Spin effects in diffractive $Q\bar{Q}$ production at BNL eRHIC

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We discuss quark-antiquark leptoproduction within a QCD two-gluon exchange model at small x. The double spin asymmetries for longitudinally polarized leptons and transversely polarized protons in diffractive $Q\bar{Q}$ production are analyzed at eRHIC energies. The predicted A_{lT} asymmetry is large and can be used to obtain information on the polarized generalized gluon distributions in the proton.

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I. INTRODUCTION

Investigation of hadron photo and leptoproduction at high energies and small Bjorken x is a problem of considerable interest. In this region the predominant contribution is determined by Pomeron exchange. Intensive experimental study of diffractive processes was performed in DESY (see, e.g., [1–4] and references therein). They give reach information on the Pomeron structure and properties of spin-average gluon distributions in the proton. The spin structure of the Pomeron was analyzed by different authors (see, e.g., [5–7] and reference therein). Such spin effects which do not vanish at high energies might be determined by the large distance contributions in the hadron structure which lead to a complicated spin-dependent form of the Pomeron-proton vertex. The gluon-loop corrections to the Pomeron coupling with the hadron might produce other sources of the spin-flip part in this coupling [8]. Manifestation of spin-dependent Pomeron can be investigated in the elastic pp scattering at low t [9], near diffraction minimum [10] and in polarized diffractive hadron leptoproduction [11].

Spin effects in diffractive processes at small x should be studied at accelerators with polarized beams. The Pomeron in QCD is related with a two-qluon colorless exchange [12], and in polarized experiments the spin-dependent two-gluon coupling with the proton can be analyzed. In diffractive hadron photoproduction the momentum carried by the two-gluon system is usually not equal to zero. In this case, the two-gluon coupling with the proton might be expressed in terms of the generalized parton distribution (GPD) in the nucleon [13].

The spin-dependent gluon distributions contain significant information on the spin structure of the proton. The important role in investigation of polarized gluon GPD should play the diffractive $Q\bar{Q}$ leptoproduction at small x. Information on this process can be obtained from dijet events in lepton-proton interaction. Theoretical analysis of these reactions was carried out in [14–17]. It was shown that the cross sections of diffractive quark-antiquark production are expressed in terms of the same gluon distributions as in the case of vector meson production. Thus the diffractive $Q\bar{Q}$ leptoproduction at small x really might be an excellent tool that can be used to study the gluon GPD at small x. Spin effects in $Q\bar{Q}$ production in lepton-proton reaction at small $x<0.1$, where the gluon contribution prevails, was studied, for example, in [11]. The double spin A_{lT} asymmetries in $Q\bar{Q}$ production for a longitudinally polarized lepton and a transversely polarized proton were analyzed within the two-gluon exchange model. The predicted A_{lT} asymmetry is not small and is sensitive to the spin-dependent part of the two-gluon coupling with the proton.

In future one of the best places to study spin effects in diffractive lepton-proton reactions will be the eRHIC accelerator [18] with a polarized lepton beam which will collide with the RHIC beam. The eRHIC kinematics, where the photon momentum is much smaller than the proton momentum, is asymmetric. Such a kinematics is similar to the HERA accelerator and is suitable to study hard diffractive events. The polarized protons from RHIC can be used to study spin effects in diffractive hadron leptoproduction at small x. In this paper, we discuss a possibility to study A_{lT} asymmetry in diffractive $Q\bar{Q}$ production in future experiments at eRHIC in order to receive information on the polarized gluon distributions (preliminary results can be found in [19]). In the second section, we analyze the kinematics of the final particle in this reaction. It is shown that the final proton moves practically in the same direction as the initial one. Jets from the final quarks have large angles and should be analyzed by the eRHIC detector. In the third section, the main theoretical equations which determine the spin asymmetry in $Q\bar{Q}$ production are presented. Predictions for spin asymmetries at eRHIC energies are made in Sec. IV. The expected asymmetries are not small, about a few percent. This shows a possibility to study A_{lT} asymmetry at the future eRHIC experiments where the information on the polarized gluon GPD can be obtained.

