Advances in Physics Theories and Applications
ISSN 2224-719X (Paper) ISSN 2225-0638 (Online)
Vol.32, 2014

Production Of Neutralinos As Adark Matter Via Z^0 Boson Propagator

$$e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) + \tilde{\chi}_\ell^0(P_5)$$

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Abstract .The cross-section, in electron (e-) positron (e+) collision, are calculated over range of center of mass energy S for the process.

$$e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) + \tilde{\chi}_\ell^0(P_5)$$

Production of $\tilde{\chi}_\ell^0(P_5)$when $\tilde{\chi}_\ell^0(P_5)$ is a leg from electron or positron , and Z^0 is the propagator.

(Where i , j, ℓ = 1, 2, 3, 4)

The cross section is calculated according to a carefully selected set of parameters. These different possible situations are graphed and tabulated.

The production mechanisms can be detected as $e^+(P_1) + e^-(P_3 - P_5) \rightarrow Z^0(P_2 + P_4) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4)$

we found that: At S increase from 1600 to 3000 we have different values for the cross-section at different value of neutralino mass $\tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_3^0$.

Keywords: Z bosons; neutralinos ; selectron.

1. *Introduction:*

One of the main open problems of particle physics is the understanding of the mechanism responsible for breakdown of the electroweak symmetry. The cross-sections for the production of neutralinos due to electron-positron annihilation, is calculated according to the reaction.

$$e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) + \tilde{\chi}_\ell^0(P_5)$$

(Where ℓ = 1, 2, 3, 4)

The MSSM contains a great number of free parameters which considerably limit the predictive power of the model. These are some commonly used ways to reduce the number of free constants and parameters in this theory. The most often employed method is to obtain values of parameters at the scale of the order of m_W by renormalization-group equations from the coupling constants of the supergravity theories investigated at the Plank mass. Usually such theories are much more unified and contain typically only few free numbers. Of course, there are also many constraints originating from the experimental data-first of all the masses of the superpartners are bounded from below by their absence in the present experiments, but one can find also many more subtle limits. The Higgs has a fermionic superpartner, called the Higgsino that would have the same mass.

a slepton is a sfermion which is hypothetical boson Superpartner of a lepton whose existence is implied by Supersymmetry. Slepton have the same flavour and electric charge as corresponding leptons and their spin is zero. For example slectron $\tilde{e}_h$ is superpartner of electron

The MSSM contains four neutralinos $\tilde{\chi}_\ell^0$ (ℓ = 1, 2, 3, 4), which are due to the mixing of photino, Zion and neutral Higgsinos. The neutralino sector depends on four parameters [1]: gaugino masses M and M' associated with the SU(1) and SU(2) subgroups of standard model.

Neutralinos $\tilde{\chi}_\ell^0$ tends to have

1) It mixing of the two neutral gauginos $\tilde{B}$ (Bino), $\tilde{W}^3$ (neutral W – ino), and the two neutral Higgsinos, $\tilde{H}_1^0$and $\tilde{H}_2^0$ [2] Note that that $\tilde{\gamma}$and $\tilde{Z}$ are linear combinations of the $\tilde{B}$ and $\tilde{W}^3$[3].
2) Masses at the weak scale (10-1000 Gev).
3) In models in which R-parity is conserved and the lightest of the four neutralinos is the lightest supersymmetric particle LSP [4, 5], the lightest neutralino is stable.

4) The lightest neutralino is an excellent candidate [6] to comprise the universe's cold dark matter, and consider as the basic *Weak Interaction Massive Particle* (WIMP) [7, 8, 9].

5) Neutralinos are related by the weak nuclear force to each other and to charginos and are mixtures of superpartner's fields in the MSSM that have zero lepton number.

6) Neutralino dark matter could be observed experimentally in nature either indirectly or directly

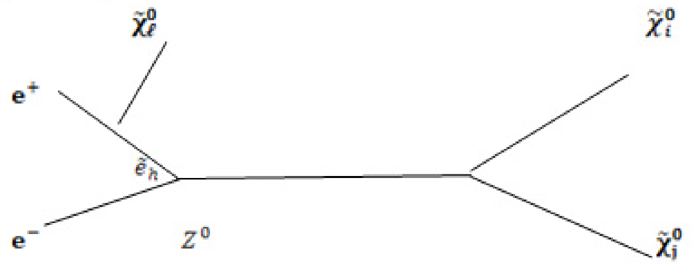
   i- Indirectly using γ ray and neutrino telescopes [10].

   ii- Direct through experiments such as Cryogenic dark matter search (CDMS) it is a series of experiments designed to directly detect particle dark matter in the form of WIMPs. Using an array of semiconductor detectors.

