A study of intermittent behavior in ^{32}S-^{197}Au interaction at 200A GeV

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INTRODUCTION

One of the main goals of high energy heavy-ion collisons is to look for the possibility of occurence of phase transition. Various experiments have been carried out at Relativistic Heavy-Ion Collider (RHIC) and Large Hadron Collider (LHC) to find out the evidence of critical point in these collisions. The production of large number of final state particles in a collision within finite volume suggests a very large energy density; and thus occurs the possibility of quark-gluon plasma (QGP) formation. Thus, it is envisaged that the analysis of events with high multiplicity should serve as a tool to decipher the underlying mechanism of particle production in hadronic matter under the extreme conditions of temperature and/or pressure. In heavy-ion collisions, it is of particular interest to look for the enhanced multiplicity fluctuation as it may imply the presence of mixed phase of hadronic matter and QGP.

The statistical fluctuations are of no interest while as it is the dynamical origin of non-statistical fluctuations which makes them useful [1]. The fluctuations can be of two types: (i) event-to-event fluctuations of spatial patterns and (ii) bin-multiplicity fluctuations from bin to bin within an event [1]. The later can just be randomly occuring fluctuations which can also manifest in the form of clusters of all sizes, as it occurs in second-order phase transition [1]. The scaled factorial moments [2, 3] have been employed to look into the fluctuations in multi-particle production at various energies.

FORMALISM

The self-similar behavior of fluctuations which shows scale-invariance on bin sizes is referred to as intermittency [2, 3]. For the given multiplicity distribution, the scaled factorial moment, $\langle F_q \rangle$, is calculated by dividing the pseudorapidity (η) interval ($\Delta\eta = \eta_{max} - \eta_{min}$) into M number of bins resulting in each interval of size $\delta\eta = \Delta\eta/M$. The factorial moment, f_q, of order q is expressed as:

$$f_q = \langle n_m(n_m-1)....(n_m-q+1) \rangle, \qquad (1)$$

The *"horizontal"* SFMs are defined as:

$$\langle F_q \rangle = \frac{1}{N_{evt}} \sum_{i=1}^{N_{evt}} M^{q-1} \sum_{m=1}^{M} \frac{n_{m,i}(n_{m,i}-1)....(n_{m,i}-q+1)}{\langle n \rangle^q} \qquad (2)$$

where $\langle n \rangle = N_{evt}{}^{-1} \sum_{i=1}^{N_{evt}} n$ is the average multiplicity within the considered $\Delta\eta$ window.

A power-law behavior i.e., dependence on phase space bin sizes e.g., in pseudorapidity

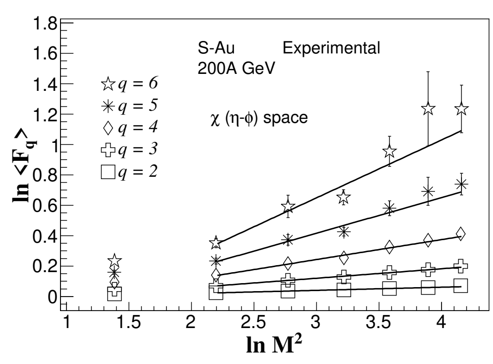

FIG. 1. Variation of $ln\langle F_q \rangle$ as a function of ln M^2 in $\chi(\eta-\phi)$ space for experimental ^{32}S-^{197}Au interaction at 200A GeV.

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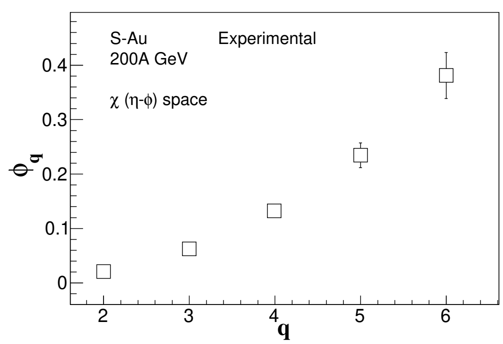

FIG. 2. Variation of ϕ_q as a function of q in $\chi(\eta-\phi)$ space for experimental ^{32}S-^{197}Au interaction at 200A GeV.

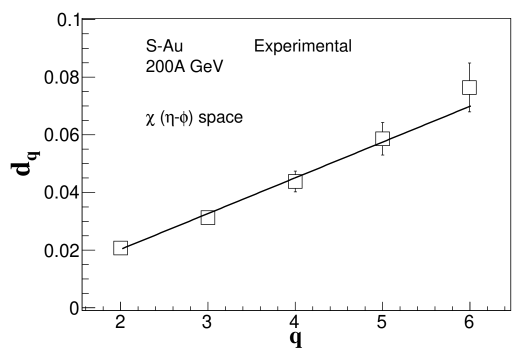

FIG. 3. Variation of d_q as a function of q in $\chi(\eta-\phi)$ space for experimental ^{32}S-^{197}Au interaction at 200A GeV.

phase space: $F_q(\delta\eta) \propto \delta\eta^{-\Phi_q}$ as $\delta\eta \to 0$, is referred to as intermittency. The Φ_q is known as scaling exponent and it quantifies the strength of intermittency. For $\Phi_q = 0$, i.e., $F_q = 1$, the dynamics is trivial; and thus the particle production is Poissonian i.e., it is completely uncorrelated.

The $d_q = D - D_q$, where D and D_q are ordinary topological dimension and generalized fractal dimension, respectively. The ϕ_q is related to d_q through the following relation:

$$\mathrm{d_q} = \frac{\phi_\mathrm{q}}{\mathrm{q}-1}, \tag{3}$$

An increase in the values of d_q with increasing q would hint towards the multifractal nature of multiparticle particle production mechanism whereas its order invariance will suggest the monofractal nature.

RESULTS AND DISCUSSION

The main aim of this investigation is to employ the cumulative variable, (χ), in order to reduce the shape dependence effect. The experimental data of ^{32}S-^{197}Au interaction at 200A GeV, collected from a series of experiments performed by EMU01 collaboration at CERN SPS in 1987, have been utilized to carry out the investigation [4]. A strong increasing trend in the values of ln $\langle F_q \rangle$ can be observed, as shown in Fig. (1). There is a power law behavior of values of ln $\langle F_q \rangle$ as a function of ln M^2, which corroborates the presence of intermittency in $\chi(\eta)$ space. The variation of ϕ_q as a function of q in $\chi(\eta)$ space is shown in Fig. (2), and it exhibits an increasing trend as a function of q. Thus, intermittency strength increases with the order of moments. The variation of d_q as a function of q for the experimental data in $\chi(\eta-\phi)$ space is shown in Fig. (3). The d_q exhibits a strong increasing trend with the order of the moments, suggesting the presence of multifractal behaviour. This hints towards the particle production taking place via self-similar cascade or branching mechanism.

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