II. KINEMATICS OF DIFFRACTIVE $Q\bar{Q}$ LEPTOPRODUCTION AT eRHIC

Let us study the diffractive quark initiated dijet production in lepton-proton reactions

$$l+p\to l+p+H \tag{1}$$

at high energies in a lepton-proton system. The hadronic state H contains two diffractively produced quarks which are observed as two final jets.

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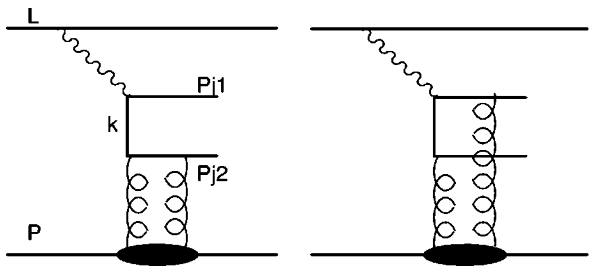

FIG. 1. Two-gluon contribution to $Q\bar{Q}$ production.

The graphs with t-channel gluon exchange in diffractive $Q\bar{Q}$ leptoproduction are shown in Fig. 1. This contribution predominates at small $x \leqslant 0.1$ for light quark and essential for heavy (charm) quark production, because the charm component in the proton is small. The reaction (1) is described in terms of the kinematic variables which are defined by

$$q^2=(L-L')^2=-Q^2, \quad t=r_P^2=(P-P')^2,$$

$$y=\frac{P\cdot q}{L\cdot P}, \quad x=\frac{Q^2}{2P\cdot q}, \quad x_P=\frac{q\cdot(P-P')}{q\cdot P}, \quad \beta=\frac{x}{x_P}, \tag{2}$$

where L,L' and P,P' are the initial and final lepton and proton momenta, respectively, Q^2 is the photon virtuality, r_P is the momentum carried by the Pomeron, t is a momentum transfer squared and x is a Bjorken variable. In Eq. (2) y and x_P represent the fractions of the longitudinal momenta of the lepton and proton carried by the photon and Pomeron, respectively. The energy of the lepton-proton system reads as $s=(L+P)^2$. The effective mass of a produced quark system is equal to $M_X^2=(q+r_P)^2 \sim x_P y s - Q^2$ and can be large. The variable β is equal to

$$\beta=x/x_P \sim Q^2/(M_X^2+Q^2) \tag{3}$$

and can vary from 0 to 1.

We use here the light-cone variables that are determined as $a_\pm=a_0 \pm a_z$. In calculation, the center of mass system is used, where the initial lepton and proton momenta are going along the z axis. They have the form

$$L=\left(p_+,\frac{\mu^2}{p_+},\vec{0}\right), \quad P=\left(\frac{m^2}{p_+},p_+,\vec{0}\right). \tag{4}$$

Here μ and m are the lepton and proton mass. The momenta of the photon and the Pomeron can be written as follows:

$$q=\left(yp_+,-\frac{Q^2}{p_+},\vec{q}_\perp\right), \quad |q_\perp|=\sqrt{Q^2(1-y)};$$

$$r_P=\left(-\frac{|t|}{p_+},x_P p_+,\vec{r}_\perp\right), \quad |r_\perp|=\sqrt{|t|(1-x_P)}. \tag{5}$$

The final quark momenta p_1,p_2 and the momentum of the off-mass-shell quark k (see Fig. 1) are determined from the mass-shell conditions $p_1^2=m_q^2, p_2^2=m_q^2$. The vector k is mainly transverse: $k^2 \sim -k_\perp^2$. The momenta of the observed jets which are equal to the quark momenta have the following form [11]:

$$p_{J1} \sim \left(yp_+ - \frac{|t|}{p_+} - \frac{m_q^2+(\vec{r}_\perp+\vec{k}_\perp)^2}{p_+ x_P}, \times \frac{m_q^2+(\vec{q}_\perp-\vec{k}_\perp)^2}{p_+ y},(\vec{q}_\perp-\vec{k}_\perp)\right),$$

$$p_{J2} \sim \left(\frac{m_q^2+(\vec{r}_\perp+\vec{k}_\perp)^2}{p_+ x_P},x_P p_+ - \frac{Q^2}{p_+} - \frac{m_q^2+(\vec{q}_\perp-\vec{k}_\perp)^2}{p_+ y},(\vec{r}_\perp+\vec{k}_\perp)\right). \tag{6}$$

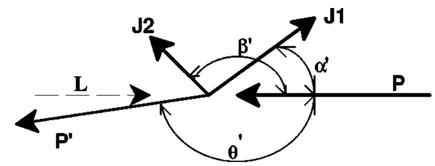

FIG. 2. Final hadron kinematics in $Q\bar{Q}$ production at eRHIC system.

