

Slepton Flavor Physics at Linear Colliders

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If low energy supersymmetry is realized in nature it is possible that a first generation linear collider will only have access to some of the superpartners with electroweak quantum numbers. Among these, sleptons can provide sensitive probes for lepton flavor violation through potentially dramatic lepton violating signals. Theoretical proposals to understand the absence of low energy quark and lepton flavor changing neutral currents are surveyed and many are found to predict observable slepton flavor violating signals at linear colliders. The observation or absence of such sflavor violation will thus provide important indirect clues to very high energy physics. Previous analyses of slepton flavor oscillations are also extended to include the effects of finite width and mass differences.

I. INTRODUCTION

If supersymmetry is discovered at the Tevatron or LHC, much of the focus of particle physics research will turn to measuring and understanding the 105 (or more) soft breaking parameters. While this problem may seem, at first, more daunting than understanding the pattern of quark and lepton masses and mixings, we know, a priori, that these parameters must show striking regularities. Otherwise, supersymmetry would lead to large, unobserved flavor violation among ordinary quarks and leptons.

From the perspective of string theory, for example, the prospect of discovering supersymmetry and measuring the soft breaking parameters is extremely exciting. Indeed, in most pictures of supersymmetry breaking, squark and slepton masses arise from non-renormalizable operators associated with some new scale of physics. This could well be, for example, the scale of string or M-theory. Thus, collider measurements of the soft breaking parameters are potentially indirect probes of extremely high energy physics, physics we might hope to eventually unravel!

To date, there are only a few theoretical proposals for the origin of the requisite regularities of the soft parameters which lead to acceptably small low energy flavor violation among the quarks and leptons. Each has important implications for the physics discoveries of future colliders. In this note, we will survey these proposals, and discuss some of their implications for collider phenomenology. One particularly exciting possibility, is the existence of dramatic flavor violating phenomena in slepton production. This can occur even given the strong bounds from the non-observation to date of flavor violation in low energy lepton decays.

We also call attention to previous work on slepton flavor violating collider phenomenology [1, 2] and extend it to include the effects of finite width and mass differences. Our motivation is the realization that, in a first phase, a linear collider is likely to have a center of mass energy of 500 GeV. As a result, one can well imagine that supersymmetry will have been discovered at the LHC, but that we will have only limited information about the spectrum, and a first generation linear collider will have access to only a few of the lightest superpartner states. In many theories these include sleptons. Even with this limited set of states, the observation – or not – of slepton flavor violation will provide important clues to the underlying supersymmetry breaking structure.

The reason that observable sflavor violation at a linear collider is possible is easy to understand. In many proposals to solve the supersymmetric flavor problem, a high degree of degeneracy among sleptons (and squarks) is predicted. As a result, there is the potential for substantial mixing of flavor eigenstates. This can lead to substantial and observable sflavor violation. To be readily observable, it is necessary that mass splittings between the states not be too much smaller than the decay widths, and that the mixing angles not be terribly

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small. In some of these proposals, and in particular gauge mediation, the predicted degree of degeneracy is extremely high, and the mixing probably unobservable. However, in most other proposals, the splittings can be comparable or even larger than the widths, and the mixing angles may be of order the Cabbibo angle or larger. In this case, dramatic collider signatures are possible.

II. MEDIATION MECHANISMS

It is instructive to review the various proposed mechanisms for understanding the suppression of flavor changing processes in supersymmetric theories. We should start by noting that most analyses of collider experiments work in the framework of what has become to known as Gravity Mediation. In such models, one simply assumes exact degeneracy of squarks and sleptons at some very high energy scale. This assumption is not natural since it is violated by quantum corrections (and is in fact scale dependent), and so surely breaks down at some level. Without some theory, or more detailed assumptions, one cannot assess the degree to which this assumption is viable. In other words, degeneracy in this case is a puzzle to be explained rather than a mechanism in itself.

There are a number of more serious proposals of which we are aware for understanding the suppression of supersymmetric contributions to quark and lepton flavor violating processes. These fall into three broad classes. The first are mechanisms which seek to ensure a high degree of degeneracy as the result of dynamics without specific assumptions about flavor. The second are flavor symmetries which enforce either a high degree of degeneracy or alignment of the squark and slepton mass matrices with those of the quarks and leptons. The third invokes heavy superpartner masses to kinematically suppress low energy processes.

