SPECTATOR FRAGMENTATION INDUCED BY RELATIVISTIC ^{12}C PROJECTILES

Ketel TURZÓ for the INDRA-ALADIN Collaboration

In 1998 and 1999, a series of experiments[1] was conducted at the GSI with the INDRA multidetector [2], using high-energy beams from the heavy-ion synchrotron SIS. A part of them was devoted to asymmetric systems like ^{12}C+^{197}Au and ^{12}C+^{112,124}Sn at bombarding energies ranging from 95 to 1800 AMeV. High resolution at backward angles, dominated by emissions from the target spectator, was achieved with the Si-Si-CsI(Tl) calibration telescopes of INDRA. The physics goals in this study of spectator fragmentation are the principal question of thermal and/or dynamical breakup of the source, and, with the isotopically pure tin targets, the role of the isospin degree of freedom in the fragmentation process.

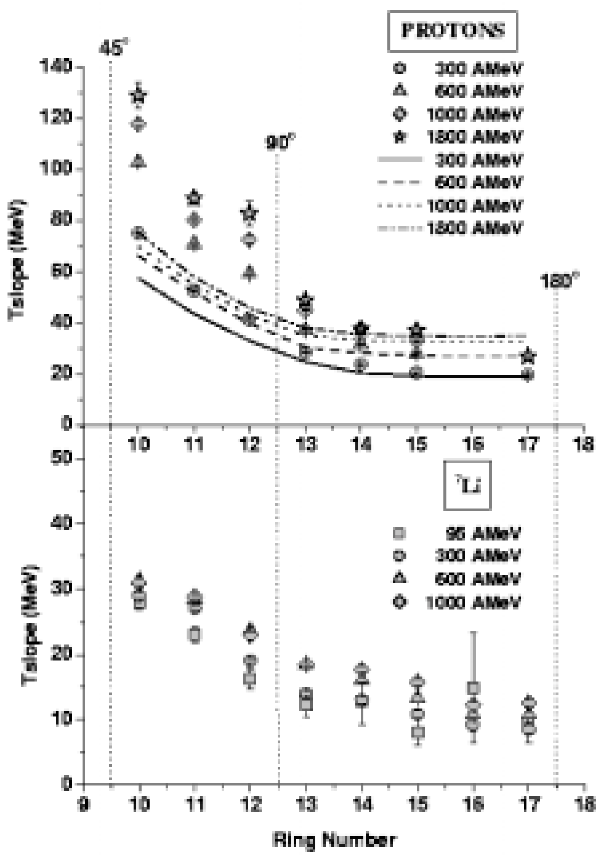

Figure 1: Slope temperatures T_{slope} of protons (top) and ^{7}Li (bottom) as a function of the ring number for ^{12}C+^{197}Au at the indicated bombarding energies. For the protons, the high-temperature values are given and compared with the results of the Gudima-Toneev cascade model (lines).

Inclusive energy spectra measured with the calibration telescopes were fitted, as a first approach, with two-parameter Maxwell-Boltzmann functions. A superposition of two such sources was required for the proton spectra which exhibit a low-energy component, probably containing the contributions of evaporation, and breakup at different time scales, superimposed on the hard component that extends to rather high energies. The temperatures given by the slopes of these Maxwellians show different behaviors. For the low-temperature component of protons and for the ^{7}Li ions, they increase very slowly with the incident energy. The lithium temperatures even seem to reach some saturation near 600 AMeV, consistent with the invariance of the fragment kinetic energies, observed for $3 \leq Z \leq 20$ in the ^{12}C+^{197}Au reaction for 600 to 1000 AMeV [3]. The evolution of the slope temperatures with the polar angle is shown in Fig. 1. A forward peaking is observed for the high-temperature component of protons and for the ^{7}Li ions. But, while the lithium spectra are only weakly dependent on the beam energy, pointing to a source equilibration, the high-temperature component of the protons is much more sensitive to the beam energy, in particular at forward angles. This is consistent with its presumable origin in the initial cascading stages of the reaction.

A comparison with the results obtained with the Gudima-Toneev intra-nuclear cascade model [4] is also shown in the figure. The calculated proton yields were sorted into spectra according to the ring structure of the INDRA geometry and fitted with one-source maxwellians. Between 90° and 180°, the experimental and theoretical slope temperatures are in good agreement, confirming that the primary nucleon yields extend into the spectator rapidity regime. However, the model fails to describe quantitatively the rise of the slope temperatures at polar angles smaller than 90°. Whether this discrepancy is due to the particular model used or a more general feature of the approximations made in the intra-nuclear cascade is not clear at present.

With the calibration part of the data analysis mostly completed, the physics analysis of the INDRA@GSI experiments has started. First results, so far derived from inclusive particle and fragment yields, demonstrate the usefulness of this detector for fragmentation studies up to the relativistic energy regime. The preliminary data for light particles and fragments from the ^{12}C+^{197}Au reaction show a gross behavior in agreement with previous ALADIN [3] and EOS [5] results. From the continuing analysis exclusive data are to be expected, complementing the existing data on this asymmetric collision system obtained in inverse kinematics.

References

[1] INDRA-ALADIN collaboration, Scientific Report 1999, report GSI-2000-1, p. 39 (2000)

[2] J. Pouthas et al., Nucl. Inst. and Meth. A 357(1995)418

[3] A. Schüttauf et al., Nucl. Phys. A 607(1996)457

[4] V.D. Toneev and K.K. Gudima, Nucl. Phys. A 400(1983)173c

[5] J.A. Hauger et al., Phys. Rev. C 62(2000) 024616