We can write the same momenta at the eRHIC asymmetric system, Fig. 2. We use here the standard variables $v=(v_0,v_\perp,v_z)$ and do not consider in details of scattering in the transverse plane, for simplicity. Only one transverse component which is determined by $v_\perp=\sqrt{v_x^2+v_y^2}$ is used in the vectors. In this approximation, we can write

$$L=(p_l,0,p_l),$$

$$L'=(p_l^f,p_l^f\sin\gamma',p_l^f\cos\gamma'),$$

$$P=(\sqrt{m^2+p^2},0,-p),$$

$$P'=(\sqrt{m^2+p_f^2},p_f\sin\theta',-p_f\cos\theta'),$$

$$P_{J1}=(\sqrt{m_Q^2+J_1^2},J_1\sin\alpha',J_1\cos\alpha'),$$

$$P_{J2}=(\sqrt{m_Q^2+J_2^2},J_2\sin\beta',J_2\cos\beta'). \tag{7}$$

One can estimate the momenta and the scattering angles in the eRHIC system in terms of variables (2) by comparison of scalar productions of momenta in different systems. For the final lepton and hadron momenta and their angles we have

$$p_l^f \sim 2p_l \frac{1-y}{1+\cos\gamma'}, \quad \cos\gamma' \sim \frac{4p_l^2(1-y)-Q^2}{4p_l^2(1-y)+Q^2},$$

$$p_f \sim p(1-x_P) - \frac{|t|+2m^2x_P}{4p(1-x_P)},$$

$$\cos\theta' \sim -1 + \frac{|t|+m^2(1+x_P)}{4p^2(1-x_P)}. \tag{8}$$

For jet momenta and its angles the following solutions were found:

$$J_1 \sim yp_l + \frac{m_q^2+(q_\perp-k_\perp)^2)}{4yp_l},$$

$$\cos\alpha' \sim \frac{(2yp_l)^2-m_q^2-(q_\perp-k_\perp)^2}{(2yp_l)^2+m_q^2+(q_\perp-k_\perp)^2},$$

$$J_2 \sim x_P p - \frac{m_q^2+yQ^2+(q_\perp-k_\perp)^2}{4yp_l},$$

$$\cos\beta' \sim -1 + \frac{m_q^2+(k_\perp+r_\perp)^2}{2(x_P p)^2}. \tag{9}$$

In the eRHIC system the lepton momentum should be $p_l=5$ GeV or $p_l=10$ GeV. For the proton momentum two possibilities are analyzed $p=100$ GeV and $p=250$ GeV. The energy in the lepton-proton system is $s \sim 4p_l p + m^2$ and for our choice the minimum and maximum energy for eRHIC will be $\sqrt{s} \sim 50$ GeV and $\sqrt{s} \sim 100$ GeV. To estimate the kinematics of the final particles at eRHIC, we use some typical values of the variables determined in Eq. (2): $x_P=0.05$, $y=0.3$, $Q^2=5$ GeV^2, $k_\perp^2=2$ GeV^2 and $r_\perp$ is small. In this case, the final lepton momentum and angle can be estimated for $p_l=5$ GeV as

$$p_l^f \sim 3.75 \text{ GeV}, \quad \gamma' \sim 30°. \tag{10}$$

For $p_l=10$ GeV we find

$$p_l^f \sim 7.13 \text{ GeV}, \quad \gamma' \sim 15°. \tag{11}$$

The kinematics of the final hadron production for energies $\sqrt{s} \sim 50$ GeV and $\sqrt{s} \sim 100$ GeV is shown in Table I. The results are presented for the light quarks. We consider here two cases when the vector $k_\perp$ is parallel $(+k)$ or antiparallel $(-k)$ to the transverse component of the photon momentum $q_\perp$.

