SPIN EFFECTS IN DIFFRACTIVE J/Ψ AND $Q\bar{Q}$ LEPTOPRODUCTION

S.V.Goloskokov
Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna 141980, Moscow region, Russia.
E-mail: goloskkv@thsun1.jinr.dubna.su

We study the dependencies of spin asymmetries in diffractive leptoproduction on the spin structure of the pomeron coupling. It is shown that the A_{ll} asymmetry in diffractive processes is proportional to the fraction of the initial proton momentum x_p carried off by the pomeron. The resulting asymmetries decrease with increasing energy for diffractive J/Ψ production and are energy independent for diffractive $Q\bar{Q}$ leptoproduction. The connection of these asymmetries with the non-forward gluon distribution in the proton is discussed.

The study of nature of the pomeron becomes again popular now due to the progress in investigation of diffractive reactions at HERA. The diffractive J/Ψ and $Q\bar{Q}$ leptoproduction is a keystone of this problem. The pomeron is a vacuum t-channel exchange that contributes to high-energy diffractive processes. The hadron-hadron scattering amplitude determined by the pomeron exchange can be written in the form $T(s,t)^{A,B} = \mathrm{i}\boldsymbol{P}(s,t)V_{A\mathbb{P}} \otimes V^{B\mathbb{P}}$, where $\boldsymbol{P}$ is a "bare" pomeron contribution, and $V_{A\mathbb{P}}$ and $V^{B\mathbb{P}}$ are the pomeron couplings with particles A and B, respectively.

The spin structure of the pomeron coupling is an open problem up to now. When the gluons from the pomeron couple to a single quark in the hadron, a simple matrix structure of the pomeron vertex $V^{\mu}_{h\mathbb{P}} = \beta_{h\mathbb{P}}\gamma^{\mu}$ appears. This standard coupling leads to spin-flip effects decreasing with increasing energy like $1/s$. The complicated spin structure of the pomeron coupling can be connected with the nonperturbative structure of the proton. Really, in a QCD–based model in which the proton is viewed as being composed of a quark and a diquark, the following structure of the proton coupling with a two-gluon system has been found

$$V^{\mu\nu}_{p\mathbb{P}}(p,r) = 4p^{\mu}p^{\nu}A(r) + (\gamma^{\mu}p^{\nu} + \gamma^{\nu}p^{\mu})B(r). \tag{1}$$

Here r is the momentum transfer. The term proportional to $B(r)$ represents the standard pomeron coupling that leads to the non-flip amplitude. The $A(r)$ contribution is determined by the effects of vector diquarks inside the proton, which reflects the nonperturbative contributions. They produce the spin-flip effects in the pomeron coupling which do not vanish at high-energies. A similar form of the proton-pomeron coupling has been found in [2].

When the absolute values of initial and final proton momenta do not coincide, the functions A and B in (1) should depend on the fraction of the initial proton momentum x_p carried off by the pomeron. It can be seen that this structure is connected with the non-forward gluon distributions. The spin-independent function B might be related to $G(r, x_p)$ and spin-dependent part A should be expressed in terms of $\Delta G(r, x_p)$ (see e.g. [3]). For zero x_p they represent some proton form factors.

A convenient tool to study the spin-dependent pomeron structure might be the polarized diffractive leptoproduction reactions. We shall consider here the A_{ll} asymmetry of J/Ψ and $Q\bar{Q}$ production in these processes. It has been shown in [4] that the A_{ll} asymmetry in the diffractive processes is proportional to the fraction of the initial proton momentum x_p carried off by the pomeron. The mass of the produced hadron system is determined by $M_h^2 \sim s y x_p$. For diffractive J/Ψ production M_h is a vector meson mass and we find that $x_p \sim (m_J^2 + Q^2 + |t|)/(sy)$. As a result, the relevant A_{ll} asymmetry should decrease with growing energy. For the pomeron coupling (1) spin asymmetry looks as follows

$$A_{ll} \sim \frac{|t|}{s} \frac{(2-y)(1+2m\alpha_{flip})}{(2-2y+y^2)((1+2m\alpha_{flip})^2+\alpha_{flip}^2|t|)}, \tag{2}$$

where $\alpha_{flip} = A(t)/B(t)$. Thus, the form of A_{ll} asymmetry depends on the ratio of spin-flip to non-flip parts of the pomeron coupling which have been found in [1] to be about 0.1. The predicted asymmetry at HERMES energies is shown in Fig.1. At HERA energy, the asymmetry will be negligible. The A_{ll} asymmetry might be connected with the spin-dependent gluon distribution ΔG only for $|t| = 0$. We have found that this asymmetry is equal to zero in the forward direction and ΔG can not be extracted from A_{ll} in agreement with results of [3]. However, this asymmetry might be expressed in terms of the non-forward gluon distributions inside the proton.

