**Feynman Diagrams**

Crisscrossing the entire wall are wavy lines emanating from the Sun, one of which meets a solid line near the lower left corner. These lines are the world-lines of photons, the particles of light. Instead of thinking of a particle as tracing a path in space, in quantum physics one thinks of the entire history of the particle as a line moving back and forth through space-time, its world-line. The solid line represents the world-line of an electron, and each of the two points where it bends represents an elementary interaction, in which the electron emits or absorbs a photon.

These diagrams of solid and wavy lines are known as Feynman diagrams, after the physicist Richard Feynman (1918-1988). He proposed the diagrams, both as a simple way to envision the basic interactions of fundamental physics, and as a set of rules to calculate the amplitudes of quantum processes. The results one gets for the interactions of photons and electrons are among the most precisely tested predictions in all of physics.

Looking more closely at the two interaction vertices, one sees that they are surrounded by a faint pattern of circles connected by curves. This is a string diagram, representing the interactions of superstring theory. According to superstring theory, each of the particles we see, each electron and photon, is actually a tiny loop of “string.” Each of the world-lines entering or exiting the interaction region is replaced by the tube swept out by the corresponding string; in the interaction the tubes join to form a two-dimensional surface, the “world-sheet” of the string, representing its history in space-time.

The relation between the Feynman diagram and the string diagram is the following. Each interaction point of particles becomes a string interaction, which can be pictured as a “pair of pants,’’ with two cylinders (the legs) joining into a single cylinder (the waist). By sewing two pairs of pants together at the waists, leaving four holes for the four legs, one realizes the string diagram depicted here. In string theory, interactions are not special points at which particles are created or destroyed, rather they follow from a continuous change in the topology of the world-sheet.

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