Supersymmetry - Experimental Issues and Developments

Abstract

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1 Motivation for SUSY[1]

There are a variety of currently unexplained pieces of physics which appear to be explainable by postulating the existence of supersymmetry in nature.[2]

These include the convergence of the electromagnetic, weak and strong coupling constants at very high energy. If SUSY is excluded from the calculations, it seems that the coupling constants, though coming close, don't converge. On the other hand if SUSY is included in the calculations, the coupling constants do converge.[3]

The muon magnetic moment is found to differ from a theoretically calculated value by a small amount[3]. A simple argument given by Dirac for the electron, when applied to the muon gives the magnetic moment to be 1. When QED corrections are included to account for 'shielding' by virtual particles in the vacuum continuously appearing and disappearing the value is still close to 1 but is inconsistent with current experimental results. If SUSY particles are included in the calculation then theory agrees much better with experiment.[5]

The lightest supersymmetric particle (LSP) is a candidate for cold dark matter. If R-parity is conserved then SUSY particles can only decay to other SUSY particles so the lightest SUSY particle must be stable since it has nothing to decay into (This is similar to the electron being stable since it is the lightest charged particle).

No direct experimental evidence of any SUSY particle has yet been found, but mainly based on non-observation of SUSY particles limits can be set on their masses.

2 WMAP

The Wilkinson Microwave Anisotropy Probe has recently set limits on the mass of the LSP $(M_{\chi_1^0} \leqslant 400-500\, GeV)$ in the constrained minimal supersymmetric standard model (CMSSM)[6].

3 LEP

The LEP experiment based in CERN has placed limits on the masses of a number of SUSY particles including the sleptons, for which final results are available - $M_{\tilde{e}} > 99.9\, GeV$, $M_{\tilde{\mu}} > 96.6\, GeV$ and $M_{\tilde{\tau}} > 92.6\, GeV$.[7]

They have searched for sleptons produced in pairs from an electron-positron collision mediated by an excited Z. It is then expected that the slepton would decay into a lepton and the LSP. Since the LSP would not be detected in any detectors, the signal for this event is a large missing energy.

4 Tevatron

There are two experiments at the Tevatron[8] where SUSY searches have been carried out: CDF and D0. Searches have been carried out[9] for, amongst other things, bottom squarks via $\tilde{b} \rightarrow \tilde{\chi}_1^0 + b$, photon plus missing energy searches which may indicate $NLSP \rightarrow LSP + \gamma$ and also searches for R-parity violation.

5 LHC

There are two general purpose detectors – CMS[10] and ATLAS[11] – which will be looking for SUSY particles when the LHC starts in CERN in 2007. SUSY production is expected to be dominated by gluino and squark production with a cross section comparable to the jet cross section at the same q^2. Again SUSY particles are expected to decay to the LSP which escapes the detector leaving a distinctive signature compared with the standard model background of large missing energy and multiple jets.[12]

6 ILC

The International Linear Collider will probably be the next large particle accelerator built after the LHC. Being a linear electron-positron collider it will be able to be fine tuned to the mass of a particular SUSY particle discovered at the LHC in order to determine its properties very accurately. It provides a clean environment with low background with large electron polarisation[13]. The recent WMAP data has suggested that a 1TeV collider might be sufficient to examine the LSP, whereas previously it appeared that at least a 1.2TeV collider would be needed.

7 References

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