

Supergravity Theory Encyclopedia Article

Supergravity Theory

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Supergravity Theory

Supergravity theories merge the notions of supersymmetry and gravitation. Supersymmetry requires that every bosonic particle (integer spin) has a fermionic counterpart (half-integer spin) and vice versa. Spin-0 particles (scalars) and spin-1 particles (**vectors**), together with their identical **mass** spin- $\frac{1}{2}$ superpartners, comprise supermultiplets. It is natural to ask whether a gauge transformation can mediate a change from a bosonic degree of freedom to a fermionic one. Such an operation is highly non-trivial. Since spin has units of **angular momentum**, changing the spin of a particle also alters its **space-time** coordinates. In contrast, a gauge transformation within the context of the standard model rephases a field, and this effect is compensated by a shift of the covariant derivative in such a way that the Lagrangian of the theory remains invariant. The key difference here is that the position of the field itself is unchanged.

The general theory of relativity treats the **gravitational force** in terms of the response of **matter** to the curvature of space-time, which in turn results from the presence of matter or **energy**. A gauge transformation in the theory of **gravity** can therefore be thought of as producing a slight displacement in the position of a particle. A theory that allows transitions among particles of different spin must also be consistent with the theory of gravity. In particular, it must include a particle that mediates gravity as a fundamental **force** on an equal footing with the electromagnetic, strong, and weak interactions. That particle is the **graviton**, and it carries spin-2. The supersymmetric partner of the graviton is called a gravitino, and it has spin- $\frac{3}{2}$.

Different supergravity theories are classified by the types of particles in each supermultiplet. The extensively studied N=8 theory, has supermultiplets with particles of all spins between 0 and 2. Because supergravity treats each of the fundamental forces in a similar way, it was initially viewed as a candidate for the so-called *theory of everything*, which would unify all of physics. Unfortunately, infinities in the theory do not completely cancel because gravity is not renormalizable. However, because supersymmetry and supergravity can be extended to a theory with more than four space-time dimensions, these concepts served as an important step towards constructing superstring theory.