Proton Emission from Target Spectators in ^{197}Au + ^{197}Au Collisions at E/A = 1000 MeV

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The excitation energy at breakup residing in excited spectators is an important global quantity for characterizing their decay and for establishing its potential connection to the nuclear liquid-gas phase transition. The excitation energy is the observable plotted along the abscissa in the representation of the caloric curve [1].

A recent evaluation of the excitation energy [2, 3], that has taken into account the data for hydrogen emission measured in the 1995 experiment, has resulted in corrections to the published energy values of the order of 10%. However, the deduced spectator energy was also found to depend considerably on the bombarding energy (Fig. 1). It increases by about 40% over the range 600 to 1000 MeV per nucleon which is in contrast to the universality observed for the products with $Z \geq 2$ of the spectator decay [4]. This rise is caused by the behavior of the mean kinetic energies of neutrons in the spectator frame. It has a rather large effect on the deduced total excitation energy, first, because the neutron multiplicity is large and, second, because the hydrogen isotopes, in the absence of equivalent data, were assumed to scale in the same way as the neutrons do. The kinetic energies of neutrons and hydrogens together amount to typically half the total spectator energy. It is obvious that this uncertainty represents a considerable problem for the quantitative interpretation of the caloric curve. The assumption that nucleons observed at spectator rapidities are partly emitted prior to the final breakup stage represents a possible explanation [5], in agreement with expectations derived from intranuclear-cascade calculations. It leads to the obvious question whether there is any structure in the energy spectra that may permit a distinction of different stages of nucleon emission.

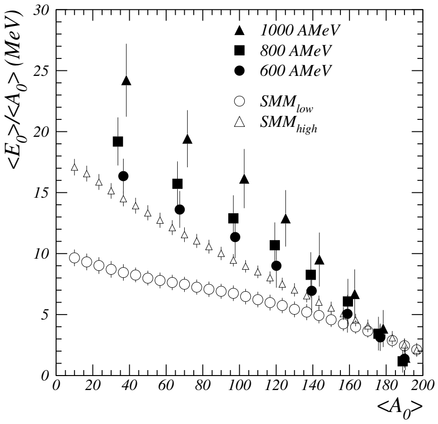

Figure 1: Exitation energy as a function of the system size for different bombarding energies (closed symbols) and SMM predictions (open symbols).

Energy spectra of protons, measured in the reaction ^{197}Au + ^{197}Au at 1000 MeV per nucleon at $\theta_{lab} = 150°$, are shown in Fig. 2 (left panel). They exhibit two components with rather different properties. Fits assuming Maxwellian spectra shapes show that their temperature parameters change very little with Z_{bound} while the relative intensity of the low-temperature component decreases rapidly with decreasing Z_{bound} (Fig. 2, right panels). Two components with very similar behavior of their relative intensities have also been identified in the neutron spectra [3]. A quantitative interpretation of these components of nucleon emission is underway. It seems obvious, however, that the low-temperature component will have to be associated with evaporation from excited heavy fragments and residues of the spectator decay. Its intensity is strongly correlated with the intensity of heavier fragmentation products [4]. The high temperature component carries of the order of 40 to 50% of the decay energy observed at spectator rapidity. Its association with pre-breakup processes is therefore likely to resolve, also quantitatively, the present discrepancy between the excitation energies obtained from caloric measurements and from reconstructions using statistical multifragmentation models [6]. The main uncertainty, thereby, will come from the fact that the nucleon component to be associated with the final breakup stage seems not easily discernible in the measured spectra.

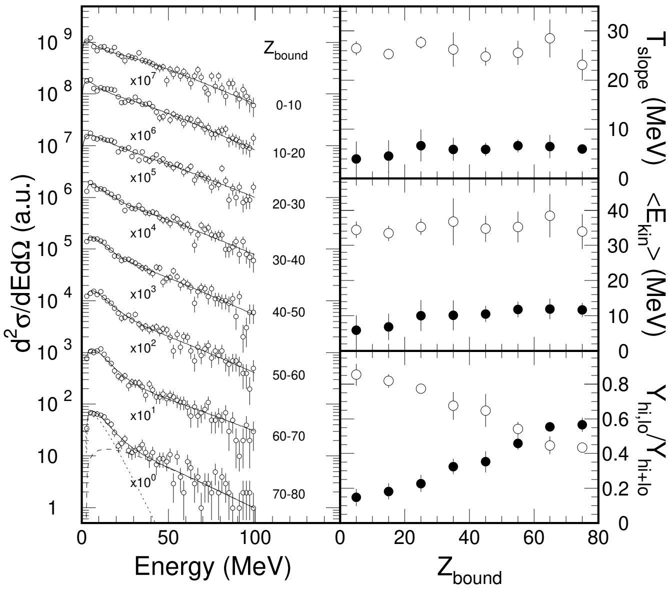

Figure 2: Energy spectra of protons for different Z_{bound} intervalls (left panel) and temperatures, mean kinetic energies and yield ratios (right panels).

References

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