What Is An Elementary Particle?

by STEVEN WEINBERG

WHEN A STRANGER, hearing that I am a physicist, asks me in what area of physics I work, I generally reply that I work on the theory of elementary particles. Giving this answer always makes me nervous. Suppose that the stranger should ask, "What is an elementary particle?" I would have to admit that no one really knows.

Let me declare first of all that there is no difficulty in saying what is meant by a *particle*. A particle is simply a physical system that has no continuous degrees of freedom except for its total momentum. For instance, we can give a complete description of an electron by specifying its momentum, as well as its spin around any given axis, a quantity that in quantum mechanics is discrete rather than continuous. On the other hand, a system consisting of a free electron and a free proton is not a particle, because to describe it one has to specify the momenta of both the electron and the proton—not just their sum. But a bound state of an electron and a proton, such as a hydrogen atom in its state of lowest energy, is a particle. Everyone would agree that a hydrogen atom is not an *elementary* particle, but it is not always so easy to make this distinction, or even to say what it means.

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