We can see from the table that the final proton is going inside the cone with angle $\theta_p^f=(\pi-\theta')<0.4°$. It moves practically in the same direction as the initial proton and it is possibly difficult to detect it. It is shown in the table that the final quarks have large angles $\alpha' \gg \theta', \beta' \gg \theta'$. Thus the final proton and jet angles are very different and final jets should be detected by the eRHIC.

TABLE I. Kinematics of the final hadron production. Light quark case.

	$s^{1/2}$ (GeV)	50	100
	p_f (GeV)	95	237
	θ'	179.6°	179.8°
$+k$ *case*	J_1 (GeV)	1.5	3.0
	a'	17°	8.7°
	J_2 (GeV)	4.7	12.4
	β'	163°	173°
$-k$ *case*	J_1 (GeV)	3.3	3.9
	a'	95°	57°
	J_2 (GeV)	2.9	11.5
	β'	163°	173°

III. POLARIZED DIFFRACTIVE $Q\bar{Q}$ LEPTOPRODUCTION

To study spin effects in diffractive hadron production, one must know the structure of the two-gluon coupling with the proton at small x. The two-gluon coupling with the proton which describes transverse spin effects in the proton can be parametrized in the form [11]

$$V_{pgg}^{\alpha\beta}(p,t,x_P,l_\perp) = B(t,x_P,l_\perp)(\gamma^\alpha p^\beta + \gamma^\beta p^\alpha) + \frac{iK(t,x_P,l_\perp)}{2m}(p^\alpha\sigma^{\beta\gamma}r_\gamma + p^\beta\sigma^{\alpha\gamma}r_\gamma) + \cdots. \tag{12}$$

Here m is the proton mass. In the matrix structure (12) we wrote only the terms with the maximal powers of a large proton momentum p which are symmetric in the gluon indices α,β. The structure proportional to $B(t, \ldots)$ determines the spin-nonflip contribution. The term $\propto K(t, \ldots)$ leads to the transverse spin-flip at the vertex. These distribution functions should be connected with $F_\zeta(x), K_\zeta(x)$ which describe the spin-average and transverse spin distributions, respectively. If one considers the longitudinal spin effects, the asymmetric structure $\propto \gamma_\rho\gamma_5$ should be included in Eq. (12).

There are some models (see e.g. [5,6,9] and references therein) that provide spin-flip effects which do not vanish at high energies. The models [5,6] describe the experimental data on single spin transverse asymmetry A_N [20] quite well. The spin asymmetries in *pp* scattering at RHIC energies (pp2pp experiment) were predicted to be not small [21]. The conclusion was made that the weak energy dependence of spin asymmetries in exclusive reactions is not now in contradiction with experiment [5,21]. Thus, the ratio $|\tilde{K}|/|\tilde{B}|$ might have a weak x dependence and be about 0.1, as was found in [5,6]. This value will be used here in estimations of the asymmetry in diffractive $Q\bar{Q}$ production.

The spin-average and spin dependent cross sections with longitudinal polarization of a lepton and a transverse proton polarization are determined by

$$d\sigma(\pm) = \frac{1}{2}(d\sigma(\rightarrow\Downarrow) \pm d\sigma(\rightarrow\Uparrow)). \tag{13}$$

To calculate the cross sections, we integrate the amplitudes squared over the $Q\overline{Q}$ phase space. The cross section of diffractive processes are expressed in terms of the soft gluon coupling (12), which is convoluted with the hard hadron production amplitude. The spin-average and spin-dependent cross section can be written in the form

$$\frac{d^5\sigma(\pm)}{dQ^2 dy dx_p dt dk_\perp^2} = \left(\frac{2-2y+y^2}{2-y}\right) \frac{C(x_P,Q^2)N(\pm)}{\sqrt{1-4(k_\perp^2+m_q^2)/M_X^2}}. \tag{14}$$

Here $C(x_P,Q^2)$ is a normalization function which is common for the spin average and spin dependent cross section, and $N(\pm)$ is determined by a sum of graphs integrated over the gluon momenta.

The $N(+)$ function, which determines the spin-average cross section, can be written as

$$N(+) = (|\tilde{B}|^2 + |t|/m^2 |\tilde{K}|^2)\Pi^{(+)}(t,k_\perp^2,Q^2). \tag{15}$$

The function $\Pi^{(+)}$ has a complicated form and was calculated numerically. The details of calculations can be found in [11].

