SEARCHES FOR MONOPOLES, SUPERSYMMETRY, TECHNICOLOR, COMPOSITENESS, EXTRA DIMENSIONS, etc.

Magnetic Monopole Searches

Isolated supermassive monopole candidate events have not been confirmed. The most sensitive experiments obtain negative results.

Best cosmic-ray supermassive monopole flux limit:

$< 1.4 \times 10^{-16}$ cm^{-2}sr^{-1}s^{-1} for $1.1 \times 10^{-4} < \beta < 1$

Supersymmetric Particle Searches

All supersymmetric mass bounds here are model dependent.

The limits assume:

1) $\widetilde{\chi}^0_1$ is the lightest supersymmetric particle; 2) R-parity is conserved;

See the Particle Listings for a Note giving details of supersymmetry.

$\widetilde{\chi}^0_i$ — neutralinos (mixtures of $\widetilde{\gamma}$, $\widetilde{Z}^0$, and $\widetilde{H}^0_i$)

Mass $m_{\widetilde{\chi}^0_1} > 0$ GeV, CL = 95%
[general MSSM, non-universal gaugino masses]

Mass $m_{\widetilde{\chi}^0_1} > 46$ GeV, CL = 95%
[all tanβ, all m_0, all $m_{\widetilde{\chi}^0_2} - m_{\widetilde{\chi}^0_1}$]

Mass $m_{\widetilde{\chi}^0_2} > 620$ GeV, CL = 95%
[$\widetilde{\chi}^0_2 \to \ell^\pm \ell^\mp \widetilde{\chi}^0_1$, simplified model, $m_{\widetilde{\chi}^0_1} = 0$ GeV]

Mass $m_{\widetilde{\chi}^0_3} > 620$ GeV, CL = 95%
[$\widetilde{\chi}^0_3 \to \ell^\pm \ell^\mp \widetilde{\chi}^0_1$, simplified model, $m_{\widetilde{\chi}^0_1} = 0$ GeV]

Mass $m_{\widetilde{\chi}^0_4} > 116$ GeV, CL = 95%
[1<tanβ <40, all m_0, all $m_{\widetilde{\chi}^0_2} - m_{\widetilde{\chi}^0_1}$]

$\widetilde{\chi}_i^{\pm}$ — charginos (mixtures of $\widetilde{W}^{\pm}$ and $\widetilde{H}_i^{\pm}$)

Mass $m_{\widetilde{\chi}_1^{\pm}} > 94$ GeV, CL = 95%

[$\tan\beta < 40$, $m_{\widetilde{\chi}_1^{\pm}} - m_{\widetilde{\chi}_1^0} > 3$ GeV, all m_0]

Mass $m_{\widetilde{\chi}_1^{\pm}} > 500$ GeV, CL = 95%

[simplified model, $2\ell^{\pm}+\not{E}_T$, $m_{\widetilde{\chi}_1^0} = 0$ GeV]

$\widetilde{\chi}^{\pm}$ — long-lived chargino

Mass $m_{\widetilde{\chi}^{\pm}} > 620$ GeV, CL = 95% [stable $\widetilde{\chi}^{\pm}$]

$\widetilde{\nu}$ — sneutrino

Mass $m > 41$ GeV, CL = 95% [model independent]

Mass $m > 94$ GeV, CL = 95%

[CMSSM, $1 \le \tan\beta \le 40$, $m_{\widetilde{e}_R} - m_{\widetilde{\chi}_1^0} > 10$ GeV]

$\widetilde{e}$ — scalar electron (selectron)

Mass $m(\widetilde{e}_L) > 107$ GeV, CL = 95% [all $m_{\widetilde{e}_L} - m_{\widetilde{\chi}_1^0}$]

$\widetilde{\mu}$ — scalar muon (smuon)

Mass $m > 94$ GeV, CL = 95%

[CMSSM, $1 \le \tan\beta \le 40$, $m_{\widetilde{\mu}_R} - m_{\widetilde{\chi}_1^0} > 10$ GeV]

$\widetilde{\tau}$ — scalar tau (stau)

Mass $m > 81.9$ GeV, CL = 95%

[$m_{\widetilde{\tau}_R} - m_{\widetilde{\chi}_1^0} > 15$ GeV, all θ_τ, $B(\widetilde{\tau} \to \tau\widetilde{\chi}_1^0) = 100\%$]

Mass $m > 286$ GeV, CL = 95% [long-lived $\widetilde{\tau}$]

Where the limits below show a **range** of lower bounds, the bounds depend on different simplified models, different signals, different assumptions, and different luminosities.

