MULTIFRAGMENT EMISSION IN THE ^{3}He + ^{nat}Hg REACTION AT 0.90 AND 3.6 GeV*

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We report experimental data from multifold coincidence studies of IMFs emitted in the bombardment of ^{nat}Ag nuclei with 0.90 and 3.6 GeV ^{3}He ions at the Laboratoire Nationale Saturne. High purity, self-supporting ^{nat}Ag targets of thickness 900 μg/cm^2 and area 20 cm^2 were bombarded with ^{3}He ions of energies 0.90 and 3.6 GeV. An array of 36 particle-identification telescopes that covered 8% of the total solid angle was employed in these studies.

At both energies the evidence for multiple fragment events is clear. Even with the relatively low solid-angle coverage, events with multiplicity M_{IMF}^{obs} up to four are observed. In addition there is a significant increase in probability for multifragment emission at the higher energy. For example, the cross section for $M_{IMF}^{obs} = 3$ events is over 40 times larger at 3.6 GeV than at 0.90 MeV.

In Fig. 1 we show the summed IMF charge distributions and the summed IMF kinetic energies for $M_{IMF}^{obs} \geq 2$ events. Light-charged particles are not included in these sums. At 3.6 GeV bombarding energy events are detected which account for up to 75% of the total available charge—even with only 8% of total solid-angle coverage. Fig. 1(a) demonstrates that the observed events contain significant contributions from higher-Z fragments and are not exclusively due to light elements such as Li and Be. In addition, the total observed kinetic energy per event extends up to 400 MeV; light-charged particles are excluded from these sums. The solid line in Fig. 1(b) is the result of a calculation based upon sequential statistical emission of IMFs from an equilibrated target-like source with normal nuclear matter density, initially at a temperature of 8 MeV, and corrected for detector acceptance. The simulation assumed as input experimental values from the fragment charge distributions[1] and reconstructed multiplicity results. In order to assess the upper limit for fragment kinetic energies, cooling by H and He emission was blocked in this calculation. Even for this extreme assumption, the calculated total kinetic energies fail to approach the experimental distribution, suggesting that the fragment acceleration mechanism is more complex than simple Coulomb repulsion from a thermal source.

The most striking result is found in the systematic evolution of the fragment kinetic energy distributions with increasing multiplicity and bombarding energy. In Fig. 2 the kinetic energy spectra for carbon fragments measured at each of the three angles are shown as a function of observed multiplicity, M_{IMF}^{obs}, for both bombarding energies. Similar results are observed for all IMF Z values. Each frame presents spectra gated on $M_{IMF}^{obs} = 1$, 2 and 3, respectively, from the entire detector array. When the spectra are examined as

