Unconventional supersymmetry: Local SUSY without SUGRA

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Eugene Wigner defined particle physics as a study of group representations. Assuming spacetime to be essentially flat and therefore invariant under global (rigid) Poincaré transformations, it was Wigner's genius to observe that elementary particle states must correspond to irreducible representations of the Poincaré group. Hence, the intrinsic particle properties mass and spin (M, J) should correspond to the eigenvalues of the Casimir operators that classify those representations.

In the Standard Model, fundamental interactions result from locally realized internal symmetries (gauge groups). It has been a long-sought idea that spacetime and internal symmetries could be combined in a natural way through a "super" symmetry. The simplest implementation of supersymmetry (SUSY) has two fundamental weaknesses:

a) It predicts for each fermionic matter field a bosonic one in the same gauge representation and with the same mass, and vice-versa;
b) In spite of decades of intensive search, no experimental evidence of SUSY has been found yet.

The fact that no trace of SUSY has been observed so far has been excused by saying that it is a broken symmetry at experimentally accessible energies, but it must be unbroken at sufficiently high energy. A statement of this sort can never be falsified because it can always be said that the energy range for SUSY restoration is such high energy that it remains unobserved, which puts SUSY on a doubtful scientific basis.

In this work, we consider a gauge theory based on a superalgebra that includes an internal gauge symmetry, the local Lorentz invariance and supersymmetry gen-

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erators. The important distinctive features between this theory and standard supersymmetry are:

- The number of fermionic and bosonic states are not necessarily equal.
- There are no fermionic superpartners of gauge bosons (bosoninos), or bosonic partners of matter (s-leptons).
- Although this supersymmetry originates in a local gauge theory and gravity is included, there are no gravitini.
- Fermions acquire mass from the coupling to the background while bosons remain massless.

The existence of bosonic SUSY-invariant vacua depends on the existence of globally defined Killing spinors. Hence the fact that supersymmetry is not manifest in a given situation might be understood as a consequence of the absence of Killing spinors, a contingent phenomenon rather than a mysterious breaking of a local symmetry.

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Further reading and References

The discussion of the SUSY theories described here can be found in the following articles:

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