Home-exam FYS5190 Supersymmetry

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Abstract

This is the home-exam for FYS5190 for the fall of 2011. The exam counts as 20% of the final grade for the course. Please limit your answers to four pages maximum showing only as much details as necessary, and no touching the layout! Send me a pdf-version of your answer by Monday the 30th of October.

1 Problems

In the following assume the mass hierarchy $m_{\tilde{\chi}_2^0} > m_{\tilde{\ell}_L} > m_{\tilde{\chi}_1^0}$, and that all other sparticles are heavier than $\tilde{\chi}_2^0$ and can effectively be ignored. Assume that all leptons ℓ are massless. For Feynman rules and details on conventions, a useful guide is found in the appendices of [1].

a) Calculate the width of the decay $\tilde{\chi}_2^0 \to \tilde{\ell}_L^{\pm} \ell^{\mp}$.

b) Calculate the width of the decay $\tilde{\ell}_L^{\pm} \to \tilde{\chi}_1^0 \ell^{\pm}$.

c) Calculate the width of the decay $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \ell^{\pm} \ell^{\mp}$ via $\tilde{\ell}_L$ in the *narrow width approximation* $\Gamma \ll M$ and $\Gamma \to 0$, *i.e.* where the intermidate (scalar) propagator

$$D(q^2) \equiv \frac{i}{(q^2 - M^2) + iM\Gamma}, \tag{1}$$

when squared reduces to

$$|D(q^2)|^2 \simeq \frac{\pi}{M\Gamma} \delta(q^2 - M^2). \tag{2}$$

d) Calculate the decay $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \ell^{\pm} \ell^{\mp}$ via Z. Compare to the result in problem c. What decides which process is dominant?

e) Find the differential decay width $\frac{d\Gamma}{dm_{\ell\ell}}$ as a function of $m_{\ell\ell}$, where $m_{\ell\ell}$ is the invariant mass of the lepton pair from the decay in problem c. Assume that we can identify the lepton from the decay of $\tilde{\chi}_2^0$ into the slepton as being positively charged, what happens to the distribution? Does this make sense?

f) Find the differential decay width $\frac{d\Gamma}{dm_{\ell\ell}}$ with the full propagator. Compare to the narrow width approximation in problem e, and in particular comment on the mass choice $m_{\tilde{\ell}_L} = \sqrt{m_{\tilde{\chi}_2^0} m_{\tilde{\chi}_1^0}}$.

References

[1] H. E. Haber, G. L. Kane, Phys. Rept. **117** (1985) 75-263.