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A.A. Arkhipov

ON THE RELATION BETWEEN THE SLOPES OF DIFFRACTION CONE IN SINGLE DIFFRACTION DISSOCIATION AND ELASTIC SCATTERING

This paper is partially included in the review talk presented at the VIIIth Blois Workshop on Elastic and Diffractive Scattering, Protvino, Russia, June 28–July 2, 1999

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Abstract

Arkhipov A.A. On the Relation between the Slopes of Diffraction Cone in Single Diffraction Dissociation and Elastic Scattering: IHEP Preprint 99-44. – Protvino, 1999. – p. 3, refs.: 8.

The fundamental relation between the slopes of diffraction cone in single diffraction dissociation and elastic scattering has been derived.

Аннотация

Архипов А.А. Связь между наклонами дифракционного конуса в упругом рассеянии и дифракционной диссоциации: Препринт ИФВЭ 99-44. – Протвино, 1999. – 3 с., библиогр.: 8.

Получено фундаментальное соотношение между наклонами дифракционного конуса в упругом рассеянии и дифракционной диссоциации.

Not long ago we observed that the slope b_{SD} of diffraction cone in single diffraction dissociation $NN \to NX$ was related to the effective interaction radius R_0 for the three-body (three-nucleon) forces [1]

$$b_{SD}(s, M_X^2) = \frac{1}{2} R_0^2(\bar{s}, s_0'), \tag{1}$$

$$\bar{s} = 2(s + M_N^2) - M_X^2, \quad s_0' = 2s_0,$$

where s_0 is a scale defining unitarity saturation asymptotic in hadron-hadron interaction. At the same time it was established that the quantity R_0^2 was related to the structure of hadronic total cross section in a physically clear and transparent form [1] (see also [2,3])

$$\sigma^{tot}(s) = 2\pi \left[B^{el}(s) + R_0^2(s)\right] (1 + \chi(s)), \tag{2}$$

where B^{el} is the slope of diffraction cone in elastic NN scattering and

$$\chi(s) = O\left(\frac{1}{\sqrt{s}\ln^3 s}\right), \quad s \to \infty.$$

This circumstance gives rise to the nontrivial consequences which are discussed in this note.

Let us define the slope B^{sd} of diffraction cone in a single diffraction dissociation at the fixed point over the missing mass

$$B^{sd}(s) = b_{SD}(s, M_X^2)|_{M_X^2 = 2M_N^2}. \tag{3}$$

Now taking into account Eq. (2), where the effective interaction radius for three-body forces can be extracted from [4]

$$R_0^2(2s, 2s_0) = R_0^2(s, s_0) = \frac{1}{2\pi}\sigma^{tot}(s) - B^{el}(s), \tag{4}$$

and the equation

$$\sigma^{el}(s) = \frac{\sigma^{tot}(s)^2}{16\pi B^{el}(s)}, \quad (\rho = 0), \tag{5}$$

we come to the fundamental relation between the slopes in the single diffraction dissociation and elastic scattering

$$\boxed{B^{sd}(s) = B^{el}(s)\left(4X - \frac{1}{2}\right)}, \tag{6}$$

where

$$X \equiv \frac{\sigma^{el}(s)}{\sigma^{tot}(s)}. \tag{7}$$

The quantity X has a clear physical meaning, it has been introduced in the papers of C.N. Yang and his collaborators [5,6].

In paper [7] we search for $X = 0.25$ at $\sqrt{s} = 1800\,GeV$. Hence in that case we have $B^{sd} = B^{el}/2$ which is confirmed not so badly in the experimental measurements [7].

In the limit of black disk ($X = 1/2$) we obtain

$$B^{sd} = \frac{3}{2}B^{el}, \tag{8}$$

and

$$B^{sd} = B^{el}, \quad at \quad X = \frac{3}{8} = 0.375. \tag{9}$$

So, we find that there is quite a nontrivial dynamics in the slopes of diffraction cone in the single diffraction dissociation and elastic scattering processes. In particular, we can study an intriguing question on black disk limit not only in the measurements of total hadronic cross sections compared with elastic ones but in the measurements of the slopes in single diffraction dissociation processes together with elastic scattering ones.

There is a more general formula which can be derived with account of the real parts for the amplitudes. This formula looks like

$$\boxed{B^{sd}(s) = B^{el}(s)\left(4X\frac{1-\rho_{el}(s)\rho_0(s)}{1+\rho_{el}^2(s)} - \frac{1}{2}\right)}, \tag{10}$$

where ρ_0 is defined in terms of three-body forces scattering amplitude similar to ρ_{el} [8]. If $\rho_{el} = 0$ or $\rho_0 = -\rho_{el}$ then we come to Eq. (6). In the case when $\rho_{el} \neq 0$, we can rewrite Eq. (10) in the form

$$\rho_0 = \frac{1}{\rho_{el}}\left[1 - \frac{1+\rho_{el}^2}{8X}\left(1 + \frac{2B^{sd}}{B^{el}}\right)\right]. \tag{11}$$

Eq. (11) can be used for the calculation of the new quantity ρ_0. Anyway it seems that the measurements of real parts for the amplitudes will play an important role in the future high energy hadronic physics.

Equations (6,10) can be rewritten in a unique form

$$\frac{Y}{Y'} + \frac{1}{2} = \alpha_\varrho X, \tag{12}$$

where the quantity Y has also been introduced in the above mentioned papers of C.N. Yang and his collaborators [5,6]

$$Y = \frac{\sigma^{tot}}{16\pi B^{el}}, \tag{13}$$

α_ϱ is a known function of ρ's (see Eq. (10)) and we introduced a new dimensionless quantity Y'

$$Y' = \frac{\sigma^{tot}}{16\pi B^{sd}}. \tag{14}$$

It is obvious

$$\frac{Y}{Y'} \equiv \frac{B^{sd}}{B^{el}}, \tag{15}$$

and we have for the quantity $\alpha_\varrho = 4$ if $\rho_{el} = 0$ or $\rho_0 = -\rho_{el}$.

Equation (12) represents the fundamental constraint on three dimensionless quantities Y, Y' and X. It would be very desirable to experimentally study this constraint.

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А.А.Архипов
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ГНЦ РФ Институт физики высоких энергий
142284, Протвино Московской обл.

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