A study of maximum pseudorapidity gap fluctuations in relativistic nuclear collisions.

M. Mohisin Khan*, Danish F Meer
[1] *Department of Applied Physics, ZHCET, Aligarh Muslim University, Aligarh - 202002, INDIA*
*. * email: mohsinkhan.ph@amu.ac.in*

Introduction

Studying the correlations and fluctuations has always been an important directions towards the understanding of the underlying dynamics of the multiparticle production in high energy hadronic and nuclear interactions. These aspects have caught special attention of both the theorists and experimentalists from the nuclear and high energy physics communities after the results from the RHIC and LHC supported the possibilities of the quark-gluon plasma (QGP) formation in the laboratory [1-6]. Various studies at SPS, RHIC and LHC have indicated that such observations are useful tools to understand the signatures of the phase transition and might be helpful to study the properties of QGP formation[2,5]. When these studies are carried out on event-by-event basis, proven to be even more powerful tools to address the issues related to the occurrence of collective phenomena, correlations and fluctuations. High energy nuclear collisions may effectively offer an opportunity of carrying out event-by-event analysis because multiplicity of the produced particle per event are quite high. Such event-by-event analysis of global observables and their gaps has been carried out extensively starting from cosmic ray events to SPS,BNL, RHIC and to LHC data. Study of maximum pseudorapidity gaps and their fluctuations also help in understanding the underlying short- and long-range correlation and fluctuations. It also helps to find out whether the particles produced are strongly correlated or weakly correlated. in the η-space. In relativistic heavy-ion collisions these observations are not easy to point out due to the imposement of the correlation arising due to the kinematical conditions by the conservation laws which can overshadow the correlation occurring due to the dynamical conditions. An event-by-event analysis approach to look for the correlation and the fluctuations of the global observables related to the produced charged particles may provide significant information about the mucltiparticle dynamics. In this context, **the maximum pseudorapidity(η) gap, Δ_{max}** and the fluctuations in its value turns out to be very important characteristic of multiparticle production and qualifies for the special attention in an eventt-by-event analysis[3,7,8]. A number of studies have predicted the large pseudorapidity gaps between neighboring particles and the maximum pseudorapidity gap distribution and the fluctuations in it have been generally used as a measure to find the extent of diffractive dissociation/pomeron exchange in the relativistic nuclear collision data[3,7,8]. The study of event-by-event fluctuations of the maximum pseudo-rapidity gap is expected to be an important parameter to explore the dynamics of multiparticle production process. Maximum pseudorapidity gap values are also important to study long-range correlations suppressing the contributions from resonance and mini-jets [8]. So far investigations of fluctuations of pseudo-rapidity gaps have been carried out by different groups [7,8] to extract the dynamical signal of the particle production process. Only a few analyses have been carried out on the event-by-event fluctuations of Δ_{max}. This study may be proven to be an vital information regarding the hidden dynamics of the particle production process. In the present study an attempt has been made to look for the Δ_{max} fluctuation for the experimental and HIJING simulated ^{208}Pb-Em. Interactions at 160 A GeV/c and for the HIJING simulated Pb-Pb events at $\sqrt{S_{NN}}$ = 2.76 TeV.

Details of the Data

The present analysis has been carried out for the two experimental samples of the data comprising 285 minimum bias events and 58 high multiplicity events($n_s \geq 50$) obtained in the interactions of Pb-Pb at 160A GeV/c. These events are taken from the emulsion experiment performed by EMU01 Collaboration. For comparing the experimental results with the simulated data 1000 high multiplicity events have been generated using HIJING stand alone at 160A GeV/c. To compare present results with the data at LHC energy 1000 Pb-Pb events have also been simulated using HIJING standalone at $\sqrt{S_{NN}}$ = 2.76 TeV. The other details of the data and the procedure of selecting events can be found elsewhere [4].

Results and Discussion

To look into the fluctuation of the Δ_{max} the variable, ω, called the scaled variance defined as

$$\omega = \frac{\langle \Delta^2_{\max} \rangle - (\langle \Delta_{\max} \rangle)^2}{\langle \Delta_{\max} \rangle}$$

was calculated[7,8]. The maximum η-gap, Δ_{max} is calculated on event-by-event basis by picking the maximum of the 2-particle η-gaps for each events in the data samples. For calculating the 2-particle η-gaps, first we arranged the η values of the produced particles in each events in the increasing order and then calculated the differences between consecutive η values(η_{i+1}-η_i). The calculated values of the Δ_{max} along with their statistical errors are given in Table 1 and their variation with mean multiplicity of the relativistic charged particles ,$\langle n_s \rangle$, is depicted in Fig.1 for the experimental and simulated data sets.

Tab.1 *Calculated values of ω for all the events of the experimental and simulated data sets.*

Pb-Em. 160A GeV/c (minimum bias)	Pb-Em. 160A GeV/c (n_s ≥50)	Pb-Em 160A GeV/c HIJING	Pb-Pb $\sqrt{S_{NN}}$ = 2.76 TeV
0.339 ±0.008	0.464 ±0.011	0.288 ±0.009	0.464 ±0.009

We obtained non zero values of ω which point towards the presence of the maximum pseudorapidity gap fluctuations. This effect is more prominent in the experimental data as compared to the simulated data from GeV to TeV range. Similar trends have been reported by other workers[3,7,8]. The work will be extended for more statistics and for the data at other energies.

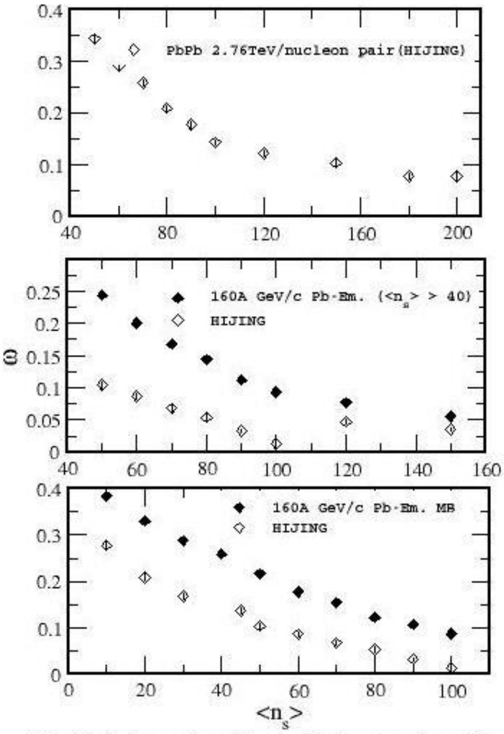

Fig.1 Variations of ω with $\langle n_s \rangle$ for the experimental and simulated data.

References

[1] L.W. Lin et al., Phys. Rev. Lett. C 72 064901 (2005).
[2] ALICE Collab.(K. Aamodt et al.),Eur. Phys. J. C 68 89 (2010).
[3] Dipak Ghosh, Argha Deb. et al., FIZIKA B (Zagreb) 12 133 (2006).
[4] S. Khan and S. Ahmad, Int. J. Mod. Phys. E 27 1850004 (2018).
[5] S. A. Bass, P. Danielwicz and S. Pratt, Phys. Rev. Lett. 85 2689 (2000).
[6] S. A. Voloshin, J. Phys.:Conf. Proc. 50 111 (2006)
[7] S. Bhattacharyya et al. EPL 126 42001(2019)
[8] Lungwitz Benjamin, The CERN SPS,PhD Thesis, Frankfurt, Germany (2008).