Characteristics of Multiplicity Distributions of Shower Particles and Target Fragments with $^{84}Kr_{36}$ - Emulsion at Relativistic Energy

M K Singh*[1, 2,] Ramji Pathak[1] and V Singh[2]

1. Physics Department, Tilak Dhari Postgraduate College, Jaunpur – 222002, India
2. Physics Department, Banaras Hindu University, Varanasi – 221005, India

*Email: singhmanoj59@gmail.com

The paper focuses on the multiplicity distributions of shower particles and target fragments for the interaction of $^{84}Kr_{36}$ with nuclear emulsion target at energy around 1 A GeV. The experimental multiplicity distributions of shower particles, grey particles, black particles, and heavily ionization particles are well described by the multi-component Erlang distribution of the multi-source thermal model. We observed a linear correlation in multiplicities for the above mentioned particles or fragments.

1. Introduction

The search of final state particles produced in nucleon-nucleus or nucleus-nucleus interactions at high energy is the main objective of studying the relativistic heavy ion experiments [1]. Nuclear Emulsion Detector (NED) is one of the oldest detector technologies and has been in use from the birth of experimental nuclear and astroparticle physics. The size and range of ionization sensitivity of NED depends upon nature and need of the experiments. The interaction of nucleus (such as $^{84}Kr_{36}$) with NED's target at relativistic energy reveals the picture of the nucleus – nucleus collisions [1, 2]. The recoil target nucleons are emitted shortly after the passage of leading hadrons. Therefore, it is worthy to study the multiplicity of recoil target fragments.

2. The model

In this study, we used multi-source thermal model [2] to describe the characteristics of multiplicity distributions. In this model, many emission sources are assumed to form intermediate as well as high energy nucleus-nucleus collisions. In multiplicity distribution, the multi-source thermal model results a multi-component Erlang distribution which describes different kinds of particles as well as fragments. On the basis of this model, we divided the experimental event sample into groups based on impact parameter and reaction mechanisms such as evaporation, absorption, spallation, multi-fragmentations etc. [2, references therein].

Let us consider there are β_j sources in the j^{th} group. Each source is assumed to contribute an exponential form to the multiplicity distribution. Thus, we have the multiplicity $<\alpha_{ij}>$ distribution contributed by the i^{th} source in the j^{th} group to be,

$$P_{ij}(\alpha_{ij}) = \frac{1}{<\alpha_{ij}>}\exp\left(-\frac{\alpha_{ij}}{<\alpha_{ij}>}\right) \qquad (1)$$

Where, (α_{ij}) the mean multiplicity is contributed by the i^{th} source in the j^{th} group and is not related to i. The multiplicity distribution contributed by the j^{th} group is an Enlang distribution,

$$P_j(\alpha_x) = \frac{\alpha_x^{\beta_j - 1}}{(\beta_j - 1)! <\alpha_{ij}>}\exp\left(-\frac{\alpha_x}{<\alpha_{ij}>}\right) \qquad (2)$$

It is the folding result of β_j exponential functions and $\alpha_x = \sum_{i=1}^{\beta_j} \alpha_{ij}$ and x denotes s, g, b, h respectively. The multiplicity distribution obtained in final state is the weighed sum of l group contributions. We then have,

$$P(\alpha_x) = \frac{1}{N}\frac{dN}{d\alpha_x} = \sum_{j=1}^{l} k_j P_j(\alpha_x) \qquad (3)$$

Where, N and k_j denote the particle fragment number and weight factor, respectively. In the Monte Carlo method, let R_{ij} denote random numbers in (0, 1). Thus, equations (1) and (2) leads to,

$$\alpha_{ij} = -<\alpha_{ij}> l\alpha R_{ij} \qquad (4)$$

and

$$\alpha_x = -\sum_{i=1}^{\beta_j} <\alpha_{ij}> l\alpha R_{ij} \qquad (5)$$

The multiplicity distribution is then finally obtained by statistical method in accordance with different k_j [2, references therein].

