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Is supersymmetry a real symmetry of Nature ? Aspects of supersymmetry breaking.

Supersymmetry (SUSY) was first introduced to address unanswered aspects of the Standard Model of particle physics such as the unification of gauge couplings at high energies. It then proved useful in broader theoretical contexts, from string theory to dark-matter models. SUSY assumes the existence of N symmetries relating fermionic and bosonic fields. When N>1, it is referred to as « extended » SUSY. Supersymmetry predicts additional particles, called superpartners, for each particle of the Standard Model (electrons, muons, quarks ⋯). Superpartners are not observed at our energy scales, therefore SUSY might exist at higher energy but « break » at a certain scale: this phenomenon is called spontaneous symmetry breaking. In analogy to the famous Brout-Englert-Higgs (BEH) mechanism for electroweak symmetry breaking, SUSY breaking models predict the existence of a massless fermion, called Goldstino, for each broken SUSY generator. In this talk, I will discuss models making use of Fayet-Iliopoulos (FI) terms [1] to implement spontaneous breaking. Depending on the context, Goldstini are viewed as superpartners of various bosonic fields (standard model fields, inflation field⋯) and the SUSY breaking scale is related to the corresponding energy scales (electroweak scale, inflation scale⋯). Hence, the study of SUSY breaking contributes to the understanding of the hierarchy between the dark energy, electroweak, inflation or Planck scales. Goldstino dynamics can be described through non-linear formulations of SUSY [2] in which SUSY operators act non-linearly on fields. Recent progress [3] has lead to systematic descriptions of the connection between SUSY breaking models and the low energy dynamics of Goldstini fields. in extended SUSY, « partial » breaking [4] can occur when at least one combination of SUSY generators remains unbroken. Partial SUSY breaking plays an important role in the understanding of D-branes, fundamental string theory objects. In this talk I will first give an overview of SUSY in particle physics, its spontaneous breaking and non-linear realisations. I will then present my work on partial SUSY breaking with a new FI term induced by the « deformation » of N=2 SUSY [5], and its physical consequences [6] in the non-linear SUSY context.

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