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STUDY OF TWO-PARTICLE CORRELATION AMONG BLACK AND GREY PARTICLES IN CENTRAL $^{24}Mg-AgBr$ INTERACTION AT 4.5 GeV/c/n

DIPAK GHOSH, JAYA ROY*, AMITABHA MUKHERJEE and ANIT GHOSH

High Energy Physics Division, Department of Physics, Jadavpur University, Calcutta—700 032, India

**Regional Computer Center, Jadavpur University Campus, Calcutta—700 032, India*

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Two-particle correlation study among grey and black fragments emitted in central $^{24}Mg-AgBr$ interaction at 4.5 GeV/c/n have been studied comparing the experimental two-particle correlation function with those of Monte Carlo simulated events. Practically no correlation was found to exist in both black and grey cases. The result is compared with the other works and possible implications discussed.

1. Introduction

Recent years have witnessed tremendous activity in relativistic nuclear collision using different projectile with increasing value of beam energy per nucleon. Although the main motivation of studying collision at higher and higher energy is to look for if there is any phase transition — possible formation of quark-gluon-plasma occurs, other interesting aspects should also be studied to gain informations needed for framing the relevant models. One important and interesting aspect is the correlation between target fragments the study of which might reveal the interesting phenomena predicted by different models, e. g. shock waves, production of multinucleon fireball or even production of quark-gluon-cluster[1]. Thus, new data on correlations among target fragments are not only interesting but also essential. Reporting of a few works on correlation studies in case of hadron-hadron and hadron-nucleus interaction at high energy exists in the literature but in case of nucleus-nucleus collision data are practically insignificant[2]. The motivation of this work is to present new data on two-particle correlation among target fragments (both black and grey) emitted in central ^{24}Mg-AgBr interaction at 4.5 GeV/c/n. Experimental data have been compared with Monte Carlo events assuming independent emission to search for true dynamical correlation, if any. However, it is interesting to observe that in case of both black and gray fragments no correlation exists at all except backwardmost region where statistics is insufficient to show any real behaviour.

2. *Experimental procedure*

For this experiment a stack of NIKFI-BR2 nuclear photo-emulsion plates was exposed in Synchrophasotron at J. I. N. R. Dubna (U. S. S. R.) to a ^{24}Mg beam with an average beam momentum 4.5 GeV/c/n of the projectile. Each stack of plates were irradiated with its plane parallel to the incident beam direction. Thus the incident ^{24}Mg track along with the very forward cone of shower particles could be followed for sufficient distances to guarantee accurate angular measurement. After development of the plates were scanned and the angular distribution of the tracks produced in the interactions were measured by two independent observers with the help of Leitz Ortholux microscopes. Objectives with a magnification of 100x and ocular lenses with that of 16x were used for this purpose. The ^{24}Mg-AgBr interactions which were taken in this experiment were selected according to the following criteria:

i) the incident projectile ^{24}Mg track should be at an angle less than three degree to the average beam direction,

ii) each of the interactions must not occur within 20 μm thickness from the top or bottom of the emulsion pellicle,

iii) all projectile tracks were followed back to an appreciable distance to assure that the interaction is not caused by any heavy projectile fragment emitted from the primary interaction at a very small angle to the average beam direction,

iv) further, the number of heavily ionizing tracks ($n_h = n_b + n_g$) must be greater than a value of six in each event. This ensured that the interactions are not peripheral collision with silver or bromine nucleus nor any with the light target nuclei like carbon, nitrogen or oxygen.

As this type of stars easily attracts the eye the scanning efficiency ensures to an appreciable and high value. In the above procedure four hundred primary interactions were selected for analysis.