3. Results and Discussion

Figure 1, shows multiplicity distributions of Ns, N_g, N_b and N_h particles in $^{84}Kr_{36}$ -emulsion collisions at ~1 GeV per nucleon. The histograms are experimental data while curves are modeling results. The mean multiplicities of N_s, N_g, N_b and N_h are 3.65 ± 0.07, 3.39 ± 0.09, 4.39 ± 0.24 and 5.74 ± 0.57, respectively. We used a two-component Erlang distribution for the calculation. The fitting parameter values are summarized in Table 1. We found that there are two different group of events in the experimental data and the contributions from each groups is almost same ($k_1 = k_2 = 0.50 \pm 0.10$) [2]. The first group corresponds to the light target nuclei (H, CNO) and peripheral collisions of projectile with heavy target nuclei (Ag / Br). The second group corresponds to Ag / Br. The

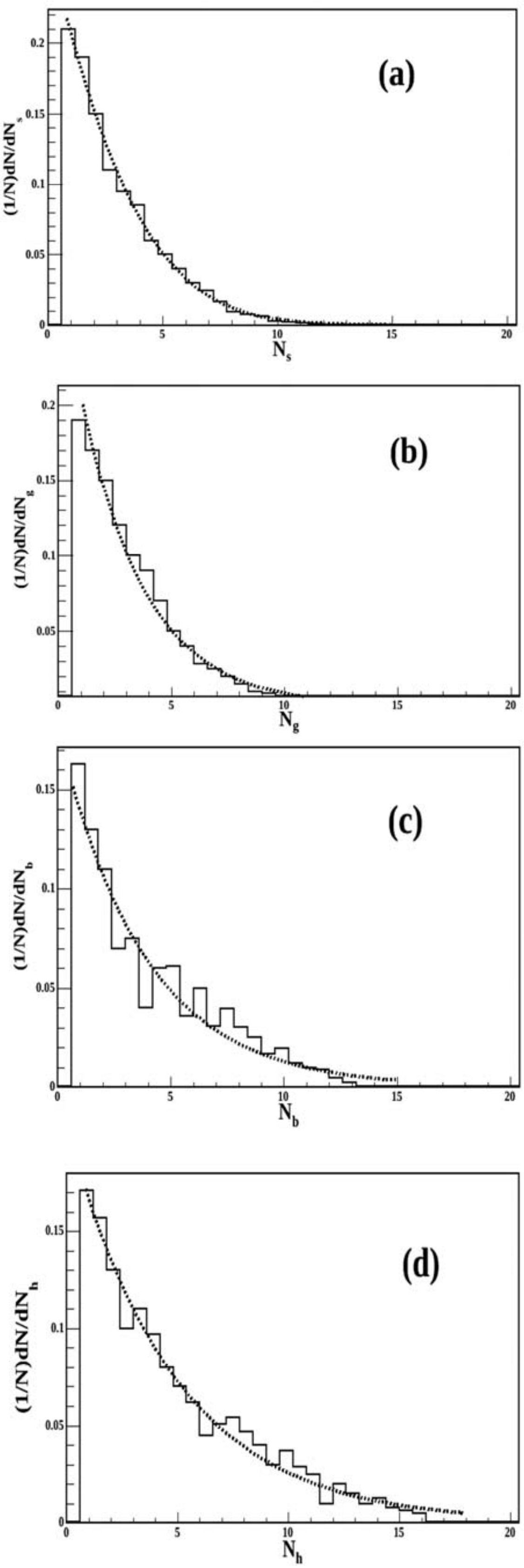

Figure 1. Multiplicity distributions of (a) shower particles, (b) grey particles, (c) black particles, and (d) heavily ionization particles produced in $^{84}Kr_{36}$ – Emulsion Interactions at ~1 GeV per nucleon. The histograms are experimental data and dotted curves are results from the model.

Fig.	$\langle\alpha_{i1}\rangle$	β_1	k_1	$\langle\alpha_{i2}\rangle$	β_2	χ^2 /dof	Ref.
1 (a)	0.8	3	0.50	1.2	3	0.55	Present work
	0.9	3	0.50	1.6	3	0.58	[3]
1 (b)	1.2	1	0.47	1.8	2	0.57	Present work
	1.6	1	0.40	2.2	2	0.47	[3]
1 (c)	0.8	2	0.52	1.7	3	0.83	Present work
	0.9	3	0.48	2.4	4	1.04	[3]
1 (d)	1.3	3	0.57	1.9	4	0.89	Present work
	1.6	3	0.55	2.6	6	0.79	[3]

Table 1: Parameter values and the corresponding χ^2 /dof for the curves in Fig. 1

mean multiplicities of N_s, N_g, N_b and N_h obtained from model as per the fitting details in Table 1 are 3.25, 3.47, 4.87, and 5.47 respectively. Thus, the experimental multiplicity values are well described by the model [2] and results are consistence with other experimental results [3].

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