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Non-standard peak values of the Bose-Einstein correlations and their possible interpretation by a metric description of strong interactions

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Abstract. We critically reanalyze some recent experimental data on the Bose-Einstein (BE) correlations in pion production. We show that there is, in some cases, an experimental evidence for a peak height of the correlation function greater than two, contrarily to the predictions of the “canonical” theory of BE correlations. Although an explanation of such an “anomalous” value can be given by means of suitable phenomenological models, we show that this result is a straightforward consequence of the treatment of BE correlations within the framework of a description of strong interactions in terms of a deformed Minkowski metric.

1 Introduction

It is known since 1959 that the “normal” pionic correlations have an enhancement at low dipion mass M [1]. These “normal” pionic correlations are defined by

$$C^{\rm nor}_{(2)}(p_1,p_2)=\frac{N_U}{N_L}\frac{D_L(p_1,p_2)}{D_U(p_1,p_2)}, \qquad (1)$$

where $D_L(p_1,p_2)$ and $D_U(p_1,p_2)$ are respectively the probability density for like ($2\pi^+$ and $2\pi^-$) and unlike ($\pi^+\pi^-$) charged pionic pairs having four-momenta p_1 and p_2, and N_L and N_U are the total number of like and unlike combinations.

This effect is interpreted to be due to the fact that pions obey the Bose-Einstein statistics [2]. Afterwards, the works of several authors developed this interpretation and led to the formulation of the “canonical” theory of Bose-Einstein correlations (CTBEC) [3]. In this theory, the pionic correlations are defined by

$$C^{\rm th}_{(2)}(p_1,p_2)=\frac{D_L(p_1,p_2)}{D_0(p_1,p_2)}, \qquad (2)$$

where $D_0(p_1,p_2)$ is the probability one would have in absence of correlation. They are related to the square of the Fourier transform of the pionic source distribution $F_{(2)}(p_1,p_2)$ by

$$C^{\rm th}_{(2)}(p_1,p_2)=N[1+\lambda F_{(2)}(p_1,p_2)],$$

where N is a normalization factor and λ, called “incoherence parameter”, is bounded by

$$0\le\lambda\le 1. \qquad (3)$$

The CTBEC predicts $\lambda=0$ if the pions are produced coherently and $\lambda=1$ in case of total incoherence.

The interpretation given by the CTBEC has been disproved by recent analyses [4–6] which studied the “normal” correlations in $\bar{\rm p}$N annihilations at rest as a function of the four-momentum transfer[1]

$$Q=\sqrt{(p_1-p_2)^2}=\sqrt{M^2-4m_\pi^2}.$$

Firstly, the CPLEAR collaboration studied the “normal” correlations in $\bar{\rm p}$p annihilation into four charged pions [4]. The results were that the peak heights are $h^{\rm nor}_{(2)}=C^{\rm nor}_{(2)}(0)=N(1+\lambda)>3$. This does not fit with the limit (3) because the data show a normalization factor N close to one.

Afterwards, one of us (M.G.) studied the “normal” correlations in the annihilations at rest [5, 6]

$$\bar{\rm p}{\rm n}\to 2\pi^+3\pi^-, \qquad (4)$$
$$\bar{\rm p}{\rm n}\to \pi^+2\pi^-, \qquad (5)$$

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[1] Actually, the paper [5] reported the $2\pi^+$ and $2\pi^-$ correlations as functions of Q^2. The correlations of the same reaction as functions of Q can be found in [7]