Some Results on ^{32}S-Emulsion Interactions at 200 AGeV

[1]Mir Hashim Rasool, [2]M.Ayaz Ahmad and [1]Shafiq Ahmad*
[1]*Department of Physics, AMU, Aligarh -202002, INDIA*
[2]*Physics Department, TabukUniversity,Tabuk, KSA*
* *e-mail: sahamd2004amu@yahoo.co.in*

Introduction

The study of relativistic heavy-ion collisions has provided new avenues in the field of high energy physics for giving information about the mechanism of particle production. The availability of heavy-ion beams at high energies has given an opportunity to detect the existence of new phase of hadronic matter, namely the Quark-Gluon-Plasma (QGP) [1] in laboratory. It is important to achieve complete information regarding the mechanism of particle production in nucleus-nucleus collisions. When an energetic projectile collides with targets of nuclear emulsion, a number of charged and uncharged particles are produced. The emergence of these particles occurs in a very short time and after this the nucleus remains excited for quite a long time on nuclear scale. The nucleus then de-excites resulting in the emission of a large number of nucleons and other heavy fragments. Usually, the particles emitted through this process of evaporation appear as black tracks as well as low energy grey tracks in nuclear emulsion. In this paper results on the scaling of multiplicity distributions of slow particles (black and grey) produced in the interactions of ^{32}S-Em at 200 AGeV/c has been studied in order to check the validity of KNO-scaling. A simplified universal function has been used to represent the experimental data.

Experimental Techniques

In the present study two Stacks of G5 nuclear emulsion plates have been horizontally exposed to a ^{32}S- beam at 200 AGeV from Supper Proton Synchrotron, SPS at CERN and being utilized for the data collection.

Results and Discussions

The possibility of scaling, i.e., similarity in the multiplicity distributions of grey tracks produced in hadron-nucleus and nucleus-nucleus interactions has been examined. In the present analysis, the events with $N_g = 0$ have been excluded because the coherent processes may also contribute to such events. Fig.1 shows the $N_g /\langle N_g\rangle$ - distribution from ^{32}S-Em interactions at 200 AGeV. A straight line of the form: $\ln(N_{ev}) = A(N_g /\langle N_g\rangle) + B$ is found to represent the present data, N_{ev} denotes the number of events in the given bin and A and B are constants. The best fit to the data is given as:

$$\ln(N_{ev}) = -(0.97 \pm 0.07)Ng/\langle Ng\rangle + (4.62 \pm 0.09)$$

The values of the slopes obtained by other workers [2] for ^{28}Si-Em at 14.5AGeV and ^{28}Si-Em, ^{12}C-Em and p-Em interactions at 4.5 AGeV are -0.89±0.08, -0.86±0.06, -0.88±0.04 and -0.96±0.04 respectively. The constancy in the values of slopes for nucleus-nucleus collisions as well as hadron-nucleus collisions data may be interpreted as existence of some kind of scaling for the production of grey tracks.

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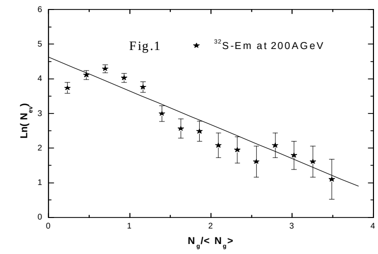


Asymptotic scaling of multiplicity distributions in hadron collisions was predicted in 1971 by Koba, Nielsen and Olesen [3] by assuming the validity of Feynman scaling [4]. Koba, Nielsen and Olesen have predicted that the multiplicity distributions of the produced particles in high-energy hadron-hadron collisions should obey a simple scaling law known as KNO scaling when expressed in terms of the scaling variable Z (=N/<N>). If $P_n(s)$ represents the probability for the production of n charged particles in an inelastic hadron-hadron collision at a centre of mass energy √s, then the multiplicity distributions in high energy collision obey a scaling law

