Isospin Asymmetry of Reaction Products Originating from Projectile-target Systems with Different N/Z

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With increasing violence of the nucleus-nucleus collision, a hot composite system can be created. Such a source can consist of parts of both the projectile and target. The excitation energy of such a source is high enough for emission of intermediate mass fragments (IMF). Another possibility for emission of intermediate mass fragments is a dynamical scenario where a neck is formed and IMFs are remnants of its rupture. Information on both mass and charge of emitted IMFs can be crucial for the determination of the emission mechanism and thus the properties of the emitting source.

The reactions of ^{124}Sn, ^{124}Xe beams with ^{112,124}Sn targets have been studied at 28 MeV/nucleon at the Cyclotron Institute of Texas A&M University using the 4-pi multidetector array NIMROD [1]. The aim of the experiment was to study the interplay of isospin degree of freedom with reaction dynamics of the projectile-target system. NIMROD is a 4-pi neutron and charged particle detection system. Neutrons are detected using a liquid scintillator which is contained in vessels around the target. Charged particles are detected using 96 charged particle detection modules in 12 rings. A typical detection module consists of a gas ionization chamber and one or two CsI(Tl) detectors. In each ring there are several modules where one or two silicon detectors are placed between the ionization chamber and the CsI(Tl) detector. NIMROD has nearly complete coverage for both charged particles and neutrons, as well as selective coverage for isotopically resolved charged particles up to oxygen. An isospin asymmetry of the reaction products can be examined with respect to the observables characterizing the dynamical evolution of different projectile-target systems. The systems studied have significantly different values of initial isospin asymmetries of both projectile and target.

Recently developed calibration methods [2] have been employed in the data analysis. The calibration coefficients are obtained from a minimization procedure where three isotope lines assigned in the experimental two-dimensional spectra are fitted to the calculated energy losses in the telescope. A functional for the dependence of energy on light output in the CsI(Tl) detector was taken from ref. [3]. An example of the velocity plot constructed using calibrated alpha spectra from rings 2-9 measured in the reaction ^{124}Xe+ ^{124}Sn at 28 MeV/nucleon is given in Fig. 1. The features of the velocity plot appear to be consistent with the kinematics of the reaction. The alpha particles emitted close to mid-rapidity are consistent with a highly excited emitting source.

Fig. 2 shows the systematics of corrected isotopic ratios $Y_{N,Z}/Y_{N+1,Z}$ from the four reactions plotted against the difference of binding energies. The inclusive data from the three Si-Si-CsI(Tl) telescopes positioned at different angles was used. Isotopic ratios were corrected to g.s. spin and mass in order to investigate the possibility to estimate the temperature at which fragments have been emitted. For the macrocanonical ensemble the quantity shown in Fig. 2 becomes proportional to $e^{-\Delta B/T}$ when assuming that the difference of free energies can be approximated by the difference of binding energies. The experimental systematics given in Fig. 2 appear to follow a similar trend. There are no significant differences in the data from the different reactions. The apparent temperature at given angles was estimated using exponential fits to data (see Fig. 2). It is lowest at forward angles and appears to saturate at more central angles. It is one of the goals of further analysis to obtain similar information for subsets of data with well-defined centrality selection and excitation energy and to carry out comparison to various double isotope ratio thermometers.

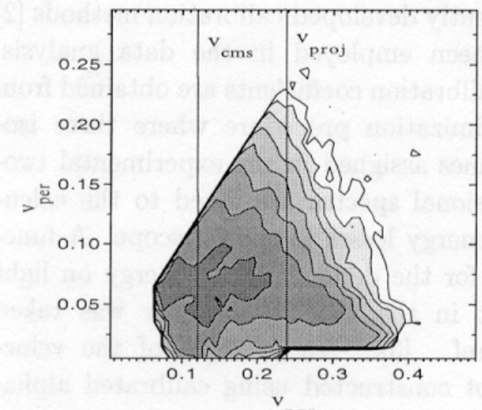

Figure 1: Velocity plot of alpha particles in the reaction $^{124}Xe+$ ^{124}Sn at projectile energy 28 MeV/nucleon. The angular range covered (3-45 deg.) corresponds to rings 2-9.

References

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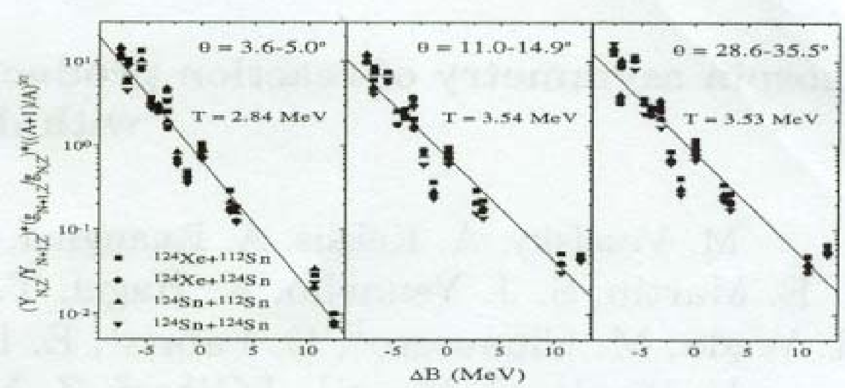

Figure 2: Systematics of corrected isotopic ratios $Y_{N,Z}/Y_{N+1,Z}$ from four reactions plotted against the difference of binding energies.