Energy Dependence Study of Projectile Fragmentation of $^{84}Kr_{36}$ + Emulsion Interactions

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Introduction

It is strongly believed that the nuclear collision geometry plays an important role in the study of particular behavior of the nucleus - nucleus collisions. According to the PS Model, the overlapping part of two colliding nuclei is called the *participant*, from where freshly produced particles occurs and the remaining parts of nuclei which do not participate in the collision are called the *target spectator* and the *projectile spectator*, respectively. In the collisions, due to the existence of the relative motion between the participant and the spectator, the friction is assumed to be caused on the contact layer.

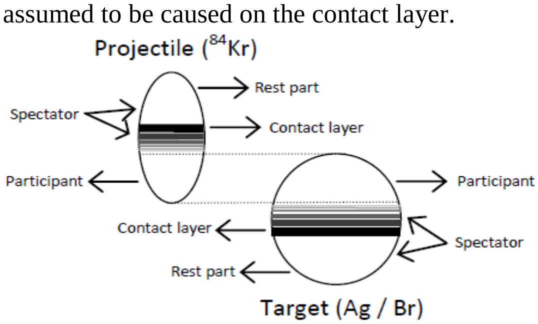

Fig. 1: Schematic layout of two source model.

In this situation, both the participant and the spectator get heat due to friction. It takes some time when the contact layer transmits heat of friction to the rest part of the spectator and therefore, we believe, that this may be the cause of temperature gradient in the spectator region of projectile. The contact layer and rest part, which are separated from each other because of heat of friction. Therefore, the contact layer and rest part of the spectator are considered as two sources to emit nuclear fragments with two different temperatures. It could be possible that during collision contact layer portion have highest temperature after participant region. The fall in temperature is rapid towards the farther side of projectile spectator region. It can also be possible that the temperature is almost constant in a layer and the thickness of layers increases with distance from contact layer as shown in Fig. 1. The two emission sources are the hot spectator having comparatively high temperature and the cold spectator having comparatively low temperature.

Result and Discussion

We explored the projectile fragmentation (PF) phenomena and their effect on the emission of other PFs at the same time with different emission. We used nuclear emulsion detector [1] and for the separation of different target events up to the level of Ag and Br, and cut off value for each target group has been fixed [2]. Our observations confirm the physics that, while considering the nuclear collision induced by massive beam, the relativistic PFs must be described by two emission sources [2].

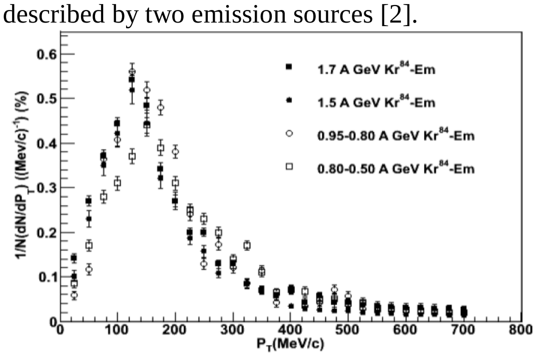

Fig. 2: Transverse momentum distribution of projectile fragments alphas emitted in ^{84}Kr nuclei interactions with emulsion target nuclei at different kinetic energies.

The study of projectile fragmentation of heavy ions such as ^{84}Kr reveals that some of the fragmentation characteristics does not show strong dependence on projectile kinetic energy but have strong dependence on the mass number of the projectile. The transverse momentum distributions of relativistic fragments are described by two - source emission model [3]. The distribution of transverse momentum is the sum of two Rayleigh distributions as shown in Fig. 2 and fitting parameter are tabulated in table 1. The helium projectile fragments belonging to hot source with high temperature are distributed in the tail portion of the transverse momentum distribution of helium projectile fragments.

Table 1: Rayleigh scattering fitting function parameters for different energy projectiles are listed.