During the investigation the charged secondaries produced in an event were classified in accordance to their energetic characteristics into different groups using traditional criteria of the emulsion method:

a) Particles with β-values less than 0.23, range less than 3 mm, and ionization greater than 6 I_P lead black tracks (b) within the emulsion (here I_P is the plateau ionization value). They are mainly evaporated target fragments in an event.

b) Particles with β-value within 0.23 to 0.7, range greater than 3 mm, and ionization $6I_P > I < 1.4\, I_P$ lead grey tracks (g) within the emulsion. They are mainly the knocked out protons from the target nucleus with a very little contamination with deuterium and tritium and slow mesons.

c) Singly charged particles with β-values greater than $1.4\, I_P$ and particles non fragments of the projectile lead shower (s) tracks in the emulsion. They are mainly the produced pi-mesons in these high energy collisions.

d) There is also another kind of particles which are the projectile fragments (pf) having β-values 0.97 and emitted within a very small cone in the forward direction with a constant value of ionization throughout the length.

e) The number of heavily ionizing tracks n_h becomes equal to $n_b + n_g$.

3. *Two — particle correlation*

Two-particle correlation function in general can be defined as,

$$C(z_1, z_2) = \frac{1}{\sigma_{in}} \frac{d^2\sigma}{dz_1\, dz_2} - \frac{1}{\sigma_{in}^2} \frac{d\sigma}{dz_1} \frac{d\sigma}{dz_2} \tag{1}$$

where σ_{in}, $\frac{d\sigma}{dz}$ and $\frac{d^2\sigma}{dz_1\, dz_2}$ are the inelastic cross-section, single particle distribution and two-particle distribution, respectively. In case of black and grey particles we may take $\cos\Theta$ as the variable z. Thus we may write the correlation function for black and grey fragments as,

$$C(\cos\Theta_1, \cos\Theta_2) = \frac{1}{\sigma_{in}} \frac{d^2\sigma}{d(\cos\Theta_1)\, d(\cos\Theta_2)} - \left(\frac{1}{\sigma_{in}}\right)^2 \frac{d\sigma}{d(\cos\Theta_1)} \frac{d\sigma}{d(\cos\Theta_2)} =$$

$$= \frac{N_2(\cos\Theta_1, \cos\Theta_2)}{N} - \frac{N_1(\cos\Theta_1)\, N_1(\cos\Theta_2)}{N^2} \tag{2}$$

where $N_1(\cos\Theta)$ is the number of black or grey particles with $\cos\Theta$ between $\cos\Theta$ to $\cos\Theta + d(\cos\Theta)$ and $N_2(\cos\Theta_1, \cos\Theta_2)$ is the number of parts of black or grey particles with $\cos\Theta$ between $\cos\Theta_1$ to $\cos\Theta_1 + d(\cos\Theta_1)$ and $\cos\Theta_2$ to $\cos\Theta_2 + d(\cos\Theta_2)$ in an event having N number of inelastic interactions in the sample.

The normalized two-particle correlation function can be defined as,

$$R(z_1, z_2) = \left[\sigma_{in} \frac{d^2\sigma}{dz_1\, dz_2} \Big/ \frac{d\sigma}{dz_1} \frac{d\sigma}{dz_2}\right] - 1. \tag{3}$$

In case of black or grey particles we may consider $\cos \Theta$ as a variable, thus, normalized two-particle correlation function becomes,

$$R(\cos \Theta_1, \cos \Theta_2) = \left[\sigma_{in} \frac{d^2\sigma}{d(\cos \Theta_1)\, d(\cos \Theta_2)} \bigg/ \frac{d\sigma}{d(\cos \Theta_1)} \frac{d\sigma}{d(\cos \Theta_2)}\right] - 1 =$$

$$= N \frac{N_2(\cos \Theta_1, \cos \Theta_2)}{N_1(\cos \Theta_1)\, N_1(\cos \Theta_2)} - 1. \quad (4)$$

4. *Monte Carlo simulation*

Correlation between the heavy fragments emitted in high energy heavy ion collision may arise due to (i) broad multiplicity distribution of heavy fragments; (ii) dependence of one particle spectrum $d\sigma/d(\cos \Theta)$ on total multiplicity of heavy fragments (n_b or n_g); (iii) trivial correlations which may arise due to some kinematical constraints in an individual reaction process.

