UWThPh-2003-28
WUE-ITP-2003-017

Production of Singlino-dominated Neutralinos with Polarized Beams*

S. HESSELBACH[1] AND F. FRANKE[2]

[1] *Institut für Theoretische Physik, Universität Wien, A-1090 Vienna, Austria*

[2] *Institut für Theoretische Physik und Astrophysik, Universität Würzburg, D-97074 Würzburg, Germany*

1 Introduction

Nonminimal extensions of the Minimal Supersymmetric Standard Model (MSSM) are characterized by an additional singlet superfield with vacuum expectation value x. The singlino character of these singlino-dominated neutralinos crucially depend on the parameter x. In the Next-to-Minimal Supersymmetric Standard Model (NMSSM) [1–4] or an E_6 inspired model with one extra neutral gauge boson Z' and one additional singlet superfield [5] neutralinos with a dominant singlet higgsino (singlino) component exist for large values $x \gtrsim 1$ TeV. Since the singlino component does not couple to gauge bosons, gauginos, (scalar) leptons and (scalar) quarks, cross sections for the production of the exotic neutralinos are generally small [6–9]. However, they may be produced at a high luminosity e^+e^- linear collider with cross sections sufficient for detection, which can even be enhanced by the use of one or both beams polarized. We analyze the regions of x where the associated production of the singlino-dominated neutralino yields detectable cross sections for different beam polarisations in scenarios where the MSSM-like neutralinos have similar masses and mixing character as in the 'typical mSUGRA' SPS 1a scenario for the MSSM [10, 11].

2 Production of singlino-dominated neutralinos

In the NMSSM the parameters (for details see [1]) $M_1 = 99$ GeV, $M_2 = 193$ GeV, $\tan\beta = 10$, the effective μ parameter $\mu_{\text{eff}} = \lambda x = 352$ GeV and the selectron masses $m_{\tilde{e}_R} = 143$ GeV and $m_{\tilde{e}_L} = 202$ GeV are chosen according to the scenario SPS 1a. For large $x \gg |M_2|$ a singlino-dominated neutralino $\tilde{\chi}^0_S$ with mass $\approx 2\kappa x$ in zeroth approximation decouples in the neutralino mixing matrix while the other four neutralinos $\tilde{\chi}^0_{1,\ldots,4}$ have MSSM character as in SPS 1a with masses 96 GeV, 177 GeV, 359 GeV and 378 GeV.

*Contribution to *Beam Polarisation at a LC* by the POWER (POlarisation at Work in Energetic Reactions) group, http://www.ippp.dur.ac.uk/ gudrid/power

Further we consider an E_6 inspired model with one extra neutral gauge boson Z' and one additional singlet superfield which contains six neutralinos [5]. Again the MSSM parameters and masses of the MSSM-like neutralinos are fixed according to the scenario SPS 1a, while a nearly pure light singlino-like neutralino $\tilde{\chi}_S^0$ with mass $\approx 0.18\, x^2/|M'|$ in zeroth approximation exists for very large values $|M'| \gg x$ [12]. The sign of M' is fixed by requiring relative sign $+1$ between the mass eigenvalues of $\tilde{\chi}_S^0$ and $\tilde{\chi}_1^0$ [6].

In Fig. 1 we show the associated production of the singlino-dominated $\tilde{\chi}_S^0$ together with the lightest MSSM-like neutralino $\tilde{\chi}_1^0$ for unpolarized beams and beam polarizations $P_- = +0.8$, $P_+ = 0$ and $P_- = +0.8$, $P_+ = -0.6$ for two masses 70 and 120 GeV of $\tilde{\chi}_S^0$, where the singlino-dominated neutralino is the LSP and NLSP, respectively. Electron beam polarisation $P_- = +0.8$ enhances the cross section by a factor 1.5 to 1.8, while additional positron beam polarisation $P_+ = -0.6$ gives a further enhancement factor of about 1.6. The cross sections are decreasing in good approximation as $1/x^2$ governed by the gaugino content of $\tilde{\chi}_S^0$ [6,7]. If we assume a cross section of 1 fb to be sufficient for discovery, the singlino-dominated neutralino can be detected with unpolarized beams for $x < 7.4$ TeV (9.7 TeV) in the NMSSM with $m_{\tilde{\chi}_S^0} = 70$ GeV (120 GeV) and for $x < 8.5$ TeV (6.4 TeV) in the E_6 model. For polarized electron beam the reach in x is enhanced to $x < 10.0$ TeV (12.3 TeV) in the NMSSM and $x < 11.4$ TeV (7.9 TeV) in the E_6 model, whereas for both beams polarized to $x < 12.6$ TeV (15.5 TeV) in the NMSSM and $x < 14.4$ TeV (10.0 TeV) in the E_6 model. Direct experimental evidence of a fifth neutralino would be an explicit proof for an extended SUSY model and is also crucial to apply sum rules in order to test the closure of the neutralino system [13].

3 Conclusion

We have studied the production of singlino-dominated neutralinos in the NMSSM and an E_6 inspired model at a linear collider with polarized beams. With both beams polarized the cross sections are enhanced by a factor 2.4 – 2.9 in comparison to unpolarized beams, depending on the scenario. This enhances the reach for the singlino-dominated neutralinos to singlet vevs as large as 15 TeV.

Acknowledgements

We thank A. Bartl and H. Fraas for useful discussions This work is supported by the 'Fonds zur Förderung der wissenschaftlichen Forschung' of Austria, FWF Projects No. P13139-PHY and No. P16592-N02 and by the European Community's Human Potential Programme under contract HPRN-CT-2000-00149.

References

[1] F. Franke and H. Fraas, Int. J. Mod. Phys. A **12** (1997) 479 [arXiv:hep-ph/9512366] and references therein.

[2] F. Franke, H. Fraas and A. Bartl, Phys. Lett. B **336** (1994) 415 [arXiv:hep-ph/9408217].

[3] F. Franke and H. Fraas, Z. Phys. C **72** (1996) 309 [arXiv:hep-ph/9511275].

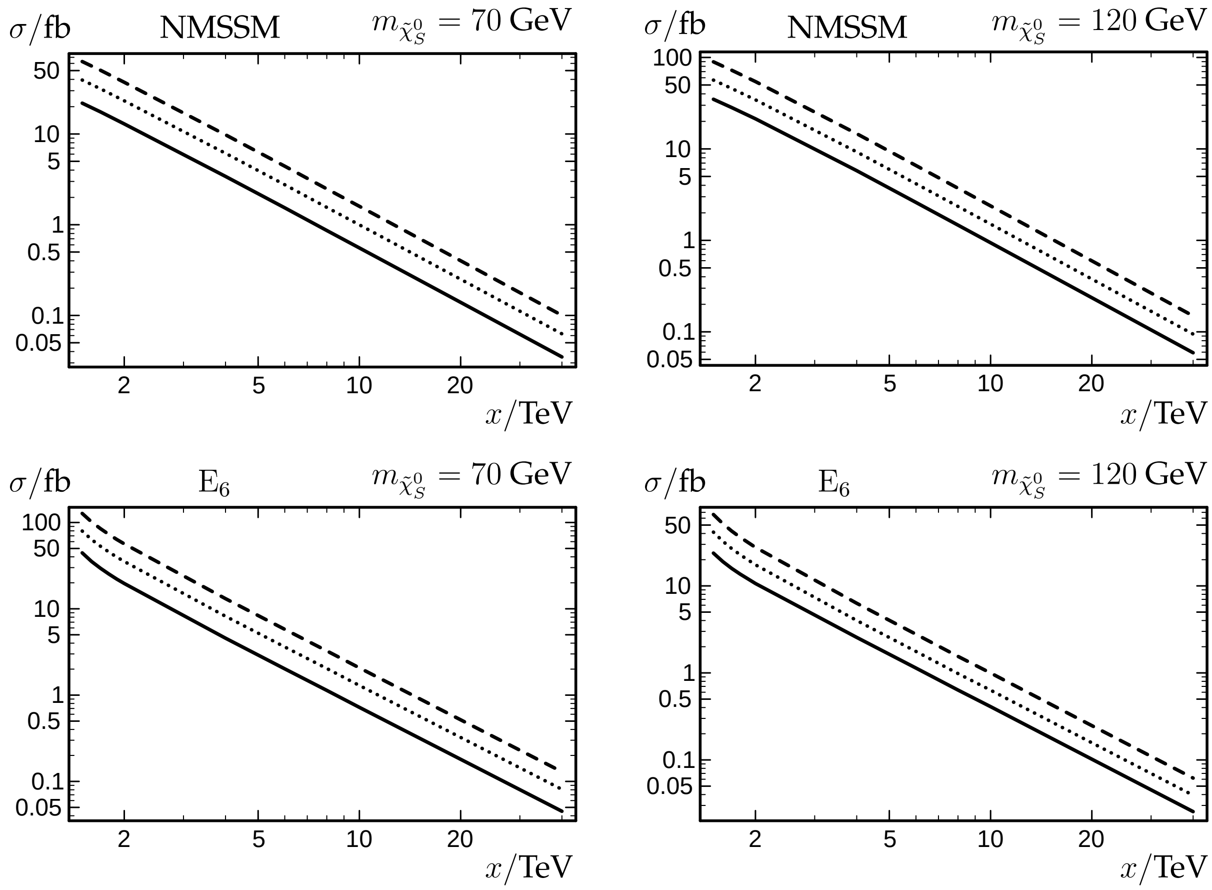

Figure 1: Cross sections for the production of a singlino-dominated neutralino $\tilde{\chi}^0_S$ via $e^+e^- \to \tilde{\chi}^0_S\tilde{\chi}^0_1$ for $\sqrt{s} = 500$ GeV in the SPS 1a inspired scenarios in the NMSSM and E_6 model with $M_1 = 99$ GeV, $M_2 = 193$ GeV, $\tan\beta = 10$ and $\mu_{\rm eff} = \lambda x = 352$ GeV with unpolarized beams (solid) and beam polarizations $P_- = +0.8$, $P_+ = 0$ (dotted) and $P_- = +0.8$, $P_+ = -0.6$ (dashed). The mass of $\tilde{\chi}^0_S$ is fixed at 70 GeV and 120 GeV by the parameters κ (NMSSM) and M' (E_6 model).

[4] U. Ellwanger and C. Hugonie, Eur. Phys. J. C **5** (1998) 723 [arXiv:hep-ph/9712300].

[5] S. Hesselbach, F. Franke and H. Fraas, Eur. Phys. J. C **23** (2002) 149 [arXiv:hep-ph/0107080] and references therein.

[6] F. Franke and S. Hesselbach, Phys. Lett. B **526** (2002) 370 [arXiv:hep-ph/0111285].

[7] S. Hesselbach and F. Franke, arXiv:hep-ph/0210363.

[8] G. Moortgat-Pick, S. Hesselbach, F. Franke and H. Fraas, arXiv:hep-ph/9909549.

[9] S. Hesselbach, F. Franke and H. Fraas, arXiv:hep-ph/0003272.

[10] N. Ghodbane and H. U. Martyn, in *Proc. of the APS/DPF/DPB Summer Study on the Future of Particle Physics (Snowmass 2001)* ed. N. Graf, arXiv:hep-ph/0201233.

[11] B. C. Allanach *et al.*, in *Proc. of the APS/DPF/DPB Summer Study on the Future of Particle Physics (Snowmass 2001)* ed. N. Graf, Eur. Phys. J. C **25** (2002) 113 [eConf **C010630** (2001) P125] [arXiv:hep-ph/0202233].

[12] B. de Carlos and J. R. Espinosa, Phys. Lett. B **407** (1997) 12 [arXiv:hep-ph/9705315].

[13] S. Y. Choi, J. Kalinowski, G. Moortgat-Pick and P. M. Zerwas, Eur. Phys. J. C **22** (2001) 563 [Addendum-ibid. C **23** (2002) 769] [arXiv:hep-ph/0108117].