Study of Intermittency in Two Dimensional Phase-space

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Introduction

The study of relativistic heavy ion experiments at AGS, CERN, SPS and relativistic heavy ion collider, RHIC at BNL may provide an opportunity to investigate strongly interacting matter at high energy, which may give an evidence for quark-gluon plasma (QGP) formation. The QGP [1] is a state of matter in which quarks and gluons are no longer confined to volumes of hadronic dimensions. To understand the mechanism of particle production the most suitable method known as scaled factorial moments (SFMs) was first introduced to study the non-statistical fluctuations in the distribution of relativistic shower particles produced in high energy collisions. The power law behaviour of SFMs is known as intermittency. So far the existence of non-statistical fluctuations has been made in one dimension (η or ϕ) space only. Very few results are available in the azimuthal plane to study two dimensional ($\eta\phi$) phase-space. In the present study some features of higher order and second order scaled factorial moments in one dimensional and two dimensional $\eta\phi$-spaces in different Ns-intervals have been made.

Experimental technique

In the present experiment, FUJI nuclear emulsion pellicles were irradiated horizontally with a beam of ^{28}Si nuclei at 14.6AGev/c [2] at AGS of Brookhaven National Laboratory (BNL), New York, USA.

For present data η_{min} is –2.309 and η_{max} is 6.129.

RESULTS AND DISCUSSIONS

Intermittency in One Dimension

It is well known that the statistical fluctuations are suppressed in the study of scaled factorial moments (SFMs), where as, ordinary multiplicity moments $(<n^q>/<n>^q)$ is unable to reveal the existence of non-statistical fluctuation due to significant contribution of the purely statistical fluctuations. The SFMs are capable of measuring the large-scale fluctuations and provide information about the pattern of these fluctuations. The cumulative interval of $X(\eta)$ or $X(\phi)$ variable, is successively divided into M = 2-30 bins. The values of $\ln<F_q>$ as a function of $\ln M$ in η and ϕ -spaces for each order of moments are calculated for three distinct groups of Ns–intervals as bellow (i) $8 \le N_S \le 15$ with, $<N_S> = 11.45 \pm 0.19$ (ii) $16 \le N_S \le 23$ $<N_S> = 19.15 \pm 0.25$ and (iii) $N_S \ge 24$ with $<N_S> = 34.32 \pm 0.33$, in ^{28}Si-Em collisions at 14.6A GeV. The present result is also compared with UrQMD predictions for different N_S-intervals in η and ϕ-spaces respectively. The linear rise in $\ln<F_q>$ values with increasing $\ln M$ shows a power law scaling behaviour as described in Eqn 1.

$$F_q(\delta X) \propto M^{\alpha_q} \quad (M \to 0) \qquad (1)$$

where, α_q is the intermittency exponents, and δX is bin size, which is defined as: $\delta X = \Delta / M$ *or* $\delta X = \{X(y)_{\max} - X(y)_{\min}\}/M$. is really obeyed by the SFMs (not shown in Fig.) This confirms the presence of intermittent pattern in the dynamical fluctuation of multiparticle production, as predicted by Bialas and Peschanski [3]. Similar trend is observed in the corresponding UrQMD predictions for different N_S-intervals. It is observed that UrQMD data also exhibit a linear dependence similar to the experimental data. It may be further observed that the experimental values of $\ln<F_q>$ are somewhat larger than the events simulated using UrQMD model. It may readily be seen that the dependence of SFMs on M in dimension ϕ shows almost the same characteristics as in η-phase space. In order to check the presence of the statistical fluctuations, uncorrelated Monte Carlo events were generated randomly. The generated events exhibit no such dependence on M as expected. The experimental result is not reproduced by the independent emission model. This gives an indication for the absence of statistical contribution in the experimental data. The flat behaviour in MC events is expected for independent emission of particle.

On the basis of results presented, it is emphasized that the dynamical fluctuations of the relativistic shower particles might exist in the pseudorapidity (η) and azimuthal angle (ϕ)-phase spaces respectively. The power law behaviour of SFMs on M reveals self- similar behaviour. Also, a comparison of the experimental results with corresponding results for events generated using UrQMD model indicates that the fluctuations observed in the case the experimental data are not only because of statistical reasons, but may have some dynamical origin. Similar result is also evident from different N_S-intervals.

Intermittency in Two Dimension

In order to check the existence of intermittency signal in the two-dimensional $(\eta\phi)$ phase-space, the data have been analysed with a rectangle in $(\eta\phi)$-space. The rectangle was divided into $M_{\eta,\phi}$ bins each of size $(\delta\eta\delta\varphi) = (\Delta\eta/M_\eta)(\Delta\varphi/M_\varphi)$. Fig.1(a-c) shows the plots of $\ln < F_q >$ as a function of $\ln M_\eta M_\phi$ in the interactions of ^{28}Si-Em collisions at 14.6A GeV for q = 2-6 for different N_S–intervals as discussed above. A linear rise of SFMs is seen from the figure. A stronger intermittency effect is observed in 2D, in comparison with a weak signal observed in one-dimension (1D). Result obtained using UrQMD model is also shown in Fig.1(a-c) for comparison, which also follows the similar trend. The values of $\ln < F_q >$ for uncorrelated Monte Carlo generated events were shown in Fig.1 by dotted lines. The flat behaviour gives an evidence for the absence of statistical contribution in the experimental data. The individual analysis in pseudorapidity or azimuthal space may not be favourable to detect the existence of quark-gluon plasma. Instead of QGP, intermittent behaviour is observed. The analysis of experimental result in two-dimensions is more effective than the one-dimension in different N_S -intervals. Finally, it may be concluded that the results in nucleus-nucleus interactions with ^{28}Si beam at 14.6A GeV fulfil the predictions of the self-similar cascade model in observing the intermittency.

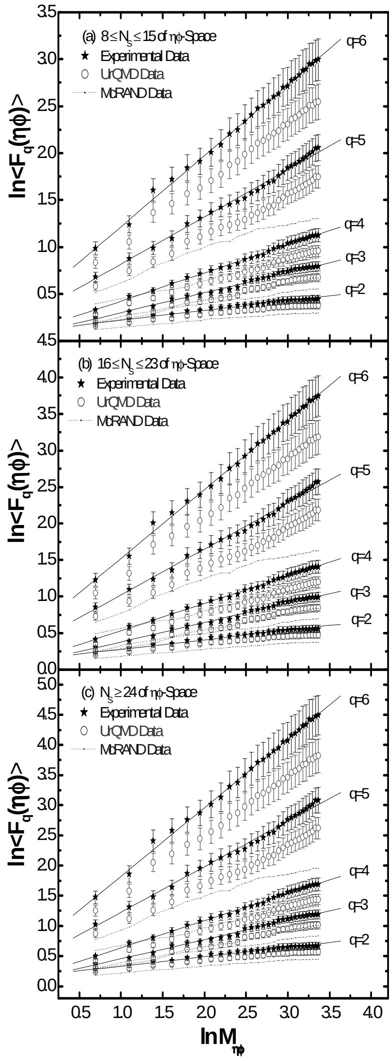

Fig.1 (a-c): Variations of $\ln\langle F_q(\eta\phi)\rangle$ as a function of $\ln M_{\eta\phi}$ in $\eta\phi$-phase space.

Refrences

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