AN INVESTIGATION OF NON-LINEAR EFFECTS IN NUCLEAR MATTER IN HEAVY-ION INTERACTION

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ABSTRACT

We present in this paper a first investigation of non-linear effects in nuclear matter by studying coherence of pion production processes in relativistic heavy-ion collisions using data from emulsion plates exposed to $^{16}$O beam at 2.1 GeV/n. Comparing the inclusive pion distribution at different angular bins with the chaotic and Poisson's distribution information on coherent pion processes was obtained. At some angular bins, quite prominent 'Poissonicity' was observed and a possible significance of the results has been discussed.

1. Introduction

It has been suggested (Fowler et. al., 1981) that in case of high-energy hadron-nucleus and nucleus-nucleus reactions a partially coherent intense mesonic field is created and the response of the nuclear medium will be non-linear in the mesonic field.

Although there have been some studies of coherence in case of hadron-hadron and hadron-nucleus collisions, such study in case of nucleus-nucleus collisions is practically insignificant. In this paper we present a first study on the coherence in heavy-ion collisions. Following Fowler et. al. (1981), one for look for the coherence through the shape of the multiplicity distribution, when the fields are completely coherent, the multiplicity distribution should be Poissonic (Glauber, 1964).

In the present paper we present an investigation in multiplicity distribution in different angular bins. The distribution in each angular bin has been matched against the Poisson distribution, the chaotic distribution and a superimposition of chaotic and Poisson distribution. Following Fowler et. al. (1981), an investigation on the Poissonicity of the particles emitted in different cases in the interaction of $^{16}$O at 2.1 GeV/n with emulsion was investi-
gated and evidence for Poissonicity has been found in some angular region.

2. Method of Analysis

For the purpose of analysis, each event was divided into several angular bins in terms of the variable

\[ U = -\ln \tan \theta/2 \]

each bin is treated as a 'mini star' of multiplicity \( n_i \). The total multiplicity \( n \) of each event is

\[ n = \sum_i n_i \]

In Figs. 1 we present the observed multiplicity distribution in five intervals. The curves represent the Poisson distribution

\[ P(n_i) = e^{-\langle n_i \rangle} \frac{\langle n_i \rangle^{n_i}}{n_i!} \]

corresponding to the estimated mean multiplicities \( \langle n_i \rangle \).

In Figs. 2 the curves represent the chaotic distribution

\[ P(n_i) = \frac{1}{1+\langle n_i \rangle} \left[ \frac{\langle n_i \rangle}{\langle n_i \rangle + 1} \right]^{n_i} \]

corresponding to the estimated mean multiplicities \( \langle n_i \rangle \).

In Figs. 3 the curves represent the superimposition of the chaotic and Poisson distribution.

Since \( P_i(0) = \exp (-\langle n_i \rangle) \), the quantity

\[ \Delta_i = \left| (\ln P_i(0)) - \langle n_i \rangle \right| \]

should vanish for a Poisson distribution.

3. Results

In Fig. 4 we plot the values of \( \Delta \) for different intervals. It is observed that

(a) \( \Delta \) value for bins 1, 2 are well compatible with zero, and, significant deviations occur at other values.

(b) With the increase in the value of \( \langle n \rangle \) compatibility of the multiplicity distribution shifts to a chaotic distribution and then to the superimposition of a chaotic and a Poisson distribution, as will be apparent from Fig. 5.

We propose to proceed further with the investigation so as to get evidences of confirmed zonal coherence.
Fig. 1: Experimental multiplicity distribution and Poisson curve.

Fig. 2: Experimental multiplicity distribution and chaotic curve.

Fig. 3: Experimental multiplicity distribution and superposition of Poisson and chaotic curves.
Fig. 4: Plot of $\Delta$ at different intervals.
Fig. 5: Plot of $\Delta$ against multiplicity.

References

Glauber, R., (1964), Optique et Electronique Quantique in Les Houees Lectures (Gordon and Breach).