$\widetilde{q}$ – squarks of the first two quark generations

The first of these limits is within CMSSM with cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$, and assuming two-generations of mass degenerate squarks ($\widetilde{q}_L$ and $\widetilde{q}_R$) and gaugino mass parameters that are constrained by the unification condition at the grand unification scale.

Mass $m > 1450$ GeV, CL = 95%

[CMSSM, $\tan\beta = 30$, $A_0 = -2\max(m_0, m_{1/2})$, $\mu > 0$]

Mass $m > 608$–1260 GeV, CL = 95%

[mass degenerate squarks]

Mass $m > 490$–600 GeV, CL = 95%

[single light squark bounds]

$\widetilde{q}$ — long-lived squark

Mass $m >$ 1000, CL = 95%
[$\widetilde{t}$, charge-suppressed interaction model]

Mass $m >$ 845, CL = 95% [$\widetilde{b}$, stable, Regge model]

$\widetilde{b}$ — scalar bottom (sbottom)

Mass $m >$ 323–880 GeV, CL = 95%
[There is dependence on mass difference $\widetilde{b}$-LSP]

$\widetilde{t}$ — scalar top (stop)

Mass $m >$ 323–800 GeV, CL = 95%
[Lower value is a decay via charm, and upper a decay via top]

$\widetilde{g}$ — gluino

Mass $m >$ 700–1780 GeV, CL = 95%

Technicolor

The limits for technicolor (and top-color) particles are quite varied depending on assumptions. See the Technicolor section of the full *Review* (the data listings).

Quark and Lepton Compositeness, Searches for

Scale Limits Λ for Contact Interactions (the lowest dimensional interactions with four fermions)

If the Lagrangian has the form

$$\pm \frac{g^2}{2\Lambda^2}\, \overline{\psi}_L \gamma_\mu \psi_L \overline{\psi}_L \gamma^\mu \psi_L$$

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda^{\pm}_{LL}$. For the full definitions and for other forms, see the Note in the Listings on Searches for Quark and Lepton Compositeness in the full *Review* and the original literature.

