About Target Fragmentation in Nuclear Emulation at Relativistic Energies

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Introduction

Study of target fragmentation process through nucleon-nucleus and nucleus-nucleus collisions at high energy attracting a great deal of attention during the recent past[1-6].The difference between the projectile and the target fragment is easy to make. The projectile fragments corresponding to the spectator part are distinguished in the forward narrow cone having cone angle, $\theta_{lab} \leq 3$ degrees, while the produced particles and rescattering protons have a much broader distribution.

The target fragments are observed as highly ionizing particles, distributed isotopically. They are black particles, which are essentially evaporated fragments from the target or grey particles which are knockout protons or slow pions.The target fragmentation is sometimes called spallation.

In the present work, we have analyzed the data resulted from the interactions of carbon and silicon with emulsion nuclei at 4.5 AGeV.In order to compare our results with those obtained in hadron-nucleus interactions,We have also investigated the different characteristic of such collisions by analyzing our data obtained in 24 & 400 GeV proton-nucleus 50 GeV π^- -nucleus collisions.

Experimental Details

Two emulsions stacks of NIKFI-BR2 with dimensions 18.7X9.7X0.06 cm^3 and 16.9X9.6X0.06 cm^3 were irradiated by 4.5 AGeV Carbon and silicon beams at synchrophasotron in Dubna, Russia.All the experimental details regarding the scanning, measurement and selection criteria are given in our earlier publications[7,8].The emitted secondary charged particles in each event are classified in the following three groups:

(i)Shower particles are singly charged relativistic particles with relative velocity $\beta>0.7$ They are generally pions emitted due to projectile fragmentation process and their multiplicity in an event is denoted by Ns.

(ii)Grey particles have $0.3 \leq \beta \leq 0.7$.These tracks are mostly due to protons with kinetic energy in the range 26-400 MeV and their multiplicity is denoted by Ng.

(iii)Black particles are those having $\beta < 0.3$.They are due to evaporated target fragments and their multiplicity in an event is denoted by Nb. In an event, the black and the grey tracks taken together are termed as heavily ionizing tracks. Their multiplicity in the event is denoted by Nh (=Nb+Ng).

Experimental Results and Discussion

The experimental study has been performed on the interactions caused by 24 and 400 GeV protons,50 GeV π^-,4.5 AGeV carbon and Silicon with emulsion nuclei.

In the present work,an attempt has been made to analyse the experimental data obtained in the interactions of proton(24 and 400 GeV),π (50 GeV),12C(4.5 A GeV) and 28 Si(4.5 A GeV) with emulsion nuclei.

As given in the experimental details , the shower particles are mostly pions produced due to the projectile fragmentation process. In order to study the target fragmentation process, it is convenient to select those event with no shower particles in the laboratory frame i.e. with no pionization, Ns=0 as an indicator of the target fragmentation.

The percentage probabilities of events with Ns=0 are given in the table alongwith the results compiled in ref.6.It may be seen in the table that the percentage of probabilities of events having Ns=0 decreases with increasing energy of the impinging hadrons. It is evidently clear from the table that about 68.23% of proton interactions at

2.2 GeV suffer pionozation process ,while at 400 GeV the percentage is 99.21%.Thus,our results indicate that the incident energy gives a chance for pionization process to be more probable. The percentage probabilities of events having Nh ≥ 28 are also listed in the same table.It is also clear from the table that the impact parameter has no significant effect in the collisions with the target.

Table 1: The percentage probability ofevents having Ns=0.

Projectile	Energy A GeV	P(Ns=0)% Nh ≥ 0	P (Nh≥28)	Ref.
Proton	2.2	31.45±2.11	0	6
	3.7	9.85±0.61	0	6
	24	8.33±0.13	0.026±0.009	Present work
	400	0.79±0.04	0.007±0.004	Present work
π^-	50	7.42±0.15	0.030±0.012	Present work
d	3.7	2.6±0.40	1.58±0.31	6
4He	2.1	7.12±0.59	2.86±0.37	6
7Li	2.2	10.37±1.02	3.69±0.61	6
24Ca	4.5	0	11.85±1.32	Present work
28Si	4.5	0	25.98±1.09	Present work

The percentage probabilities of events having Ns=0 obtained in 12C-nucleus and 28Si-nucleus reactions at 4.5 A GeV are also calculated and are presented in The table along with the results of other workers[6].It is reported[6] that the probability of events with Ns=0 rises systematically with increasing mass of the projectile. However, we observed that the percentage of events with Ns=0 is zero in both 12C-nucleus and 28Si-nucleus collisions at 4.5 A GeV.Thus, our findings are in marked disagreement with those reported in ref.6.It may be concluded that in nucleus-nucleus interactions the projectile mass is not an effective parameter in the target fragmentation process where the impact parameter effect begins to appear.
Fragmentation of target nucleus is manifested by the emission of slow heavily ionizing particles.Thus,the probabilities of events having Nh ≥ 28 are listed in the table.It is reported that the events with Nh ≥ 28 may be taken as the events of complete destruction of AgBr nuclei[8].The reason for including the events having Nh ≥ 28 may be due to the fact that these events corresponds to total charge close to the average charge of AgBr nuclei(z=41) and hence they cause a very high degree of break up of the target nucleus.It may be noted in the tables that for protons the destruction of AgBr nuclei is not achieved significantly.However,it may increase wih increasing mass of the projectile.It is reported [6]that the probability of complete destruction of AgBr nuclei does not depend on the projectile mass beyond the projectile of mass 12.Thus,our findings do not agree with those reported in ref.6.

Conclusions

On the basis of the finding of the present work it may be concluded that the pionzation process is more probable with the incident energy in hadron-nucleus collisions.In nucleus-nucleus collisions the mass of the projectile may not be an effective parameter in target fragmentation.The catastrophic destruction of AgBr target nuclei in nuclear emulsion is achieved in nucleus-nucleus reactions.The destruction probability increases with the increasing mass of the projectile and this finding is in marked disagreement with those reported in ref.6.

References

[1] Y.Yariv and Z.Fraenkrer et.al: Phys.Rev,C20,2227(1979).
[2] S.B.Kaufman, and, E.P. stainberg:Phys. Rev.C22,167(1980).
[3] J.Hufner:Phys.Rep.125,129(1985).
[4] K.Summerer,et.al:Phys.Rev.C42,2546(1990)
[5] M.L.Cherry,et.al:Eur.Phys.J.C5,641(1998).
[6] A.Abdelsalam, and B.M.Badawy, J.Nuclear and Radiation Phys3,109(2008).
[7] M.saleem khan et al,nuovo cim A108,147(1995).
[8] Sheikh Sarfaraz Ali and H,Khushnood:Euro physics Lett.65,773(2003).