In this paper to search for correlation between heavy fragments (black and grey) we have compared the experimental data with the data obtained by Monte Carlo simulation. The Monte Carlo method is based on independent emission model using following assumptions:

i) Emission angle (Θ) of all the heavy fragments (black or grey) must be statistically independent.

ii) The one particle spectrum $d\sigma/d(\cos \Theta)$ in the simulated events reproduces the empirical »semi-inclusive« distribution $1/\cos \Theta \times d\sigma/d(\cos \Theta)$ with the corresponding values of n_b or n_g for real ensemble.

This method was successfully applied in case of hadron-hadron and hadron-nucleus interactions. If one finds an excess over Monte Carlo simulated values, then, one may conclude that there may be some kinematical reason within the reaction process which leads towards short-range dynamical correlation among heavy fragments (black or grey). If we denote experimental normalized correlation function by R and that of the Monte Carlo calculated events by R_M, then dynamical surplus which is the measure to the amount of correlation can be represented as $R_D = R - R_M$.

Fig. 1a represents two-particle correlation function $R(\cos \Theta_1, \cos \Theta_2 = \cos \Theta_1)$ for grey fragments. Here solid curve represents Monte Carlo calculated values. Fig. 1b represents $R(\cos \Theta_1, \cos \Theta_2 = \cos \Theta_1)$ for black fragments. Fig. 2a and 2b denotes respectively R_D values for grey and black fragments.

5. *Conclusions*

Figures clearly indicate that in case of grey except in backwardmost region i. e. $\cos \Theta = -0.8$ to -1.0 no two-particle correlation seem to exist over the whole angular space and in case of black no correlation exists at all. Comparing this result

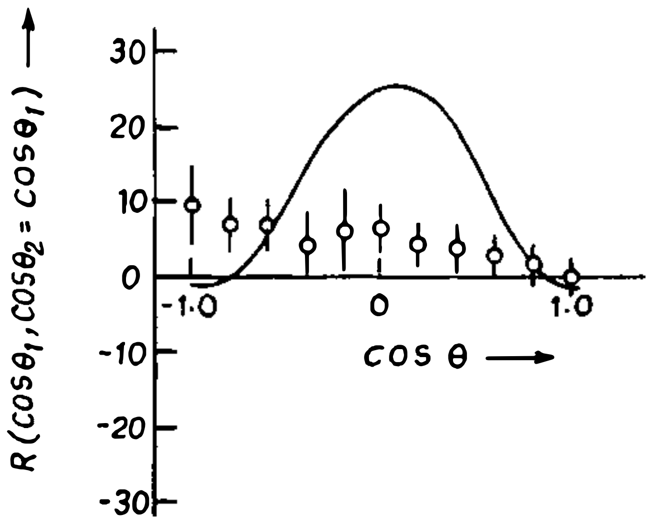

Fig. 1a. $R(\cos\Theta_1, \cos\Theta_2 = \cos\Theta_1, \cos\Theta_3 = \cos\Theta_1)$ against $\cos\Theta$ for gray fragments. Solid curve represents Monte Carlo calculated values.

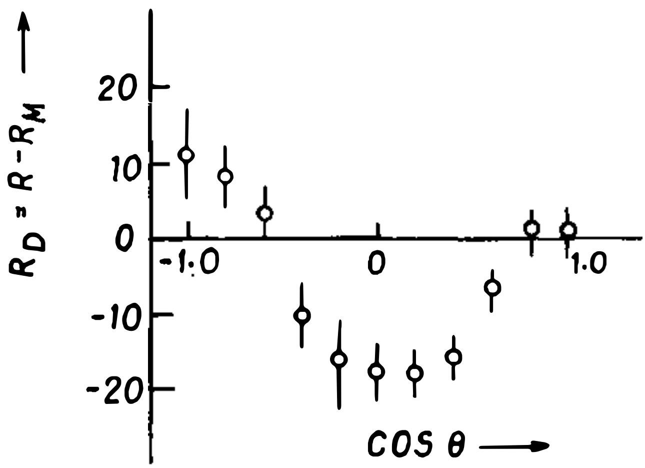

Fig. 1b. $R(\cos\Theta_1, \cos\Theta_2 = \cos\Theta_1, \cos\Theta_3 = \cos\Theta_1)$ against $\cos\Theta$ for black fragments. Solid curve represents Monte Carlo calculated values.

