# 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:

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

## Supersymmetric Particle Searches

Limits are based on the Minimal Supersymmetric Standard Model.

Assumptions include: 1) $\widetilde{\chi}^0_1$ (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.

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

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

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

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

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

$\widetilde{e}$ — 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 $\theta_\tau$]

$\widetilde{q}$ — scalar quark (squark)

These limits include the effects of cascade decays, evaluated assuming a fixed value of the parameters $\mu$ 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 $m >$ 379 GeV, CL = 95% [tan$\beta$=3, $\mu$ <0, $A$=0, any $m_{\widetilde{g}}$]

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

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

$\widetilde{t}$ — scalar top (stop)

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

[$\widetilde{t} \rightarrow c\,\widetilde{\chi}_1^0$, all $\theta_t$, $m_{\widetilde{t}} - m_{\widetilde{\chi}_1^0}$ >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 $\mu$ 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 $m >$ 308 GeV, CL = 95% [any $m_{\widetilde{q}}$]
Mass $m >$ 392 GeV, CL = 95% [$m_{\widetilde{q}} = m_{\widetilde{g}}$]

## Technicolor

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

## 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%
$\Lambda^{+}_{LL}(eeuu)$ > 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%
$\Lambda^{-}_{LL}(eebb)$ > 4.9 TeV, CL = 95%
$\Lambda^{+}_{LL}(\mu\mu qq)$ > 2.9 TeV, CL = 95%
$\Lambda^{-}_{LL}(\mu\mu qq)$ > 4.2 TeV, CL = 95%
$\Lambda(\ell\nu\ell\nu)$ > 3.10 TeV, CL = 90%
$\Lambda(e\nu qq)$ > 2.81 TeV, CL = 95%
$\Lambda^{+}_{LL}(qqqq)$ > 2.7 TeV, CL = 95%
$\Lambda^{-}_{LL}(qqqq)$ > 2.4 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 $\lambda$ (where $\lambda$ is the $\ell\ell^*$ transition coupling). The $\lambda$-dependent limits assume chiral coupling.

$e^{*\pm}$ — excited electron

Mass $m >$ 103.2 GeV, CL = 95% (from $e^* e^*$)
Mass $m >$ 272 GeV, CL = 95% (from $e e^*$)
Mass $m >$ 310 GeV, CL = 95% (if $\lambda_\gamma = 1$)

$\mu^{*\pm}$ — excited muon

Mass $m >$ 103.2 GeV, CL = 95% (from $\mu^* \mu^*$)
Mass $m >$ 221 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 $\tau\tau^*$)

$\nu^*$ — 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 $m >$ 775 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 ($\ell_8$)

Mass $m >$ 86 GeV, CL = 95% (Stable $\ell_8$)

Color Octet Neutrinos ($\nu_8$)

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

$M_{TT} >$ 1.48 TeV, CL = 95% (dim-8 operators; $p\overline{p} \rightarrow$ dijet, angular distrib.)

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

$M_D >$ 1050 GeV, CL = 95% ($p\overline{p} \rightarrow G \rightarrow e^+ e^-, \gamma\gamma$)

### 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)

$R <$ 210 $\mu$m, CL = 95% ($e^+ e^- \rightarrow \gamma G$)

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