BEÜ Fen Bilimleri Dergisi
8 (Özel Sayı), 16-24, 2019

BEU Journal of Science
8 (Special Issue), 16-24,2019

Araştırma Makalesi / Research Article

Proton-proton Collision at High Energies

Mohsun ALIZADE*, Azar AHMADOV

Baku State University, Department of Theoretical Physics, Baku, Azerbaijan
(ORCID: 0000-0002-9664-5465) (ORCID: 0000-0003-0662-5549)

Abstract
The presented work effective section of neutralino birth calculated for proton-proton collision at high energies. Proton-proton collision is considered in parton model and Feynman diagram was used in calculations. One of possible process: a process with γ photon formation was considered. It is shown that an effective section of process with unpolarized and polarized protons is different. The ratio of effective sections of process with unpolarized and polarized protons is $1-\lambda_1\lambda_2$. The energy spectrum of neutralino born has been studied. The spectrum has an asymmetric shape and is shallow towards lower energies. The maximum value of the spectrum increases exponentially as the energy of proton collision increases.

Keywords: Proton-proton collision, Polarization, Quarks, Feynman diagram, Cross section, Phase volume.

Yüksek Enerjilerde Proton-proton Çarpışması

Öz
Bu çalışmada yüksek enerjili proton-proton çarpışmalarında nötrino oluşumunun etkin kesiti hesap edilmiştir. Proton-proton çarpışmaları parton modeli ile incelenmiş ve hesaplarda Feynman diyagramları uygulanmıştır. Mümkün proseslerden birisi olarak γ foton oluşumu dikkate alınmıştır. Kutuplaşmış ve kutuplaşmamış protonlarla gerçekleşen proseslerin etkin kesitlerinin farklı olduğu gösterilmiştir. Bu iki etkin kesitlerin oranının $1-\lambda_1\lambda_2$ olduğu belirlenmiştir. Nötrino oluşumunun enerji spektrumu incelenmiştir. Spektrumun asimetrik şekile sahip olduğu ve yüksek enerjilere doğru daraldığı görülmüştür. Proton çarpışma enerjisi yükseldikce spektrumun maksimum değerinin eksponansiyel olarak yükseldiği belirlenmiştir.

Anahtar kelimeler: Proton proton çarpışması, Kutuplaşma, Kuark, Feynman'ın diagramı, Etkili bir oran, Faz hacim.

1. Introduction

At present work proton - proton collisions in quark model is investigated. These investigations give the possibility will receive information on properties of quarks, on the nature of the gluon field, and etc. At very high energies, the proton turns out to be filled mainly with gluons, and quarks and antiquarks in it are noticeably smaller. Protons and antiprotons in such conditions look almost the same, and therefore there is no special difference what to push protons with protons (as on LHC) or protons with antiprotons (as on the Tevatron Collider) [1-3].

When two protons collide, it does not necessarily mean that each parton hits something inside the oncoming proton. Usually everything is simpler one quark from one proton collides with someone from an oncoming proton, and the rest of the partons just fly by. Occasionally occurs especially hard process in which the colliding bullets get a strong cross shot. These cartridges are emitted with a large transverse momentum. Sometimes there is a hard collision, and then in addition to the standard hadrons background fly narrow streams of high-energy hadrons - hadrons jets [4-7].

*Sorumlu yazar:*mohsunalizade@yahoo.com*
Geliş Tarihi: 20.10.2019, Kabul Tarihi: 19.12.2019

Processing the results of proton-proton collisions on hadrons colliders and comparing them with theoretical predictions also has its own peculiarities in comparison with other types of colliders. They relate to the following two aspects [1-4]:

1. In a typical collision of two protons, many (several tens) hadrons are born, many of them flying out at very small angles and avoiding detection ("flying into the tube"). Catch brand all born particles, and especially to recover some of them born, rarely.
2. Theoretical calculations are usually carried out at the level of cartridges, and hadrons are detected in the experiment. The process of transformation of a set of cartridges into a set of hadrons is not yet amenable to theoretical calculations from first principles. It has to be modeled based on both the theory and the data of previous experiments. Therefore, the connection between theory and experiment is not as direct as, for example, in electron-positron collisions.

The collision of spin-polarized protons leads to the formation of pines - neutral particles, the trajectory of which depends on the properties of gluons in the proton [8-10].