$\Lambda^{+}_{LL}(eeee)$ $>$ 8.3 TeV, CL = 95%

$\Lambda^{-}_{LL}(eeee)$ $>$ 10.3 TeV, CL = 95%

$\Lambda^{+}_{LL}(ee\mu\mu)$ $>$ 8.5 TeV, CL = 95%

$\Lambda^{-}_{LL}(ee\mu\mu)$ $>$ 9.5 TeV, CL = 95%

$\Lambda^{+}_{LL}(ee\tau\tau)$ $>$ 7.9 TeV, CL = 95%

$\Lambda^-_{LL}(ee\tau\tau)$	$>$	7.2 TeV, CL = 95%
$\Lambda^+_{LL}(\ell\ell\ell\ell)$	$>$	9.1 TeV, CL = 95%
$\Lambda^-_{LL}(\ell\ell\ell\ell)$	$>$	10.3 TeV, CL = 95%
$\Lambda^+_{LL}(eeqq)$	$>$	16.4 TeV, CL = 95%
$\Lambda^-_{LL}(eeqq)$	$>$	20.7 TeV, CL = 95%
$\Lambda^+_{LL}(eeuu)$	$>$	23.3 TeV, CL = 95%
$\Lambda^-_{LL}(eeuu)$	$>$	12.5 TeV, CL = 95%
$\Lambda^+_{LL}(eedd)$	$>$	11.1 TeV, CL = 95%
$\Lambda^-_{LL}(eedd)$	$>$	26.4 TeV, CL = 95%
$\Lambda^+_{LL}(eecc)$	$>$	9.4 TeV, CL = 95%
$\Lambda^-_{LL}(eecc)$	$>$	5.6 TeV, CL = 95%
$\Lambda^+_{LL}(eebb)$	$>$	9.4 TeV, CL = 95%
$\Lambda^-_{LL}(eebb)$	$>$	10.2 TeV, CL = 95%
$\Lambda^+_{LL}(\mu\mu qq)$	$>$	15.8 TeV, CL = 95%
$\Lambda^-_{LL}(\mu\mu qq)$	$>$	21.8 TeV, CL = 95%
$\Lambda(\ell\nu\ell\nu)$	$>$	3.10 TeV, CL = 90%
$\Lambda(e\nu qq)$	$>$	2.81 TeV, CL = 95%
$\Lambda^+_{LL}(qqqq)$	$>$	12.0 TeV, CL = 95%
$\Lambda^-_{LL}(qqqq)$	$>$	17.5 TeV, CL = 95%
$\Lambda^+_{LL}(\nu\nu qq)$	$>$	5.0 TeV, CL = 95%
$\Lambda^-_{LL}(\nu\nu qq)$	$>$	5.4 TeV, CL = 95%

Excited Leptons

The limits from $\ell^{*+}\ell^{*-}$ do not depend on λ (where λ is the $\ell\ell^*$ transition coupling). The λ-dependent limits assume chiral coupling.

$e^{*\pm}$ — excited electron

Mass $m >$ 103.2 GeV, CL = 95% (from $e^* e^*$)
Mass $m >$ 3.000×10^3 GeV, CL = 95% (from ee^*)
Mass $m >$ 356 GeV, CL = 95% (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

Mass $m >$ 103.2 GeV, CL = 95% (from $\mu^*\mu^*$)
Mass $m >$ 3.000×10^3 GeV, CL = 95% (from $\mu\mu^*$)

$\tau^{*\pm}$ — excited tau

Mass $m >$ 103.2 GeV, CL = 95% (from $\tau^* \tau^*$)
Mass $m >$ 2.500×10^3 GeV, CL = 95% (from $\tau \tau^*$)

ν^* — excited neutrino

Mass $m >$ 1.600×10^3 GeV, CL = 95% (from $\nu^* \nu^*$)
Mass $m >$ 213 GeV, CL = 95% (from $\nu^* X$)

q^* — excited quark

Mass $m >$ 338 GeV, CL = 95% (from $q^* q^*$)
Mass $m >$ 5.200×10^3 GeV, CL = 95% (from $q^* X$)

Color Sextet and Octet Particles

Color Sextet Quarks (q_6)

Mass $m >$ 84 GeV, CL = 95% (Stable q_6)

Color Octet Charged Leptons (ℓ_8)

Mass $m >$ 86 GeV, CL = 95% (Stable ℓ_8)

Color Octet Neutrinos (ν_8)

Mass $m >$ 110 GeV, CL = 90% ($\nu_8 \rightarrow \nu g$)

Extra Dimensions

Please refer to the Extra Dimensions section of the full *Review* for a discussion of the model-dependence of these bounds, and further constraints.

Constraints on the radius of the extra dimensions, for the case of two-flat dimensions of equal radii

$R <$ 30 μm, CL = 95% (direct tests of Newton's law)
$R <$ 10.9 μm, CL = 95% ($p p \rightarrow j G$)
$R <$ 0.16–916 nm (astrophysics; limits depend on technique and assumptions)

Constraints on the fundamental gravity scale

$M_{TT} >$ 6.3 TeV, CL = 95% ($p p \rightarrow$ dijet, angular distribution)
$M_c >$ 4.16 TeV, CL = 95% ($p p \rightarrow \ell \overline{\ell}$)

Constraints on the Kaluza-Klein graviton in warped extra dimensions

$M_G >$ 3.3 TeV, CL = 95% ($p p \rightarrow e^+ e^-, \mu^+ \mu^-$)

Constraints on the Kaluza-Klein gluon in warped extra dimensions

$M_{g_{KK}} >$ 2.5 TeV, CL = 95% ($g_{KK} \rightarrow t \overline{t}$)