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Radiatively Corrected Chargino Pair Production at LEP2[†]

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Abstract

One-loop radiative corrections to the production cross section of a pair of light charginos in e^+e^- colliders are calculated within the MSSM. Top and bottom quarks and squarks are considered in the loops, and they are renormalized using the \overline{MS} scheme. If the center of mass energy is equal to 192 GeV, positive corrections typically of 10% to 15% are found when the squark mass parameters are equal to 1 TeV.

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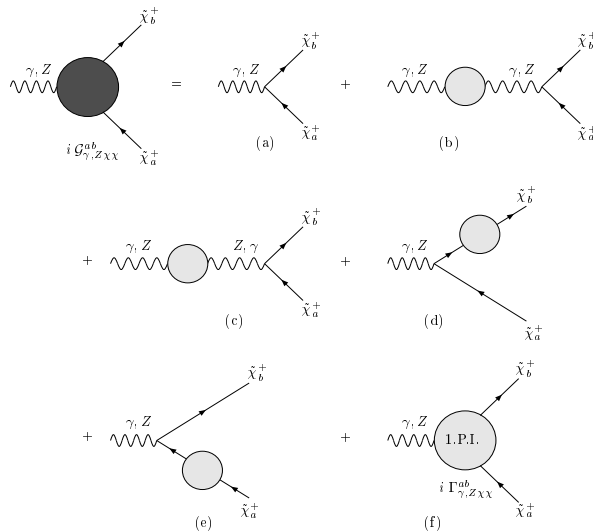


Figure 1: One-loop renormalized $\gamma\chi_b^+\chi_a^-$ and $Z\chi_b^+\chi_a^-$ vertex functions.

In the Minimal Supersymmetric Standard Model (MSSM), the supersymmetric partners of the charged Higgs and the W gauge bosons mix to form a set of two charged fermions called charginos. Experimental searches for charginos at LEP2 have been negative so far, and lower bounds on the lightest chargino mass have been set. The bound depends mainly on the sneutrino mass and the mass difference between the chargino and the LSP $\Delta m = m_{\chi_1} - m_{\chi_1^0}$. ALEPH has found that $m_{\chi_1} > 85$ GeV for $m_{\tilde{\nu}_e} > 200$ GeV [1]. DELPHI's bound corresponds to $m_{\chi_1} > 84.3$ GeV for $m_{\tilde{\nu}_e} > 300$ GeV and $\Delta m > 10$ GeV [2]. A lower bound of $m_{\chi_1} > 85.5$ GeV was found by L3 for $m_{\tilde{\nu}_e} > 300$ GeV [3]. Finally, OPAL has found that if $\Delta m > 10$ GeV then $m_{\chi_1} > 84.5$ GeV if $m_0 > 1$ TeV and $m_{\chi_1} > 65.7$ GeV for the smallest m_0 compatible with current limits on sneutrino and slepton masses [4].

In the Born approximation, chargino masses and mixing angles in the MSSM depend only on the $SU(2)$ gaugino mass M , the ratio between Higgs vacuum expectation values $\tan\beta$, and the supersymmetric Higgs mass parameter μ . Much can be learned about these parameters from an accurate measurement of the total chargino production cross section and masses in e^+e^- colliders, and also about the rest of the supersymmetric particles in the case of MSSM-SUGRA [5]. Nevertheless, for this to work, accurate experimental measurements must be accompanied by precise theoretical calculations. In this talk we report on a recent calculation of the one-loop corrections to the total production cross section of a pair of charginos in e^+e^- colliders [6].

Charginos are produced in the s-channel with intermediate Z bosons and photons,

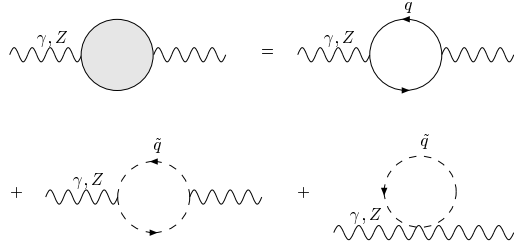


Figure 2: Top and bottom quark and squark contributions to the unrenormalized Z and γ self-energies and to the $Z - \gamma$ mixing.

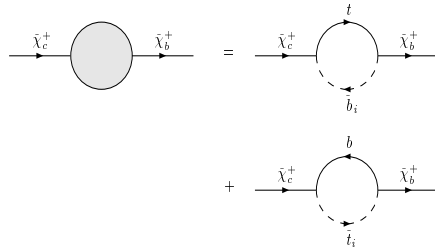


Figure 3: Feynman diagrams contributing to the unrenormalized chargino two-point functions (self-energies and mixing).

and in the t -channel with intermediate electron sneutrino. In our approximation only $Z\tilde{\chi}^+\tilde{\chi}^-$, $\gamma\tilde{\chi}^+\tilde{\chi}^-$, $e^+\tilde{\nu}_e\tilde{\chi}^-$, and $e^-\tilde{\nu}_e\tilde{\chi}^+$ vertices are renormalized. We denote these one-loop renormalized total vertex functions $i\mathcal{G}_{Z\chi\chi}^{ab}$, $i\mathcal{G}_{\gamma\chi\chi}^{ab}$, $i\mathcal{G}_{\tilde{\nu}_e e\chi}^{+b}$, and $i\mathcal{G}_{\tilde{\nu}_e e\chi}^{-a}$ respectively. The first two total vertex functions are given in Fig. 1, where we have the following contributions: (a) tree level, (b) gauge boson self energies, (c) $Z - \gamma$ mixing, (d)–(e) chargino self energy and chargino mixing, and (f) the 1PI triangular diagrams. The two total vertex functions involving sneutrinos are simpler because they receive contributions only from the tree level vertex and chargino self energy and mixing, and we do not display them.