- **Gauge Mediation:** In its simplest form, any flavor violation in gauge mediation occurs at a high order in the loop expansion, or due to non-renormalizable operators. In the former case, the suppressions are typically by powers of small Yukawa couplings and extra loop factors. These effects are automatically aligned with flavor violation in the Yukawa sector and are therefore not dangerous and do not give rise to interesting processes. In the latter case, the suppression is by powers of Λ^2/M^2 , where Λ represents some typical scale associated with the supersymmetry-breaking interactions, and M some large scale associated with new physics such as a flavor scale at which flavor is spontaneously broken or the Planck or string scale. For $\Lambda \ll M$ the distinctive feature is the absence of sflavor violating processes.
- **Dilaton Domination:** At weak coupling in the heterotic string there is a regime in which a gravity-mediated spectrum with a high degree of degeneracy is obtained. If the weak coupling picture is valid, one might hope that generic flavor violating corrections to squark and slepton mass matrices are of order α_{GUT}/π . Numerically this is just enough to understand the suppression of flavor changing neutral currents [3]. It suggests that mass splittings among the lightest sleptons will be at least of order a few parts in 10^{-3} . We will see that this is within the range (albeit at the low end) of what one might hope to measure directly at a linear collider. Without further assumptions about flavor, one expects mixings of squarks and sleptons to be of order one. Such a mass splitting is comparable to the expected decay widths of these states, so this sflavor violating mixing might well be observable. In the strongly coupled limit, it seems likely that the violations of degeneracy are larger [4].
- **Anomaly Mediation:** The anomaly-mediated hypothesis superficially has some features in common with gauge mediation. However, the mediation scale is now comparable to the Planck scale, and one has to ask about the magnitude of flavor violating corrections to squark and slepton mass matrices. It has been argued that brane world realizations of supersymmetry breaking might naturally provide a context for anomaly mediation with small corrections to degeneracy [5]. However, anomaly mediation turns out not a robust feature of brane world supersymmetry breaking, and violations of degeneracy are generally large [4]. Still, the degeneracy might be small enough to suppress low energy flavor violating processes in very special circumstances.
- **Gaugino Domination (and the closely related idea of gaugino mediation):** With no-scale boundary conditions one assumes that scalar masses vanish or are very small compared to gaugino masses at the high messenger scale. Without a detailed underlying model, it is hard to know how large the violations of degeneracy might be at this scale, but it seems reasonable to suppose that at the high scale, the magnitude of the squark and slepton mass matrices are suppressed relative to gaugino masses by an amount of order α_{GUT}/π . At lower scales, renormalization group evolution gives a flavor independent gaugino mass contribution to slepton masses which leads to a high degree of degeneracy. As in the case of dilaton domination, without further assumptions about flavor, the violations of degeneracy are expected to be maximally flavor violating, and to lead to large mixings in the high scale squark and slepton masses which in turn leads to large mixings at the electroweak scale.

- **Conformal Sequestering:** Another possibility for obtaining a high degree of degeneracy is to postulate that the first two generation squarks and sleptons are coupled to an approximately conformal sector over a few orders of magnitude in renormalization group evolution [6]. This has the effect of exponentially suppressing squark and slepton masses as well as fermion Yukawa couplings. Below this approximately conformal range of scales further renormalization group evolution gives a flavor independent gaugino mass contribution to slepton masses which leads to a high degree of degeneracy much as with no-scale boundary conditions. Violations of conformal invariance by standard model gauge interactions limit the degree of slepton degeneracy to roughly $\alpha_W/\pi \sim 10^{-2}$. Without further assumptions about flavor in the high scale theory above the approximately conformal scale, slepton mixings are related to ratios of lepton masses by roughly $\sin \phi_{ij} \gtrsim \sqrt{m_{\ell_i}/m_{\ell_j}}$.
- **Non-Abelian Flavor Symmetries:** If the explanation of squark and slepton degeneracy lies in non-abelian flavor symmetries, it is reasonable to expect that violations of degeneracy are correlated with the values of quark and lepton masses and the KM angles. In this case, one might hope to obtain tighter predictions in a given model for the pattern of flavor violation in the slepton sector. The level of degeneracy is model dependent, but again a few parts times 10^{-3} is a reasonable expectation for the violations of degeneracy, with values for the mixings of order Cabibbo angles $\sin \phi_{ij} \sim \sqrt{m_{\ell_i}/m_{\ell_j}}$ [7].
- **Abelian Flavor Symmetries:** As an alternative to degeneracy among squarks and sleptons, it has been suggested that the squark and slepton mass matrices might be approximately aligned with the quark and lepton matrices [8]. This can come about in theories with Abelian (discrete) flavor symmetries. In this case, one does not expect any approximate degeneracy among sleptons. In order to suppress flavor changing lepton decays the mixings need to be somewhat small. Still, the mixing can be large enough, in particular for mixing involving taus, such that sflavor violation can be observable at colliders.
- **First Two Generations Heavy:** Another possibility to suppress dangerous levels of supersymmetric contributions to low energy quark and lepton flavor violation is to postulate that the superpartners are very heavy. The first two generation squarks and sleptons can have masses up to of order 20 TeV without introducing significant tuning of electroweak symmetry breaking [9]. In this case only the (mostly) stau slepton(s) would be kinematically accessible at future colliders. Without additional assumptions about flavor, naturalness of the full slepton mass matrix implies that mixing of this light state(s) among the flavor eigenstates would be of order m/M where m and M are the light and heavy slepton masses.

