Probing Top Quark Polarization Effects in Topcolor-Assisted Technicolor Model*

GU Qin-Zhong[1,2;1)]　JIANG Feng-Chun[3]　WANG Xue-Lei[2]　YANG Hua[4]

1 (Shangqiu Teachers College, Shangqiu 476000, China)
2 (Henan Normal University, Xinxiang 453007, China)
3 (Zhengzhou University of Light Industry, Zhengzhou 450002, China)
4 (Information Engineering University, Zhengzhou 450004, China)

Abstract We study the polarization effects of the top-quark on the $t\bar{t}$ production cross sections at hadron colliders in the topcolor-assisted technicolor model . The MRS set A′ parton distributions and the helicity projection operators methods are used in the calculation. It is shown that the polarization effects of the top quark are too small to produce enough identified signals at the Tevatron while they can be large enough to be detected at the LHC with reasonable values of the parameters. The polarization effects at the LHC can reach 16%, therefore, they provide feasible tests of the topcolor-assisted technicolor model.

Key words topcolor-assisted technicolor model, electroweak symmetry breaking, polarization

1 Introduction

So far, the most unclear part of the Standard Model (SM) is its symmetry breaking sector. Studying the electroweak symmetry breaking (EWSB) mechanism will be one of the most important tasks in particle physics. On the theoretical aspect, some new physics models beyond the SM (such as the minimal supersymmetric standard model (MSSM), the topcolor-assisted technicolor (TC2)[1] model, the top sea-saw model[2] and extra dimensions[3] have been proposed. These fancy ideas can explain the EWSB, and at the same time, avoid the shortcomings of triviality and unnaturalness arising from the elementary Higgs field in the SM[4]. On the experimental aspect, the planned high energy and luminosity colliders are extremely well-suited to study the forefront problem of the EWSB. The hadron colliders play an important role among the various colliders. The proton-antiproton collider Tevatron with a center-of-mass energy (c.m.) 2TeV, which is now engaged in RUN II, has the significant potential to discover a light Higgs boson with mass up to about $M_{\rm h} \leqslant 130$GeV in the SM or MSSM. However, it will have very little capability to determine the overarching model that governs the EWSB if a Higgs or Higgs-like candidate is observed. The proton-proton collider LHC, with 14TeV c.m. energy, will have a considerably expanded capability to discover and measure almost all the quantum properties of a SM Higgs of any mass or several of the MSSM Higgs bosons over the entire MSSM parameter space[5]. On the other hand, the LHC also has the capability to detect the signals of other new heavy Higgs-like particles in the new physics models related to the EWSB (such as the top-pions in the TC2 model).

Among the various new physics models, the topcolor-assisted technicolor(TC2) model is an attractive idea that gives a reasonable explanation of the EWSB and heavy top quark mass, furthermore,

Received 25 January 2007, Revised 6 February 2007
* Supported by National Natural Science Foundation of China (10375017)
1) E-mail: qinzhong001@126.com

it is consistent with the current experiment. In the TC2 model, the topcolor interaction makes small contribution to the EWSB, and gives rise to the main part of the top quark mass $(1-\epsilon)m_{\rm t}$ with a model dependent parameter $0.03 \leqslant \epsilon \leqslant 0.1$. The technicolor interaction plays a main role in the breaking of electroweak gauge symmetry. To account for the explicit breaking of quark and lepton flavor symmetries, the extended technicolor(ETC) was invented. The ETC interaction gives rise to the masses of the ordinary fermions including a very small portion of the top quark mass $\epsilon m_{\rm t}$. This kind of model predicts three CP odd top-pions ($\Pi_{\rm t}^0$, $\Pi_{\rm t}^{\pm}$) and one CP even top-Higgs-boson ($\rm h_t^0$) with large Yukawa couplings to the third family. There are three significant characters in the TC2 model: (1) There exist three typical physical particles, the top-pions, and the observation of top-pions can be regarded as the direct evidence of the TC2 model. (2) Topcolor interaction is non-universal and therefore does not possess a GIM mechanism. This is an essential feature of this kind of models due to the need to single out the top quark for condensation. Such non-universal gauge interaction results in the new flavor-changing coupling vertices (such as: $\Pi_{\rm t}^0 {\rm t\bar{c}}$) when one writes the interaction in the quark mass eigen-basis. (3) The Yukawa couplings of the top-pions to the quarks are proportional to the quark masses, therefore, the top quark should have the large coupling to the top-pions and the processes involving top quark should be very important. These characters of the TC2 model can help us to search for the signals of the TC2 model and to distinguish the TC2 model from other new physics models.