Projectile	Energy (A GeV)	A_H	A_L	σ_H (MeV/c)	T_H (MeV)	σ_L (MeV/c)	T_L (MeV)
^{84}Kr	1.7	0.5	0.5	175	8.16	96	2.46
^{84}Kr	1.5	0.5	0.5	172	8.02	95	2.43
^{84}Kr	0.95 – 0.80	0.5	0.5	170	7.93	93	2.38
^{84}Kr	0.80 – 0.50	0.5	0.5	169	7.88	92	2.36

The number of such type of helium projectile fragments is few percent of the total helium projectile fragments. Most of the emitted projectile fragments are from cold source with low temperature. The temperature changes in this region of the projectile spectator part sharply and follow an exponential law. As the projectile energy becomes less and less the volume of the rest part becomes larger and larger and play an important role of heavy fragment emission. We, thus conclude that two source model gives a good physics description in the case of helium projectile fragments emitted in ^{84}Kr nuclei interactions with emulsion target nuclei [3].

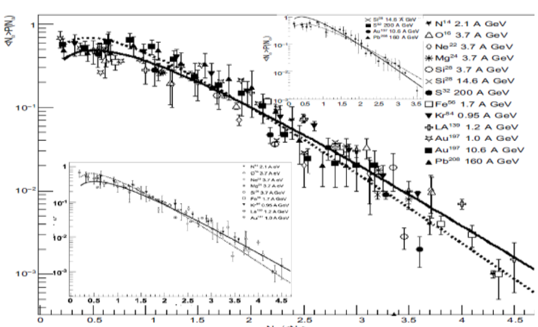

Fig. 3: $<N_\alpha>P(N_\alpha)$ distribution Vs scaled variable $N_\alpha<N_\alpha>$ for alpha fragments for different projectiles with the universal KNO scaling. Upper and lower insets are for higher and lower energies.

Based on the Liu's two-source emission picture, a kind of KNO scaling is obtained and describes the multiplicity distribution of alpha projectile fragments as shown in Fig. 3. The multiplicity distributions of alpha PFs emitted in the interactions of various projectiles with different target at different energies are well described by the KNO scaling [2]. The angular distribution study of the PFs reveals the behavior of fragments on each other during emission that affects the Fermi motion of the particle. From this study we found that the emitted PFs are strongly affected by the rest of the associated projectile fragments. The distribution of the PFs is showing symmetrical nature for lighter charge projectile fragments and as we move from lower to higher charge symmetrical distribution behavior decrease and both peak merge into a single peak, as shown in Fig. 4. Which show that the heavy charge PFs moving with nearly same velocity as the incident projectile, with very small deviation in comparison to lighter charge PF and they are not affected too much by their neighboring PFs. We also observed peaks of significant strength on both side of the strong peaks for almost all light charge PFs having different $\Delta\theta$ values. It reflects that there are few percent of PFs that are coming from the decay of heavy PFs or any other decay process [4].

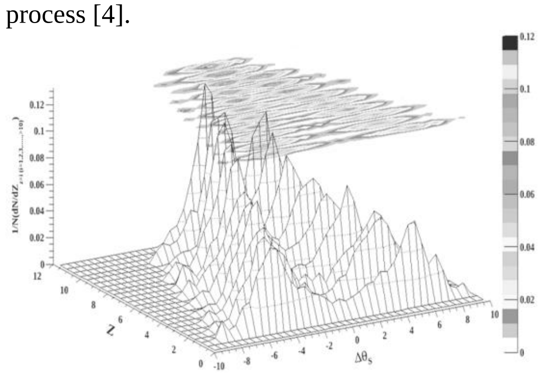

Fig. 4: Normalized distribution of the space angle difference ($\Delta\theta_s$) of different charge projectile fragments with respect to the rest of the projectile fragments of the interactions.

From Figure 4, we can calculate that 14.3, 6.7, 8.8, 6.5, 9.1, 10.4, 15.8, 11.1 and 11.1% of charge (Z) equal to 1 to 9, respectively of PFs are not coming from direct interaction i.e. are possibly coming from the decay process of the heavy PFs that are by products of the direct interaction or may be some other process [4].

References:

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