In sum, of the various proposals to understand the absence of flavor violation at low energies, several predict dramatic violations of flavor at colliders. Among those which don't, there tend to be distinctive predictions for the spectrum. Models of gauge mediation, for example, tend to be highly predictive. While there is no one compelling model of this type, many models exist, and one can imagine detailed measurements distinguishing between them. In the case of alignment mechanisms, while there should flavor mixing it will not be so dramatic, one should observe correlations between the squark and slepton and the ordinary quark and lepton masses.

In the case of non-Abelian flavor symmetries, not only does one expect significant mixing, but one can hope to obtain, given some assumptions about the form of flavor symmetry breaking, precise predictions for some of the violations of flavor symmetry. Moreover, these are likely to be correlated with quark, lepton and neutrino mass matrices. In such a case, precision measurements might ultimately permit distinguishing between different models. Clearly, all of these are directions for further theoretical work, but the discovery of supersymmetry and unraveling the pattern of symmetry breaking would provide important insights into the nature of physics at very high energy scales. The observation of flavor violation – or its absence – at linear colliders will provide important clues to the nature of the underlying mechanisms of supersymmetry breaking and mediation.

III. SFLAVOR OSCILLATIONS OF UNSTABLE SLEPTONS

Slepton flavor oscillations arise if the sleptons mass eigenstates are not flavor eigenstates. Consider for simplicity the case in which leptons are produced initially in flavor eigenstates. If the mass eigenstates have distinct mass, then the flavor eigenstate oscillates in time and space with a frequency given by the mass splittings. If the slepton decay rate is much smaller than the mass splitting, oscillations average out and the probability of decay from a given flavor eigenstate is given simply by mixing angles, as implicitly assumed previously [1]. If the slepton decay is rapid compared with the oscillation frequency then the probability of decay to another flavor eigenstate is suppressed [2]. There are additional effects which can affect the flavor violating decay probability. First, different flavor eigenstates need not have the same decay width. This is particularly true for the $\tilde{\tau}$ slepton which can have a non-trivial decay amplitude to the Higgsino component of a neutralino at moderate to large $\tan \beta$. In addition, the probability amplitude or cross section for production of different mass eigenstates need

not be equal. This is potentially important in S -wave processes such as $e^-e^- \rightarrow \tilde{\ell}^-\tilde{\ell}^-$ near threshold due to finite mass differences. Both of these effects might in principle enhance flavor violating effects in decays, and are considered below.

For simplicity throughout we consider the two flavor CP conserving case with flavor and mass eigenstates related by

$$|\tilde{e}\rangle = c|1\rangle + s|2\rangle, \quad |\tilde{\mu}\rangle = -s|1\rangle + c|2\rangle \quad (\text{III.1})$$

where c and s are complex numbers that satisfy $|c|^2 + |s|^2 = 1$. (Only in the limit where the width difference is neglected s and c can be chosen to be real, thus getting their regular interpretations as a sine and a cosine of an angle.) The other relevant physical dimensionless parameters characterize the ratio of mass splitting or oscillation frequency to decay width, the relative width difference of the mass eigenstates, and the relative rate or cross section for production of the mass eigenstates

$$x \equiv \frac{\Delta m}{\Gamma}, \quad y \equiv \frac{\Delta\Gamma}{2\Gamma}, \quad z \equiv \frac{\Delta\sigma}{2\sigma} \quad (\text{III.2})$$

where Δm and $\Delta\Gamma$ are the mass and width differences of the two mass eigenstates, and Γ is their average width. σ_i is the cross section to produce the i th mass eigenstate, and

$$\sigma = \frac{\sigma_1 + \sigma_2}{2}, \quad \Delta\sigma = \sigma_2 - \sigma_1. \quad (\text{III.3})$$

