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:

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

Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model.

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

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

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

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

Mass $m_{\widetilde{\chi}_2^0} > 62.4$ GeV, CL = 95%
[1<$\tan\beta$ <40, all m_0, all $m_{\widetilde{\chi}_2^0} - m_{\widetilde{\chi}_1^0}$]

Mass $m_{\widetilde{\chi}_3^0} > 99.9$ GeV, CL = 95%
[1<$\tan\beta$ <40, all m_0, all $m_{\widetilde{\chi}_2^0} - m_{\widetilde{\chi}_1^0}$]

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

$\widetilde{\chi}_i^{\pm}$ — 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]

$\widetilde{\nu}$ — sneutrino

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

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

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

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

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

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

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

$\widetilde{q}$ — 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 $m >$ 1.110×10^3 GeV, CL = 95% [$\tan\beta = 10$, $\mu > 0$, $A_0 = 0$]

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

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

$\widetilde{t}$ — scalar top (stop)

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

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

$\widetilde{g}$ — gluino

The limits summarised here refer to the high-mass region ($m_{\widetilde{g}} \gtrsim 5$ 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 $m >$ 800 GeV, CL = 95%   [any $m_{\widetilde{q}}$]

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
$$\pm \frac{g^2}{2\Lambda^2}\, \overline{\psi}_L \gamma_\mu \psi_L \overline{\psi}_L \gamma^\mu \psi_L$$
(with $g^2/4\pi$ set equal to 1), then we define $\Lambda \equiv \Lambda_{LL}^{\pm}$. 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.

$$\Lambda_{LL}^+(e\,e\,e\,e) \quad > 8.3 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,e\,e) \quad > 10.3 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,\mu\,\mu) \quad > 8.5 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,\mu\,\mu) \quad > 9.5 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,\tau\,\tau) \quad > 7.9 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,\tau\,\tau) \quad > 7.2 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(\ell\,\ell\,\ell\,\ell) \quad > 9.1 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(\ell\,\ell\,\ell\,\ell) \quad > 10.3 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,u\,u) \quad > 23.3 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,u\,u) \quad > 12.5 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,d\,d) \quad > 11.1 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,d\,d) \quad > 26.4 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,c\,c) \quad > 9.4 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,c\,c) \quad > 5.6 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(e\,e\,b\,b) \quad > 9.4 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^-(e\,e\,b\,b) \quad > 10.2 \text{ TeV, CL} = 95\%$$
$$\Lambda_{LL}^+(\mu\,\mu\,q\,q) \quad > 9.6 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(\mu\mu qq) \quad > 13.1 \text{ TeV, CL} = 95\%$$
$$\Lambda(\ell\nu\ell\nu) \quad > 3.10 \text{ TeV, CL} = 90\%$$
$$\Lambda(e\nu qq) \quad > 2.81 \text{ TeV, CL} = 95\%$$
$$\Lambda^+_{LL}(qqqq) \quad > 7.6 \text{ TeV, CL} = 95\%$$
$$\Lambda^-_{LL}(qqqq) \quad > 7.6 \text{ TeV, CL} = 95\%$$
$$\Lambda^+_{LL}(\nu\nu qq) \quad > 5.0 \text{ TeV, CL} = 95\%$$
$$\Lambda^-_{LL}(\nu\nu qq) \quad > 5.4 \text{ TeV, CL} = 95\%$$

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 $m > 1.870 \times 10^3$ GeV, CL $= 95\%$ (from $e e^*$)
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 $m > 1.750 \times 10^3$ 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 $m > 3.320 \times 10^3$ 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

$M_{TT} > 3.2$ TeV, CL $= 95\%$ $(pp \to e^+e^-,\ \mu^+\mu^-,\ \gamma\gamma)$
$M_C > 4.16$ TeV, CL $= 95\%$ $(pp \to \ell\bar{\ell})$
$M_D > 2.16$ TeV, CL $= 95\%$ $(pp \to G \to \ell\bar{\ell})$

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

$R < 30\ \mu$m, CL $= 95\%$ (direct tests of Newton's law)
$R < 23\ \mu$m, CL $= 95\%$ $(pp \to jG)$
$R < 0.16$–916 nm   (astrophysics; limits depend on technique and assumptions)