On one hand, the large mass of the top quark measured at Fermilab[6] allows to probe physics at high energies where new physics is expected to appear as well, and the top quark is expected to decay keeping its polarization[7]. Due to the confinement phenomena of the strong interaction, the spin of a quark is in general very difficult to measure directly. Even if the quark is produced in a particular polarized state, the spin information is quickly averaged out by the hadronization process. One of the important effects of the polarizations of unstable particles is that the different polarized intermediate states can interfere. For lighter quarks, this effect may be smeared heavily by the hadronization process. However, in the case of the top quark, because of its mass, the decay rate is much faster than the other quarks. The top quark decays before the hadronization effect has the time to smear its polarization information at production[7, 8]. This allows us to neglect the effect of hadronization. Therefore, in this sense, this polarization effect also provides a unique possibility of direct observation of the spin of top quark.

On the other hand, studies of the contributions of s-channel new heavy gauge bosons and new vector resonances in TC models of masses ranging from 600GeV to 1TeV to $\rm t\bar{t}$ productions at the Tevatron have been given in Ref. [9], which show that the effects are experimentally detectable. Another characteristic feature of the TC models is that most TC models predict certain PGBs of masses below 1TeV, and the properties of the PGBs are different in different models. Therefore, studying the effects of the PGB contributions in $\rm t\bar{t}$ productions at high energy colliders can serve as good tests of TC models. The effects of color-octet technipions $\prod^{0a} (a=1,\cdots,8)$ on $\rm t\bar{t}$ productions at the Tevatron have been studied in Ref. [10], and it shows that $\prod^{0a}$ can make important contributions via the gluon fusion process due to the large PGB-gluon-gluon coupling contributed by the techniquark triangle-loop, and such effect can be tested by measuring the differential cross section. A more complete study of the PGB effects in the $\rm t\bar{t}$ productions at the Tevatron and the LHC in the topcolor-assisted multiscale TC model has been made in Ref. [11] in which the contributions from the color-singlet technipion and the top-pion are included as well, and the total effects are shown to be large enough to be experimentally detected. As a comparison, in this paper, we extend the study of Ref. [11] to include top-higgs ($\rm h_t^0$) , furthermore, we also consider the polarization effects of the top quark both at the Tevatron and the LHC, and the MRS set A′ parton distributions[12] and helicity projection operators methods[13] are used in the calculation. Our calculation will show that, with reasonable values of the parameters in TC2 model and the expected systematic errors in the $t\bar{t}$ cross section measurements at the LHC, experimentally testing TC2 model is possible, therefore, the top quark polarization effect provides a feasible test of TC2 model.

2 Calculations

In this paper, we shall take into account the tree-level SM amplitude $M_{\rm tree}^{\rm SM}$ and the PGBs contributed amplitude $M_{\rm PGB}$ described in Ref. [14] and in Fig. 1.

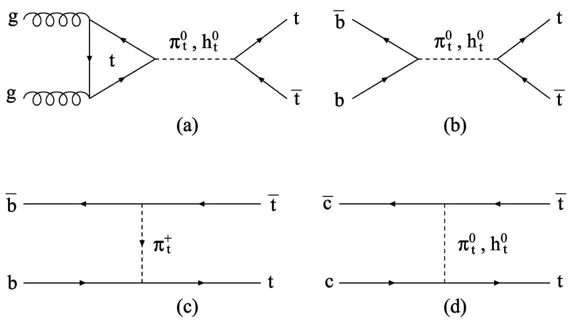

Fig. 1. Feynman diagrams of the subprocesses $q\bar{q}\to t\bar{t}$ and $gg\to t\bar{t}$ in TC2 model.

