Wavelet analysis of unusual Superspiky event produced in ^{32}S-Ag/Br interactions at 200A GeV/c

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1. Introduction

High energy collisions of elementary particles result in the production of many new particles in a single event. Each newly produced particle can be represented by its momentum vector, i.e., by a dot in the three dimensional phase space. Each single event has a distribution of these dots. Different patterns formed by these dots in the phase space would correspond to different dynamics. To understand this dynamics is a main goal of all studies done at accelerators and in cosmic rays. In the past, event-by-event analysis was performed to search the dense groups of particles isolated from other particles in the event. The dense groups could look like single dense jets or ring-like events. It is the method of wavelet analysis that allows the recognition of patterns due to correlations at different scales and to damp down the statistical noise even if it is very large in the original sample. By choosing the strongest fluctuations, one may chuck out statistical fluctuations and observe those dynamic ones which exceed the statistical component. In this paper we have chosen one event, having multiplicity 229 from ultrarelativistic nuclear interactions of ^{32}S- Ag/Br interactions at 200 A GeV/c and identified as unusual superspiky events, showing two distinct peaks in the pseudo rapidity distribution and getting the nuclear refractive index almost close to unity [**1**], using the concept of Cherenkov gluon radiation from the knowledge of ring-like events [**2**]. Here we have introduced the wavelet analyses technique to recognise the peculiar patterns (ring and/orjet) in the above said event. P Carruthers had the first attempt to use wavelet analysis in multiparticle production [**3**].

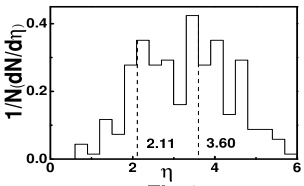

Fig.1

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2. Methodology

In general, the continuous wavelet transform of function f(x) has the form:

$$W_\psi(a,b)f = \frac{1}{\sqrt{C_\psi}} \int_{-\propto}^{\propto} f(x)\psi_{a,b}(x)dx \qquad (1)$$

where x is a studied quantity and C_ψ is a normalizing constant. The functions, $\psi_{a,b}(x) = a^{-1/2}\psi(\frac{x-b}{a})$ are shifted and/or dilated derivations of mother wavelet function ψ(x) characterized by translation parameter b and dilation parameter or scale a. The distribution of pseudorapidities can be expressed as

$$f(\eta) = \frac{dn}{d\eta} = \frac{1}{N}\sum_{i=1}^{N} \delta(\eta - \eta_i), \qquad (2)$$

where N is the number of particles in a studied data sample and η_i is pseudorapidity of ith particle. Data sample can mean either a few events or one single event or only a part of event. The wavelet transform of the function (2) takes on the form

$$W_\psi(a,b)f = \frac{1}{N}\sum_{i=1}^{N} a^{-1/2}\psi(\frac{\eta_i - b}{a}) \qquad (3)$$

The wavelet transform squared is conventionally called "the power spectrum" E$_w$ in complete analogy to its Fourier transform analogue because it is related to the squared function f(x) by the following formula

$$\int f^2(x)dx = C_\psi^{-1} \int\int [W_\psi(a,b)f]^2 \frac{dadb}{a^2} \qquad (4)$$

Therefore,E$_w$= [W$_\psi$(a,b)f]^2 describes the density of the analyzed signal f(x) in two dimensional space(a,b). We have studied our analysis using 'Mexican hat' wavelet, which is the second derivative of the Gaussian function and the expression is $g_2 = (1 - x^2)e^{-x^2/2}$.

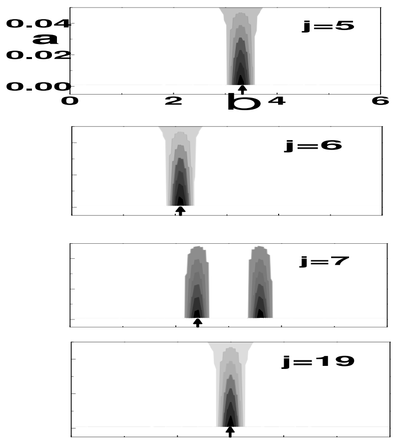

Fig.2

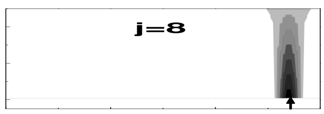

Fig.3

3. Result and discussion

Lego-plots have been used for jets, and some ring-like densely populated regions corresponding to semi-isolated dense groups on the pseudorapidity axis. We consider just a single event to clearly show the power of the wavelet method. Pseudorapidity distribution of that particular event is shown in Fig.1. We can find the maxima and minima in the previous diagram in the region $2.11<\eta<3.60$, which could raise some speculation on their physics origin. This kind of maximas and minimas were considered as the indication of ring like substructure inherent to this event. We show that wavelet analyses give more complete and quantitative results. The idea behind this method is to resolve any pattern at different locations with variable resolution. We have divided the total (η,ϕ) plane of the target diagram in to 24 equal sectors with $\Delta\phi=\pi/12$. Sectors are labeled by j where limits of j is $1\leq j\leq 24$. All $f(\eta)'s$ in 24 sectors have been analyzed according to eq. (3) and their power spectra E_w have been plotted. In Fig.2 from top to bottom, we have shown the equal-height levels (denoted by different density black regions) of the corresponding spectra for sectors 5, 6, 7 and 19 (i.e., $(k-1)\pi/12<\phi_k<k\pi/12$). Their most remarkable common feature is the dark strips indicated by arrows which appear in the most densely populated regions on the (η,ϕ) plane. They are rather narrow in η (as seen from their extension along the b-axis) and cover an extended part of all available azimuthal angles ϕ (since they propagate to many ϕ-sectors). It reminds the part of a ring (or an ellipse). The ring is not centered around the collision axis. From the position of the arrows in Fig.2, it can be identified that the azimuth-asymmetric ring covers those regions of pseudorapidity η where the peaks are located on the pseudorapidity plot in Fig.1. The same kind of analysis has been performed in [**4**]. However due to its non-centered position it is not so easy to guess this new structure from the traditional analysis of Fig.1 directly since it is smoothed there while the wavelet analysis reveals it and provides the more detailed information about it. However in Fig.3, we have shown a strong jet-like structure seen just for j=8 and not extending to the neighboring ϕ sectors.

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