Investigating Gaugino Masses With Data From High And Low Energies

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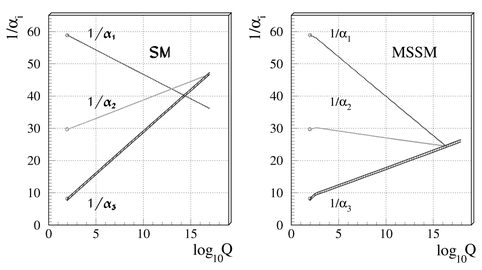
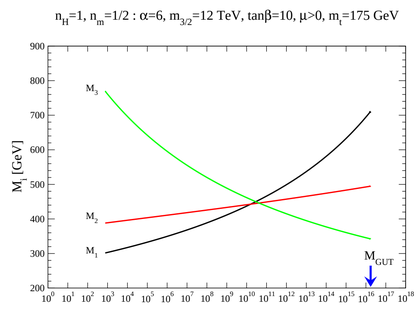
Motivation



A hint that Nature is supersymmetric, and that the forces unify? (Picture taken from U. Amaldi, W. de Boer and H. Furstenau, Phys. Lett. B **260** (1991) 447.)

- Supersymmetry: extension of the Standard Model
- Predicts *gauginos*, fermionic partners of gauge bosons.
- Masses: depends on mechanism of supersymmetry breaking.



Gaugino masses do not necessarily unify at the GUT scale in some models, such as mirage models. (Picture taken from H. Baer, E. K. Park, X. Tata and T. T. Wang, JHEP **0706** (2007) 033 [arXiv:hep-ph/0703024].)

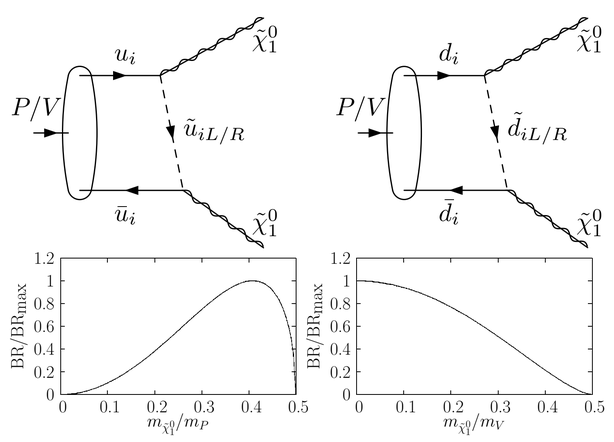
Rare Meson Decays To Very Light Neutralinos

What Can Mesons Tell Us About Supersymmetry?

- PDG: $m_{\tilde{\chi}_1^0} > 46$ GeV
- assumes simple grand unification
- Drop assumption $\Rightarrow$ no lower bound on $m_{\tilde{\chi}_1^0}$

This section presents work in collaboration with H. K. Dreiner (Bonn), S. Grab (Bonn at the time), D. Koschade (Aachen at the time), M. Kramer (Aachen) and U. Langenfeld (Bonn at the time), published in Phys. Rev. D **80** (2009) 035018 [arXiv:0905.2051 [hep-ph]].

Invisible Decays



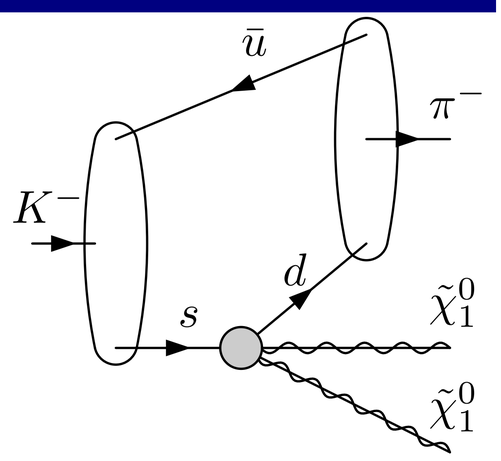
Meson	$BR_{max}(\to\tilde{\chi}_1^0\tilde{\chi}_1^0)$	Exp. bound
Pseudoscalars:		
π^0	1.63×10^{-10}	2.7×10^{-7}
η	7.60×10^{-11}	6×10^{-4}
η'	3.83×10^{-12}	1.4×10^{-3}
Vectors:		
ρ^0	8.01×10^{-15}	none
ω	7.51×10^{-14}	none
ϕ	1.57×10^{-13}	none
J/ψ	5.12×10^{-9}	5.9×10^{-4}
Υ	4.47×10^{-8}	2.5×10^{-3}

- Light enough neutralino $\Rightarrow$ new invisible meson decays.
- Mediated by squarks, which are constrained to be heavy.
- Pseudoscalars need "helicity flip".

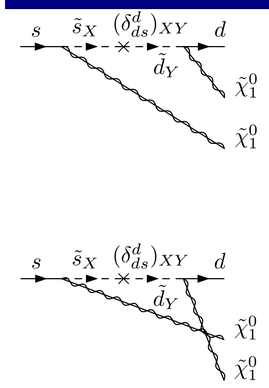
$K^-\to\pi^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ And $B^-\to K^-\tilde{\chi}_1^0\tilde{\chi}_1^0$

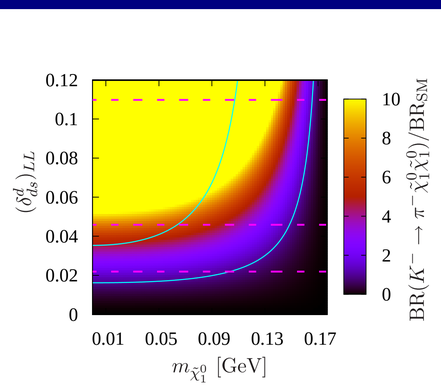
Overview

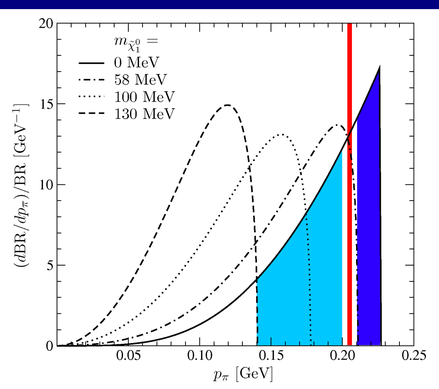
- No "helicity flip" suppression.
- BNL experimental measurement of $K^-\to pi^-+$ invisible consistent (with 100% error bars) with SM branching ratio to pion plus neutrinos.