The case $x = y = z = 0$ was considered in [1] while $y = z = 0$ with x arbitrary was considered in [2]. In the first subsection below, the flavor decay probability is derived for small but non-vanishing x , y , and z . In the next subsection the decay probability for small x and y is shown to depend directly on the off-diagonal slepton mass squared mixing, as required in this limit. In the final subsection, estimates of the widths are given.

A. Decay Probability

The probability for an initial selectron state to decay as a smuon state, $P(\tilde{e} \rightarrow \tilde{\mu})$, may be calculated from the time evolution of the state. A selectron flavor state produced at time $t = 0$ is a linear combination of mass eigenstates

$$\psi(t=0) = N [\sigma_1 c|1\rangle + \sigma_2 s|2\rangle] = N [\sigma|\tilde{e}\rangle - \Delta\sigma|\tilde{\mu}\rangle], \quad (\text{III.4})$$

where the normalization factor is

$$N = (c^2\sigma_1^2 + s^2\sigma_2^2)^{-1/2} \quad (\text{III.5})$$

and $\sigma_i \equiv \sigma_i/\sigma$ are the dimensionless cross sections. The factors of σ_i in the relative amplitudes account for the possibility that the cross section for each mass eigenstate is distinct; for example, from mass difference effects near threshold. Using the standard oscillation formalism the time evolution formula for a selectron initial state is

$$\psi(t) = N [c\sigma_1 e^{-i\mu_1 t}|1\rangle + s\sigma_2 e^{-i\mu_2 t}|2\rangle], \quad (\text{III.6})$$

where

$$\mu_i = m_i - i\Gamma_i/2 \quad (\text{III.7})$$

and m_i (Γ_i) is the mass (width) of the i th mass eigenstate. The time dependent oscillation probability is given by

$$P(\tilde{e} \rightarrow \tilde{\mu})[t] = \frac{|\langle\tilde{\mu}|\psi(t)\rangle|^2}{|\langle\psi(t)|\psi(t)\rangle|^2} \quad (\text{III.8})$$

so that the projection onto the smuon flavor eigenstate is

$$|\langle\tilde{\mu}|\psi(t)\rangle|^2 = N^2 c^2 s^2 [\sigma_2^2 e^{-\Gamma_2 t} + \sigma_1^2 e^{-\Gamma_1 t} - 2\sigma_1\sigma_2 e^{-\Gamma t} \cos(\Delta m t)] . \quad (\text{III.9})$$

After integration over time from zero to infinity

$$\int_0^\infty dt |\langle \tilde{\mu} | \psi(t) \rangle|^2 = N^2 c^2 s^2 \left[\frac{\sigma_2^2}{\Gamma_2} + \frac{\sigma_1^2}{\Gamma_1} - \frac{2\sigma_1\sigma_2\Gamma}{\Delta M^2 + \Gamma^2} \right], \quad (\text{III.10})$$

and

$$\int_0^\infty dt |\langle \psi(t) | \psi(t) \rangle|^2 = N^4 \left[\frac{s^4\sigma_2^4}{\Gamma_2} + \frac{c^4\sigma_1^4}{\Gamma_1} + \frac{2c^2s^2\sigma_1^2\sigma_2^2}{\Gamma} \right]. \quad (\text{III.11})$$

Then the time integrated oscillation probability is

$$P(\tilde{e} \rightarrow \tilde{\mu}) = \frac{|cs|^2}{N^2} \left(\frac{\sigma_2^2}{\Gamma_2} + \frac{\sigma_1^2}{\Gamma_1} - \frac{2\sigma_1\sigma_2\Gamma}{\Delta M^2 + \Gamma^2} \right) \times \left(\frac{|s|^4\sigma_2^4}{\Gamma_2} + \frac{|c|^4\sigma_1^4}{\Gamma_1} + \frac{2|cs|^2\sigma_1^2\sigma_2^2}{\Gamma} \right)^{-1}. \quad (\text{III.12})$$

