Supersymmetry: an exposition for laymen

According to physicists, there are two kinds of matter in our universe: bosons and fermions. Bosons include, among many others, photons (particles of light), W bosons and Z bosons (which mediate weak force), gluons (which mediate strong force), and gravitons (which mediate gravity). Fermions include, among many others, electrons, neutrinos, and quarks. Bosons are described by ordinary numbers and fermions are described by Grassmann numbers. Ordinary numbers have the property that a times b is equal to b times a, while Grassmann numbers have the property that a times b is equal to negative b times a. This implies that a Grassmann number times itself equals zero. For example, a times a would be equal to negative a times a, so a times a must be zero ($0 = -0$).

The theory of supersymmetry says that bosons and fermions form onetoone pairs in our universe,[1] and the name supersymmetry refers to this onetoone symmetry. The theory of supersymmetry first came out in 1971 and has been a very active research area. However, particles discovered so far do not form supersymmetric pairs. In fact, not a single pair has been found. Even so, most physicists believe not that our universe is not supersymmetric, but rather that the level of energy accessible with current accelerators is lower than that required to generate the unknown particles which form supersymmetric pairs with known particles. They expect that these currently unknown particles will soon be found with the LHC (large hadronic collider), which began operation in November 2009.

The theory of supersymmetry is also applied to string theory, the most viable candidate for 'theory of everything.' In fact, the idea of supersymmetry first emerged in the context of string theory. In string theory, supersymmetry is mandatory, because physicists cannot account for fermions without supersymmetry. A string theory without supersymmetry would contain only bosons, in contrast to our universe containing both bosons and fermions. String theory is frequently called superstring theory, with 'super' referring to 'supersymmetry.'

To understand supersymmetry, it is desirable to study one year of quantum field theory as a prerequisite. The most famous book that treats supersymmetry is "Supersymmetry and Supergravity" by Wess and Bagger.

Summary

- There are two kinds of matter in our universe: bosons and fermions.

[1] Here the correspondence is not between individual particles, but between types of particles. For example, when supersymmetry predicts the existence of "selectrons" corresponding to electrons, this is not to say that there must be ten selectrons for every ten electrons, but simply that there must exist a species of particle forming a supersymmetric pair with electrons.

- Bosons are described by ordinary numbers and fermions are described by Grassmann numbers.
- Ordinary numbers satisfy $a \times b = b \times a$.
- Grassmann numbers satisfy $a \times b = -b \times a$. This implies $a \times a = 0$.
- The theory of supersymmetry says that bosons and fermions form onetoone pairs in our universe.