Isoscaling studies in ^{86}Kr+^{112,124}Sn, ^{197}Au reactions at beam energy of 30 MeV/nucleon

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Introduction

Nuclear multifragmentation is one of the dominant reaction mechanisms in heavy reactions in Fermi energy domain. Isoscaling of the fragment yields from the sources with different isospin asymmetry (m=(N-Z)/A) provides information about the nuclear symmetry energy [1,2]. Such studies would help in constraining the nuclear equation of state away from the ground state nuclear density which has important implications in nuclear physics and astrophysics [3].

In the present work, isoscaling studies have been carried out in ^{86}Kr + ^{112,124}Sn, ^{197}Au reactions at E_{lab}=30 MeV/nucleon. Isospin asymmetry values of the projectile, target and composite system (CS) for different reactions are given in Table I.

Table 1: Isospin asymmetry (m) for different reactions

Reaction	m=(N-Z)/A		
	Projectile	Target	Composite system
^{86}Kr+^{112}Sn	0.163	0.107	0.131
^{86}Kr+^{124}Sn		0.194	0.181
^{86}Kr+^{197}Au		0.198	0.187

It can be seen from the Table I that ^{86}Kr+^{124}Sn and ^{86}Kr+^{197}Au reaction are expected to form more neutron rich sources compared to that in ^{86}Kr+^{112}Sn reaction. Further, CS isospin asymmetry for the ^{86}Kr+^{124}Sn and ^{86}Kr+^{197}Au reactions are similar. Therefore, any difference in the isospin asymmetry of the fragmenting source in the two reactions can be attributed to Coulomb effect.

Experimental details

Experiments were carried out using 30 MeV/nucleon ^{86}Kr beam at the Cyclotron Institute, Texas A&M University, College Station, USA. Fragments were measured using FAUST detector array which consists of 68 Si-CsI telescopes and covers 1.6^0 to 45^0 in the forward hemisphere. Free neutrons were not detected in these measurements. The detector thresholds and angular acceptance provide a preference for the fragments from the projectile like source or quasiprojectile by rejecting majority of slow moving target-like products. The E-ΔE spectra from FAUST array were linearized using a point to curve method and calibrated using the existing calibration data of FAUST.

Results and discussion

In the analysis, only the events with full isotopic identification were used. Average isospin asymmetry of fragments ($\langle m_f \rangle$), which is related to the isospin asymmetry of the fragmenting source, was 0.035, 0.047, 0.047 for ^{86}Kr+^{112}Sn, ^{86}Kr+^{124}Sn and ^{86}Kr+^{197}Au reactions, respectively. Similar $\langle m_f \rangle$ values for the last two reactions suggest that the process of N/Z equilibration is mainly governed by the isospin difference between the projectile and the target nuclei and Coulomb effect is not very significant. According to the isoscaling relation, ratio of fragment yields for a given Z from two different reaction systems is given as [2,3]

$$R_{21} = \ln\left(\frac{Y_2}{Y_1}\right) \propto \alpha N \qquad (1)$$

where N is neutron number and α is an isoscaling parameter which is equal to

'$(4C_{Sym}/T)\Delta$' [2]. C_{Sym} is the symmetry energy coefficient, T is the temperature of the system and Δ is the difference in $\langle m_F \rangle$ for the two reactions. In order to determine α values, R_{21} values were calculated by taking the ratio of fragment yields in the reactions ^{86}Kr+^{124}Sn and ^{86}Kr+^{197}Au with respect to ^{86}Kr+^{112}Sn reaction. Plots of R_{21} values calculated for ^{86}Kr+^{124}Sn/ ^{86}Kr+^{112}Sn along with the fitted lines for Z=4-13 are shown in Fig. 1. Behavior of fragments with Z≤3 was not consistent, possibly, due to the contribution from pre-equilibrium and neck emission.

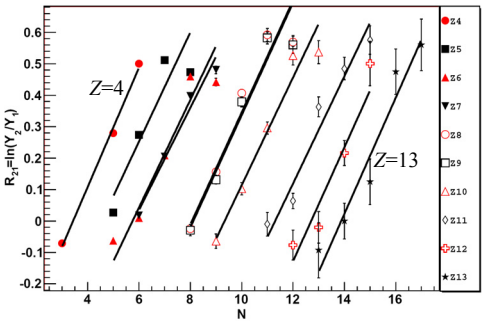

Fig. 1 Plot of R_{21} for ^{86}Kr+^{124}Sn/^{86}Kr+^{112}Sn

In Fig. 2, α values, obtained as slopes of linear fits to R_{21} values for '^{86}Kr+^{124}Sn/^{86}Kr+^{112}Sn', '^{86}Kr+^{197}Au/^{86}Kr+^{112}Sn' and '^{86}Kr+^{197}Au /^{86}Kr+^{124}Sn' are shown. The error weighted average values of α for these reaction pairs were 0.177±0.008, 0.175±0.024 and -0.002±0.024 respectively. The close agreement between the α values for the first two reaction pairs further suggests similar isospin asymmetry of the fragmenting sources in ^{86}Kr+^{124}Sn and

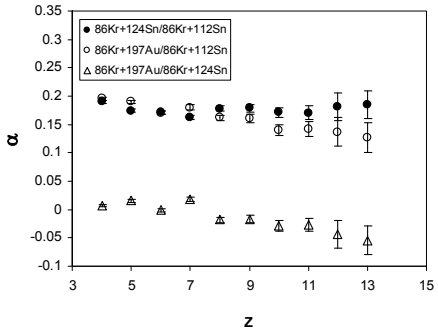

Fig. 2 Plot of α values vs. Z for different pairs of reactions

^{86}Kr+^{197}Au reactions, which is also the reason for negligibly small α values for the third pair. For Z>9, a systematic difference between the α values for ^{86}Kr+^{124}Sn/^{86}Kr+^{112}Sn and ^{86}Kr+^{124}Sn/^{86}Kr+^{112}Sn pairs needs further investigation. In Fig. 3, C_{Sym}/T values calculated using average α values are shown as a function of apparent excitation energy [1] of the

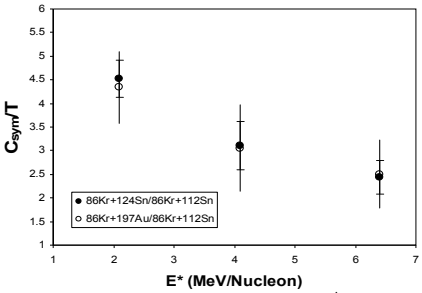

Fig. 3 Plot of C_{Sym}/T vs. E* of the source

fragmenting source. As seen in Fig. 3, decrease in C_{Sym}/T with increasing excitation energy has also been reported in recent isoscaling studies [1,4]. Further work is going on to determine the temperature of the system, in order to extract information about C_{Sym}.

To conclude, isoscaling studies showed formation of projectile like fragmenting sources with similar isospin asymmetry in ^{86}Kr+^{124}Sn and ^{86}Kr+^{197}Au reactions which have significantly different Coulomb repulsion in the entrance channel. C_{Sym}/T values determined form isoscaling parameter α showed a systematic decrease with increasing excitation energy of the fragmenting source.

On leave from Radiochemistry Division, BARC.

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