with ^{14}N and ^{16}O at 2.1 GeV/c/n[3,4] and ^{12}C at 4.5 GeV/c/n[5] it is observed that this result agrees well with ^{14}N data but disagrees ^{16}O and ^{12}C data, where correlations were found to exist. It is to be mentioned that the nature of the interactions is different from that with ^{14}N or ^{12}C. Here only the events with small impact parameters have been chosen. This absence of correlation in case of ^{24}Mg--AgBr at 4.5 GeV/c/n is very striking observation and should simulate further study essential for understanding of the physical processes involved.

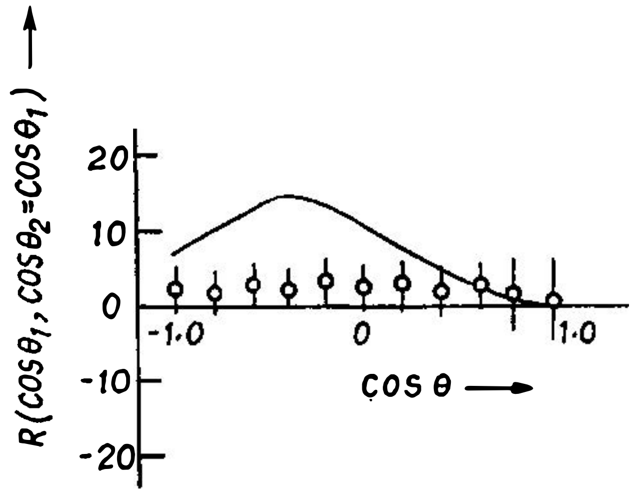

Fig. 2a. $R_D (= R - R_M)$ for gray fragments against $\cos \Theta$.

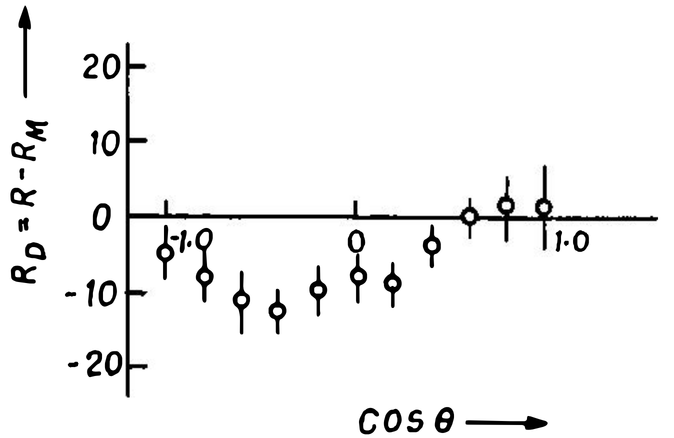

Fig. 2b. $R_D (= R - R_M)$ for black fragments against $\cos \Theta$.

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STUDIJA DVOČESTIČNE KORELACIJE IZMEĐU CRNIH I SIVIH ČESTICA U CENTRALNOM SUDARU ^{24}Mg-AgBr PRI 4,5 GeV/c/n

DIPAK GHOSH, JAYA ROY, ANITABHA MUKHERJEE i ANIT GHOSH

High Energy Physics Division, Department of Physics, Jadavpur University, Calcutta-700 032, India

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Provedena je analiza dvočestične korelacije između sivih i crnih fragmenata u centralnom sudaru ^{24}Mg-AgBr pri 4,5 GeV/c/n usporedbom eksperimentalnih dvočestičnih korelacionih funkcija s događajima simuliranom Monte Carlo metodom. Gotovo nikakva korelacija ne postoji između crnih i sivih slučajeva. Rezultati su uspoređeni s ostalim radovima i diskutirane moguće implikacije.