It is useful to expand P in the (presumably) small parameters, x , y and z . To lowest order

$$P(\tilde{e} \rightarrow \tilde{\mu}) = 2c^2s^2 [x^2 + y^2 + 2z^2 - 2zy] \quad (\text{III.13})$$

The oscillation probability in this limit is quadratic in all three small parameters. The x^2 term describing the effect of finite mass difference is the lowest order form of the effect discussed in [2]. The y^2 term describing the effect of a width difference between the two mass eigenstates parametrically plays a similar role as x^2 , as is well known from the D -meson system. The z parameter describes the effect of the difference of production probability for the two mass eigenstates. This effect has never been mentioned in the context of meson mixing, since there it is always completely negligible. As discussed below, also in the present case of slepton production, its effect is somewhat smaller than the effects of x and y .

We first consider the possible effect of the z parameter. Ignoring the decay width, the cross section for $e^-e^- \rightarrow \tilde{\ell}^- \tilde{\ell}^-$ is S -wave and proportional to the final state velocity β near threshold. Far above threshold, where the cross section is large, $\beta \rightarrow 1$ and z vanishes. Only near threshold, where the cross section is small, z can be sizeable. The Monte Carlo program Pandora may be used to estimate z . As an example, we considered small mixing angles and took $m_{\tilde{\ell}} = 150$ GeV, $\Delta m = 1$ GeV, $m_{\chi^0} = 100$ and a center of mass energy of 305 GeV, and found $z = 0.13$. Note that in this case $\Gamma = 240$ MeV, so $x \approx 4$, and it is the dominant effect. Also at smaller x the inequality $z < x$ still holds. We conclude that the effect of z is smaller than that of x and y . This is because z is generated only for finite x or y , and in such a way that it is smaller than x and y . Even so, it does increase the flavor violating decay probability somewhat.

B. Calculating x and y

It is instructive to derive the x and y parameters from the general form of the slepton mass matrix including the effects of flavor mixing and decay

$$M = \begin{pmatrix} m_{11} - i\Gamma_{11}/2 & m_{12} - i\Gamma_{12}/2 \\ m_{21} - i\Gamma_{21}/2 & m_{22} - i\Gamma_{22}/2 \end{pmatrix} \quad (\text{III.14})$$

where $m_{21} = m_{12}^*$, $\Gamma_{21} = \Gamma_{12}^*$ and m_{ii} and Γ_{ii} are real. Solving the eigenvalue equation $\det(M - \mu_i) = 0$ gives the mass eigenstates, the mass and width differences, and the mixing angles. The general calculation is not very illuminating, so several simplifying assumptions are employed.

First, we note that in the MSSM there are no flavor violating decays. Thus, we set $\Gamma_{21} = 0$. (This may not be the case in models beyond the MSSM, for example, in supersymmetric models with 4 Higgs doublets, where the Higgs bosons can mediate flavor changing decays.) Second we assume CP conservation and then m_{12} may be taken real. Next, for simplicity, we assume that $m_{11} - m_{22} \ll m_{12}$ and may be approximated by zero. This is because in the opposite limit $m_{11} - m_{22} \gg m_{12}$ the mixing angle is small and we are not interested in that case.

With these assumptions we solve the eigenvalue equation. We define the real parameters $a \equiv m_{11} = m_{22}$, $b = \Gamma_{11}/2$, $d = \Gamma_{22}/2$ and $f = m_{12}$ and find that for $(b - d) > 2f$

$$x = 0, \quad y = \frac{\sqrt{(b-d)^2 - 4f^2}}{b+d}, \quad (\text{III.15})$$

while for $(b - d) < 2f$

$$x = \frac{2\sqrt{4f^2 - (b - d)^2}}{b + d}, \quad y = 0. \quad (\text{III.16})$$

For simplicity for the mixing angles we present results only in some limits. For $(b - d) \gg 2f$ we find

$$c \approx \frac{1}{\sqrt{2}}(1 + i), \quad s \approx \frac{f}{\sqrt{2}(b - d)}(1 - i), \quad (\text{III.17})$$

and for $(b - d) \ll 2f$ we find

$$c \approx s \approx \frac{1}{\sqrt{2}}. \quad (\text{III.18})$$

We see that in the $(b - d) \gg 2f$ limit, where the width difference is large, the mixing angles are suppressed. Actually, the oscillation probability is the same in both limits considered above

$$P \approx 2|cs|^2(x^2 + y^2) \approx \frac{2m_{12}^2}{\Gamma^2}. \quad (\text{III.19})$$

In particular, it does not depend on $\Gamma_{11} - \Gamma_{22}$.

