fragments, the spectral shapes are well-reproduced, although the absolute cross sections are too small at forward angles. Somewhat more rapidly decreasing angular distributions can be obtained by using a lower value of the accretion rate. The charge and isotopic distributions, as well as energy spectra, are relatively insensitive to such a change. To obtain flatter energy spectra, however, it is necessary to increase the Fermi energy, which in turn causes the charge and isotopic distributions to become flatter. Thus, the accreting source model describes many features of these data satisfactorily, although complete self-consistency cannot be achieved for all observables.

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