The cross section (14),(15) is expressed in terms of the functions B and K integrated over the gluon momentum

$$\tilde{B} \sim \int_0^{l_\perp^2<k_0^2} \frac{d^2 l_\perp (l_\perp^2 + \vec{l}_\perp \vec{r}_\perp)}{(l_\perp^2+\lambda^2)[(\vec{l}_\perp+\vec{r}_\perp)^2+\lambda^2]} B(t,l_\perp^2,x_P,\ldots)$$
$$= \mathcal{F}^g_{x_p}(x_P,t,k_0^2),$$

$$\tilde{K} \sim \int_0^{l_\perp^2<k_0^2} \frac{d^2 l_\perp (l_\perp^2 + \vec{l}_\perp \vec{r}_\perp)}{(l_\perp^2+\lambda^2)[(\vec{l}_\perp+\vec{r}_\perp)^2+\lambda^2]} K(t,l_\perp^2,x_P,\ldots)$$
$$= \mathcal{K}^g_{x_p}(x_P,t,k_0^2), \tag{16}$$

where $k_0^2 \sim (k_\perp^2+m_q^2)/(1-\beta)$ [15,16]. The connection with the gluon GPD [11] is achieved in Eqs. (16). This shows that the functions $B(t,l_\perp \ldots)$ and $K(t,l_\perp \ldots)$ are the nonintegrated gluon distributions.

The spin-dependent cross section is determined by the interference between spin-average and spin-dependence distributions. It was found in [11] that the $N(-)$ function in Eq. (14) contains two terms which are proportional to the scalar production $\vec{Q}\vec{S}_\perp$ and to $\vec{k}_\perp \vec{S}_\perp$ where $S_\perp$ is transverse polarization of the proton

$$N(-) = \sqrt{\frac{|t|}{m^2}}(\tilde{B}\tilde{K}^* + \tilde{B}^*\tilde{K})\left[\frac{(\vec{Q}\vec{S}_\perp)}{m}\Pi_Q^{(-)}(t,k_\perp^2,Q^2) + \frac{(\vec{k}_\perp \vec{S}_\perp)}{m}\Pi_k^{(-)}(t,k_\perp^2,Q^2)\right]. \tag{17}$$

The contributions of these terms to the asymmetry can be analyzed independently. Really, if one does not consider the azimuthal jets kinematics and integrate over $k_\perp$, only the term proportional to $\vec{Q}\vec{S}_\perp$ will contribute to the asymmetry.

IV. PREDICTIONS FOR $Q\overline{Q}$ LEPTOPRODUCTION

The spin-average cross section of the vector meson production at small momentum transfer is approximately proportional to the $|\tilde{B}|^2$ function (15) which is connected with the generalized gluon distribution $\mathcal{F}^g$. We use here the simple parameterization of the GPD as a product of the t-dependent form factor and the ordinary gluon distribution

$$\tilde{B}(t,x_P,\overline{Q}^2) = F_B(t)[x_P G(x_P,\overline{Q}^2)]. \tag{18}$$

A more general form of GPD (see e.g. [19,22]) can be analyzed. However, some enhancement factor which appears in this case will be mainly canceled in the asymmetry. The form factor $F_B(t)$ in Eq. (18) is chosen as an electromagnetic form factor of the proton. Such a simple choice can be justified by the fact that the Pomeron-proton vertex might be similar to the photon-proton coupling [23]

$$F_B(t) \sim F_p^{em}(t) = \frac{(4m_p^2 + 2.8|t|)}{(4m_p^2+|t|)(1+|t|/0.7\ \ \mathrm{GeV}^2)^2}. \tag{19}$$

The energy dependence of the cross sections at small x is determined by the Pomeron contribution to the gluon distribution function

$$[x_P G(x_P,\overline{Q}^2)] \sim \frac{\mathrm{const}}{x_P^{\alpha_p(t)-1}}. \tag{20}$$

