On Scaling Properties of Multiplicity Fluctuations in 60A and 200A GeV/c ^{16}O-AgBr Collisions

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Introduction

The main objective behind the study of relativistic heavy-ion collisions is to look for the possibility of obtaining nuclear matter at extremely high-energy density and temperature. The space-time evolution of such collision process under go various sub-stages resulting finally the production of final state particles.[1]. These particles carry sevral information of great importance related to the mechanism of particle production involved in nucleus-nucleus collisions..

Physical quantities measured in any experiment are subject to fluctuations. These fluctuations depend on the properties of the fire-ball produced in collisions like heavy-ions. Fluctautions have contributions of different nature. First, there are the trivial statistical fluctuations due to finite number of particles used to define a particular observable in a given event. Secondly there are dynamical fluctuations; that carry the information about the properties of the system. The obvious challenge is, therefore, is to separate trivial one from the interesting components.

Scaling properties of fluctuations in spatial distribution are studied by earlier workers [1-4] to investigate the dynamics of multiparticle production in nuclear collisions. A model for the purpose was proposed as the specific measures for the detection of scaling properties of the multiplicity fluctuations by the Ginzberg-Landau[2]. The model suggests that normalized factorial momrnt, F_q obey power law behaviour:

$$F_q(M) \; \alpha \; (M)^{\phi_q} \qquad (1)$$

where $M = \Delta\eta/\delta\eta$, $\Delta\eta = \eta_{max} - \eta_{min}$ and $\delta\eta$ is width of each pseudorapidity bin. The phenmenaon referred to as intermittency and is a signature of self-similarity of fluctuation patterns of particle multiplicity. The slope, ϕ_q of the plot $\ln F_q$ versus lnM is called intermittency index. A non-vanishing, ϕ_q is an evidence for the existence of the dynamical fluctuations, Even if the scaling behaviour as above is not strictly obeyed, it is possible that F_q satisfies the power law of the form:

$$F_q \; \alpha \; (F_2)^{\beta_q} \qquad (2)$$

Hwa and Nazirov{2} found that in the Ginzberg-Landau model of the second order phase transition, Eq. (2) is well satisfied and the scaling exponent, β_q, satisfiese the following relation:

$$\beta_q = (q-1)^\nu \quad \text{for } \nu = 1.304. \qquad (3)$$

The power law scaling of F_q with F_2 as defined in Eq. (3) is referred to as F-scaling and characterizes the system under the study.

Although, experimental evidence of the F-scaling has been observed for optical system at the threshold of lasing, however, such investigation in the heavy-ion collisions at relativistic energies are still in progress. An attempt is, therefore, made to investigate the scaling properties of multiplicity fluctuations in ^{16}O-AgBr collisions at 60A and 200A GeV/c from SPS, CERN..

Brief experimental details

The data analyzed in the present paper are collected from the two emulsion stacks exposed to oxygen beams at 60A and 200A GeV/c at CERN, SPS (EMU01 Collaboration). The other relevant details about the data selection, scanning procedure, etc. may be found in our earlier publications [5-6].

Results and discussion

We calculated normalized factorial moments, F_q for each pseudorapidity bins, δη and taken average over sample for each order of moments. q (2 to 5). Shown in the Fig 1 for 60A and 200A GeV/c ^{16}O-AgBr collisions are the ln.F_q versus -lnδη plots. It is interesting to note from the figures that F_q increases with decreasing bin width, δη on log-log scale, indicating thereby the presence of self-similar behaviour in the particle production mechanism. The slope of the least squares fits to the data of the plots shown below gives us intermittency index, ϕ_q.

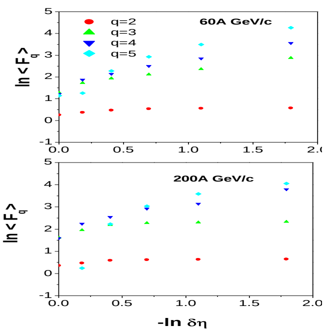

Fig. 1 Variations of ln <F_q>versus – lnδη for ^{16}O-AgBr collisions.

Variations of Fq with F_2 on log-log scale for for 60A and 200A GeV/c ^{16}O-AgBr collisions are displayed in Fig.2 A linear behavoiur (F-scaling) is observed for q=3,4 and 5. Using equations 2 and 3 to describe power law behaviour, scaling exponent, ν=1.330 is obtained by the least equares fits to the data plotted in Fig.3

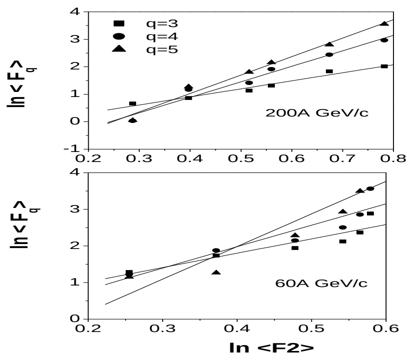

Fig. 2 ln <F_q> versus ln <F_2> plots for ^{16}O-AgBr collisions.

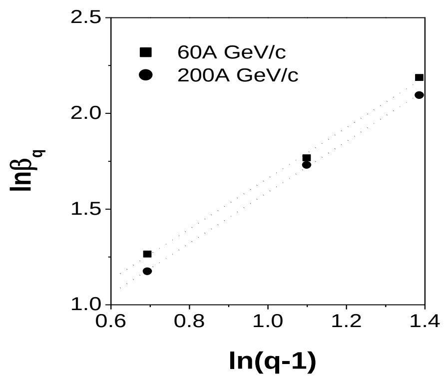

Fig. 3 Variations of lnβ_q versus ln(q-1) in ^{16}O-AgBr collisions.

Conclusions

The study of local multiplicity fluctuations in the spatial patterns of the data on 60A and 200A GeV/c ^{16}O-AgBr collisions, leads to draw followings important conclusions:

1. The study of the variations of normalized factorial moments with decreasing bin width for different order of the moments exhibits the presence of intermittency in the considered interactions**.**

2. Variations of ln Fq with lnF_2 shows the presence of F-scaling. in the data.

3. The value of the scaling index, ν is found to be 1.33 which is very close to the value predicted by the model.

References

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