The angel α can be taken to lie in the interval $-\pi/2 \leq \alpha \leq 0$. And the angel β lie in the interval $0 \leq \beta \leq \pi/2$, $tan\beta = v_2/v_1$

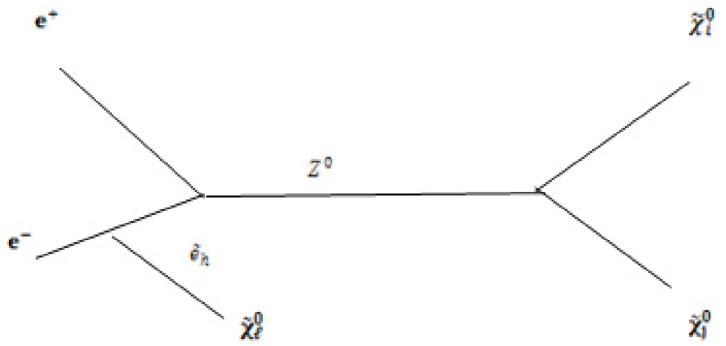
2. *Production via Z^0 boson propagator*

2.1 Feynman Diagrams



(a)

Figure.(1.a) Feynman diagrams for the process $e^+(P_1)+e^-(P_3)\rightarrow \tilde{\chi}_i^0(P_2)+\tilde{\chi}_j^0(P_4)+\tilde{\chi}_\ell^0(P_5)$ Neutralino is emitted from e^+leg via Z^0 boson. There are (1-128) diagrams.



(b)

Figure.(1.b) Feynman diagrams for the process $e^+(P_1)+e^-(P_3)\rightarrow \tilde{\chi}_i^0(P_2)+\tilde{\chi}_j^0(P_4)+\tilde{\chi}_\ell^0(P_5)$ Neutralino is emitted from e^-leg via Z^0 boson . There are (1-128) diagrams.

2.2_The Matrix Elements

2.2.1 for a (1-128) are

$$M_{a(1-128)} = \frac{g^2}{4}\gamma_k\ \bar{V}_{e^+}(P_1)\left(\mathrm{N}+\mathrm{N}^*\ \gamma_5\right)_\mu\ U_{e^-}(P_3)$$

$$(s-\mathrm{P}_5)\ \frac{1}{(P_1-P_5)^2-m_{\tilde{e}}^2}\ \left((s-\mathrm{P}_5)^2-m_{z^0}^2\right)^{-1}{}_{\nu}\ \left[\mathrm{B}+\mathrm{D}\gamma_5\right]_\kappa\ \bar{U}_{\tilde{\chi}^0}(P_5)\ \bar{U}_{\tilde{\chi}^0}(P_2)\ \bar{U}_{\tilde{\chi}^0}(P_4)$$

2.2.2 for b (1-128) are

$$M_{b(1-128)} = \frac{g^2}{4} \gamma_k U_{e^-}(P_3)(N + N^* \gamma_5)_\mu \bar{V}_{e^+}(P_1)$$

$$(s - P_5)\frac{1}{(P_3 - P_5)^2 - m_{\tilde{e}}^2} \left((s - P_5)^2 - m_{\tilde{Z}^0}^2\right)^{-1}_{\nu} [B + D\gamma_5]_K \; \bar{U}_{\tilde{\chi}^0}(P_5)\, \bar{U}_{\tilde{\chi}^0}(P_2)\, \bar{U}_{\tilde{\chi}^0}(P_4)$$

Where: N are the (4×4) matrices diagonalizing of the neutralino mass matrix. The Feynman rules for $e^- e^+ \tilde{\chi}^0$ vertices [13,14,15]
and $m_{\tilde{e}}$ is the electron mass,
$B = \mathcal{Q}_{ij}^{L} + \mathcal{Q}_{ij}^{R}$
$D = \mathcal{Q}_{ij}^{R} - \mathcal{Q}_{ij}^{L}$

$P_L = 1 - \gamma_5$; $P_R = 1 + \gamma_5$
$\beta = 56.3$, $\alpha = -34.48$

The Feynman rules for $e^- e^+ \chi^0$ vertices are
$P_1 + P_3 = P_2 + P_4 + P_5$, $S = \sigma + P_5$

2.3 Cross section calculations:

In this work we have 3-body final states with momentum P_2, P_4, P_5 and the initial states have momentum P_1, P_3.In general, the cross section for the process $e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) + \tilde{\chi}_\ell^0(P_5)$can be written in the form

$$\sigma = \int \pi^2 |M|^2 \frac{dx \; dy \; d\sigma^2}{\Lambda(S, m_1, m_3)\, \Lambda(S, \sigma, m_5)}$$

where M is the matrix element previously mentioned, the integration is performed using a simple approximation obtained by an improved Weizsacker-Williamson procedure [11,12]. Where

$$\Lambda(x, y, z) = [x^4 + y^4 + z^4 - 2x^2y^2 - 2x^2z^2 - 2y^2z^2]^{1/2}$$

The limit of integration is given as follows:

