Influence of Radial Flow on the Multifragmentation Phase Space

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In collisions between two heavy nuclei with beam energies up to about 100 MeV per nucleon the maximum multiplicity of intermediate mass fragments (IMFs) is reached in central collisions [1]. The observation of the '*Rise and Fall of Multifragment Emission*' in Au induced reactions at E/A = 600 MeV [2] revealed the increasing importance of peripheral collisions for the multifragmentation channel at higher energies. In order to explore the similarities of and/or the differences between the multifragmentation processes in central and peripheral collisions, a joint experiment of the ALADIN-collaboration and the MSU-MINIBALL/-WALL group was performed. The combination of the two detector systems provided a high detection efficiency for fragments in nearly 4π geometry.

In this experiment, Au+Au reactions were studied at incident energies between 100 and 400 MeV per nucleon. The upper part of Fig. 1 shows the mean IMF multiplicity normalized to its maximum value as a function of the reconstructed impact parameter $\hat{b}$. At E/A =100 MeV a maximum mean fragment multiplicity of $\langle M_{IMF}\rangle \approx 10$ is observed in central collisions [3]. The majority of the fragments originate from the interaction region. On the other hand, at E/A = 400 MeV, the maximum multiplicity of $\langle M_{IMF}\rangle \approx 5$ is seen in peripheral collisions. In this case, the two spectators are the main sources of the IMFs. Correcting these numbers for the detection efficiency we find that in both cases the maximum IMF multiplicity normalized to the size of the decaying system (2×197 nucleon in central collisions at E/A=100 MeV; approximately 2×150 spectator-nucleons in peripheral events at E/A=400 MeV) is about *one* IMF per 33 nucleons.

Despite this similarity, the element distributions are significantly different for the two groups of multifragmentation events. The lower part of Fig. 1 shows these distributions (normalized to the yield at Z=3) for both cases, where the selection criteria imposed on the impact parameter are indicated by the rectangles in the upper part of Fig. 1. In central collisions an exponential charge distribution is observed, whereas in peripheral reactions more heavy clusters are produced giving rise to a power-law behaviour. The ratio between these two distributions - normalized at Z=3 - is displayed in Fig. 2 as a function of the charge.

The suppression of heavy fragments in central collisions may be related to a reduction of the density in momentum space which is caused by the additional radial flow. Within a coalescence picture [4] and assuming a fixed freeze-out temperature, the reduction factor is determined by the ratio between the collective radial motion – characterized by the maximum flow energy per nucleon ϵ_0 - and the random thermal motion - controlled by the temperature parameter T. The lines in Fig. 2 show results of these calculations for various ratios ϵ_0/T. With $\epsilon_0/T = 1.4$ a satisfactory description of the measured intensity ratios is obtained.

[1] See e.g. W. Bauer *et al.*, Nucl. Phys. A**553**, 749c (1993).
[2] C.A. Ogilvie *et al.*, Phys. Rev. Lett. **67**, 1214 (1991).
[3] M.B. Tsang *et al.*, Phys. Rev. Lett. **71**, 1502 (1993).
[4] G.J. Kunde, PhD thesis, Universität Frankfurt (1994).

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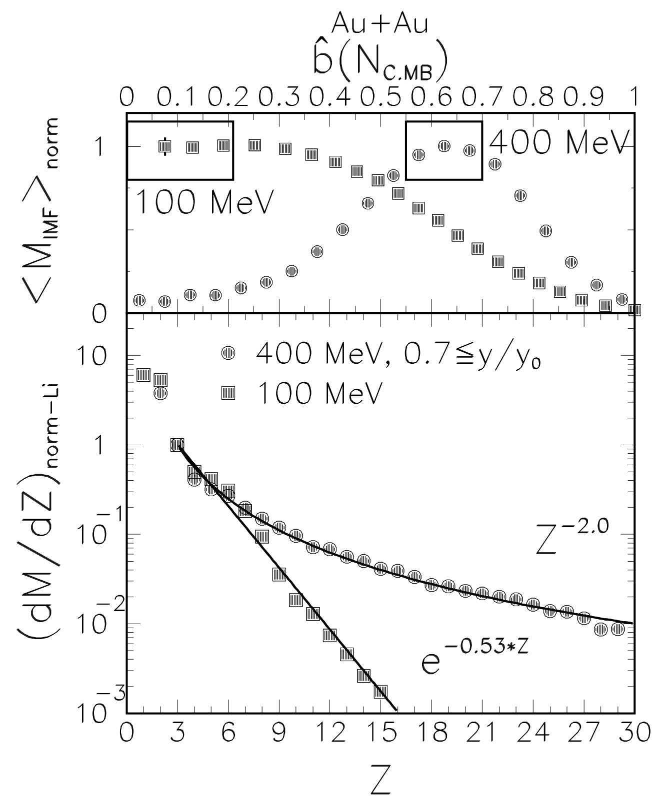

Figure 1: Top Part: Mean multiplicity of IMFs produced in Au+Au collisions at E/A=100 and 400 MeV and detected in the ALADIN+MINIBALL setup as a function of the reconstructed impact parameter $\hat{b}$. $\hat{b}$=1 corresponds to an impact parameter of about 15 fm. The distributions have been normalized with respect to the maximum. The lower part shows the charge distributions in the indicated regions of the maximum IMF multiplicity.

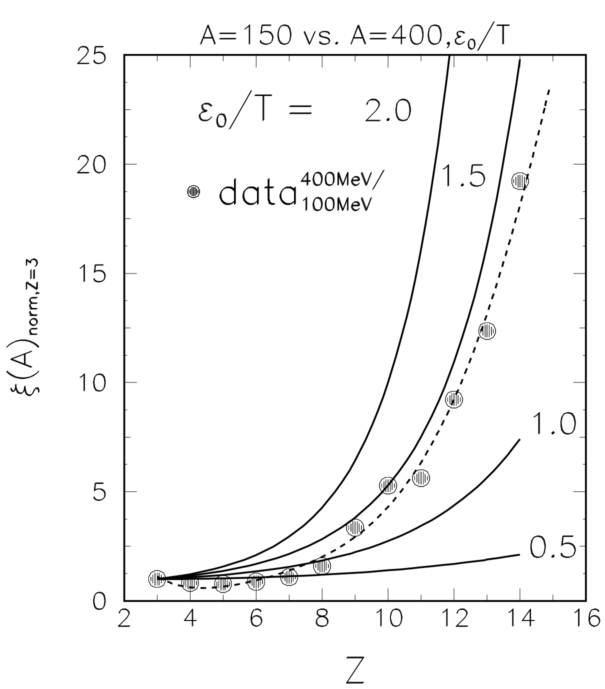

Figure 2: Suppression of heavy IMFs due to radial flow within a simple coalescence picture. The dots represent the ratio between the charge distributions measured at E/A=400 MeV and 100 MeV (Fig. 1, bottom). The full lines are results of a simple (analytic) coalescence model which takes the reduction of the density in momentum space due to a radial flow into account. The dashed line is meant to guide the eye.