

On Scaling Properties of Multiplicity Fluctuations in 60A and 200A GeV/c ¹⁶O-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 several 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 fireball produced in collisions like heavy-ions. Fluctuations 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 moment, F_q obey power law behaviour:

$$F_q(M) \propto (M)^{\phi_q} \quad (1)$$

where $M = \Delta\eta/\delta\eta$, $\Delta\eta = \eta_{max} - \eta_{min}$ and $\delta\eta$ is width of each pseudorapidity bin. The phenomenon 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 $\ln M$ 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:

$$F_q \propto (F_2)^{\beta_q} \quad (2)$$

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 , satisfies the following relation:

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

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 ¹⁶O-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, $\delta\eta$ 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 $^{16}\text{O-AgBr}$ collisions are the $\ln F_q$ versus $-\ln\delta\eta$ plots. It is interesting to note from the figures that F_q increases with decreasing bin width, $\delta\eta$ 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 .

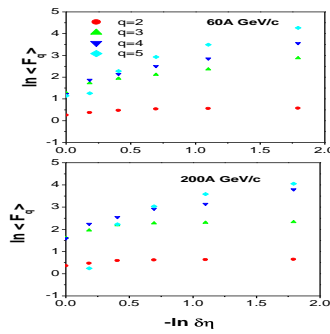


Fig. 1 Variations of $\ln \langle F_q \rangle$ versus $-\ln \delta\eta$ for $^{16}\text{O-AgBr}$ collisions.

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

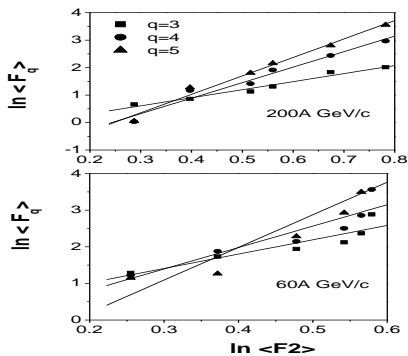


Fig. 2 $\ln \langle F_q \rangle$ versus $\ln \langle F_2 \rangle$ plots for $^{16}\text{O-AgBr}$ collisions.

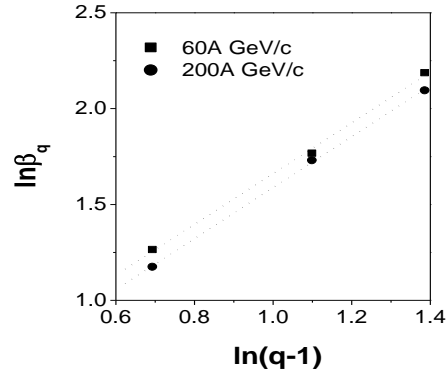


Fig. 3 Variations of $\ln \beta_q$ versus $\ln(q-1)$ in $^{16}\text{O-AgBr}$ collisions.

Conclusions

The study of local multiplicity fluctuations in the spatial patterns of the data on 60A and 200A GeV/c $^{16}\text{O-AgBr}$ 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 $\ln F_q$ with $\ln F_2$ 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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