$$x_\pm = \frac{1}{4S^2}[(S^2 + m_1^2 - m_3^2)(S^2 - \sigma^2 + m_5^2) \pm \Lambda(S, m_1, m_3)\Lambda(S, \sigma, m_5)]$$

$$y_\pm = \frac{1}{4\sigma^2}[(\sigma^2 + m_2^2 - m_4^2)(S^2 - \sigma^2 + m_5^2) \pm \Lambda(\sigma, m_2, m_4)\Lambda(S, \sigma, m_5)]$$

$$(m_2 + m_4)^2 \leq \sigma^2 \leq (S^2 - m_5^2)^2$$

In all our calculations by using Mathematica program, we assume the following values for vector-boson masses suggested:
$M_W = 81Gev$, $M_Z = 100Gev$

$m_{\chi_1^0} = 900GeV$, $m_{\chi_2^0} = 1000GeV$, $m_{\chi_3^0} = 1100GeV$,

The Cross section as a function of center of mass energy for the Feynman diagrams of figure(1.a)are calculated by using above equations and Mathematica program and the result are given in figs.(2) by interchanging the indices i & j and the mass of Neutralino

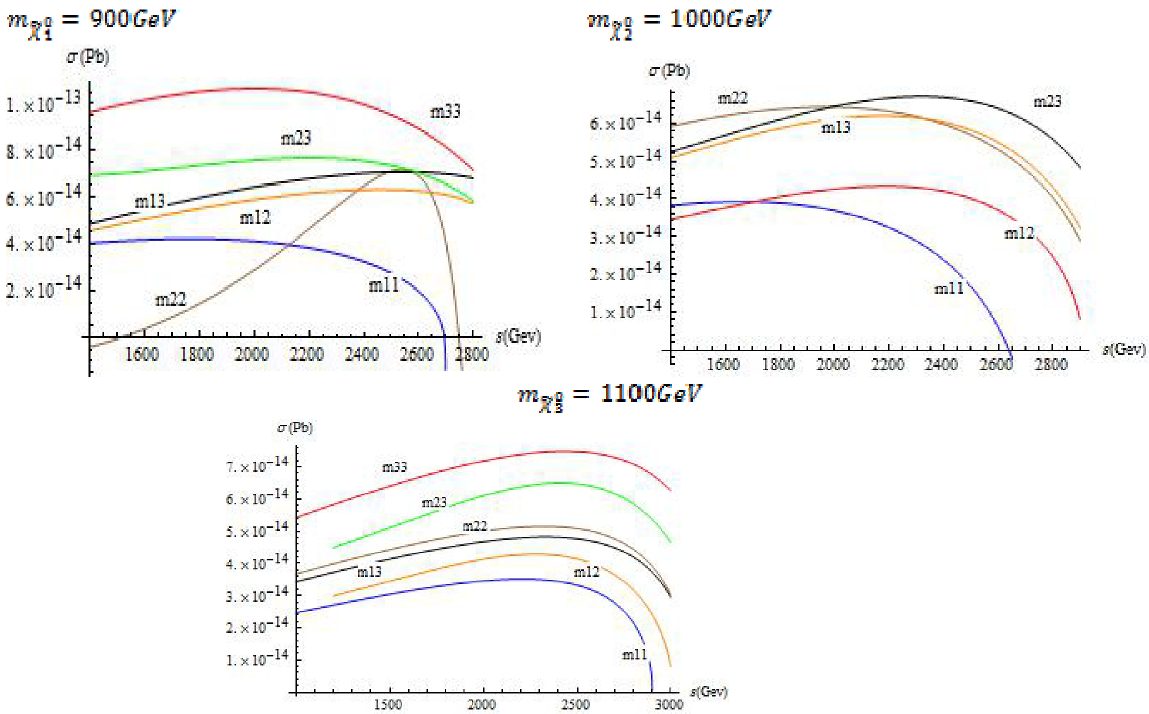


FIGURE 2 . The cross section for a (1-128).

The Cross section as a function of center of mass energy for the Feynman diagrams of figure(1.b)are calculated and the result are given in figs.(3) by interchanging the indices i & j the mass of Neutralino