In the case of $Q\bar{Q}$ diffractive leptoproduction, the produced hadron mass is not fixed and x_p is arbitrary, typically, of about $.05 - .1$. The A_{ll} asymmetry in this case is proportional to x_p as previously and it should have a weak energy dependence. This was confirmed by specific calculations. The cross section integrated over the pomeron momentum transfer was calculated because the recoil proton is usually not detected in diffractive experiments. Strong dependence of the polarized cross sections on the mass of produced quarks and $\beta \simeq Q^2/(Q^2 + M_x^2)$ has been observed. Some results for the spin-dependent vertex and forms of the cross sections can be found in [4]. The estimated A_{ll} asymmetry of the diffractive open charm ($c\bar{c}$) production is shown in Fig.2.

The standard pomeron coupling with the pomeron looks as $\bar{u}(p_2)\gamma_\mu u(p_1)$, which is completely equivalent to the form of lepton-photon interaction. This leads to the same spin-dependent parts in the lepton and hadron blocks and a non small amount of A_{ll} asymmetry for $\alpha_{flip} = 0$ (see Figs. 1 and 2). This asymmetry might be an important background in the lepton-proton experiments where the final proton is not detected. The predicted non small value of the asymmetry in diffractive $Q\bar{Q}$ production and its weak energy dependence permit one to study, in these reactions, the spin-dependent gluon distributions inside the proton at $\sqrt{s} \leq 20\mathrm{GeV}^2$ as well as at HERA energies.

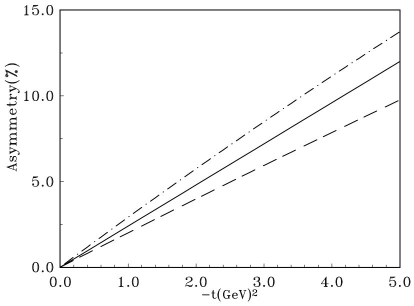

Fig.1 A_{ll} asymmetry of J/Ψ production at HERMES: solid line -for $\alpha_{flip} = 0$; dot-dashed line -for $\alpha_{flip} = -0.1$; dashed line -for $\alpha_{flip} = 0.1$.

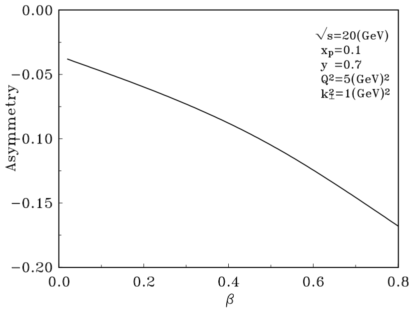

Fig.2 β– dependence of A_{ll} asymmetry of diffractive open charm production for the standard pomeron coupling.

We have found that the spin structure of the pomeron coupling should modify the spin–dependent cross section in diffractive processes. Not small values of the A_{ll} asymmetry in the diffractive $Q\bar{Q}$ production have been predicted. The asymmetry is free from the normalization factors and is sensitive to the dynamics of pomeron interaction. Thus, the A_{ll} asymmetry in diffractive J/Ψ and $Q\bar{Q}$ leptoproduction is convenient to test the pomeron coupling structure and the non-forward spin-dependent gluon distributions. The polarized diffractive ϕ –meson leptoproduction can be used for this purpose too.

References

1. S.V. Goloskokov, P. Kroll, e-print: hep-ph/9807529.
2. C. Bourrely, J. Soffer, T.T. Wu, *Phys. Rev.* D **19**, 3249 (1979);
   S.V. Goloskokov, S.P. Kuleshov, O.V. Selyugin, *Z. Phys.* C **50**, 455 (1991).
3. M. Vänttinen. L. Mankiewicz, e-print: hep-ph/9805338.
4. S.V. Goloskokov, e-prints: hep-ph 9506347; hep-ph 9509238;
   S.V. Goloskokov, *Mod. Phys. Lett.* A **12**, 173 (1997).