In angular moment the proton exists and the third component is the contribution of orbital angular moment. The physical meaning of this magnitude is that, like electrons in an atom, gluons and quarks can rotate within a proton. It is much more difficult to estimate this value experimentally. In addition, theoretical physicists are ambiguous in their interpretation of this value, which has caused serious disputes in the scientific environment It is known that the effect of higher-order contributions to cross section usually increases with increment of colliding energy and would be more significant at very high energies

In the experiment, scientists encountered proton beams with clearly defined spin directions. In the first series of collisions, the backs in the tufts were co-directed. One of the tufts was then "turned over" and monitored for how the nature of the fragments changed from particle collision. In particular, physicists monitored the rate of birth in the collisions of neutral pioneers. Gluons are actively involved in this process, so if their contribution to proton spin is significant, beam "preloading" will lead to significant changes in the properties of the pines - their pulses and paths [11,12].

Spin is one of the most fundamental properties of elementary particles. This dictates symmetry behavior in space-time transformation. This is additional, so in high-energy experiments it is possible to use degrees of freedom to study, aspects of the interaction of elementary particles that we will not be able to study in experiments with non-polarized particle [13].

Experimental search for supersymmetric particles is one of the main tasks of the experimental program on hadron colliders, especially on the Large Hadron Collider (LHC), after the recent discovery of the Higgs boson with a mass of about 126 GeV is consistent with the MSSM-predicted range for the mass of the lightest Higgs scalar h_0 [14,15].

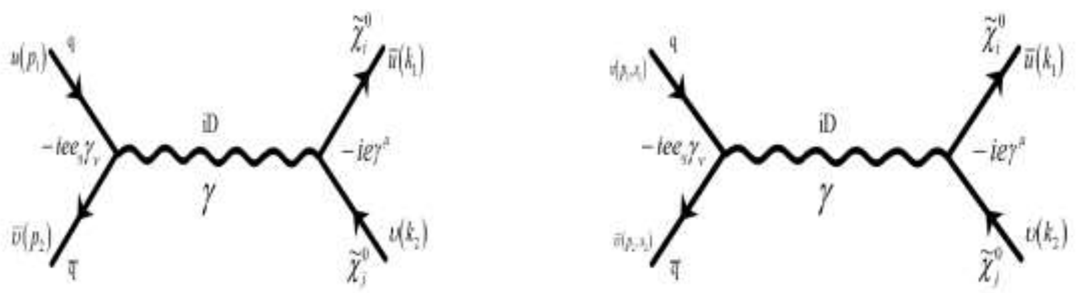
Among all supersymmetric models, the minimum supersymmetric standard model (MSSM) is one of the most motivated and well-studied extensions of the standard model. MSSM predicts many new particles such as Sleeptons, Squares, gluinos, light/heavy neutral scalar (CP-even) higgs bosons, pseudoscalar (CP-odd) Higgs boson A_0, and a pair of charged Higgs bosons, four neutrally and two chargino. Moreover, pair production of neutralino/chargino begins to be questioned as a channel of discovery of supersymmetry [16,17].

At present work we considered unpolarized and polarized proton collision with birth of neutralino. Calculated effective section of neutralino formation and its energy spectrum.

2. Calculations

We considered reaction of collision of protons in two cases: a) process unpolarized protons, b) process polarized protons (figure 1), found her effective section, phase volume is analyzed.

2.1. Process Production of Neutralino at Collision of UnpolarizedProtons (fig.1a)



a *b*

Figure 1. Feynman diagram of process of collision unpolarized protons (a) and polarized protons (b) with the formation neutralino

We denote p_1, p_2, q_1, q_2 - pulses of initial and final particles. m_1, m_2 - mass of initial particles, M_{q_1}, M_{q_2} - mass of washed-up particles.

$$pp \to \tilde{\chi}_i^0 \tilde{\chi}_j^0; \quad (i, j = 1,2)$$

$$q(p_1)\bar{q}(p_2) \to \tilde{\chi}_i^0(k_1)\tilde{\chi}_j^0(k_2), \quad (i, j = 1,2,3,4)$$

Mandelstam's variables are:

$$s = (p_1 + p_2)^2 = (k_1 + k_2)^2$$

$$t = (p_1 - k_1)^2 = m^2_{\tilde{\chi}_i^0} - 2p_1k_1 \Rightarrow 2p_1k_1 = \left(m^2_{\tilde{\chi}_i^0} - t\right)$$

$$u = (p_1 - k_2)^2 = m^2_{\tilde{\chi}_j^0} - 2p_1k_2 \Rightarrow 2p_1k_2 = \left(m^2_{\tilde{\chi}_j^0} - u\right)$$

Propagator of this process is: $iD = \dfrac{-i}{k^2 + i\varepsilon}\left[g_{\mu\nu} + \dfrac{(\xi - 1)k_\mu k_\nu}{k^2}\right]$. All calculation has been carried out in Feynman calibration: $\xi = 1 \Rightarrow iD = \dfrac{-ig_{\mu\nu}}{k^2}$.