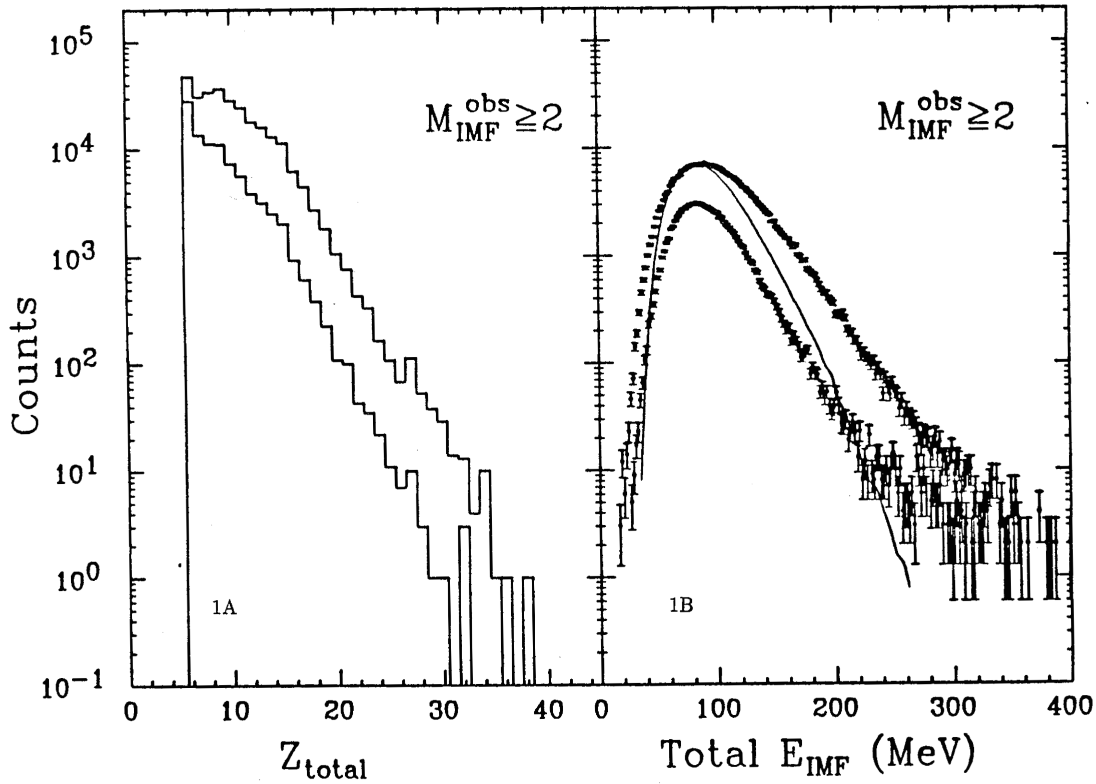

Figure 1. Top: Distributions of summed IMF charge for IMFs with $M_{IMF}^{obs} \geq 2$ for the 3.6 (top) and 0.90 (bottom) GeV ^{3}He + ^{nat}Ag reactions. Bottom: Distributions of summed detected kinetic energy per event for IMFs for $M_{IMF}^{obs} \geq 2$ for 3.6 (top) and 0.90 (bottom) GeV. The solid line is the result of a simulation based on sequential statistical emission, normalized to the peak of the 3.6 GeV data.

a function of M_{IMF}^{obs}, one observes marked changes in which the spectral shapes become increasingly flat with increasing multiplicity. This is most apparent in the backward-angle data. A simple Maxwellian fit to the $\Theta = 117°$ spectra at 3.6 GeV gives slope parameters of T $\cong$ 13, 15, and 19 MeV for M_{IMF}^{obs} = 1, 2, and 3, respectively.

The fragment angular distributions become increasingly isotropic with increasing multiplicity, which can be deduced from examination of Fig. 2. The effect is most noticeable for the 900 MeV data, where the spectra for high M_{IMF}^{obs} events are found to be much flatter and exhibit Coulomb peaks which extend to much lower energies than for the singles observations. This is consistent with an interpretation that at an energy of 0.90 MeV, the IMF yield is dominated by binary nonequilibrium emission or statistical decay. At 3.6 GeV the probability for multifragment emission is greatly enhanced, thus masking the spectra of simpler binary-like processes and producing a more isotropic emission pattern.

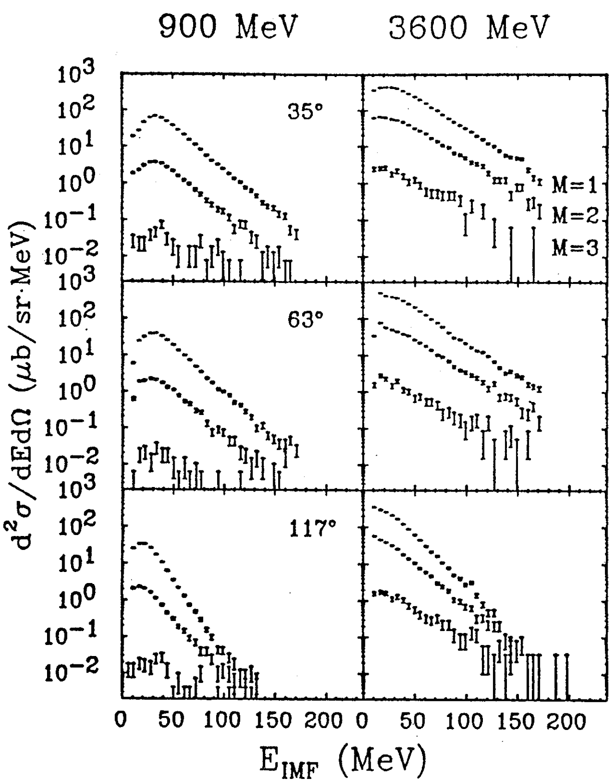

Figure 2. Energy spectra of carbon fragments for 900 MeV (left column) and 3.6 GeV (right column) observed at 35° (top row), 63° (middle row) and 117° (bottom row). In each frame top spectrum is for $M^{obs}_{IMF} = 1$, middle is for $M^{obs}_{IMF} = 2$ and bottom is for $M^{obs}_{IMF} = 3$. Errors are statistical, based on total counts.

Finally, comparison of the spectra at the two bombarding energies shows that at 3.6 GeV the Coulomb peaks are systematically broadened toward lower fragment energies and the spectral tails are much harder. This behavior suggests significant modifications of the Coulomb field of the emitting system, consistent with the predictions of the expanding, evaporating source model of Friedman[2] which can also successfully reproduce the multiplicity data.

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