Two-dimensional intermittency in ^{16}O-Ag/Br interactions at 200A GeV/c

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The anomalous behavior of 2-dimensional (2D) scaled factorial moments (SFM), calculated over the density distribution of singly charged particles produced in ^{16}O-Ag/Br interactions at an incident momentum of 200A GeV/c, has been studied [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 $\langle n_s \rangle = 119.26 \pm 3.59$. In 1D the intermittency effect has not been found to be very prominent. So the second order SFM is calculated over a 2D distribution in pseudorapidity – azimuthal angle (η - φ) space. Corresponding to η and φ the cumulant variables were obtained, and the entire range of each cumulant variable has been partitioned into M_1 intervals of equal size, resulting in $M = (M_1)^2$ such intervals in the 2D space.

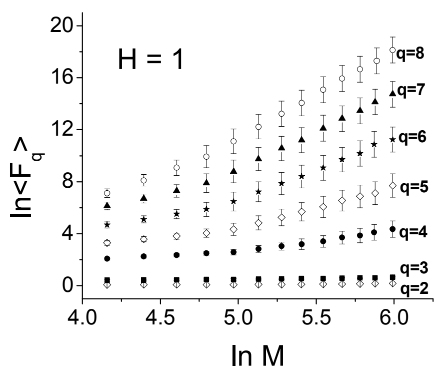

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Fig.1

The variation of ln $\langle F_q \rangle$ in 2D is not linear over the entire range of ln M. So, within a restricted region (for $400 \geq M \geq 64$) in Fig.1 2D moments of different orders have been plotted and linear fit to experimental data have been obtained (not shown in the figure), and the 2D intermittency indices Φ_q has been evaluated from these straight line fits (shown in Table 1). It has been argued that [3] multiparticle production in high energy interactions is an anisotropic process. The longitudinal momenta can vary over a wide range, whereas the transverse momentum range is limited with a universal average of $\langle P_t \rangle \approx 0.35$ GeV/c only. The nonlinearity in the 2D analysis is a result of this asymmetry. If a QGP like state is formed there will not be any elementary nucleon-nucleon (NN) collision, and the entire nucleus-nucleus (AB) system will melt down to thermalize into a unique system. Under such a situation an upward bending of the 2D SFM may not be observed. But under ordinary circumstances, an AB collision can be looked upon as a superposition of many elementary NN collisions. When the fluctuations are scaled in different ways in different directions of phase space, it is a characteristic of a self-affine fractal rather than a self-similar one. This kind of self-affinity in non-statistical fluctuation can be investigated by differently shrinking the entire phase space interval available experimentally, along two independent directions e.g.,

$$M_\varphi = M_\eta^H \qquad M_\eta = 2, 3 \ldots, 60; \qquad H < 1.0$$

$$M_\eta = M_\varphi^{(1/H)} \qquad M_\varphi = 2, 3 \ldots, 60; \qquad H > 1.0$$

Here M_η (M_φ) is the partition number of the η (φ) space. The new parameter H is called the Hurst exponent and it is a measure of the self-affine property of the fractal structure. The way the self-affine SFM for q=2 depends on M, has been graphically shown in fig. 2 and 3 for different values of H, respectively for H≤1 and H > 1.0.

Table. 1

Order q	Φ_q	χ^2 / dof
2	0.115±0.025	0.065
3	0.364±0.048	0.212
4	0.869±0.118	0.404
5	1.799±0.206	0.636
6	2.981±0.262	0.768
7	4.140±0.295	0.875
8	5.218±0.317	1.047

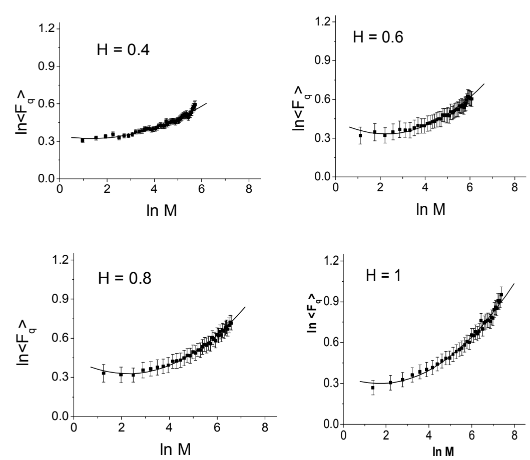

Fig.2

In each case, the experimental points are fitted with a quadratic function like: $f(\xi) = a\xi^2 + b\xi + c$ and the values of the fit parameters 'a' and 'b' are given in table 2. The parameter 'a' can obviously be used to characterize the degree of upward bending.