At the hadron colliders, $M_{\rm tree}^{\rm SM}$ mainly contains two parts, namely, the quark fusion amplitude $M_{\rm tree}^{\rm SM}(q\bar{q}\to t\bar{t})$ and the gluon fusion amplitude $M_{\rm tree}^{\rm SM}(gg\to t\bar{t})$: i.e.,

$$M_{\rm tree}^{\rm SM}=M_{\rm tree}^{\rm SM}(q\bar{q}\to t\bar{t})+M_{\rm tree}^{\rm SM}(gg\to t\bar{t}). \qquad (1)$$

For the Tevatron, although $M_{\rm tree}^{\rm SM}(q\bar{q}\to t\bar{t})$ is dominant, the interference term between

$M_{\rm tree}^{\rm SM}(gg\to t\bar{t})$ and $M_{\rm PGB}$ is actually not negligibly small, and for the LHC, although $M_{\rm tree}^{\rm SM}(gg\to t\bar{t})$ dominates, considering that the polarization effects of top quark come from the sub-process $q\bar{q}\to t\bar{t}$ mainly, we shall take account of both $M_{\rm tree}^{\rm SM}(q\bar{q}\to t\bar{t})$ and $M_{\rm tree}^{\rm SM}(gg\to t\bar{t})$ in our calculation. The details will be presented as follows.

We first consider the couplings of the PGB's to $t\bar{t}$. In the TC2 model, the topcolor interaction is non-universal and the top-pions and top-Higgs have large couplings to the third family quarks which result in the tree-level FC couplings. The correlative couplings of the top-pions and top-Higgs to the quarks are[15]:

$$\begin{aligned}\mathscr{L}=&\frac{m_t}{v_w}\tan\beta\big[{\rm i}\,K_{UR}^{tt}K_{UL}^{tt*}\overline{t_L}t_R\Pi_t^0+\\&\sqrt{2}K_{UR}^{tt*}K_{DL}^{bb}\overline{t_R}b_L\Pi_t^++\\&{\rm i}K_{UR}^{tc}K_{UL}^{tt*}\overline{t_L}c_R\Pi_t^0+\sqrt{2}K_{UR}^{tc*}K_{DL}^{bb}\overline{c_R}b_L\Pi_t^++\\&{\rm i}\frac{m_b^*}{m_t}\overline{b_L}b_R\Pi_t^0+K_{UR}^{tt}K_{UL}^{tt*}\overline{t_L}t_Rh_t^0+\\&\frac{m_b^*}{m_t}\overline{b_L}b_Rh_t^0+K_{UR}^{tc}K_{UL}^{tt*}\overline{t_L}c_Rh_t^0+{\rm h.c.}\big].\end{aligned} \qquad (2)$$

Where $\tan\beta=\sqrt{(v_w/v_t)^2-1}$, $v_t\approx 60$—100GeV is the top-pion decay constant, v_w=246GeV is the EWSB scale, $K_{U,D}^{ij}$ are the matrix elements of the unitary matrix $K_{U,D}$, from which the Cabibbo-Kobayashi-Maskawa (CKM) matrix can be derived as $V=K_{UL}^{-1}K_{DL}$. Their values can be written as: $K_{UL}^{tt}=K_{DL}^{bb}\approx 1$, $K_{UR}^{tt}=1-\varepsilon$, $K_{UR}^{tc}=\sqrt{2\varepsilon-\varepsilon^2}$. The mass m_b^* is a part of b-quark mass which is induced by the instanton, and it can be estimated as[1]: $m_b^*=\frac{3\kappa m_t}{8\pi^2}\sim 6.6\kappa$GeV with $\kappa\sim 1$ to 10^{-1} as in QCD.

Next we consider the couplings of the PGB's to the gluons. The coupling of π_t^0 to gluons via the top-quark triangle-loop is isospin-violating similar to the coupling of π^0 to gluons in the Gross-Treiman-Wilczek formula[16]. It can also be calculated as follows:

$$\begin{aligned}S_{\Pi_t^0 g_a g_b}=&\frac{{\rm i}m_t^2\tan\beta g_s^2(1-\varepsilon)}{4\pi^2 v_\omega}\delta_{ab}\times\\&C_0(p_1,p_2,m_t,m_t,m_t)\varepsilon_{\rho\mu\sigma\nu}p_1^\rho p_2^\sigma\ .\end{aligned} \qquad (3)$$

Similarly, the coupling of h_t^0 to gluons via the top-quark triangle-loop is

$$\begin{aligned}S_{h_t^0 g_a g_b}=&\frac{{\rm i}m_t^2\tan\beta g_s^2(1-\varepsilon)}{4\pi^2 v_\omega}\times\\&\delta_{ab}\big(p_{1\nu}p_{2\mu}(4C_{23}+4C_{12}+C_0)+\\&g_{\mu\nu}(4\bar{C}_{24}-\frac{\hat{s}C_0}{2}-\hat{s}C_{12}+\bar{B}_0)\big),\end{aligned} \qquad (4)$$

where the functions B_i, C_{ij} are the two-point and three-point Feynman integrals.

