Binary and multifragment emission of light residues in the spallation of ^{56}Fe

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The study of light fragment emission from ion-proton and ion-ion collisions provides a valuable probe for investigating the reaction dynamics at relativistic energies [1]. New data were obtained in the interaction of ^{56}Fe projectiles of 1 A GeV in a hydrogen and a titanium target, respectively. Mass and charge of the fragments were identified with the FRS. The velocities of the residues were deduced from the magnetic rigidity.

The study presented in the figure demonstrates the evidence that the light-fragment emission results from two substantially distinct mechanisms, when changing from the ^{56}Fe+Ti system to the less excited ^{56}Fe+p system. Only in the proton-induced spallation, the residues lighter than ^{12}C are observed forward and backward with respect to the beam frame: this distribution reflects a *strong Coulomb component* and carries the signature of a *binary process* [2]. On the other hand, the high excitation induced in ^{56}Fe+Ti goes mainly into the disintegration of the system, and multifragmentation is expected to be the dominating process. In this case, the velocity distributions show a bell shape. The high emission velocities, and the analysis of the kinetic-energy spectra of the light residues of the proton-induced reaction reveal that the light residues are repelled from a *heavy partner*.

Calculations with SMM [3] relate the binary break-up mode observed for ^{56}Fe+p to an excitation-energy window extending from 1.5 MeV/u to 2.5 MeV/u; according to INC calculations, the excitation energy of the hot fragments generated after the collision with protons could indeed rise slightly above 3 MeV/u: this could lead to the onset of more rare multifragmentation phenomena where IMFs with $A > 12$ are produced with higher probability. The binary break-up is well described assuming the splitting of the hot source in two very asymmetric fragments in a freeze-out state. This scenario would limit the probability for the formation of a compound nucleus. Further conclusions would require the knowledge of the time scale of the reaction.

References

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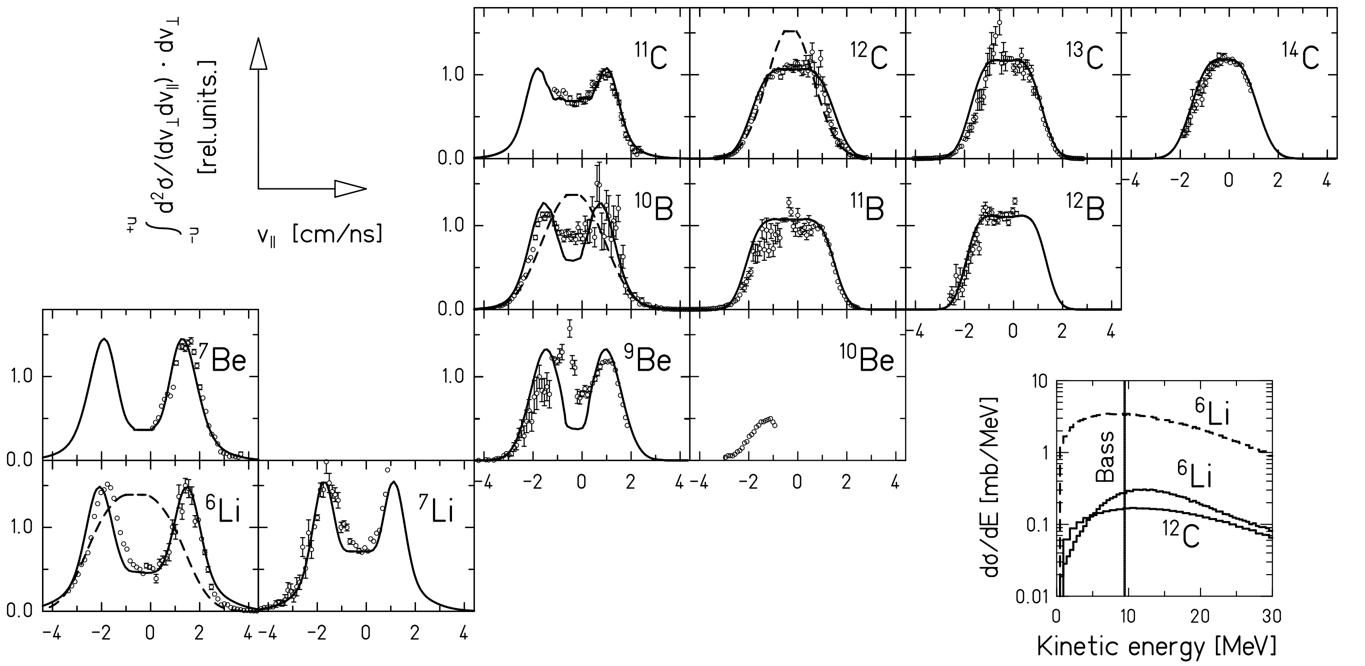

Figure: The velocity spectra of the light residues produced from ^{56}Fe+p at 1 A GeV ordered on a nuclear chart. $v_{\parallel}$ is the velocity in the beam direction in the beam frame. The observed spectra are marked with points, and they represent all the fragmets transmitted through the FRS. $v_{\perp}$ is the transverse velocity measured in the beam frame; the largest absolute value u is defined by the largest emission angle ($\approx 15mr$ in the laboratory frame) selected by the finite acceptance of the spectrometer. The solid lines indicate the reconstructed velocity spectra, obtained for $u \mapsto 0$. The reconstructed spectra for ^{6}Li, ^{10}B and ^{12}C emitted from ^{56}Fe+Ti are superimposed with a dashed line. On the right-hand side of the panel, the energy spectra for ^{6}Li and ^{12}C emitted from ^{56}Fe+p (solid line) and ^{6}Li emitted from ^{56}Fe+Ti (dashed line) are presented in the beam frame. The vertical thick line indicates the kinetic energy obtained from the Bass barrier when the emitting source is ^{56}Fe.