Studying the Evolution of the Nuclear Symmetry Energy of Hot Fragments from the Compound Nucleus Regime towards Bulk Multifragmentation

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The evolution of the symmetry energy coefficient of the binding energy of hot fragments with increasing excitation was explored in multifragmentation processes following heavy-ion collisions below the Fermi energy. High-resolution mass spectrometric data on the isotopic distributions of projectile-like fragments from collisions of 25 MeV/nucleon ^{86}Kr and ^{64}Ni beams on heavy neutron-rich targets were systematically compared to calculations involving a two-stage Monte Carlo approach based on the Deep-Inelastic Transfer (DIT) code [1] for the primary interaction stage and the Statistical Multifragmentation Model (SMM) [2] for the de-excitation stage. The study indicated a likely decrease of the symmetry energy coefficient from the conventional value of ~25 MeV at the compound nucleus regime ($E^*/A < 2$

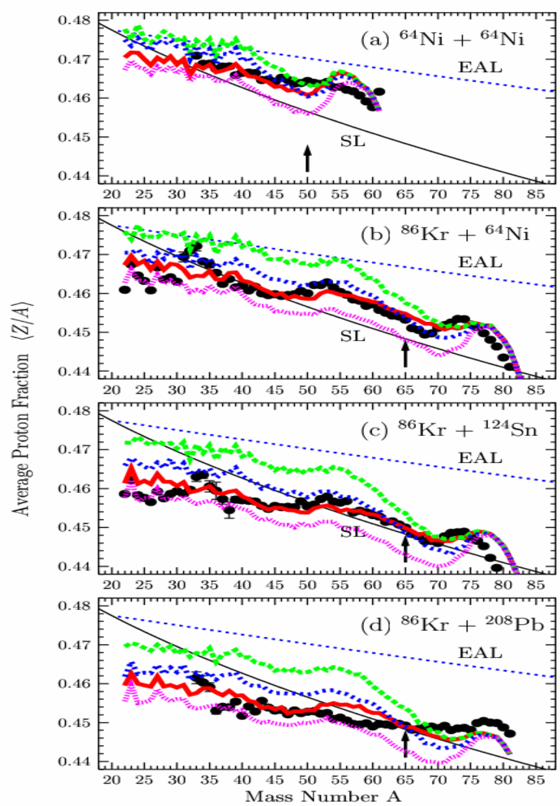

Figure 1. Average Z/A vs A. (a) ^{64}Ni (25 MeV/nucleon)+ ^{64}Ni (BigSol data). (b), (c), (d) ^{86}Kr (25 MeV/nucleon) + ^{64}Ni, ^{124}Sn, ^{208}Pb, respectively (MARS data). Solid points: experimental data. Thin solid line (SL): line of stability. Thin dotted line (EAL): evaporation attractor line. Thick lines: DIT/SMM calculations. Dotted lines, top to bottom: with C_{sym} = 25, 20, 15 MeV, respectively, in the SMM code. Thick solid line: with $C_{sym}(E^*/A)$ in SMM given by the thick line in Fig. 2 [3]. The arrow in the various panels indicates an approximate separation between the multifragmentation regime (to the left) and the compound nucleus regime (to the right of the arrow) based on velocity considerations [4] and on the DIT/SMM calculations.

MeV) towards ~15 MeV in the bulk multifragmentation regime (E*/A > 4 MeV). The isotopic distributions of the hot fragments were found to be very wide and extend towards the neutron drip-line for the most neutron-rich systems studied [3]. Apart from a nuclear physics standpoint, these findings may have important implications to the composition and evolution of hot astrophysical environments, such as core-collapse supernova and the ensuing nucleosynthesis processes, such as the r process.

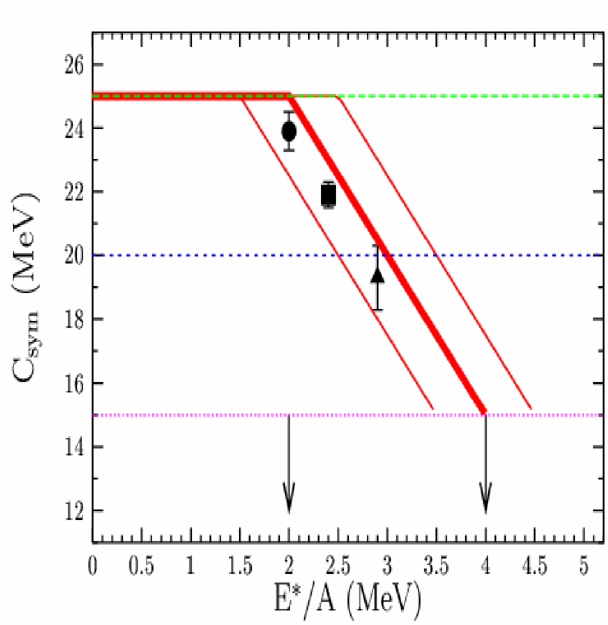

Figure 2. Thick solid line: form of C_{sym}(E*/A) dependence employed in the SMM calculations,expressing the evolution of the symmetry energy of hot fragments with respect to excitation [3] shown if Fig. 1. Thin solid lines: other forms of C_{sym}(E*/A) evolution tested. Thin horizontal lines (from top to bottom): C_{sym} = 25, 20, 15 MeV, respectively, used in the calculations of Fig. 1. Solid points: values of C_{sym} from the heavy-residue isoscaling analysis of the ^{86}Kr (circle, square) and ^{64}Ni (triangle) reactions of [4]. The arrows indicate the various de-excitation regimes (schematically): the compound nucleus regime (to the left of the left arrow), the bulk multifragmentation regime (to the right of the right arrow) and the transition region (in between arrows) where the evolution of the symmetry energy is observed.

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