

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:

$$< 1.0 \times 10^{-15} \text{ cm}^{-2}\text{sr}^{-1}\text{s}^{-1} \quad \text{for } 1.1 \times 10^{-4} < \beta < 0.1$$

Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model.

Assumptions include: 1) $\tilde{\chi}_1^0$ (or $\tilde{\gamma}$) is lightest supersymmetric particle; 2) R -parity is conserved; 3) With the exception of \tilde{t} and \tilde{b} , all scalar quarks are assumed to be degenerate in mass and $m_{\tilde{q}_R} = m_{\tilde{q}_L}$. 4) Limits for sleptons refer to the $\tilde{\ell}_R$ states. 5) Gaugino mass unification at the GUT scale.

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

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

Mass $m_{\tilde{\chi}_1^0} > 46 \text{ GeV}$, CL = 95%

[all $\tan\beta$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_2^0} > 62.4 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_3^0} > 99.9 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

Mass $m_{\tilde{\chi}_4^0} > 116 \text{ GeV}$, CL = 95%

[$1 < \tan\beta < 40$, all m_0 , all $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$]

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

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

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

\tilde{e} — scalar electron (selectron)

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

$\tilde{\mu}$ — scalar muon (smuon)

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

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

$\tilde{\tau}$ — scalar tau (stau)

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

[$m_{\tilde{\tau}_R} - m_{\tilde{\chi}_1^0} > 15$ GeV, all θ_τ]

\tilde{q} — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling.

Mass $m > 1.100 \times 10^3$ GeV, CL = 95% [$\tan\beta=10$, $\mu > 0$, $A_0=0$]

\tilde{b} — scalar bottom (sbottom)

Mass $m > 89$ GeV, CL = 95% [$m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0} > 8$ GeV, all θ_b]

\tilde{t} — scalar top (stop)

Mass $m > 95.7$ GeV, CL = 95%

[$\tilde{t} \rightarrow c\tilde{\chi}_1^0$, all θ_t , $m_{\tilde{t}} - m_{\tilde{\chi}_1^0} > 10$ GeV]

\tilde{g} — gluino

The limits summarised here refer to the high-mass region ($m_{\tilde{g}} \gtrsim 5$ GeV), and include the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. The limits are weakly sensitive to these parameters over much of parameter space. Limits assume GUT relations between gaugino masses and the gauge coupling,

Mass $m > 500$ GeV, CL = 95% [any $m_{\tilde{q}}$]

Technicolor

Searches for a color-octet techni- ρ constrain its mass to be greater than 260 to 480 GeV, depending on allowed decay channels. Similar bounds exist on the color-octet techni- ω .

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

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

(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda_{LL}^\pm$. 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%
$\Lambda_{LL}^+(eeuu)$	> 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%
$\Lambda_{LL}^+(\mu\mu qq)$	> 4.5 TeV, CL = 95%
$\Lambda_{LL}^-(\mu\mu qq)$	> 4.9 TeV, CL = 95%
$\Lambda(\ell\nu\ell\nu)$	> 3.10 TeV, CL = 90%
$\Lambda(e\nu qq)$	> 2.81 TeV, CL = 95%
$\Lambda_{LL}^+(qqqq)$	> 5.6 TeV, CL = 95%
$\Lambda_{LL}^-(qqqq)$	> 6.7 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 $m > 1.070 \times 10^3$ 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 $m > 1.090 \times 10^3$ GeV, CL = 95% (from $\mu\mu^*$)

$\tau^{*\pm}$ — excited tau

- Mass $m > 103.2$ GeV, CL = 95% (from $\tau^*\tau^*$)
- Mass $m > 185$ GeV, CL = 95% (from $\tau\tau^*$)

ν^* — excited neutrino

- Mass $m > 102.6$ GeV, CL = 95% (from $\nu^*\nu^*$)
- Mass $m > 213$ GeV, CL = 95% (from $\nu\nu^*$)

q^* — excited quark

- Mass $m > 338$ GeV, CL = 95% (from q^*q^*)
- Mass $m > 2.490 \times 10^3$ 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 fundamental gravity scale

$M_{TT} > 1.74$ TeV, CL = 95% (dim-8 ops; $\Lambda = +1$; $pp \rightarrow \gamma\gamma$)

$M_C > 1.59$ TeV, CL = 95% (compactification scale with TeV extra dimensions; $p\bar{p} \rightarrow$ dijet, angular distrib.)

$M_D > 1.63$ TeV, CL = 95% ($pp \rightarrow G \rightarrow \ell\bar{\ell}$)

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)

$R < 72$ μm , CL = 95% ($pp \rightarrow jG$)

$R < 0.16\text{--}916$ nm (astrophysics; limits depend on technique and assumptions)
