Graviton Encyclopedia Article

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Gravitons are proposed quantum particles that form gravitational fields. Just as electromagnetic fields produce photons, which can be seen with image intensifiers, physicists believe that gravitational fields produce gravitons. However, because the gravitational equations proposed by **Albert Einstein** are nonlinear, unlike the linear electromagnetic particle equations, gravitons cannot (according to current theory) be observed directly. But scientists are convinced that gravitons exist, because their presence leaves perturbations that are observable, even if the particles themselves are not. Gravitons are supposed to have a rest **mass** and charge of zero, and a spin of 2.

Fundamental particles possess intrinsic **angular momentum**, or "spin." Spin is quantized, coming only in either integer or half-integer multiples of Planck's reduced constant (). Particles of half-integer spin are "fermions," while those of integer spin are "bosons." It can be shown that in order to produce a **force**, an exchange particle must be a boson. A **photon** is a spin-1 boson. And finally, electromagnetic fields do not interact with themselves, so a photon has no charge--photons do not couple to photons.

In an analogous manner, in a **quantum field theory** of **gravity** two massive particles interact gravitationally via the exchange of a quantum of the gravitational field--a virtual graviton. Gravitons couple to the source of the **gravitational field**, mass. A graviton is emitted by one massive particle, and absorbed by the other, resulting in the familiar **gravitational force** between the particles.

A graviton's properties are such that its exchange results in the gravitational force. It, too, is massless, as gravity's range is infinite. It is a spin-2 boson; if it were of spin-1, gravity, like the electromagnetic force, could be either attractive or repulsive.

But here a crucial difference between gravitons and photons emerges. Einstein's mass-energy equivalence implies that gravitational potential energy--the **energy** stored in the gravitational field--must *itself* act as a source of that field. Thus, although they possess no mass, gravitons *do* couple to gravitons. It is this self-coupling (among other things) that makes the gravitational field so difficult to quantize. In fact, no fully consistent **quantum theory** of gravity yet exists.