Nonstatistical fluctuation in $^{16}$O-Ag/Br collisions at 200A GeV/c

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Presence of non-statistical fluctuations in the density distribution of singly charged particles produced in $^{16}$O-Ag/Br interactions at an incident momentum of 200A GeV/c, has been identified and characterized with the help of the intermittency technique [1]. Nuclear photo-emulsion data on $^{16}$O-Ag/Br events have been used in the analysis [2]. In each of the 280 events present in the sample, the projectile nucleus underwent complete fragmentation. The average shower track multiplicity $<n_s>$ = 119.26 ± 3.59. The one-dimensional analysis of data is confined to pseudorapidity ($\eta$) and azimuthal angle ($\varphi$) spaces. We have calculated and plotted the Scaled Factorial Moments ($F_q$) of different orders ($q = 2$–$6$) both in the $\eta$-space (Fig.1) and in the $\varphi$-space (Fig.2). A power law type scaling behavior: $F_q = (\delta M)^{-q\Phi}$ at phase space resolution $\delta M$, characterizes the intermittency phenomenon. This scaling property is verified from the linear variations of $ln<F_q>$ against $lnM$ in both $\eta$ and $\varphi$ space, where $M$ is the phase space partition number. For each $q$ the best linear behavior is obtained by the Pearson’s $r^2$ coefficient.

In $\eta$-space the experimental results have been compared with the FRITIOF prediction [3] and in $\varphi$-space with the independent emission model. The intermittency exponent $\Phi_q$ is a measure of self-similarity in the density fluctuations beyond statistical origin. They are evaluated and there values are quoted in Table 1. In almost all cases the $r^2$ values are close to unity, confirming goodness of fit. In $\varphi$-space the $\Phi_q$ values are consistently higher than those in the $\eta$-space, indicating that, the observed intermittency effects are not independent of the basic phase space variable considered.

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Table 1

To examine whether or not the intermittency effects are merely due to contributions coming out of lower order correlation functions, the normalized exponents defined as: $\zeta_q = \Phi_q/C_2$ for $q \geq 2$, and three particle correlation in terms of the normalized slopes as $\zeta_q^{(3)} = (q - 2)\zeta_2 - (q - 3)\zeta_3$ are introduced in [4]. Both types of normalized exponents were evaluated and are plotted against $q$ in Fig. 3 and Fig. 4, respectively. A more or less linear dependence of $\zeta_q$ as well as of $\zeta_q^{(3)}$ with $q$ can be observed. From this analysis it cannot be unambiguously concluded that all correlations for $q \geq 4$, can be understood in terms of a two and three particle correlations.

For a self-similar cascade mechanism the underlying probability density is described by a Log-Levy type of distribution function [5] that is characterized by a stability index ($\mu$) considered to be a measure of the degree of multifractality within a physically allowed limit $0 \leq \mu \leq 2$. Under the Levy-law approximation, the ratio of
anomalous dimensions is expected to follow a relation: $\beta_q = \left( \frac{d_q}{d_2} \right) (q - 1) = (q^2 - q) / (2^\mu - 2)$.

These values of $\beta_q$ are not at all close to the universally accepted value $\nu = 1.304$, necessary for a thermal phase transition to take place.

In Fig. 5 our results on the anomalous dimensions ($d_q$) obtained from intermittency have been shown graphically. For the $\eta$-space: $\mu = 1.802$ and for $\varphi$-space: $\mu = 1.903$. In both cases $\mu > 1$, which indicate presence of wild non-Poisson type fluctuations in the density of particles.

The behavior of, $\lambda_q = \Phi_q/(q+1)$, as a function of $q$ [5] can be utilized as another tool to check occurrence of non-thermal phase transition in particle production process. The plot is given in Fig.7, where no definite minimum indicates absence of non-thermal phase transition.

The presence analysis therefore indicates presence of weak intermittency in 1-dim, that cannot be explained by the simulated data. No definite conclusion can be drawn regarding the observed effects.

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References: