SUSY SEARCHES WITH ZEUS*

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Searches for R-parity violating supersymmetry performed at the ZEUS experiment are presented. SUSY searches were focused on stop, chargino and light gravitino production. No evidence for SUSY particles production was found and limits were set in terms of the Yukawa couplings λ' for different supersymmetric models. The results are based on the data collected by HERA in the years 1994-2000, corresponding to a center-of-mass energy of 300 or 318 GeV, depending of the running period, and an integrated luminosity of 64-105 pb^{-1}.

1. Introduction

Since the resonant production of scalar quarks offers the largest discovery potential of supersymmetry at HERA, the search for stop, the supersymmetric partner of top quark, production is performed by assuming supersymmetric scenarios, which violate the R-parity (R_P). In addiction, a search for gravitino and chargino which are produced via $\not{R}_p$ t-channel exchange of a scalar electron, was performed.

2. $\not{R}_p$ supersymmetry at HERA

The R-parity (R_P) is a multiplicative, discrete symmetry, which is defined by $R_P = (-1)^{3B+L+2S}$, where B is the baryon number, L the lepton number and S the spin of the particle. The most general SUSY theory does not prevent the R_P to be violated; this allows Yukawa interaction between SM fermions and squarks and sleptons. The most important implications concerning the observation of SUSY at experiments are:

- the lightest supersymmetric particle (LSP) is not stable and can decay to SM particles;

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- the single production of SUSY particles is possible at colliders.

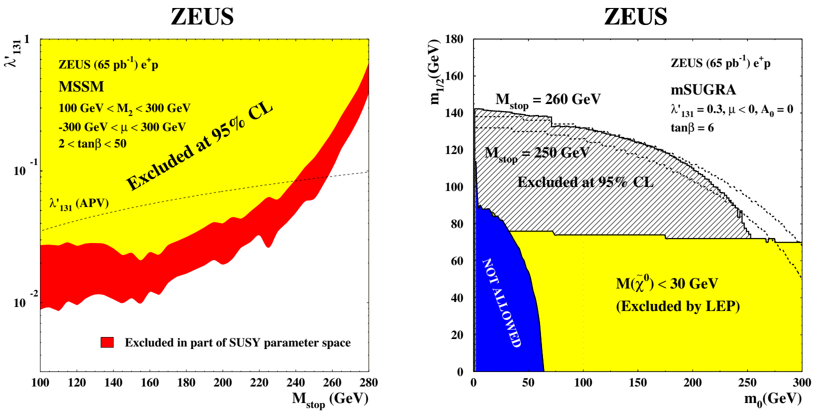
At HERA, the interactions are mediated by the trilinear term $\lambda'_{ijk} L_i Q_j D_k$ of the $\not{R}_p$ superpotential, where Q is a quark doublet superfield, L a lepton doublet superfield, $\overline{D}$ a down-like quark singlet superfield and, λ'_{ijk} is the Yukawa coupling where i, j, k denote family indices.

3. Stop search

ZEUS has performed a search for stop squark by using 65 pb^{-1} of e$^+$p collision at HERA. The main motivation for stop search comes from the large mixing of the mass eigenstates in the third family, this can lead to a non-degenerate mass state which can be rather light. At HERA, stop squarks can be resonantly produced in e$^+$p collisions via λ'_{131} Yukawa coupling. It can decay into a quark and a gaugino via R_P-conserving gauge couplings, as well as decays in a quark and electron via direct R-parity violation coupling λ'_{131}. Neutralinos and charginos are unstable and can decay via R_P violating coupling into SM particles. These decay mechanisms lead to a large variety of final state topologies which can be grouped in three main type: events with a jet and a positron (e-J channel), events with multiple jets and positron (e-MJ channel) and events with multiple jets and missing P_T due to an undetected neutrino.

Since no deviation from the SM has been observed, exclusion limits were determined in the framework of the minimal supersymmetric extention of the Standard Model (MSSM) and minimal Supergravity model (mSUGRA). Figure 1a shows the exclusion limits on λ'_{131} as a function of the stop mass. The dark area represents the exclusion limit at 95% CL for all the parameter space investigated, whereas the light region region can only be excluded by part of the parameter space. The limits for masses up to 250 GeV improve on the low energy constraints from atomic parity violation (APV) [1] measurements (dashed line) and does not depend strongly on the different SUSY scenarios. Assuming a Yukawa coupling of of electromagnetic strength stop masses up to about 270 GeV can be ruled out.

The results are also interpreted in the framework of the mSUGRA model. From a values of λ'_{131} corresponding to the electromagnetic strength ($\lambda'_{131} = 0.3$), constraints on the mSUGRA parameters were set in the plane (m_0,$m_{1/2}$), when tanβ, A_0 and the sign of μ are fixed. The parameter A_0 enters only marginally at the electroweak scale and it is set to zero. The results are shown in figure 1b where the the dashed area represents the exclusion limit area at 95% CL. The dark region corresponds to values of



(a) (b)

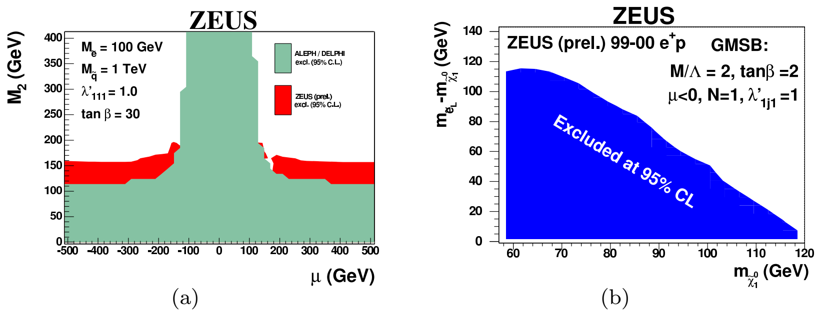
Figure 1. (a) Limits on λ'_{131} in MSSM model; (b) Exclusion region (dashed area) in mSUGRA model.

parameters where no REWSB solution is possible while the light region corresponds to neutralino masses (LSP) less than 30 GeV already excluded by LEP [2]. The dashed lines indicate the curve of constant stop mass close to the ZEUS exclusion limit area. Limits can exclude stop masses up to 250 GeV for m_0 smaller than 230 GeV.

4. Gaugino search

A search for gaugino production via t-channel selectron exchange was performed by using 121 pb^{-1} of e$^{\pm}$p collision at ZEUS. For such process the cross section is independent of the squark sector and depends only on the slepton and gaugino masses. The gaugino decays subsequently via a cascade into two quarks and an electron or positron or into two quarks and a neutrino or anti-neutrino. It is assumed that the single Yukawa coupling λ'_{111} dominates and the contribution from the other Yukawa coupling is negligible. A multi-variate discriminant method [3] was used to distinguish the signal from the background. No deviation from the SM was observed in the high discriminant region, where the signal is expected to appear.

Figure 2a shows the region (darkly-shaded area) in the μ-M$_2$ plane which can be excluded at the 95% CL by ZEUS. The result is also compared to the published results at LEP (lightly-dashed area) [4].



(a) (b)

Figure 2. (a) Limits on λ'_{131} in MSSM model; (b) Exclusion region (dashed area) in mSUGRA model.

5. Light Gravitino search

In the Gauge Mediated Supersymmetry Breaking (GMSB) model the gravitino ($\tilde{G}$), the supersymmetric partner of graviton, is the Lightest Supersymmetric Particle (LSP). The next-to-lightest supersymmetric particle (NLSP) is generally the lightest neutralino, which decays to the stable gravitino via $\tilde{\chi}^0_1 \rightarrow \gamma\ \tilde{G}$. Therefore, the signal process has a distinctive topology, containing an isolated photon, missing transverse energy and one jet.

In this analysis, 65 pb^{-1} of e^+p collisions at HERA were used. In the framework of minimal GMSB model, the left-handed slepton was treated as an independent parameter and supposed to be lighter than the right-handed one. Therefore, a scan in the selectron-neutralino mass plane was performed.

No deviation from the SM expectation was observed in the signal region. Limits were calculated at 95% CL and they were interpolated in the selectron-neutralino mass plane as illustrated in figure 2b.

References

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