In this case transition matrix of process will be:

$$M = \bar{u}(k_1)\left(-ie\gamma^\mu\right)\upsilon(k_2)\left(\frac{-ig_{\mu\nu}}{k^2}\right)\bar{\upsilon}(p_2)\left(-iee_q\gamma_\nu\right)u(p_1) = \frac{ie^2e_q}{k^2}\left[\bar{u}(k_1)\gamma^\mu\upsilon(k_2)\right]\left[\bar{\upsilon}(p_2)\gamma_\nu u(p_1)\right]g_{\mu\nu}$$

and Hermit conjugate of *M* will be:

$$M^+ = \frac{-ie^2e_q}{k^2}\left[\bar{\upsilon}(k_2)\gamma_{\mu'}u(k_1)\right]\cdot\left[\bar{u}(p_1)\gamma_{\nu'}\upsilon(p_2)\right]g_{\mu'\nu'}$$

Then

$$|M|^2 = MM^+ = \frac{e^4e_q^2}{k^4}\left[\bar{u}(k_1)\gamma^\mu\upsilon(k_2)\right]\cdot\left[\bar{\upsilon}(p_2)\gamma_\nu u(p_1)\right]g_{\mu\nu}\left[\bar{\upsilon}(k_2)\gamma_{\mu'}u(k_1)\right]\cdot\left[\bar{u}(p_1)\gamma_{\nu'}\upsilon(p_2)\right]g_{\mu'\nu'}$$

We denote: $u(k_1)\overline{u}(k_1)=\left(\hat{k}_1+m_{\tilde{\chi}_i^0}\right)$, $u(p_1)\overline{u}(p_1)=\frac{1}{2}(\hat{p}_1+m_1)$, $\upsilon(k_2)\overline{\upsilon}(k_2)=\left(\hat{k}_2-m_{\tilde{\chi}_j^0}\right)$, $\upsilon(p_2)\overline{\upsilon}(p_2)=\frac{1}{2}(\hat{p}_2-m_2)$ and moreover at high energies $E >> m$ particles can be considered massless ($m_1=0$; $m_2=0$)then obtain:

$$|M|^2=\frac{e^4e_q^2}{4k^4}\left[\gamma^{\mu}\hat{k}_2\gamma_{\mu'}\hat{k}_1-m_{\tilde{\chi}_j^0}\gamma^{\mu}\gamma_{\mu'}\hat{k}_1+\gamma^{\mu}\hat{k}_2m_{\tilde{\chi}_i^0}\gamma_{\mu'}-m_{\tilde{\chi}_j^0}\gamma^{\mu}m_{\tilde{\chi}_i^0}\gamma_{\mu'}\right]\cdot\left[\gamma^{\mu}\hat{p}_1\gamma_{\mu'}\hat{p}_2\right]$$

Knowing that: $Tr\left[\gamma^{\mu}\gamma^{\mu}\gamma^{\mu}\right]=0$ and $\hat{k}_1=\gamma_{\mu}k_1$ obtain following expression:

$$|M|^2=\frac{2e^4e_q^2}{k^4}\left[4(p_1k_2)(p_2k_1)+4(k_2p_2)(k_1p_1)+2m_{\tilde{\chi}_j^0}\,m_{\tilde{\chi}_i^0}(p_1p_2)\right]=$$

In the last expression we denote: $2p_1k_2=\left(m_{\tilde{\chi}_j^0}^2-u\right)$, $2p_2k_1=\left(m_{\tilde{\chi}_i^0}^2-u\right)$, $2k_2p_2=\left(m_{\tilde{\chi}_j^0}^2-t\right)$, $2k_1p_1=\left(m_{\tilde{\chi}_i^0}^2-t\right)$, $2(p_1p_2)=s$ finally obtain:

$$|M|^2=\frac{2e^4e_q^2}{k^4}\left[\left(m_{\tilde{\chi}_j^0}^2-u\right)\left(m_{\tilde{\chi}_i^0}^2-u\right)+\left(m_{\tilde{\chi}_j^0}^2-t\right)\left(m_{\tilde{\chi}_i^0}^2-t\right)+m_{\tilde{\chi}_j^0}\,m_{\tilde{\chi}_i^0}s\right] \tag{1}$$

Differential cross section of collision is:

$$\frac{d\sigma}{dQ}=N_c\frac{\delta_{ij}g^4\lambda_{ij}}{2304\pi^2s^2}|M|^2$$

where

$$\lambda_{ij}=\frac{1}{2}\sqrt{\left(s-m_{\tilde{\chi}_i^0}^2-m_{\tilde{\chi}_j^0}^2\right)^2-4m_{\tilde{\chi}_i^0}^2m_{\tilde{\chi}_j^0}^2}$$

