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

Limits are based on the Minimal Supersymmetric Standard Model (MSSM) with additional assumptions as follows:

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 charged sleptons refer to the $\widetilde{\ell}_R$ states. 5) Unless otherwise stated, gaugino mass unification at the GUT scale is assumed. For squarks and gluinos, the Constrained MSSM (CMSSM) limits and simplified model limits are presented.

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 $= 95\%$

        [$1 \le \tan\beta \le 40$, $m_{\widetilde{e}_R} - m_{\widetilde{\chi}_1^0} > 10$ 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 $= 95\%$

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

$\widetilde{q}$ – scalar quark partners (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 $\tan\beta$. Limits assume 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. The second limit assumes a simplified model with a 100% branching ratio for the prompt decay $\widetilde{q} \to q\widetilde{\chi}_1^0$.

    Mass $m > 1110$ GeV, CL $= 95\%$ [$\tan\beta = 10$, $\mu > 0$, $A_0 = 0$]

    Mass $m > 750$ GeV, CL $= 95\%$

        [jets $+ \not{E}_T$, $\widetilde{q} \to q\widetilde{\chi}_1^0$ simplified model, $m_{\widetilde{\chi}_1^0} = 0$ GeV]

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

    Mass $m > 89$ GeV, CL $= 95\%$

        [$\widetilde{b} \to b\widetilde{\chi}_1^0$, $m_{\widetilde{b}_1} - m_{\widetilde{\chi}_1^0} > 8$ GeV, all θ_b]

    Mass $m > 600$ GeV, CL $= 95\%$

        [jets $+ \not{E}_T$, $\widetilde{b} \to b\widetilde{\chi}_1^0$ simplified model, $m_{\widetilde{\chi}_1^0} = 0$ GeV]

$\widetilde{t}$ — scalar top (stop)

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

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

    Mass $m > 650$ GeV, CL $= 95\%$

        [$1\,\ell^{\pm} +$ jets $+ \not{E}_T$, $\widetilde{t} \to t\widetilde{\chi}_1^0$ simplified model, $m_{\widetilde{\chi}_1^0} = 0$ GeV]

$\widetilde{g}$ — gluino

> The first of these limits is within the CMSSM for ($m_{\widetilde{g}} \gtrsim 5$ GeV), and includes the effects of cascade decays, evaluated assuming a fixed value of the parameters μ and $\tan\beta$. Limit assumes GUT relations between gaugino masses and the gauge couplings. The second limit assumes a simplified model with a 100% branching ratio for the prompt 3 body decay $\widetilde{g} \rightarrow q\overline{q}\widetilde{\chi}_1^0$, independent of the squark mass.

Mass $m > 800$ GeV, CL $= 95\%$ [any $m_{\widetilde{q}}$]

Mass $m > 950$ GeV, CL $= 95\%$

    [jets $+ \not{E}_T$, $\widetilde{g} \rightarrow q\overline{q}\widetilde{\chi}_1^0$ simplified model, $m_{\widetilde{\chi}_1^0} = 0$ GeV]

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 $\Lambda \equiv \Lambda_{LL}^{\pm}$. 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.

$$\Lambda_{LL}^+(e\,e\,e\,e) \quad > 8.3 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(e\,e\,e\,e) \quad > 10.3 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(e\,e\,\mu\,\mu) \quad > 8.5 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(e\,e\,\mu\,\mu) \quad > 9.5 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(e\,e\,\tau\,\tau) \quad > 7.9 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(e\,e\,\tau\,\tau) \quad > 7.2 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^+(\ell\,\ell\,\ell\,\ell) \quad > 9.1 \text{ TeV, CL} = 95\%$$

$$\Lambda_{LL}^-(\ell\,\ell\,\ell\,\ell) \quad > 10.3 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(eeuu) \quad > 23.3 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(eeuu) \quad > 12.5 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(eedd) \quad > 11.1 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(eedd) \quad > 26.4 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(eecc) \quad > 9.4 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(eecc) \quad > 5.6 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(eebb) \quad > 9.4 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(eebb) \quad > 10.2 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(\mu\mu qq) \quad > 9.6 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(\mu\mu qq) \quad > 13.1 \text{ TeV, CL} = 95\%$$

$$\Lambda(\ell\nu\ell\nu) \quad > 3.10 \text{ TeV, CL} = 90\%$$

$$\Lambda(e\nu qq) \quad > 2.81 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(qqqq) \quad > 7.6 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(qqqq) \quad > 7.6 \text{ TeV, CL} = 95\%$$

$$\Lambda^+_{LL}(\nu\nu qq) \quad > 5.0 \text{ TeV, CL} = 95\%$$

$$\Lambda^-_{LL}(\nu\nu qq) \quad > 5.4 \text{ TeV, CL} = 95\%$$

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 $m > 2.200 \times 10^3$ 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 $m > 2.200 \times 10^3$ 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 $m > 3.500 \times 10^3$ 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 $= 95\%$ ($pp \rightarrow e^+ e^-$, $\mu^+ \mu^-$, $\gamma\gamma$)

$M_C > 4.16$ TeV, CL $= 95\%$ ($pp \rightarrow \ell\bar{\ell}$)

$M_D > 2.16$ 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)

$R < 23$ μm, CL $= 95\%$ ($pp \rightarrow j G$)

$R < 0.16$–916 nm   (astrophysics; limits depend on technique and assumptions)