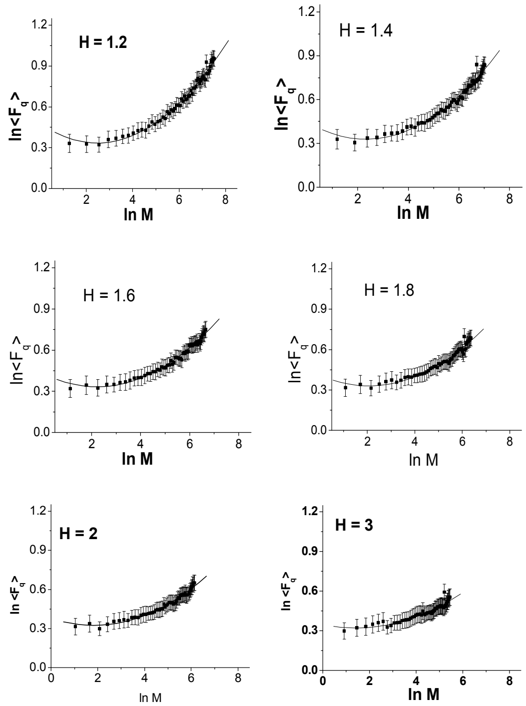

Fig.3

Table.2

H	Value of 'a'	Value of 'b'	r^2
0.4	0.0137±0.0016	-0.0448± 0.0123	0.939
0.6	0.0154±0.0011	-0.0566±0.0092	0.978
0.8	0.0205±0.0019	-0.0905±0.0171	0.963
1.1	0.0261±0.0037	-0.1403±0.0305	0.986
1.2	0.0236±0.0029	-0.1177±0.0305	0.985
1.4	0.0219±0.0034	-0.1022 ±0.0326	0.982
1.6	0.0199±0.0038	-0. 0885±0.0351	0.975
1.8	0.0180±0.0042	-0. 0750±0.0360	0.967
2.0	0.0162±0.0040	-0. 0590±0.0370	0.961
3.0	0.0127±0.0058	-0. 0365±0.0431	0.924

From fig.2 and fig.3 as well as from the parameter values in Table.2 one can see that, as H deviates more and more from unity, the non-linearity slowly disappears straightening out the ln M dependence of ln $\langle F_2 \rangle$. The result shows that the strong upward bending of ln F_2 vs. ln M for H = 1 is weakened when the value of H becomes greater than unity and at H = 2 or H = 3 the curves are almost straight. For each H the best quadratic behavior is obtained by the Pearson's r^2 coefficient. In almost all cases the r^2 values are close to unity, confirming goodness of fit. This means that the anomalous scaling of SFM is observed better when the phase space is divided finer in longitudinal direction (η) than in the transverse direction (φ).

In order to study the dependence of the superposition effect on the mass of the colliding nucli, we have compared the results with the data of ^{197}Au – Em interactions of EMU01 experiment are shown in fig.4.

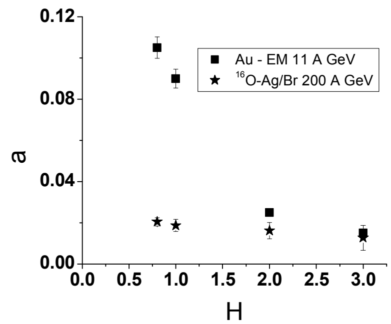

Fig.4

From fig. 4 we find that the values of 'a' is always larger in ^{197}Au – Em case than in the ^{16}O – Ag/Br interactions at the same value of H. This means that the ln F_2 vs. ln M curves bend upwards stronger for heavier colliding nuclei than for the lighter ones at the same value of H. This may due to a larger number of elementary NN collisions in heavier colliding system.

Our results are based on nuclear emulsion data obtained from the super proton synchrotron (SPS) at CERN. The data have a superiority of high spatial resolution together with a 4π coverage. All the tracks are measured directly and no acceptance correction is needed. This in particular, makes the method for FM analysis with noninteger M as proposed in [4] applicable. On the other hand, the emulsion dada have the disadvantage that no momentum is measured. Since the anomalous scaling of FM depends strongly on the momentum distribution, the physical interpretation of the present results with only η and φ variables has to be checked in further investigation.

Acknowledgement

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References:

[1] Adamovich M I et. al. (EMU01 Collaboration) 1997 *Z. Phys. C* 76, 659
[2] Chanda D, Ghosh M K, Mukhopadhyay A and Singh G, 2005 *Phys. Rev. C* 71, 034904
[3] Wu Y and liu L 1993 *Phys. Rev. lett*. 70, 3197
[4] Liu Lianshou, Zhang Yang and Wu Yuanfang, 1996 *Z. Phys. C* 69, 323