After integration we obtain:

$$\sigma=\frac{\lambda_{ij}}{1152\pi^2s^2}|M|^2\int_{-\pi}^{\pi}\sin\theta d\theta\int_0^{2\pi}d\varphi$$

In the end we obtain

$$\sigma=\frac{\lambda_{ij}}{288\pi s^2}|M|^2 \tag{2}$$

2.2. Process Production of Neutralino at Collision of Polarized Protons (fig.1b)

$$pp\rightarrow\tilde{\chi}_i^0\tilde{\chi}_j^0 \quad ; (i,j=1,2)$$

$$q(p_1,s_1)\overline{q}(p_2,s_2)\rightarrow\tilde{\chi}_i^0(k_1)\tilde{\chi}_j^0(k_2) \quad ; (i,j=1,2,3,4)$$

We use the definition of Mandelstam's variables, propagator and Feynman calibration as in section *a*, and polarization of protons was been taked as [18].
Thus transition matrix of process is:

$$M_{pol}=\overline{u}(k_1)\left(-ie\gamma^{\mu}\right)\upsilon(k_2)\left(\frac{-ig_{\mu\nu}}{k^2}\right)\overline{\upsilon}(p_2,s_2)\left(-iee_q\gamma_{\nu}\right)u(p_1,s_1)=\frac{ie^2e_q}{k^2}\left[\overline{u}(k_1)\gamma^{\mu}\upsilon(k_2)\right]\cdot\left[\overline{\upsilon}(p_2,s_2)\gamma_{\nu}u(p_1,s_1)\right]g_{\mu\nu}$$

and correspondingly Hermit conjugate of $M_{pol}$is

$$M^{+}_{pol} = \frac{-ie^2 e_q}{k^2}\left[\bar{\upsilon}(k_2)\gamma_{\mu'}u(k_1)\right]\cdot\left[\bar{u}(p_1,s_1)\gamma_{\nu'}\upsilon(p_2,s_2)\right]g_{\mu'\nu'}$$

$$|M|^{+}_{pol} = M_{pol}M^{+}_{pol} = \frac{e^4 e_q^2}{k^4}\left[\bar{u}(k_1)\gamma^{\mu}\upsilon(k_2)\right]\cdot\left[\bar{\upsilon}(p_2,s_2)\gamma_{\nu}u(p_1,s_1)\right]g_{\mu\nu}\left[\bar{\upsilon}(k_2)\gamma_{\mu'}u(k_1)\right]\cdot\left[\bar{u}(p_1,s_1)\gamma_{\nu'}\upsilon(p_2,s_2)\right]g_{\mu'\nu'}$$

We denote: $u(k_1)\bar{u}(k_1) = \left(\hat{k}_1 + m_{\tilde{\chi}_i^0}\right)$, $u(p_1,s_2)\bar{u}(p_1,s_2) = \frac{1}{2}(1-\lambda_1\gamma_5)\hat{p}_1$, $\upsilon(k_2)\bar{\upsilon}(k_2) = \left(\hat{k}_2 - m_{\tilde{\chi}_j^0}\right)$, $\upsilon(p_2,s_2)\bar{\upsilon}(p_2,s_2) = \frac{1}{2}(1+\lambda_2\gamma_5)\hat{p}_2$

$$|M|^2_{pol} = \frac{e^4 e_q^2}{4k^4}\left[\gamma^{\mu}\left(\hat{k}_2 - m_{\tilde{\chi}_j^0}\right)\gamma_{\mu'}\left(\hat{k}_1 + m_{\tilde{\chi}_i^0}\right)\right]\cdot\left[\gamma^{\mu}(1-\lambda_1\gamma_5)\hat{p}_1\gamma_{\mu'}(1+\lambda_2\gamma_5)\hat{p}_2\right]$$

Athighenergies $E >> m$ particles can be consideredmassless ($m_1 = 0\,; m_2 = 0$) and take into account $Tr\left[\gamma^{\mu}\gamma^{\mu}\gamma^{\mu}\right] = 0$ and $\hat{k}_1 = \gamma_{\mu}k_1$ obtain following expression:

$$|M|^2_{pol} = \frac{e^4 e_q^2}{4k^4}\left[8(2(p_1k_2)2(p_2k_1) + 2(p_2k_2)2(p_1k_1)) - 8\lambda_1\lambda_2(2(p_1k_2)2(p_2k_1) + 2(p_2k_2)2(p_1k_1)) + 16m_{\tilde{\chi}_j^0}m_{\tilde{\chi}_i^0}(1-\lambda_1\lambda_2)(p_1p_2)\right]$$

