Study of Phase Transition in Multiparticle Production in 14.5A GeV/c ^{28}Si-Nucleus Interactions in terms of Takagi Moments

Arshad Kamal[1],* Waleed J. Altaf[2], N. Ahmad[3], M. Tariq[3] and M. Zafar[3]
[1] *Department of Physics, Deanship of Preparatory Year, Umm AI-Qura University, Makkah-21955, KSA*
[2]*Department of Physics, College of Applied Science, Umm AI-Qura University, Makkah-21955, KSA*
[3] *Department of Physics, Aligarh Muslim University, Aligarh -202002, INDIA*

*email: akarshad@uqu.edu.sa, and arshadhep@gmail.com

Introduction

Study of phase transition has always been a subject of great interest in many fields. The possibility of obtaining evidence for the critical point in heavy-ion collisions has invigorated extensive experimental programs at various laboratories [1, 2]. A self similar fractal system can be characterized by an important parameter Levy index, μ, [3]. It may be stressed that μ is taken to be a measure of the degree of multifractality and μ estimates cascading rate in self-similar branching process as well.

The Levy index analysis helps classify intermittency regimes due to different kinds of phase transitions taking place during cascading process. The condition: (i) $0<\mu<1$, corresponds to thermal phase transition [4-7] quark-gluon plasma and (ii) $\mu>1$ corresponds to nonthermal phase transition [5, 8-9]. Our aim in this work is to find the most effective way to investigate the occurrence of phase transition using the approach of Takagi moments by calculating Levy index, μ.

The present experimental data has been collected from ILFORD G5 emulsion exposed to ^{28}Si ions from AGS BNL. The results of the present study are also compared with the corresponding results obtained for FRITIOF, HIJING and Monte Carlo, MC-RAND, generated data comprising of interactions having description identical to the experimental one.

Results and discussions

Variations of $\ln\langle n^q\rangle$ with $\ln\langle n\rangle$ for q = 2-7 for the experimental and simulated data sets are shown in Fig. 1. It may be seen from the figure that all the data sets exhibit excellent linear behavior. However, the values of $\ln\langle n^q\rangle$ obtained for different q value for the simulated data are relatively higher than those of the experimental data. The values of the generalized dimensions, D_q for q lying in the interval 2-7 have been obtained using $D_q = B_q/q\text{-}1$, from the slopes of the best linear fits to the experimental and simulated

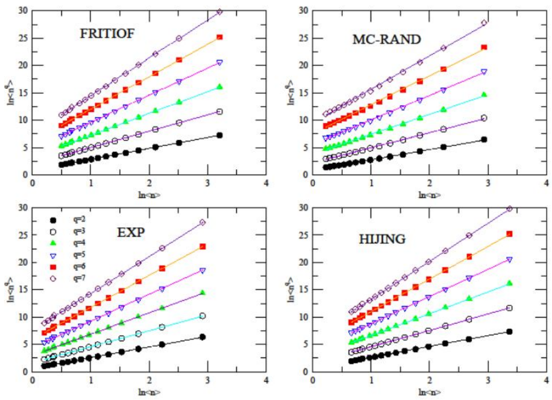

Fig. 1

data. By calculating anomalous fractal dimensions, d_q for q= 2-7 using $d_q = 1\text{-}D_q$ and d_q^*, the ratio of anomalous fractal dimensions of higher order and fractal dimensions of second order of moments $d_q^* = d_q/d_2 = \beta_q / (q\text{-}1)$ are obtained. Values of the degree of multifractality, βq, have also been obtained for experimental, FRITIOF and HIJING generated events using $\beta_q = d_q^*(q\text{-}1)$. Values of β_q are plotted against q in Fig 2 in order to determine Levy index, μ. It can be seen from the figure that the parameter β_q increases with increasing order of moment for all the data sets. The error bars shown in the figure are standard statistical errors. The values of Levy index, μ, are obtained by fitting β_q versus q plot using $\beta_q = q^\mu\text{-}q/2^\mu\text{-}2$. The values of μ for experimental, simulated, and uncorrelated Monte Carlo events are found to be 0.460±0.018, 0.447±0.011, 0.629±0.019 and 1.473±0.102 respectively. It may be noted that the values of Levy index are different for experimental and simulated data sets. Hence, degree of multifractality turns out to be different for different data sets. It is higher for uncorrelated Monte Carlo events in comparison to those for the experimental,

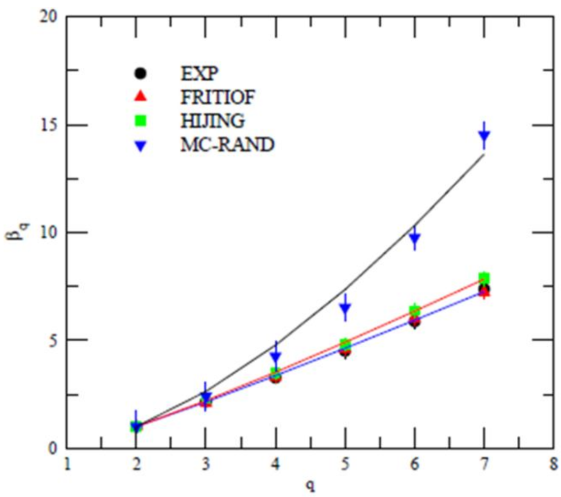

Fig. 2

FRITIOF and HIJING simulated data. Moreover, the values of μ for all the data sets are <1, which suggest occurrence of thermal phase transition of second order (QGP) and calm singularities except for randomly generated Monte Carlo events. For uncorrelated Monte Carlo events, μ>1, which would indicate occurrence of nonthermal phase transition and self-similar cascading and rules out the possibility of QGP formation.

Conclusions

Degree of multifractality, β_q, exhibits an increasing trend with q for all the data sets. The values of μ, obtained using Takagi moments are found to be less than unity for the experimental and simulated data sets, and support the idea of occurrence of existence of thermal phase transition of second order but the value of μ obtained for uncorrelated Monte Carlo events are found to be greater than unity, indicating thereby the existence of nonthermal phase transition However, in order to reach at a definite conclusion regarding phase transition, a thorough and systematic study of event-by-event fluctuations involving higher statistics needs to be done.

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