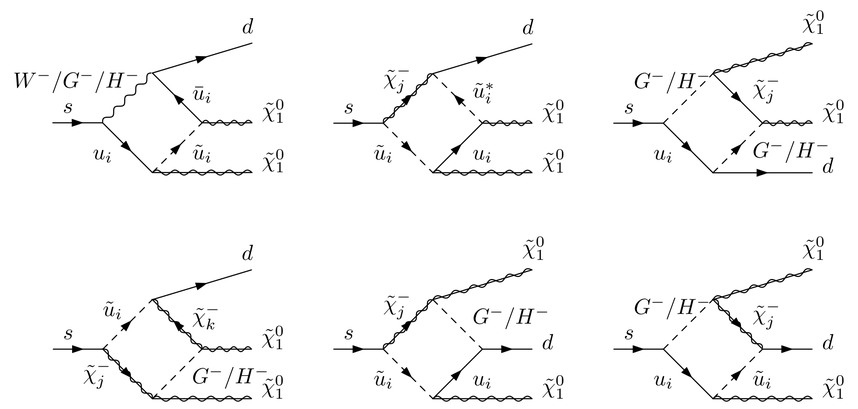
At Tree Level Without Minimal Flavor Violation







Through Loops In Minimal Flavor Violation

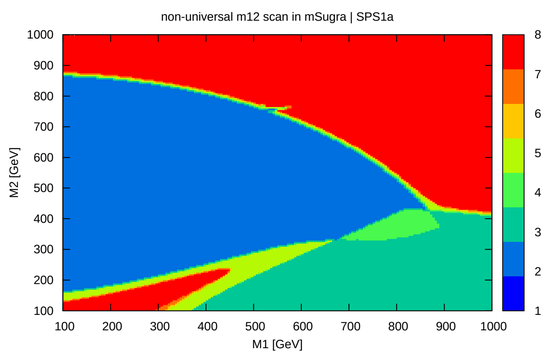


pseudo-SPS	$K^-\to\pi^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ BR	BR/exp. SM value	$B^-\to K^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ BR	BR/exp. bound
1a	3.28×10^{-16}	1.90×10^{-6}	3.35×10^{-10}	2.39×10^{-5}
2	1.47×10^{-18}	8.49×10^{-9}	2.48×10^{-12}	1.77×10^{-7}
3	6.99×10^{-17}	4.04×10^{-7}	7.19×10^{-11}	5.14×10^{-6}
4	8.76×10^{-17}	5.06×10^{-7}	2.53×10^{-10}	1.81×10^{-5}
5	5.12×10^{-16}	2.96×10^{-6}	7.14×10^{-10}	5.10×10^{-5}

"BR/exp. something" = ratio of branching ratio for $K^-\to\pi^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ to experimental value of branching ratio for $K^-\to\pi^-\nu\bar{\nu}$ (1.73×10^{-10}) or $B^-\to K^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ to current experimental upper bound on branching ratio for $B^-\to K^-\nu\bar{\nu}$ (1.4×10^{-5}).

Exploration Of LHC Signals For Non-Universal Gaugino Masses

Varying the gaugino masses can produce quite differing signals at the LHC, such as relative numbers of leptons and jets, how hard the leptons and jets are, and the shape of their invariant mass distributions. This work is being performed in conjuction with theorists and experimentalists in both Aachen and Bonn (H. Dreiner, M. Krämer, K. Desch, P. Wienemann, J. Lindert).



1 (dark blue) :$\tilde{\chi}_1^0$ not LSP $\Rightarrow$cosmological problems
2 (grey-blue) :$m_{\tilde{l}_R}, m_{\tilde{\tau}_1} < m_{\tilde{\chi}_2}$ $\Rightarrow$lots of leptons
3 (turquiose) :$m_{\tilde{l}_L}, m_{\tilde{\tau}_1} < m_{\tilde{\chi}_2}$ $\Rightarrow$lots of leptons
4 (bright green) :$m_{\tilde{l}_R}, m_{\tilde{l}_L}, m_{\tilde{\tau}_1} < m_{\tilde{\chi}_2}$ $\Rightarrow$lots of leptons
5 (light green) :$m_{\tilde{\tau}_1} < m_{\tilde{\chi}_2}$ $\Rightarrow$lots of τ leptons
6 (orange-yellow) :$m_{\tilde{l}_R}$ or $m_{\tilde{l}_L} < m_{\tilde{\chi}_2}$, $m_{\tilde{\tau}_1} > m_{\tilde{\chi}_2}$ $\Rightarrow$lots of electrons and muons
7 (orange-red) :only $m_{\tilde{\nu}_i} < m_{\tilde{\chi}_2}$ $\Rightarrow$very few leptons
8 (bright red — lower-left region) :$m_{\tilde{\chi}_2} <$ all sfermions $\Rightarrow$some leptons, all from 3-body decays
9 (bright red — upper-right region):all squarks $< m_{\tilde{\chi}_2}$ $\Rightarrow$very few leptons