Fluctuations of Voids in Relativistic Ion-Ion Collisions at SPS Energies

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A system undergoing a second order phase transition is envisaged to exhibit large fluctuations and long range correlations[1]. If the quark-gluon phase transition is of the second order then large fluctuations are expected not only from event to event but also from one region to the other in the geometrical space in which emission of hadrons takes place[1]. Such local hadron density fluctuations would give rise to the formation of spatial patterns involving cluster of hadrons and regions of no hadrons (voids) between clusters[1, 2]. Hwa and Zhang have proposed a method to study the fluctuations of such spatial patterns in terms of voids−the non hadronic regions created on event-by-event(ebe) basis. An attempt is, therefore, made to study the ebe fluctuations of voids by analysing the experimental data on 60A and 200A GeV/c ^{16}O-AgBr collisions. All the relevant details about the data used may be found elsewhere in refs.4,5. This would help identify some base line contributions to the fluctuations of voids. The findings are compared with the predictions of A Multi Phase Transport Model, AMPT.

The fluctuations of voids are studied in terms of the distributions of normalized G_q moments calculated on ebe basis as $G_q = g_q/g_1^q$, where $g_q(= \frac{1}{m}\sum_{k=1}^{m} {x_k}^q)$ is the moment of order q for each configuration; x_k is the fraction of bins that a k^{th} void occupies. A detailed description of the method of analysis may be found in refs.2,3,4. Pseudorapidity, (η) space is divided in to M bins of equal width $\delta(= 1/M)$. The presence of voids are searched for and the size of voids are determined. Void fractions, x_k, moments, g_q and normalized moments G_q are calculated for q = 2-5 by varying M from 16 to 96. Variations of $ln < G_q >$ with lnM for 60A GeV/c data are displayed in Fig.1. It is observed that $ln < G_q >$ increases with lnM. The lines in the figure are due to the best fits to the data of the form: $ln < G_q >= a_1 + b_1M + c_1M^2$ similar trends of variations of $ln < G_q >$ with lnM are observed for ^{16}O-AgBr collisions at 200A GeV/c and also for the AMPT simulated events at the two energies considered. These observations reveal that variations of $ln < G_q >$ with lnM are quadratic in nature. These findings are, however somewhat different from those reported earlier[2]. These workers have reported a linear increase of $ln < G_q >$ with lnM for 340 GeV/c π^--AgBr and 200A GeV/c S-AgBr collisions. Hwa and Zhang have also suggested such dependence to be linear. Data points shown in Fig.1 for M=32 and above also indicate a linear increase of $ln < G_q >$ with lnM and suggest a power law behaviour of the form $< G_q >\sim M^{\gamma_q}$. The values of the parameter γ_q for the real and AMPT events are estimated from the best fits to the data (for M $\geq$ 32). It is observed that the values of γ_q for the real data are slightly higher than those observed for the corresponding AMPT event samples. Such a scaling behaviour may be interpreted as the indication of the presence of voids of all sizes[3]. Since G_q moments of various orders are highly correlated, the scaling exponent, γ_q should depend on q in some simple way. In order to test this, dependence of γ_q on q for the real data at the two energies are plotted in Fig.2. The lines in the figure represent the best fits to the data of the form, $\gamma_q = c_0 + cq$. The values of slope c for the AMPT data are also estimated. These values are listed in Table-1; the parameter c is regarded as a numeric description of the scaling behaviour of voids.

The shape of G_q distribution would charaterize the nature of ebe fluctuations in the distribution. A moment which quantifies the degree of these fluctuations is expressed as $C_{p,q} = \frac{1}{N}\sum_{e=1}^{N} (G_q^{(e)})^p$. The derivative of $C_{p,q}$ at $p = 1$, $S_q = \frac{d}{dp}C_{p,q}\Big|_{p=1} =< G_q ln G_q >$

is envisaged to yield maximum information regarding the ebe fluctuations. Variations of S_q with lnM are examined which, like $ln < G_q >$ vs lnM plots, indicates the presence of a power law behaviour of the type $S_q \sim M^{\sigma_q}$ for (M≥32).

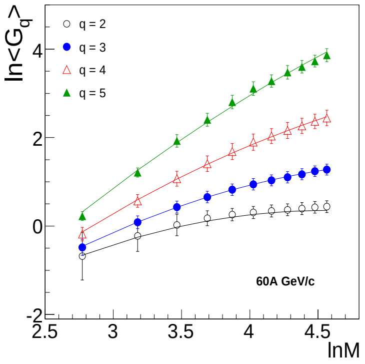

FIG. 1: Dependence of $ln < G_q >$ on lnM for the experimental events at 60A GeV energy.

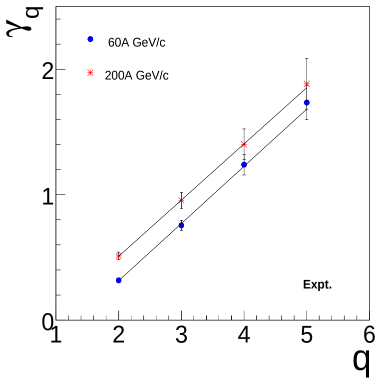

FIG. 2: Variations of γ_q with q for the experimental events at 60A and 200A GeV energies.

Dependence of σ_q on q are also studied and found to be linear, of the form $\sigma_q = s_0 + sq$. The values of s for various data sets are presented in Table-1. As a qualitative signature of 2^{nd} order quark-hadron phase transition, the values of c and s are predicted[3] to lie in the ranges 0.73-0.96 and 0.7-0.9 respectively. However, the values of these parameters obtained in the present study are much smaller suggesting that no such phase transition occurs at the energies considered in the present study.

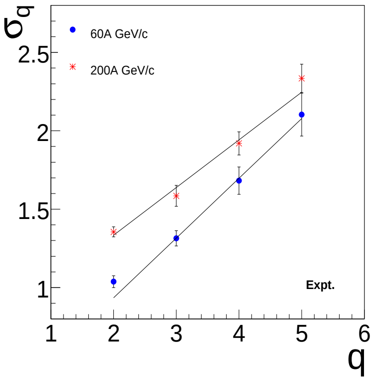

FIG. 3: Variations of σ_q with q for the experimental events at 60A and 200A GeV energies.

Table 1: Values of parameters c and s.

Energy (A GeV)	c		s	
	Expt.	AMPT	Expt.	AMPT
60	0.45±0.02	0.38±0.03	0.38±0.05	0.29±0.05
200	0.44±0.04	0.48±0.04	0.30±0.09	0.27±0.09

References

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