TRIUMF Summer Institute 2009

Questions for "Beyond the Standard Model at Colliders" lecture 2

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1. Consider pair production of sleptons $\widetilde{\ell}_R$ at the ILC, with decays to the corresponding lepton and the lightest neutralino $\widetilde{N}_1$:

$$e^+e^- \to \widetilde{\ell}_R\widetilde{\ell}_R \to \ell^+\widetilde{N}_1\ell^-\widetilde{N}_1.$$

   Use conservation of relativistic momentum and energy to derive the formula for the energy of one of the leptons in the centre-of-mass frame (set m_ℓ to zero):

$$E_\ell^{\rm CM} = \frac{M^2_{\widetilde{\ell}_R} - M^2_{\widetilde{N}_1}}{4M^2_{\widetilde{\ell}_R}} \left(\sqrt{s} + \sqrt{s - 4M^2_{\widetilde{\ell}_R}}\cos\theta^*\right),$$

   where $\cos\theta^*$ is the angle, in the $\widetilde{\ell}$ rest frame, between the direction of the $\widetilde{\ell}$ motion and the emission angle of its daughter lepton. The collider centre-of-mass energy is denoted $\sqrt{s}$ as usual. This formula gives the maximum [$\cos\theta^* = 1$] and minimum [$\cos\theta^* = -1$] lepton energies (endpoints) in terms of the SUSY particle masses. *[Hint: start in the rest frame of one of the sleptons.]*

2. Calculate the masses of the Kaluza-Klein states for a massless scalar particle propagating in an extra dimension of length L, with periodic boundary conditions. *(Hint: all you need is de Broglie and relativity.)*