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Possible angular correlation of emitted black particles in 1.8 GeV/c k^-–CNO interactions

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Abstract : In high energy disintegration of light group of photo-emulsion nuclei, the emitted black particles are confined within a narrow solid cone. This may indicate decay either from some intermediate sub state or from short lived clusters.

Keywords : Preferential emission, cascade-evaporation model, black particles

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1. Introduction

During high energy hadron-nucleus collisons, the target nucleus may undergo complete disintegration resulting in the emission of particles and nuclear fragments from the disintegrating nucleus. This is a complicated process developing both in space and time. However, the chronology of the events can be classified as follows (in the light of cascade evaporation model) :

(1) As the projectile hadron passes through the target nucleus, several pions (and in some cases kaons and hyperons too) are produced within 10^{-24}–10^{-23} sec. of the initial impact due to strong interaction between the projectile and the target nucleons. These are called shower particles ($\beta > 0.7$) with their multiplicity denoted by N_s.

(2) The initial impact is followed by intranuclear collisons of the target nucleons with the incident hadron resulting in the emission of fast nucleons that recoil, with β lying between 0.7 and 0.3. These are called grey particles with their multiplicity denoted by N_g. They are produced within 10^{-22}–10^{-17} sec. The process continues till the K.E of the recoiling nucleons is greater than the potential barrier of the target nucleus.

(3) The emission of each grey particle causes the lowering of nuclear energy. But still the nucleus remains in an excited state even after the emission of grey particles. Final de-excitation of the target nucleus takes place with the emission of slow protons, deutrons, tritons and heavy fragments in decreasing order of abundance with $\beta < 0.3$. This happens after 10^{-17} sec. of the initial impact. These are called black particles with their multiplicity denoted by N_b.

In the final stage of the hadron-nucleus collisons, the degree of the disintegration depends primarily upon the amount of energy transferred from the projectile hadron to target nucleus.

The significance of the study of the nuclear disintegration is that it helps us to understand the decay mode of excited target nucleus, internal reaction dynamics and consequent structural effect and so on. Although it is a complicated process, but its main features may be understood, atleast on the qualitative level within a large enough energy range spreading from several tens of MeV upto several hundred of GeV, by considering simple geometrical and statistical considerations. Our knowledge regarding the subject comes from ample experimental informations, predominantly on cross-sections of different channels of the reaction and multiplicity, energy, momentum and angular distribution of produced and emitted particles [1].

In this investigation, we propose to study the distribution in angles between any two pairs of emitted black particles in the disintegration of the light group (C, N, O) of the photo-emulsion nuclei. The motivation of the present work was derived from an earlier result [2,3] where emitted black particles incase of disintegration of the heavy group (Ag, Br) of the photo emulsion nuclei preferred to be confined within a narrow solid cone, contrary to the expectations of the cascade evaporation model.

2. Experimental procedure

In our experiment, a K5 emulsion stack exposed to 1.8 GeV/c k^- mesons (flux = 2×10^5 cm^{-2}) at Brookhaven AGS machine, was area scanned to detect the presence of disintegrating centres or stars. These stars were further scrutinized under magnification of 1500X, using oil immersion objective with Olympus microscope to detect (C, N, O) interactions.

3. Selection criteria

To select the genuine events representing the disintegration of CNO group of photo emulsion nuclei, the following selection criteria are adopted.

(i) $N_b \leq 6$:

Since the charge of any nucleus belonging to tne CNO group of photo emulsion nuclei is in between 6 to 8, therefore, the maximum no. of observed heavily ionising tracks can never be greater than 8. Of course, there is a possibility of contamination from heavy group (Ag, Br) due to peripherial collisons which can be elliminated by applying the selection criteria (iv) mentioned below.

(ii) The star centre should be clear :

The star centre should be clear and devoid of any blob associated. The blob may be due to short heavy recoil or short electron tracks.

(iii) The stars arising due to the capture of π, Σ *should be avoided :*

It is sometime observed that π, Σ originating for some primary interaction may be captured releasing an amount of energy. For pions this energy is approximately equal to its rest mass. But for sigmas, it is even less than the rest mass of it.

(iv) The stars containing RR should be avoided :

The stars associated with a short track of length ($\cong$10 μm) and having the characteristic of a heavy recoil should be avoided.

