ILC Physics Summary:

Supersymmetry, New Physics and the Interface with Cosmology

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Supersymmetry

- One of the major advantages of the ILC is that it will allow several precision studies of TeV-scale supersymmetry, help determine masses, branching ratios and supersymmetric parameters to a degree of accuracy that may help pinpoint the underlying mechanism of supersymmetry breaking.
- **A. Frietas**
  A fundamental relation in SUSY is that between the gauge and the Yukawa coupling:

$$\text{Gauge coupling } g = \text{Yukawa coupling } \hat{g} \tag{1}$$

- Testing these relations via precise cross-section measurements is very important.
- For example, selectron production at ILC and their decays into neutralinos can be studied and polarisation allows us to disentangle SU(2) and U(1) couplings and provides a measurement of these couplings to better than 1%.
- Things are more complicated with SU(3) at ILC because to produce coloured states one needs reactions like $e^+e^- \rightarrow \tilde{q}\tilde{q}g$. Small rates unless we have 2 TeV at ILC.
- OR, one can do a combined LHC/ILC analysis: study production of squarks and their decays through charginos at the LHC and input values of squark and chargino/neutralino BRs measured precisely at the ILC. This method gives a test of the strong coupling identity down to a 4% level.

- **S. Heinemeyer**
  Precision electroweak data and rare processes yield a relatively low scale of soft supersymmetry breaking ($m_{1/2} \sim 300 - 600$ GeV).

- Following models have been studied:

  1. CMSSM: universality of scalar masses, gaugino masses and trilinear parameters at the input GUT scale
  2. NUHM: soft susy breaking scale masses for the two Higgs doublets are not universal
  3. VCMSSM: CMSSM with additional relations between the soft tri- and bi-linear SUSY parameters
  4. GDM: MSUGRA-inspired but with a gravitino LSP.

- $m_{1/2}$ is rather constrained $\rightarrow$ light sparticles observable at the LHC and ILC in CMSSM, VCMSSM and GDM.

- m_0 values in NUHM could be considerably larger and make production of sparticles at ILC at least at 500 GeV could be difficult.

- bf M. Guchait
  Study of $e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1$ with $\tau_1 \to \tau\chi_1^0$.
- The composition of χ_1^0 determines the polarisation of the τ:
  1. MSUGRA: $P_\tau = +1$
  2. Non-universal SUGRA: $P_\tau = \cos^2\theta_\tau - \sin^2\theta_\tau$
  3. AMSB: $P_\tau = -1$
  4. GMSB: $P_\tau = \sin^2\theta_\tau - \cos^2\theta_\tau$
- Possible to distinguish different SUSY models by measuring P_τ.
- Determination of SUSY parameters also possible.

- **P.N. Pandita**
  Implications of non-universal neutralino masses in SUSY GUTs for neutralino masses and relations as well as Higgs production and decay processes.
- Upper bounds on neutralino masses and sum rules for neutralino-chargino mass relations are obtained. Masses have significant dependence on the representation of the GUT group.
- These relations can be probed in the decays of neutralinos and higgs at the ILC.

- **A. Sopczak**
  The process $e^+e^- \rightarrow \tilde{t}_1\tilde{t}_1 \rightarrow c\chi_1^0 c\chi_1^0$ is studied in the case where the stop-neutralino mass difference is small.

- Scenario motivated by SUSY Dark Matter studies where the DM precision determination is dependent on the scalar mass determination.

- A Iterative Determinant analysis method is used to weight each even in such a way as to optiize signal to background.

- For a 122 GeV stop and 107 GeV neutralino and 50 fb^{-1} luminosity and 50% efficiency 560 signal and 200 background events are estimated using the ID analysis.

- This goes towards a precise determination of the stop mass.

- **Sefkow**
  This is a proposal to look for dark matter at colliders via $\tilde{\tau}_1 \to \tau\tilde{G}$, in a model where the gravitino LSP is the DM candidate. The same can be done with the other sleptons.

- Copious $\tilde{\tau}_1$ production at ILC yields a very precise determination of the $\tilde{\tau}$ parameters.

- The results are:
  $\delta m_{\tilde{\tau}} \sim 10^{-3}$
  $\delta t_{\tilde{\tau}} \sim 10^{-2}$
  $\delta m_{\tilde{G}} \sim 10^{-1}$

Extra Dimensions

- **N. Okada**
  Low-scale SUSY breaking scenario is investigated. SUSY breaking in this model is mediated by low-scale gravity in warped extra dimension.
- Warping brings down the SUSY breaking scale Λ to the 1 – 10 TeV range.
- Hidden sector becomes visible due to strong interaction with the visible sector fields.
- Production of hidden sector fields, X, at collider energies becomes possible.
- Production and decay of X at LHC and ILC has been studied and the phenomenology is very similar to radion phenomenology.
- A 1 TeV ILC should probe via $e^+e^- \to ZX$ masses of X $\sim\ 1.85$ TeV.

- **G. Bhattacharyya**
  UED models with a 5th dimension compactified on a S_1/Z_2 orbifold is considered. KK number conservation in the model yields a LKP which is γ_1.
- The KK excitation of the electron E_1 has a mass equal to that of the γ_1 but the degeneracy is lifted by radiative corrections.
- $e^+e^- \to E_1^+E_1^-$ is studied with $E_1 \to e\gamma_1$. This decay proceeds with a 100% BR.
- KK electrons give forward peaked events due to t-channel dominance $\to$ Large FB asymmetries.
- Angular distributions at ILC will yield precise information on these KK states.

Interface with Cosmology

- **M. Peskin/J. Hewett**
  How to use the ILC to identify the DM particle and to infer DM properties from the measured particle spectrum and cross-sections.
- MSSM study with 24 independent parameters
- Scans of 24-dim space done using MCMC for 4 SUSY points (LCC1 – LCC4) of the LC/Cosmology study group.
- Masses and splittings in typical examples have errors smaller by a factor of 3 – 10 compared to LHC errors.
- Also polarisation at ILC may help resolve multiple solution ambiguities prevalent at the LHC (bino, wion, higgsino like LSP).
- Rate of production of gamma rays in galactic halos is proportional to dark matter annihilation. Determination of the annihilation cross-section allows a model independent determination of dark matter density.
- A case for a 1 TeV ILC is very strong.

- **S. Matsumoto**
  Dark matter annihilation into e^+e^- yields cosmic positron signals which can be probed in experiments like Pamela and AMS-2.
- If DM is detected in these experiments it will allow for mass determination.
- Signal guarantees ILC will see $\gamma+$ DM pair production leading to spin and properties determination of dark matter at ILC.