$$P_n(s) = \frac{\sigma_n(s)}{\sigma_{inel}(s)} = \frac{1}{\langle N\rangle}\Psi\left(\frac{N}{\langle N\rangle}\right)$$

$$= 1/\langle N\rangle\Psi(Z) \qquad (1)$$

where $\sigma_n(s)$ is the partial cross-section for the production of n charged particles, σ_{inel} is the total inelastic cross-section and <N> is the average number of charged particles produced. The KNO scaling thus implies that the multiplicity distribution is universal and $\Psi(Z)$ is an energy independent function at sufficiently high energies when expressed in terms of scaling variable Z.

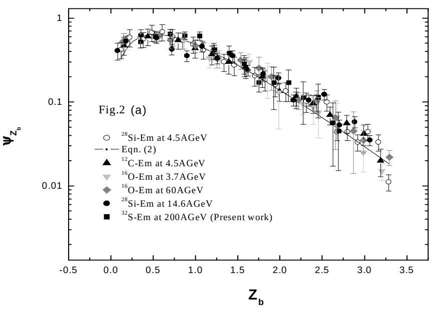
It has been found by various workers that the empirical expression for $\Psi(Z)$ in hadron-hadron and hadron-nucleus interactions obeys the semi-inclusive KNO scaling starting from few GeV. It is desirable to make similar studies in nucleus-nucleus collisions as it is expected that nucleus-nucleus collisions (A-A) at these energies can be visualized as superposition of nucleon-nucleon collisions. Several workers have reported that the validity of KNO scaling holds for the projectile helium particle and black tracks in heavy-ion interactions at Dubna, Bevatron, CERN and AGS energies. It has been shown that the multiplicity distributions of produced black and grey fragments obtained from the events of different projectiles over a wide range of energies in nucleus-nucleus collisions can be described by a KNO scaling law. These distributions can be represented by a universal function of the following form:

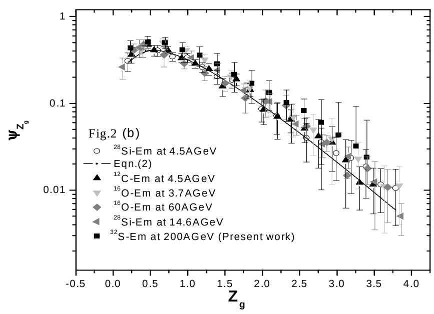
$$\Psi(Z) = AZ\exp(-BZ) \qquad (2)$$

where A and B are constants.

In the present work an attempt has been made to study the KNO scaling for the multiplicity distribution of slow and fast target associated particles produced in ^{32}S-emulsion collisions at 200 AGeV. A plot of $\Psi(Z)$ as a function of the scaling variable Z (= N/<N>) for these medium energy target associated protons is shown in Fig.2(a&b). The experimental points for ^{12}C and ^{28}Si at 4.5 AGeV [2] ^{28}Si at 14.6A GeV [2] and ^{16}O at 3.7 AGeV and 60 AGeV[5,6] respectively are also shown in the same figure for comparison. The solid curve in the figure is well represented by Eqn.2.

It is easily noticed from the figures that the multiplicity distributions of slow and fast target associated protons in nucleus-nucleus collisions at different energies are well described by Eqn.2 for the different projectiles and seem to satisfy the scaling function. The best values of A and B used in Eqn.2 are found to be 11.00 ± 1.04, 2.14±0.09 and 9.57±1.09, 2.29±0.09 respectively for slow and fast target associated protons. The values of corresponding χ^2/DOF are found to be (0.59 ± 0.01) and (1.02 ± 0.04) respectively for slow and fast target associated protons which indicates that the fitting is good for different projectiles at different energies in case of slow protons but a small deviation from exact scaling can be seen for fast target associated protons in Fig.2 (b). It is difficult to give any physical explanation of the multiplicity scaling for slow and fast protons and hence can be regarded as an empirical observation.





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