Jet-like structure and Two-dimensional intermittency study at CERN SPS Energy

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The SFM of order q is defined as

$$< F_q >= \frac{1}{M} \sum_{m=1}^{M} \frac{<n_{em}(n_{em}-1)\ldots(n_{em}-q+1)>}{<n_{em}>^q}$$

Where \( n_{em} \) is the number of target fragments falling within the \( m^{th} \) interval of the \( e^{th} \) event, \(< >\) denotes an averaging over the number of events and \( q \) is the order of the moment. \( M = M_{\eta} M_{\phi} \) is the total 2d phase space partition number and \( M_{\phi} (M_{\eta}) \) is the partition number along the \( \eta (\phi) \) direction. If the 2d dynamical fluctuations are self similar at all scales then one expect to see a linear relation like \( ln < F_q > = q \ln M + A_q \), where \( A_q \) is the intercept and the slope \( \phi_q \) is the intermittency index and it measures the strength of the intermittency. We have performed a self-affine analysis of our multiplicity fluctuation data with a continuously diminishing scale of phase-space resolution [5]. The phase-space scale factors in different directions are related as \( M_{\eta} = M_{\eta}^H \) for \( 0 < H < 1.0 \) and \( M_{\phi} = M_{\phi}^H \) for \( H > 1.0 \). The ‘H’ is called the Hurst exponent.

We have chosen \( N_{\phi} = 7 \) for \( ^{197}\text{O}-\text{Ag/Br} \) and \( ^{32}\text{S}-\text{Ag/Br} \) events. The corresponding expectation (stochastic) values of \( S_1 \) and \( S_2 \) are \(<S_1>=17.15 \) and \(<S_2>=0.25 \) respectively. In fig.1 and fig.2 we have plotted \( \Sigma \ln (\Delta \phi_i) \) vs \( \Delta \eta \) and \( \Sigma (\Delta \phi_i)^2 \) vs \( \Delta \eta \) distributions for both type of interactions. We find that the distribution of the data obtained from the MC simulation lie more or less along the stochastic expectation line indicated by the solid line, in both the cases. Experimental data points for \(^{197}\text{O}-\text{Ag/Br} \) interaction (fig.1 (a), fig.2 (a)) are more or less along the stochastic average line. But for \(^{32}\text{S}-\text{Ag/Br} \) interaction (fig.1(b), fig.2(b)), the experimental data points have a slight tendency to be above the stochastic expectation line for both the distributions. So from the average behavior of \( S_1 \) & \( S_2 \), we can conclude the faintly presence of jet-like substructure for both the interactions.

Table-1

<table>
<thead>
<tr>
<th>Order</th>
<th>106-Ag/Br</th>
<th>32-S-Ag/Br</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Phi_1$</td>
<td>$\Phi_2$</td>
</tr>
<tr>
<td>q=2</td>
<td>0.117±0.031</td>
<td>0.050</td>
</tr>
<tr>
<td>q=3</td>
<td>0.741±0.088</td>
<td>0.922</td>
</tr>
<tr>
<td>q=4</td>
<td>1.767±0.133</td>
<td>0.961</td>
</tr>
</tbody>
</table>

Table-2

<table>
<thead>
<tr>
<th>H</th>
<th>106-Ag/Br interaction at 60A GeV/c</th>
<th>32-S-Ag/Br interaction at 200A GeV/c</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>0.30</td>
<td>0.012±0.008</td>
<td>-0.039±0.045</td>
</tr>
<tr>
<td>0.35</td>
<td>0.011±0.006</td>
<td>0.023±0.044</td>
</tr>
<tr>
<td>0.80</td>
<td>0.026±0.009</td>
<td>-0.080±0.070</td>
</tr>
<tr>
<td>1.0</td>
<td>0.035±0.009</td>
<td>-0.159±0.099</td>
</tr>
<tr>
<td>3.0</td>
<td>0.0129±0.005</td>
<td>0.006±0.032</td>
</tr>
<tr>
<td>4.0</td>
<td>0.002±0.005</td>
<td>0.064±0.034</td>
</tr>
</tbody>
</table>

Fig. 1 (a)                    Fig. 1 (b)

Setting $M_s=M_n$, we have plotted 2d SFM for different order in fig.3 for both type of interactions. The variation of $\ln<F_2>$ with $\ln M$ is not linear in full $\ln M$ region. To obtain a measure of the self-affine intermittency index in 2d, one can perform a polynomial fit for data sets and can then retain the linear coefficient by setting all nonlinear coefficients to zero. The results of 2d intermittency index are presented in table-1, for both the interactions. The self-affine analysis for $q=2$ has been performed for a wide range of $H$ values for both type of interaction. Nonlinear variation in each case is fitted with a quadratic function like $y=ax^2+bx+c$. The values of ‘$a$’, ‘$b$’ and $r^2$ are tabulated for various $H$ in table-2 for $^{10}$O-Ag/Br interaction and $^{32}$S-Ag/Br interaction in table-3.

From fig.4 (a) we can find that $\ln<F_2>$ varies linearly with $\ln M$ for $H=0.3$ for $^{10}$O-Ag/Br interactions. So self similarity is obtained for $^{10}$O-Ag/Br interaction at $H=0.3$. For $^{32}$S-Ag/Br interaction the self similarity is obtained at $H=0.35$ which is also shown in fig.4 (b).

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Reference