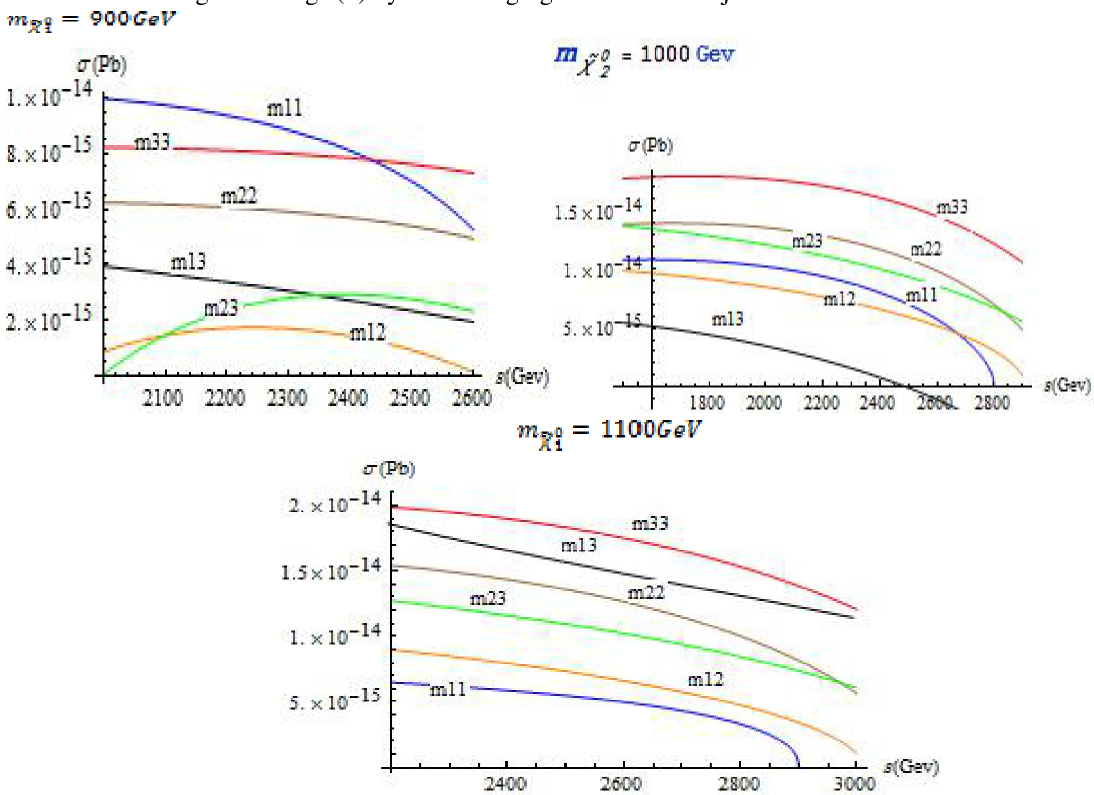


FIGURE 3 . The cross section for b (1-128).

3. Results

Figs.2 and3 show the cross-sections for the process as a function of center of mass energy (S) (Neutralino is emitted from the initial legs through Z^0 boson exchange). At S increase from 1600 to 3000 Gev we have maximum value for the cross-section by interchanging the indices i & j and the mass of Neutralino

4. *Table*

$e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) +$	fig. no.	$m_{\tilde{\chi}_l^0}$	i j	S(Gev)at max σ	σ(Pb)
Production via Z^0 propagators	**2**	$900GeV$	33	2100	1×10^{-13}
		$1000GeV$	23	2400	6×10^{-14}
		$1100GeV$	33	2500	7×10^{-14}
	3	$900GeV$	11	2300	1×10^{-14}
		$1000GeV$	33	2400	1.4×10^{-14}
		$1100GeV$	33	2600	2×10^{-14}

Table (1) shows the peak values of the cross sections of the interaction $e^+(P_1) + e^-(P_3) \rightarrow \tilde{\chi}_i^0(P_2) + \tilde{\chi}_j^0(P_4) + \tilde{\chi}_l^0(P_5)$ with different i,j&l values at different values of incident energies.

5. *Conclusion*

The Dominant process:
From table (1) We have success to identify the scenario for highest cross section for the reaction For $\tilde{\chi}_i^0 = 1100$ Gev, $\tilde{\chi}_j^0 = 1100$Gev and $m_{\tilde{\chi}_l^0} = 900$ Gev the cross section goes up to $(1 \times 10^{-13}$Pb$)$ at (S= 2100 Gev) when Neutralino is emitted from e^+leg via z propagator

The competing process:
One order of magnitude lower than highest value when $\tilde{\chi}_i^0 = 1100$ Gev, $\tilde{\chi}_j^0 = 1100$ Gev and $m_{\tilde{\chi}_l^0} = 1100$ Gev the cross section goes up to $(7 \times 10^{-14}$Pb$)$ at (S= 2500 Gev) when Neutralino is emitted from e^+leg via z propagator

6. Acknowledgment

I wish to express my deep appreciation and deepest thanks to Dr. Mona M. Ahmed and Dr. N.A.Kassem Faculty of Science, Helwan University For kindly supervision and constructive discussions, Then I wish to express my deep thanks and gratitude to Prof. Dr. Moustafa Shalaby Prof.of Theoretical Physics, Faculty of Science, Ain Shams University, for whose inspiration, encouragement and guidance

7. References

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