We conclude that no matter if we have large width difference or not, the oscillation probability is determined by the ratio between the off-diagonal mass term and the average width. While we made several assumptions in order to derive the above results, the conclusion is general. Off-diagonal mixing terms in the mass squared matrix must not be too much smaller than the decay widths in order to obtain large violations of flavor in slepton decays.

C. Decay Width

As we saw the relevant parameters that determined the flavor violation oscillation probability are M_{12}/Γ and to some extent also $(\Gamma_{11} - \Gamma_{22})/\Gamma$. While M_{12} , the off diagonal mass difference, is a parameter of the model, the widths are derived from the model parameters. Therefore, below we estimate their sizes.

We start with estimating Γ . For example we consider decays of right handed sleptons. The decay width for a right handed slepton to decay to a Bino through the emission of a lepton is

$$\Gamma(\tilde{\ell}_R \rightarrow \ell_R \tilde{B}) = \frac{\alpha m_{\tilde{\ell}_R}}{2 \cos^2 \theta_W} \left(1 - \frac{m_{\tilde{B}}^2}{m_{\tilde{\ell}_R}^2} \right)^2 \quad (\text{III.20})$$

where α is the fine structure constant evaluated at the slepton mass scale, θ_W is the weak mixing angle, and the lepton mass has been ignored. Numerically, the dimensionless width is

$$\frac{1}{m_{\tilde{\ell}_R}} \Gamma(\tilde{\ell}_R \rightarrow \ell_R \tilde{B}) \simeq 5 \times 10^{-3} \left(\frac{1 - m_{\tilde{B}}^2}{m_{\tilde{\ell}_R}^2} \right)^2 \quad (\text{III.21})$$

For a typical value of $m_{\tilde{B}}/m_{\tilde{\ell}_R} = 0.75$ the dimensionless width is $\Gamma(\tilde{\ell}_R \rightarrow \ell_R \tilde{B})/m_{\tilde{\ell}_R} \simeq 10^{-3}$.

In light of our remarks about the expected degrees of degeneracy in various proposals for supersymmetry breaking, this is a striking number. In some sense, within the range of ideas which have been proposed, a large fraction predict that the splittings should be as large or larger than the width, and thus observable.

Next we consider the possible magnitude of $\Gamma_{11} - \Gamma_{22}$ for slepton production and decay by $\tilde{\ell} \rightarrow \chi \ell$. If $m_{\tilde{\ell}} - m_{\chi}^0 \gg m_{\tau}$, the final state neutralino is pure gaugino, and the sleptons are pure left- or right-handed eigenstates, then the decay is universal and $\Gamma_{11} = \Gamma_{22}$. Universality violation due to phase space can be significant only when the mass splitting between the sleptons and the neutralino is at least comparable to or smaller than the lepton mass. Another effect can be due to significant Higgsino component in χ . The full calculation for $\tilde{\ell} \rightarrow \chi \ell$ for general gaugino-Higgsino mixing can be found in [10]. A very crude estimate in the $\tilde{\tau} - \tilde{\mu}$ case with large $\tan \beta$ is

$$\frac{\Gamma_{11} - \Gamma_{22}}{\Gamma} \sim \frac{Y_{\tau}^2}{Y_{\tau}^2 + 2g_1^2 Z_{1B}^2 / Z_{1h}^2} \quad (\text{III.22})$$

where Z_{1h} and Z_{1B} are the Higgsino and Bino amplitudes of χ , Y_{τ} is the τ Yukawa coupling, and g_1 is the hypercharge coupling. For large $\tan \beta$ and significant Higgsino component in the neutralino $\Gamma_{11} - \Gamma_{22}$ can be large.

IV. CONCLUSIONS

If superpartners are discovered, there is good reason to expect that sleptons will have a high degree of degeneracy which enhances sensitivity to sflavor violating effects. It is quite possible then that significant sflavor violation could be observed at a linear collider. The observation – or non-observation – of such sflavor breaking would provide important indirect clues about flavor and supersymmetry physics at potentially extremely high energy scales.

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