Study of the Pomeron Couplings in Diffractive Reactions at HERA

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The study of diffractive reactions has attracted considerable interest due to the observation of high p_t jets in diffractive collisions [1]. The diffractive high p_t jet production can be used as a test of the Pomeron structure. The question about the spin structure of the Pomeron arises for the reactions with polarized particles.

The Pomeron is a vacuum t-channel exchange that contributes to high-energy diffractive reactions. The Pomeron contribution to the quark-proton amplitude can be written in the form

$$T(s,t)^{A,B} = I\!\!P(s,t) V^{\mu}_{AI\!\!P} \otimes V^{BI\!\!P}_{\mu},$$

where $I\!\!P$ is a "bare" Pomeron contribution, $V_{AI\!\!P}$ and $V^{BI\!\!P}$ are the Pomeron vertices for particles A and B, respectively.

It has been shown that in models (see e.g. [2]) the Pomeron–proton vertex is of the form

$$V^{\mu}_{ppI\!\!P}(p,r) = mp^{\mu}A(r) + \gamma^{\mu}B(r), \tag{1}$$

where m is the proton mass.

The quark-Pomeron vertex has been calculated perturbatively [3]:

$$V^{\mu}_{qqI\!\!P}(r) = \gamma_{\mu}u_0 + 2m_q k_{\mu}u_1 + 2k_{\mu}\not{k}u_2 + iu_3\epsilon^{\mu\alpha\beta\rho}k_{\alpha}r_{\beta}\gamma_{\rho}\gamma_5 + im_q u_4\sigma^{\mu\alpha}r_{\alpha}. \tag{2}$$

Here k is the quark momentum, r is the momentum transfer, m_q is the quark mass.

Note that in the cases (1,2) the spin-flip effects do not vanish as $s \to \infty$ in contrast to the standard Pomeron couplings in the models [4]

$$V^{\mu}_{hhI\!\!P} = \beta_{hhI\!\!P}\gamma^{\mu}. \tag{3}$$

The new form of the Pomeron couplings (2) should modify various spin asymmetries in high–energy diffractive reactions. The magnitude of the spin effects is connected with the ratio $m^2|A|/|B|$ for (1) or $m^2|u_3|/|u_0|$ for (2) found to be of the order $0.2-0.3$ for $|t|$ about few GeV^2. Thus, the spin effects may be not small. We shall discuss the effects which can be used in the future polarized diffractive experiments at HERA to study the spin structure of the Pomeron.

The transverse single spin asymmetry in polarized diffractive $Q\bar{Q}$ production in proton-proton scattering has been calculated in [5]. It was shown that the asymmetry is different for the standard and spin-dependent Pomeron vertex at the HERA-$\vec{N}$ energy $\sqrt{s}=40GeV$ [6]. In the first case it is about 5% and approximately constant; in the second case the asymmetry is larger than 7% and depends on the transverse momenta of the produced jet.

It was shown that the asymmetry obtained from the cross sections of diffractive $Q\bar{Q}$ production integrated over transverse momenta of the produced jet depends mainly on the Pomeron-proton coupling structure. It can be used for studying the spin structure of the proton-Pomeron coupling. The single-spin transverse A_N asymmetry in elastic pp scattering can be studied at HERA-$\vec{N}$ as a test of the spin dependence of the proton-Pomeron coupling too. The predicted asymmetry is about 10% for $p_T^2 = 4 - 5(GeV)^2$ [7]. Thus, the single-spin asymmetries can be very useful in the determination of the structure of Pomeron couplings.

The effects in diffractive deep inelastic scattering connected with the spin–dependent quark–Pomeron coupling have been studied. It was shown that the double longitudinal spin asymmetry in diffractive $Q\bar{Q}$ production for the standard quark–Pomeron vertex is very simple in form [8]

$$A_{ll} = \frac{yx_p(2-y)}{2-2y+y^2}. \tag{4}$$

This asymmetry is about 8% for $y = 0.7$ and $x_p = 0.1$. For the spin–dependent Pomeron coupling the asymmetry is dependent on $k_\perp^2$ of jets and smaller than for the standard Pomeron vertex, by about 5%.

The spin effects in diffractive reactions for the quark-Pomeron coupling in the form (1) have been studied in [9]. Strong sensitivity of asymmetries was found in diffractive meson production to the form of the Pomeron vertex at HERA energies.

We can conclude that the discussed single and double spin asymmetries depend strongly on the spin structure of the Pomeron coupling. However, to obtain the information about the Pomeron–coupling structure, the relevant asymmetries should be measured with an accuracy less than 1%. The values of cross sections in diffractive $Q\bar{Q}$ production are larger than $1000pb$, which permits one to perform these investigations at the integrated luminosity about $200(pb)^{-1}$. So, the diffractive polarization experiments at HERA allow one to study spin properties of quark-Pomeron and proton-Pomeron vertices. This gives an important test of the spin properties of QCD at large distances.

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