In the last expression we denote: $2p_1k_2 = \left(m^2_{\tilde{\chi}_j^0} - u\right)$, $2p_2k_1 = \left(m^2_{\tilde{\chi}_i^0} - u\right)$, $2k_2p_2 = \left(m^2_{\tilde{\chi}_j^0} - t\right)$, $2k_1p_1 = \left(m^2_{\tilde{\chi}_i^0} - t\right)$, $2(p_1p_2) = s$ and at the end we get

$$|M|^2_{pol} = \frac{2e^4 e_q^2}{k^4}\left[\left(m^2_{\tilde{\chi}_j^0} - u\right)\left(m^2_{\tilde{\chi}_i^0} - u\right) + \left(m^2_{\tilde{\chi}_j^0} - t\right)\left(m^2_{\tilde{\chi}_i^0} - t\right) + m_{\tilde{\chi}_j^0}\,m_{\tilde{\chi}_i^0}s\right]\cdot(1-\lambda_1\lambda_2) \quad (3)$$

Thus, we obtain following expression for cross section of process collision polarized protons:

$$\left(\frac{d\sigma}{dQ}\right)_{pol} = N_c\frac{\delta_{ij}g^4\lambda_{ij}}{2304\pi^2 s^2}|M|^2_{pol}$$

where

$$\lambda_{ij} = \frac{1}{2}\sqrt{\left(s - m^2_{\tilde{\chi}_i^0} - m^2_{\tilde{\chi}_j^0}\right)^2 - 4m^2_{\tilde{\chi}_i^0}m^2_{\tilde{\chi}_j^0}}$$

$$\sigma_{pol} = \frac{\lambda_{ij}}{1152\pi^2 s^2}|M|^2_{pol}\int_{-\pi}^{\pi}\sin\theta d\theta\int_0^{2\pi}d\varphi = 4\pi\frac{\lambda_{ij}}{1152\pi^2 s^2}|M|^2_{pol}$$

$$\sigma_{pol} = \frac{\lambda_{ij}}{288\pi s^2}|M|^2_{pol} \quad (4)$$

3. Energy spectrum of born neutralino

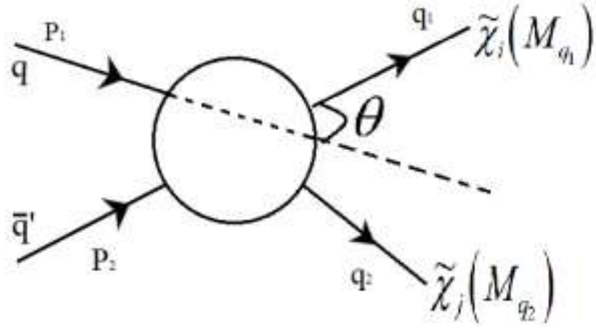


Fig.2 Energetically diagram of born neutralino.

we denote: $c' \equiv \cos\theta = \cos(q_1 \wedge p_1),\ k \equiv \cos\varphi = \cos(p_1 \wedge p_2),\ r \equiv \cos\psi = \cos(p_2 \wedge q_1)$

Use momentum and energy conservation laws:

$$\overrightarrow{p_1} + \overrightarrow{p_2} = \overrightarrow{q_1} + \overrightarrow{q_2} \qquad E_1 + E_2 - E_{q_1} - E_{q_2} = 0$$

$$\overrightarrow{q_2} = \overrightarrow{p_1} + \overrightarrow{p_2} - \overrightarrow{q_1}$$

Thus

$$p_1^0 + p_2^0 - \sqrt{\overrightarrow{q_1^2} + M_{q_1}^2} - \sqrt{\left(\overrightarrow{p_1} + \overrightarrow{p_2} - \overrightarrow{q_1}\right)^2 + M_{q_2}^2} = 0$$

$$E_1 + E_2 - \sqrt{\overrightarrow{q_1^2} + M_{q_1}^2} = \sqrt{\left(\overrightarrow{p_1} + \overrightarrow{p_2} - \overrightarrow{q_1}\right)^2 + M_{q_2}^2}$$

$$\left(E_1 + E_2 - \sqrt{\overrightarrow{q_1^2} + M_{q_1}^2}\right)^2 = \left(\overrightarrow{p_1} + \overrightarrow{p_2} - \overrightarrow{q_1}\right)^2 + M_{q_2}^2$$