One-loop diagrams contributing to the gauge boson self energies and $Z - \gamma$ mixing can be seen in Fig. 2. The first diagram corresponds to quarks and the second two diagrams correspond to squarks. Similarly, in Fig. 3 we display the diagrams contributing to chargino self energies and mixing. They involve top–bottom and bottom–stop loops. Finally, 1PI triangular diagrams are shown in Fig. 4. All diagrams in Figs. 2 to 4 have been calculated [6] in terms of Passarino–Veltman’s functions [7]. We have used the \overline{DR} scheme, which in our approximation is completely equivalent to the \overline{MS} , and taken $Q = m_Z$ as the subtraction point.

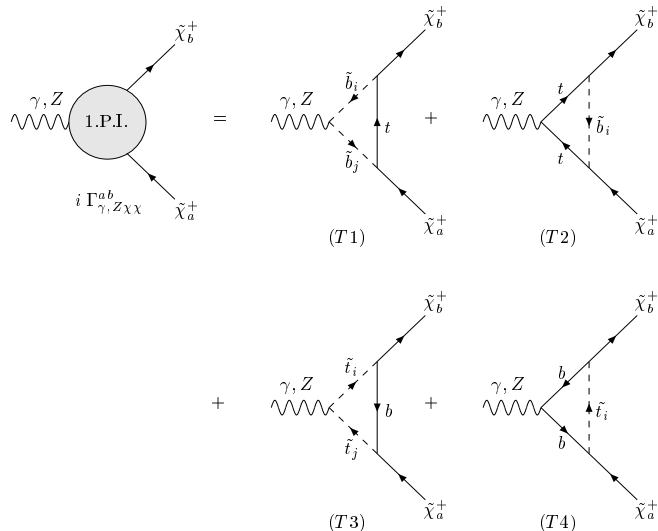


Figure 4: Unrenormalized one-particle irreducible triangular diagrams contributing to renormalization of the $Z\tilde{\chi}^+\tilde{\chi}^-$ and $\gamma\tilde{\chi}^+\tilde{\chi}^-$ vertices.

In Fig. 5 we have plot the tree-level and renormalized one-loop total production cross section of a pair of light charginos as a function of the gaugino mass M , while keeping constant the chargino mass $m_{\chi_1^\pm} = 90$ GeV, the sneutrino mass $m_{\tilde{\nu}_e} = 100$ GeV, and $\tan\beta = 10$. We consider the case $\mu < 0$ and a center of mass energy $\sqrt{s} = 192$ GeV, relevant for LEP2. The tree level cross section decreases from 1.6 pb. when $M = 500$ GeV to a minimum of 0.22 pb. at around $M = 105$ GeV, and grows again up to 0.34 pb. at $M = 90$ GeV. Below this value of the gaugino mass M there is no solution for $\mu < 0$ which gives $m_{\chi_1^\pm} = 90$ GeV. Radiative corrections to this cross section are parametrized by the squark soft masses which we take degenerate $M_Q = M_U = M_D$, and by the trilinear soft mass parameters $A \equiv A_U = A_D$, also taken degenerate. This choice is done at the weak scale and it is made for simplicity. Three radiatively corrected curves are presented given by $M_Q = A = 200$ GeV (dots), $M_Q = A = 600$ GeV (dashes), and $M_Q = A = 1$ TeV (dotdashes).

We observe from Fig. 5 that radiative corrections are positive and grow with the squark mass parameters. For M close to 90 GeV the corrections are only of a few percent, but they grow fast until a maximum of 21% at $M = 140$ GeV. For larger values of the gaugino mass, the corrections slowly decrease until they reach the value 6% at $M = 500$ GeV. A logarithmic growth of quantum corrections with the squark mass parameters is observed, as it should be. It is worth pointing out that the value of μ is not constant along the curves because it is fixed by the constant value of the chargino mass $m_{\chi_1^\pm}$.

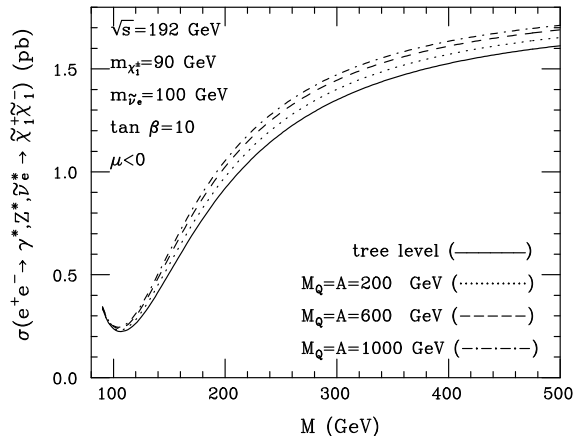


Figure 5: One-loop and tree level chargino production cross section as a function of the $SU(2)$ gaugino mass M , for 192 GeV center of mass energy.

In summary, if charginos are discovered much information can be learned from the measurements of the total production cross section and masses. Nevertheless it is essential to have a precise theoretical calculation of these observables. In this sense, one-loop radiative corrections must be included. We have found that for LEP2 energies they are typically 10% to 15% and can reach up to 30% if the squark masses are equal to 1 TeV.

Acknowledgments

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