Finally the PGBs propagator takes the form

$$\frac{\rm i}{\hat{s}-M_{\rm PGB}^2+{\rm i}M_{\rm PGB}\mathit{\Gamma}_{\rm PGB}}\ , \qquad (5)$$

Where $\sqrt{\hat{s}}$ is the c.m.energy and $\mathit{\Gamma}_{\rm PGB}$ is the total width of the PGB correspondingly. The ${\rm i}M_{\rm PGB}\mathit{\Gamma}_{\rm PGB}$ term is important when $\sqrt{\hat{s}}$ is close to $M_{\rm PGB}^2$, the widths $\mathit{\Gamma}_{\rm PGB}$ can be obtained from Ref. [17], With the above formulae, we can obtain the following production amplitudes:

$$A_{\rm tree}^{\rm TC2}\,(\mathrm{c\bar{c}\to t\bar{t}})=\frac{-\mathrm{i}m_{\rm t}^2\tan^2\beta(2\varepsilon-\varepsilon^2)}{v_{\omega}^2}\times \left(\frac{1}{(p_{\rm t}-p_1)^2-M_{\Pi}^2}+\frac{1}{(p_{\rm t}-p_1)^2-M_{\rm h}^2}\right)\times \bar{u}(p_{\rm t})Ru(p_1)\bar{v}(p_2)Lv(p_{\bar{\rm t}}), \tag{6}$$

$$A_{\rm tree}^{\rm TC2}\,(\mathrm{b\bar{b}\to t\bar{t}})=\frac{-2\mathrm{i}m_{\rm t}^2\tan^2\beta(1-\varepsilon)^2}{v_{\omega}^2}\times \frac{1}{(p_{\rm t}-p_1)^2-M_{\Pi}^2}\bar{u}(p_{\rm t})Lu(p_1)\bar{v}(p_2)Rv(p_{\bar{\rm t}})- \frac{\mathrm{i}m_{\rm b}^*m_{\rm t}\tan^2\beta(1-\varepsilon)}{v_{\omega}^2}\frac{1}{\hat{s}-M_{\Pi}^2+\mathrm{i}\Gamma_{\Pi_{\rm t}^0}M_{\Pi}}\times \bar{u}(p_{\rm t})\gamma_5 v(p_{\bar{\rm t}})\bar{v}(p_2)\gamma_5 u(p_1)+ \frac{\mathrm{i}m_{\rm b}m_{\rm t}\tan^2\beta(1-\varepsilon)^2}{v_{\omega}^2}\frac{1}{\hat{s}-M_{\rm h}^2+\mathrm{i}\Gamma_{\rm h_t^0}M_{\rm h}}\times \bar{u}(p_{\rm t})v(p_{\bar{\rm t}})\bar{v}(p_2)u(p_1), \tag{7}$$

$$A_{\rm loop}^{\rm TC2}\,(\mathrm{g_a g_b}\to\Pi_{\rm t}^0\to\mathrm{t\bar{t}})=\frac{m_{\rm t}^3\tan^2\beta g_{\rm s}^2(1-\varepsilon)^2}{4\pi^2v_{\omega}^2}\times \frac{\delta_{\rm ab}C_0(p_1,p_2,m_{\rm t},m_{\rm t},m_{\rm t})}{\hat{s}-M_{\Pi}^2+\mathrm{i}\Gamma_{\Pi_{\rm t}^0}M_{\Pi}}\times \bar{u}(p_{\rm t})\gamma_5 v(p_{\bar{\rm t}})\varepsilon_{\rho\mu\sigma\nu}p_1^{\rho}p_2^{\sigma}\varepsilon_a^{\mu}\varepsilon_b^{\nu}, \tag{8}$$