$$E_1^2 + E_2^2 + \left(\overrightarrow{q_1^2} + M_{q_1}^2\right) + 2E_1E_2 - 2(E_1 + E_2)\sqrt{\overrightarrow{q_1^2} + M_{q_1}^2} = \overrightarrow{p_1}^2 + \overrightarrow{p_2}^2 + \overrightarrow{q_1}^2 + 2p_1p_2k - 2p_1q_1c' - 2p_2q_1r + M_{q_2}^2$$

where: $E_1^2 = \overrightarrow{p_1}^2 c^2 + m_1^2 c^4$; $\quad c = 1 \Rightarrow E_1^2 = \overrightarrow{p_1}^2 + m_2^2$, $\quad E_2^2 = \overrightarrow{p_2}^2 c^2 + m_2^2 c^4$;
$c = 1 \Rightarrow E_2^2 = \overrightarrow{p_2}^2 + m_2^2$

aftersimplification we obtain:

$$\left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right) + 2\left(E_1E_2 - p_1p_2k\right) + 2\left(p_1c' + p_2r\right)\overrightarrow{q_1} = 2\left(E_1 + E_2\right)\sqrt{\overrightarrow{q_1}^2 + M_{q_1}^2}$$

Squeeze the last equation and we obtain following quadratic equation in $\overrightarrow{q_1}$:

$$4\left(\left(p_1c' + p_2r\right)^2 - \left(E_1 + E_2\right)^2\right)\overrightarrow{q_1}^2 + 4\left(p_1c' + p_2r\right)\left(\left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right) + 2\left(E_1E_2 - p_1p_2k\right)\right)\overrightarrow{q_1} + \left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)^2 +$$
$$+ 4\left(E_1E_2 - p_1p_2k\right)^2 + 4\left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)\left(E_1E_2 - p_1p_2k\right) - 4\left(E_1 + E_2\right)^2 M_{q_1}^2 = 0$$

$$a\overrightarrow{q_1}^2 + b\overrightarrow{q_1} + c = 0$$

where

$$a = 4\left((p_1c' + p_2r)^2 - (E_1 + E_2)^2\right)$$

$$b = 4(p_1c' + p_2r)\left((m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2) + 2(E_1E_2 - p_1p_2k)\right)$$

$$c = \left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)^2 + 4(E_1E_2 - p_1p_2k)^2 + 4\left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)(E_1E_2 - p_1p_2k) - 4(E_1 + E_2)^2 M_{q_1}^2 =$$
$$= \left((m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2) + 2(E_1E_2 - p_1p_2k)\right)^2 - 4(E_1 + E_2)^2 M_{q_1}^2$$

The discriminante of equation is

$$D = 16c'^2\left(2E_1E_2 + m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)^2 p_1^2 - 16\left(-4(E_1E_2)^2 M_{q_1}^2 + 2(E_1E_2)^2 + \left(m_1^2 + m_2^2 + M_{q_1}^2 - M_{q_2}^2\right)^2\right)^2 x$$

$$x\left((E_1 + E_2)^2 + c' p_1\right)$$

We will look for solutions in which the discriminate is greater from zero and the roots are non-negative

4. Results and Discussion

Cross section of collision (expressions (2) and (4)) unpolarized and polarized protons has been evaluated. Data for calculation was been take from [19,20].

In the fig.3 the dependence of cross section of proton-proton collision on its energy has been presented. As see cross section of process is increased with increasing of energy of protons. Increasing of cross section with increasing energy of colliding protons can be explained as: at high speeds (energy) of protons probability of collision is increased. As see difference between cross sections unpolarized and polarized cases is increased at high energies. Cross section of collision weakly depends on the change in mass of neutralino. However, there is a slight difference for different neutralino at √s=10Tev.

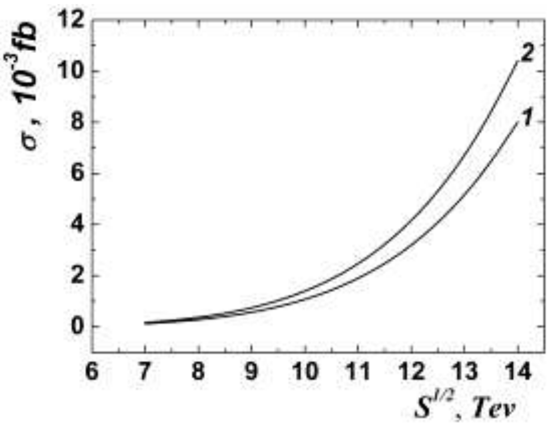


Figure 3. The dependence of cross section of collision unpolarized (1) and polarized protons (2) on its energy.