Here $\alpha_p(t)$ is a Pomeron trajectory which has the form

$$\alpha_p(t) = 1 + \epsilon + \alpha' t \tag{21}$$

with $\epsilon = 0.17$ and $\alpha' = 0$. These values are in accordance with the fit of the diffractive J/Ψ production by ZEUS [1]. For $Q_0^2 = \overline{Q}^2 \sim 4\ \mathrm{GeV}^2$ the ordinary gluon distribution can be approximated at small x by [24]

$$[x_P G(x_P,Q_0^2)] \sim 1.94 x^{-0.17}. \tag{22}$$

The A_{lT} asymmetry of hadron production is determined as a ratio of spin-dependent and spin-average cross sections (14),(15),(17)

$$A_{lT} = \frac{\sigma(-)}{\sigma(+)}. \tag{23}$$

It can be seen that at small momentum transfer the asymmetry is approximately proportional to the ratio of polarized and spin-average gluon distribution functions

$$A_{lT}^{Q\overline{Q}} \sim C^{Q\overline{Q}} \frac{|\tilde{K}|}{|\tilde{B}|} = C^{Q\overline{Q}} \frac{\mathcal{K}^g_{x_P}(x_P)}{\mathcal{F}^g_{x_P}(x_P)}. \tag{24}$$

In estimations of asymmetry we shall use the same ratio of spin-dependent and spin-average gluon structures, as in the case of elastic scattering

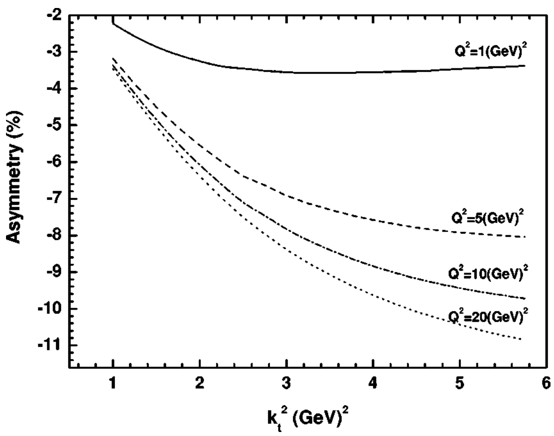

FIG. 3. The A_{lT}^k asymmetry in diffractive light $Q\bar{Q}$ production at $\sqrt{s}=50$ GeV for $x_P=0.05, y=0.3, |t|=0.3$ GeV^2.

$$\frac{|\tilde{K}|}{|\tilde{B}|}\sim 0.1 \tag{25}$$

for simplicity. This means that in this case the coefficient $C^{Q\bar{Q}}$ in Eq. (24) is equal to 10 $A_{lT}^{Q\bar{Q}}$.

The term proportional to $\vec{k}_\perp \vec{S}_\perp$ in the asymmetry (A_{lT}^k) will be analyzed for the case when the transverse jet momentum $\vec{k}_\perp$ is parallel to the target polarization $\vec{S}_\perp$. The asymmetry is maximal in this case. To observe this contribution to asymmetry, it is necessary to distinguish experimentally the quark and antiquark jets. This can be realized presumably by analyses of charge of the leading particles in the jet which should be connected with the charge of quark produced in the process. If one does not separate events with $\vec{k}_\perp$ which is parallel to $\vec{S}_\perp$ for the quark jet, e.g., the resulting asymmetry will be zero because the transverse momentum of the quark and antiquark are equal and opposite in sign.

The predicted asymmetry [19] for light quark production at energy $\sqrt{s}=50$ GeV is shown in Fig. 3. The asymmetry for heavy $c\bar{c}$ production is approximately of the same order of magnitude (Fig. 4). The model used for the ratio of gluon distribution (25) leads to the weak energy dependence of asymmetry. As a result, the asymmetry for $\sqrt{s}=100$ GeV should be practically the same. The predicted asymmetries are not small, about 5–10 %. This shows a possibility of studying the polarized gluon distribution $\mathcal{K}_\zeta^g(x)$ in a future eRHIC experiment.

The contribution to A_{lT}^Q asymmetry which is proportional to $\vec{Q}\vec{S}_\perp$ is analyzed for the case when the transverse jet momentum $\vec{Q}_\perp$ is parallel to the target polarization $\vec{S}_\perp$ (a maximal contribution to the asymmetry). The predicted A_{lT}^Q asymmetry in diffractive light $Q\bar{Q}$ production at $\sqrt{s}=50$ GeV is shown in Fig. 5. The corresponding results for heavy quarks is presented in Fig. 6. The A_{lT}^Q asymmetry has a visible mass dependence. For light quark production, asymmetry is not small. For $Q^2\sim 1$ GeV^2 it changes the sign at $k_\perp^2\sim 3.5$ GeV^2. For heavy quark production the predicted asymmetry is negative and not small, too.