$$A_{\rm loop}^{\rm TC2}\,(\mathrm{g_a g_b}\to\mathrm{h_t^0}\to\mathrm{t\bar{t}})=\frac{-\mathrm{i}m_{\rm t}^3\tan^2\beta g_{\rm s}^2(1-\varepsilon)^2}{4\pi^2v_{\omega}^2}\times \frac{\delta_{\rm ab}}{\hat{s}-M_{\rm h}^2+\mathrm{i}\Gamma_{\rm h_t^0}M_{\rm h}}\bar{u}(p_{\rm t})v(p_{\bar{\rm t}})\times (p_{1\nu}p_{2\mu}(4C_{23}+4C_{12}+C_0)+ g_{\mu\nu}(4\bar{C}_{24}-\frac{\hat{s}C_0}{2}-\hat{s}C_{12}+\bar{B}_0))\varepsilon_{\rm a}^{\mu}\varepsilon_{\rm b}^{\nu}. \tag{9}$$

Where p_1,p_2 and $p_{\rm t},p_{\bar{\rm t}}$ are the momenta of the two initial-state and the final-state particles respectively, and R, L are chiral operators. The SM tree-level $\mathrm{t\bar{t}}$ production amplitude can be found in Ref. [11].

Considering the polarization effects of the top quark, we employ the helicity projection operators which are independent of the specific Dirac matrix representation. For a massive spin-1/2 particle with four-momentum $p^{\mu}=(E;\boldsymbol{p})$, the helicity projection operators are:

$$\begin{aligned} u(p,\lambda)\bar{u}(p,\lambda)&=\frac{1}{2}(1+\gamma_5\,\not{s})(\not{p}+m),\\ v(p,\lambda)\bar{v}(p,\lambda)&=\frac{1}{2}(1+\gamma_5\,\not{s})(\not{p}-m). \end{aligned} \tag{10}$$

Note that in the rest frame, $s=2\lambda(0;\boldsymbol{p})$, while in the high energy limit, $s=2\lambda/m$, and 2λ is twice the spin-1/2 particle helicity. Furthermore, it is instructive to simplify the computation by evaluating the squared amplitude in the high energy limit. In this case, we can neglect all masses of light quarks and replace $\not{s}$ with $\pm2\lambda$, and the plus sign is chosen for particles while the minus sign is for anti-particles. In this paper, we apply the formulae to the final-state particles only.

The total top polarization is given by[18]

$$A=\frac{\sigma_+-\sigma_-}{\sigma_++\sigma_-}, \tag{11}$$

where the + and − denote spatial spin (up, down) configurations of the top quark with respect to the scattering plane.

With the above production amplitudes, we can directly obtain the cross sections of subprocesses $\mathrm{q\bar{q}\to t\bar{t}}$ and $\mathrm{gg\to t\bar{t}}$.

3 Numerical results and discussions

Once we have the cross section at the parton level $\hat{\sigma}$, the total cross section at the hadron colliders can be obtained by folding $\hat{\sigma}$ with the parton distribution functions $f_{\rm i}^{p(\bar{p})}(x_{\rm i},Q)$[19]:

$$\sigma(\mathrm{pp(\bar{p})\to t\bar{t}})=\sum\int\Big(\mathrm{d}x_{\rm i}\mathrm{d}x_{\rm j}f_{\rm i}^{p}(x_{\rm i},Q)\times f_{\rm j}^{p(\bar{p})}(x_{\rm j},Q)\hat{\sigma}(\mathrm{ij\to t\bar{t}})\Big), \tag{12}$$

where i and j stand for the partons $\mathrm{g,q,\bar{q}}$; $x_{\rm i}$ is the fraction of longitudinal momentum of the proton (antiproton) carried by the ith parton; $Q^2\approx\hat{s}$, and $f_{\rm i}^{p(\bar{p})}$ is the parton distribution function in the proton (antiproton). In this paper, we take the MRS set A′ parton distribution for $f_{\rm i}^{p(\bar{p})}$[12].