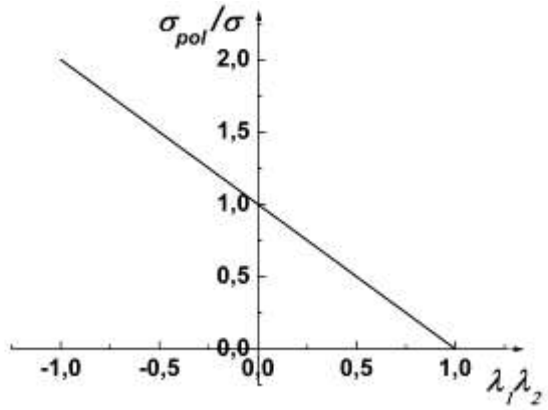


Figure 4. The dependence relationship between effective sections of collision polarized and unpolarized protons on $\lambda_1\lambda_2$.

In the fig.4 is presented thedependence relationship between effective sections of collision polarized and unpolarized protons on $\lambda_1\lambda_2$. As can be seen from the graph at $\lambda_1\lambda_2 = 1$ we get $\sigma_{pol}/\sigma = 0$. However, this does not mean that the total effective section of the proton-proton collision is zero. The present work we considered the formation neutralino by v photon (s - channel). In addition to this process of neutralino can birth by means of Z^0 and W bosons, the effective cross-section of these processes is different from zero.

The value of q_1 does not depend on the cosine of the scattering angle- θ and it is constant. The dependence of q_1 on the energy of colliding protons is presented in figure 5. The energy value corresponding to the maximum value of q_1 can simply be mathematically determined from the conditions $E_1 + E_2 = const_1$ and $E_1E_2 = const_2$. Consequently it is equal approximately to $E_1 = const_1 /2$.

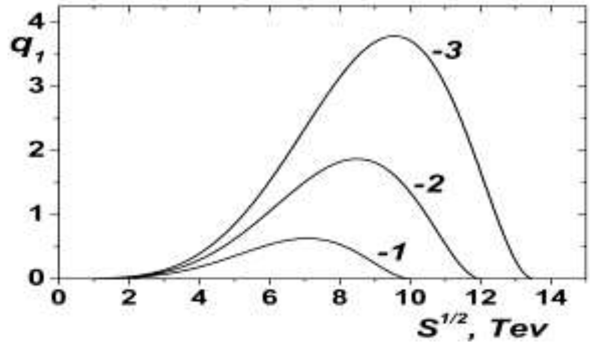


Figure 5. The dependence energy spectrum of q_1 at differentenergycollision of protons: $E_1 < E_2 < E_3$

Expressions (1) and (3) differ by a factor $(1-\lambda_1\lambda_2)$. As see polarization of protons influenced to cross section of collision. Depending on the values of $\lambda_1$and λ_2, the values of the effective cross section change. The value of the effective cross section not only depends on the polarization degree of individual beams, but also on the mutual polarization of the colliding proton beams.

As known, thedegree of polarization is determinedbytheexpression: $\lambda = \frac{|n\uparrow - n\downarrow|}{n\uparrow + n\downarrow}$. The spins of the colliding protons can have the following directions along the axis of theircollision: a)$p_1\uparrow\ p_2\uparrow$, b) $p_1\uparrow\ p_2\downarrow$, c) $p_1\downarrow\ p_2\downarrow$ d) $p_1\downarrow\ p_2\uparrow$.

The direction of the spin affects the effective cross section for proton collisions. Therefore, the effective cross section can increase and decrease depending on the mutual direction of the colliding protons.

Indeed, in the absence of polarization of one or both beams of colliding protons $\lambda_1\lambda_2=0$ expression (3) coincides with (1). $\lambda_1\lambda_2=0$ may be in these cases: a) $\lambda_1=0$, $\lambda_2=0$ or b) $\lambda_1=0$, $\lambda_2\neq0$ or $\lambda_1\neq0$, $\lambda_2=0$).

In addition, for the same value of $\lambda_1\lambda_2$ for different values of the products λ_1 and λ_2, the effective cross section for the collision of polarized protons is the same. The physical meaning of this is obvious. Consider the simple case when the first proton beam has a degree of polarization $\lambda_1$and the second beam has λ_2. If the degree of polarization of the beams is naturally changed, the value of the effective cross section will not change. Consider when the product $\lambda_1\lambda_2$ is equal to some number, for example, $\lambda_1\lambda_2 = 0.12$. These values can be obtained in 2 cases: a)$\lambda_1 = 0.3$, $\lambda_2 = 0.4$, and b) $\lambda_1 = 0.2$, $\lambda_2 = 0.6$. In the other case, for $\lambda_1\lambda_2 = 0.18$, a) $\lambda_1 = 0.2$, $\lambda_2 = 0.9$, and b) $\lambda_1 = 0.3$, $\lambda_2 = 0.6$ can be. The physical meaning of this is unclear and requires further explanation.