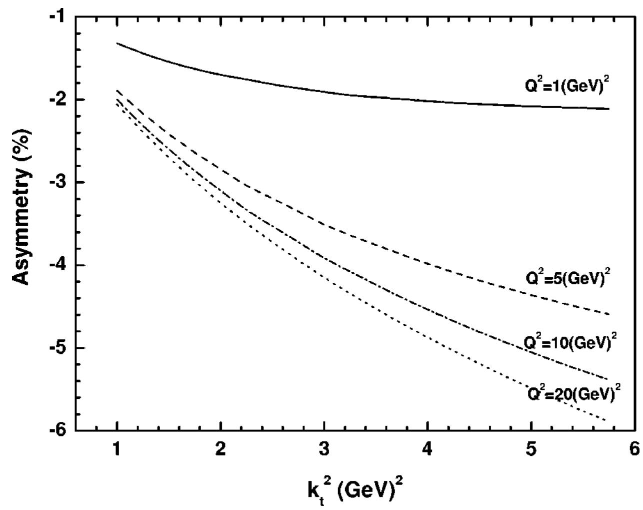

FIG. 4. The A_{lT}^k asymmetry in diffractive heavy $Q\bar{Q}$ production at $\sqrt{s}=50$ GeV for $x_P=0.05, y=0.3, |t|=0.3$ GeV^2.

Note that in most experiments it is difficult to detect the final hadron (see Sec. II) and correspondingly to determine the hadron momentum transfer. In this case, it is useful to have predictions for the asymmetry integrated over momentum transfer

$$\overline{A_{lT}^Q}=\frac{\int_{t_{min}}^{t_{max}}\sigma(-)dt}{\int_{t_{min}}^{t_{max}}\sigma(+)dt}. \tag{26}$$

We integrate cross sections from $t_{min}\sim 0$ up to $t_{max}=4$ GeV^2. The predicted integrated asymmetry for light quarks is shown in Fig. 7. It is not small, about 1–2 % for $k_\perp^2=2$–3 GeV^2. As the nonintegrated asymmetry, the integrated one changes the sign near $k_\perp^2\sim 3.5$ GeV^2.

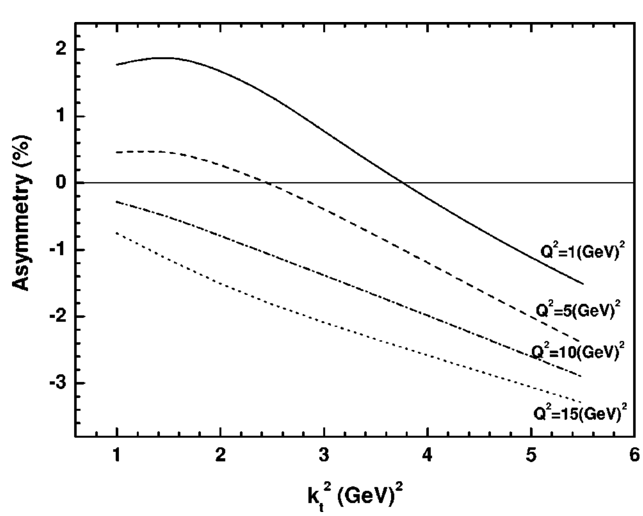

FIG. 5. The A_{lT}^Q asymmetry in diffractive light $Q\bar{Q}$ production at $\sqrt{s}=50$ GeV for $x_P=0.05$, $y=0.3, |t|=0.3$ GeV^2.