Now, we discuss the numerical results of the cross sections. In this paper, we take the values of the total $\mathrm{t\bar{t}}$ cross section σ_0 at the $\sqrt{s}$=2TeV Tevatron and the $\sqrt{s}$=14TeV LHC to be 6.1, 755.5pb[20] respectively, and the fundamental SM parameters in our calculation are taken to be $m_{\rm t}$=175GeV, and $\alpha_{\rm s}(\sqrt{\hat{s}})$, the same as that in the MRS set A′ parton distributions. For the parameters in the TC2 model, we simply take $m_{\rm b}$=4.9GeV and $v_{\rm t}$=60GeV. The values of $M_{\Pi_t^0}$, $M_{h_t^0}$, m_t^* depend on the parameters in the TC model, to see how these values affect the cross sections, we take some reasonable values for each of them, namely, $M_{h_t^0}$=200, 300, and 400GeV, and vary $M_{\Pi_t^0}$ from 150GeV to 400GeV and typically take ε=0.03, 0.06, 0.1 in our calculation.

Now we consider the dependence of the cross section and the polarization effects on top-pion mass. For this purpose, we take $M_{h_t^0}$=300GeV as the example.

In Fig. 2 and Fig. 3 we plot the cross sections and the polarization effects versus M_Π at the 2TeV Tevatron and the 14TeV LHC, in which σ denotes the total $t\bar{t}$ cross sections, and A denotes the polarization of the top quark. From Fig. 2 we see that for most values of the parameters the cross sections are consistent with the new CDF data[21]. Since the Π_t couplings are proportional to $(1-\varepsilon)m_t$, thus the cross sections $\sigma(0.03)$ are all larger than $\sigma(0.06)$ and $\sigma(0.06)$ larger than $\sigma(0.1)$. From Fig. 3 we see that the top quark polarization effects at the Tevatron are too small to be detected for all the values of the parameters, and the polarization effects of top quark lead to small enhancement for the production cross section.

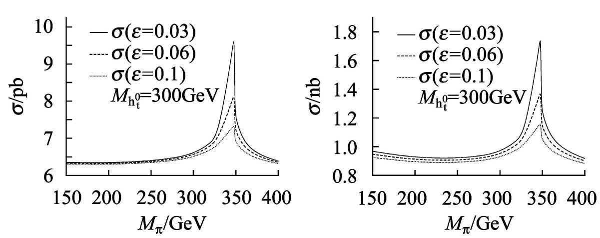

Fig. 2. The cross section of the process $p\bar{p}\rightarrow t\bar{t}$ versus the mass of top-pion.

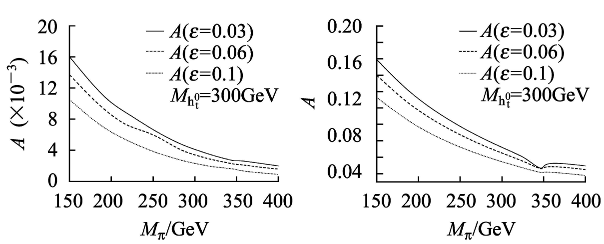

Fig. 3. The polarization effects of the top quark versus the mass of top-pion.

Due to the fact that at the LHC $t\bar{t}$ production is dominated by gluon fusion, the cross sections are much larger than those at the Tevatron, and the enhancement for the production cross section is in the range (16%—141%) for all the values of the parameters which are larger than the systematic error and the statistical uncertainty, so the polarization effects can be clearly detected. From Fig. 3 we see that the polarization effects are much better than the Tevatron: For $M_{\Pi_t^0}$=150—200GeV, $\varepsilon=0.03$, the polarization can reach 11%—16% which can be experimentally detected. For $M_{\Pi_t^0}$=150—180GeV, $\varepsilon=0.06$, the polarization can reach 11%—14% which can be experimentally detected, too. For $\varepsilon=0.1$, only when $M_{\Pi_t^0}=150$GeV, can the polarization effects be experimentally detected.

4 Conclusion

In this paper, we study the polarization effects of the top-quark on the $t\bar{t}$ production cross sections at the hadron colliders in the topcolor-assisted technicolor model. We calculate the diagrams in Fig. 1 and take into account the interferences between the tree-level SM amplitudes and the TC2 amplitudes. The MRS set A′ parton distributions and the helicity projection operators methods are used in the calculation. In the study, we take $M_{h_t^0}$=200, 300, and 400GeV, and vary other parameters in the model. It is shown that the polarization effects of top quark can lead to the enhancement of the production cross sections both at the Tevatron and the LHC, and the polarization effects of the topquark at the Tevatron are too small to be detected for all the values of the parameters. The situation is much better for the LHC. Considering the expected systematic error and the statistical uncertainty, with reasonable values of the parameters in TC2 model, the polarization effects can be experimentally detected. Therefore, the process $pp\rightarrow t\bar{t}$ not only opens an ideal window to search for top-quark but also provides a chance to test the TC2 model.