We suggested that the rest of the contribution could be made by gluons, whose angular moment was neglected in early calculations. In order to measure it, it was necessary to set an experiment in which the properties of "nuclear glue" would play a decisive role.

The QCD effects in the associated production of $\chi^{\pm}\chi^{0}$ in the MSSM within the mSUGRA scenario at both the Tevatron and the LHC, including the NLO SUSY QCD corrections and the NLL threshold resummation effects are considered in [15]. Comparing our results with [15] showed that they are agree.

All calculations were carried out with the help a package of the Mathematica-10 program, program calculation of cross section, solution of equation were written in FORTRAN algorithmic language, and figures are constructed by means of the Origin 9.5 software package.

5. Conclusions

1. The value of q_1 does not depend on the cosine of the scattering angle θ. Neutralino born have a spherically symmetric distribution.
2. The energy spectrum of the born neutralino is Gaussian like. The maximum of the energy spectrum corresponds to the value $E_1 = SQ/2$
3. The effective cross section of the process with the formation of various neutralinos, despite their different masses, does not differ. Therefore, experiments to study the effective cross section with the formation of neutralinos will not make it possible to distinguish between different neutralinos. This requires additional experiments.
4. The effective collision cross section with polarized protons is different than unpolarized protons.

References

[1] https://nplus1.ru/news/2016/02/18/gluons-protons-angular-moment.

[2] http://www.dslib.net/atom-jadro/issledovanie-spektra-jeffektivnyh-mass-dvuh-protonov-iz-reakcii-p-np-p.html.

[3] The ALIICE Collaboration K_0s K_0s correlations in pp collisions at √s = 7 TeV, 2012. arXiv: hep-ex/1206.2056v1.

[4] The ALIICE Collaboration Production of pions, kaons and protons in pp collisions at √s = 900 GeV, 2012. arXiv:hep-ph/0610012.

[5] Anferov V.A., Blinov B.B., KantsyrevD.Yu., Krisch A.D., Sivers D.W., Arbor Ann., Chu M., Schwandt P., von Przewosk B., Grishin N. 2000. Spin flipping a stored polarized proton beam with an rf dipole, Physical Review, special topics - Accelerators and beams, 3: 041001.

[6] Haber H.E., Kane G.L. 1985. The search for supersymmetry probing physics beyond the standard model. Physics Reports, Review Section of Physics Letters, 117 (2): 75-263. https://doi.org/10.1016/0370-1573(85)90051-1.

[7] Debovea J., Fuksb Bn., Klasena M. 2008. Gaugino-pair production in polarized and unpolarized hadron collisions. arXiv: hep-ph/0804.0423v2.

[8] Ahmadov A.I., Demirci M. 2013. Single neutralino production at the LHC. ArXiv: hep-ph/ 1307.3777v1.

[9] Demirci M., Ahmadov A.I. 2014. Search for neutralino pair production at the CERN LHC. Physical Review. (D 89): 075015.

[10] The ATLAS Experiment at the CERN Large Hadron Collider 2008. ATLAS Collaboration, JINST, 3: S08003.

[11] ATLAS Collaboration, 2013. Report No. ATLAS-CONF-2013-047.

[12] CMS Collaboration, 2013. Report No. CMS-PAS-SUS-13-012.

[13] De Roeck A., Gehrmann T. 1997. Physics with Polarized Protons at HERA, Introduction to the Proceedings of the Workshop on Physics with Polarized Protons at HERA", DESY.

[14] Baer H., Mustafayev A., Summi H., Tata X. 2007. Mixed higgsino dark matter from a large SU(2) gaugino mass. Journal High Energy Physics, 1-42.

[15] Li C.S., Li Sh., Yang L.L. 2008. Thershold Resummatic effects in the associate production of chargino and neutralino at the Hadron Colliaders. arXiv: hep-ph/0707.3962v4.

[16] Bper W., Ehrer R., Kazakov D.I. 2014. Redictions of SUSU masses in the Minimnal Supersymmetric Grand Unified Theory. IEKP-AK / 94-05, HEP_PH- 9405342.

[17] Fuks B., Klasen M., Lamprea D.R., Rothering M. 2016. Precision predictions for direct gaugino and slepton production at the LHC. Nuclear and Particle Physics Proceedings, 273–275.

[18] Okun L.B. 1990. Leptoni I kvarki, M.Nauka, Moscow, 346p.

[19] http://nuclphys.sinp.msu.ru/introduction/particltab.htm.

[20] http://pdg.lbl.gov.