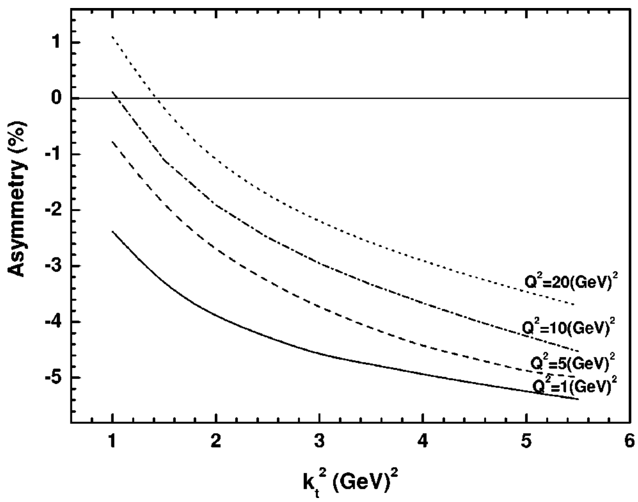

FIG. 6. The A_{lT}^{Q} asymmetry in diffractive heavy $Q\overline{Q}$ production at $\sqrt{s}=50$ GeV for $x_P=0.05$.

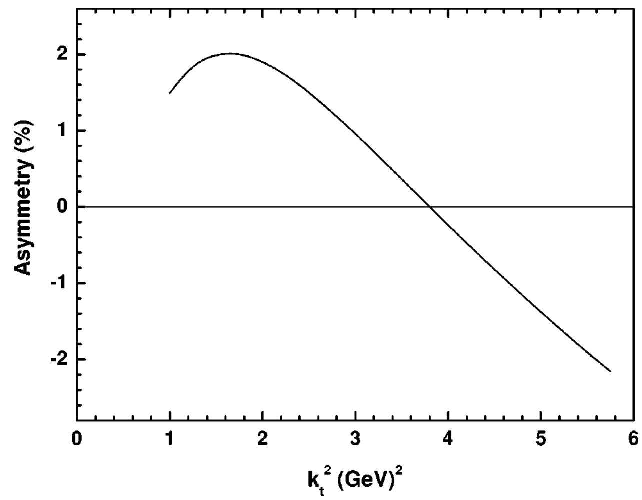

FIG. 7. The A_{lT}^{Q} asymmetry in diffractive light $Q\overline{Q}$ production at $\sqrt{s}=50$ GeV for $x_P=0.05, y=0.3, Q^2=5$ GeV^2, integrated over momentum transfer.

V. CONCLUSIONS

The diffractive $Q\overline{Q}$ leptoproduction at small x which is predominant by the gluon exchange was analyzed at eRHIC energies within the two-gluon spin-dependent exchange model. The spin asymmetry is found to be proportional to the ratio of polarized gluon GPD

$$A_{lT}\sim C\frac{\mathcal{K}^g_{x_P}(x_P)}{\mathcal{F}^g_{x_P}(x_P)}. \tag{27}$$

The information about $\mathcal{K}^g$ can be obtained from asymmetry if the coefficient C in Eq. (27) is not small. The A_{lT} asymmetry of diffractive $Q\overline{Q}$ production contains two terms which are proportional to $\vec{k}_\perp\vec{S}_\perp$ and to $\vec{Q}\vec{S}_\perp$, Eq. (17). These terms in the asymmetry have different kinematic properties and can be studied independently. The term $\propto\vec{k}_\perp\vec{S}_\perp$ has a large coefficient $C_k^{Q\overline{Q}}$ that is predicted to be about 0.3–0.5. Our results for asymmetry of light and heavy quark production in this case is quite similar. We can conclude that this term in the asymmetry might be an excellent tool to study transverse effects in the proton-gluon coupling. However, the experimental study of this asymmetry is not so simple. To find nonzero asymmetry in this case, it is necessary to distinguish quark and antiquark jets and to have a possibility to analyze the azimuthal event structure over the transverse jet momentum. The expected A_{lT} asymmetry for the term $\propto\vec{Q}\vec{S}_\perp$ is not small, too. The predicted coefficient $C_Q^{Q\overline{Q}}$ in this case is about 0.1–0.2. This asymmetry is expected to be quite different for light and heavy quark production. The asymmetry found in the model is about 2–4% for $k_\perp^2\sim 2$ GeV^2 and $Q^2\sim 1$ GeV^2 and has a different sign for light and heavy quark production.

Thus, our estimations show that the corresponding coefficient C in different terms of the A_{lT} asymmetry might not be small. It should be possible to study A_{lT} asymmetry in a future eRHIC experiment for a transversely polarized proton where the important information on the polarized gluon GPD can be obtained.

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