4. Results and discussions

A total of 300 stars were accepted as CNO-disintegrations after applying the mentioned selection criteria from a sample of 3510 stars observed in a preliminary scanning. The angle between any two tracks of the black particles emitted were measured by goniometre. The data so obtained are represented separately in Figures 1 (A–D) respectively.

According to cascade evaporation model, the black particles are assumed to be emitted isotropically in all directions from the centre of disintegration in the target rest frame of reference. In this case, the tracks should be equally inclined in space and the angle between any two tracks should be devoid of any preferential direction. Based on this considerations one finds the angle between any two successive tracks will be equal to 120°, 90°, 72° and 60° for N_b = 3, 4, 5 and 6 respectively. Of course in the target moving frame of reference the isotropy in the angular distribution of the black particles will be slightly disturbed. This has been taken into consideration and an appropriate corrections have been made accordingly.

The distribution so obtained are compared with the experimentally observed ones as shown in Figures 1(A–D) respectively. From the expected distributions one observes that the distribution in angles for all the cases of N_b should be in the ranges from cos θ = (−0.2) to 0 *i.e.* 101° to 90°. However, the experimentally observed distribution clearly shows that there is a large preference of the particles for confinement within a narrow solid cone of 30°.

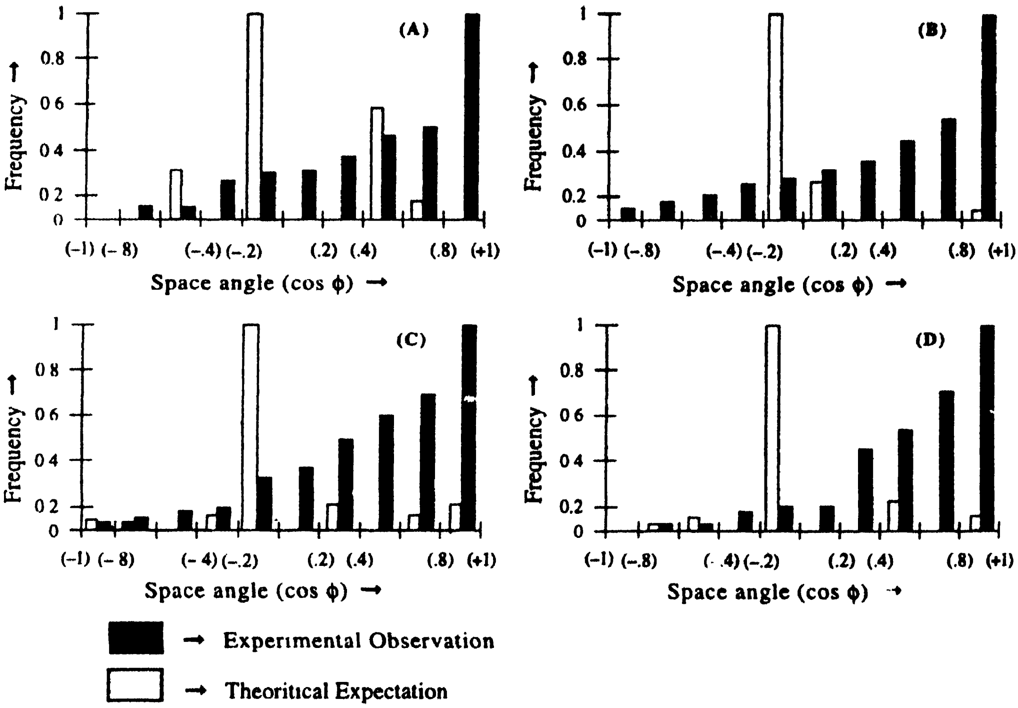

Figure 1. Distribution in angle between any two black tracks for N_b = 3, 4, 5 and 6 as shown in (A), (B), (C) and (D) respectively.

5. Conclusions

Finally, it can be concluded that the cascade evaporation model is not enough to explain the observed distribution in angle between the tracks. The narrow cone of confinement of the emitted black particles may be an indication of some intermediate bound state or short lived clusters which while coming out of the residual target nucleus disintegrate and thus resulting in the confinement into narrow solid cone.

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