References

1 Hill C T. Phys. Lett., 1995, **B345**: 483—489; Lane K, Eichten E. Phys. Lett., 1995, **B352**: 382—387; Lane K. Phys. Lett., 1998, **B433**: 96—101; Cvetic G. Rev. Mod. Phys., 1999, **71**: 513—574; Popovic M B, Simmons E H. Phys. Rev., 1998, **D58**: 095007—095020; Buchalla G, Burdman G, Hill C T et al. Phys. Rev., 1996, **D53**: 5185—5200

2 Dobrescu B A, Hill C T. Phys. Rev. Lett., 1998, **81**: 2634—2637; Chivukula R S, Dobrescu B A, Hill C T. Phys. Rev., 1999, **D59**: 075003—075032

3 CHENG H C, Dobrescu B A, Hill C T. Nucl. Phys., 2000, **B589**: 249—268

4 Lane K, Eichten E. Phys. Lett., 1995, **B352**: 382—387

5 Lerbovich A K, Rainwater D. Phys. Rev., 2002, **D65**: 055012—055025

6 YAO W M et al. (Particle Data Group). J. Phys., 2006, **G33**: 1—37

7 Bigi I, Dokhshitzer V, Khoze V et al. Phys. Lett., 1986, **B181**: 157—177

8 Bigi I, Krasemann H. Z. Phys., 1981, **C7**: 127—154

9 Hill C T, Parke S J. Phys. Rev., 1994, **D49**: 4454—4462

10 Eichten E, Lane K. Phys. Lett., 1994, **B327**: 129—135

11 YUE C X, ZHOU H Y, KUANG Y P et al. Phys. Rev., 1997, **D55**: 5541—5548

12 Martin A D, Stirling W J, Roberts R G. Phys. Lett., 1995, **B354**: 155—162

13 Howard E Haber. Spin Structure in High Energy Processes. Stanford 1993, 231—272

14 Sailesh Chopra. UMI-98-25189, Fermilab-Thesis, 1998, **36**: 7—15

15 HE H J, YUAN C P. Phys. Rev. Lett., 1999, **83**: 28—31; LU G R, YIN F R, WANG X L et al. Phys. Rev., 2003, **D68**: 015002—015016

16 Gross D J, Treiman S B, Wilczek F. Phys. Rev., 1979, **D19**: 2188—2214

17 WANG Xue-Lei, WANG Xiao-Xue. Phys. Rev., 2005, **D72**: 095012—095028

18 Hikasa Ken-ichi, YANG Jin-Min. Phys. Rev., 1999, **D60**: 114041—114056

19 Eichten E, Hinchliffe I, Lane K et al. Rev. Mod. Phys., 1984, **56**: 579—707

20 Roberto B, Stefano C, Michelangelo M L et al. Nucl. Phys., 1998, **B529**: 424—450

21 Abe F et al. (CDF Collaboration). FERMILAB-PUB-97/286-E

顶色辅助的人工色模型下顶夸克极化效应的研究*

谷勤忠[1,2;1)]　蒋逢春[3]　王学雷[2]　杨华[4]

1 (商丘师范学院　商丘　476000)
2 (河南师范大学　新乡　453007)
3 (郑州轻工业学院　郑州　450002)
4 (信息工程大学　郑州　450004)

摘要　在顶色辅助的人工色(TC2)理论下，在强子对撞机上研究了顶夸克–反顶夸克对的产生过程中顶夸克的极化效应，在计算过程中，运用了MRS set A’部分子分布函数和螺旋度投影算符的方法. 研究结果表明：在Tevatron上顶夸克的极化效应太小不可探测；参数选取得当，该效应在LHC上可以探测到，其值可达16%. 因此，顶夸克的极化效应提供了一种切实可行的检验顶色辅助的人工色模型的方法.

关键词　TC2模型　电弱对称性破缺　极化

2007 – 01 – 25 收稿，　2007 – 02 – 06 收修改稿

∗ 国家自然科学基金(10375017)资助

1) E-mail: qinzhong001@126.com