Proton Decay Encyclopedia Article

Proton Decay

Contents

Proton Decay

If observed, *proton decay* would serve as a clue to new physical theories. It is not predicted by the Standard Model of **particle physics**, and has not yet been observed. The non-observation of **proton** decay implies a lower limit on the proton lifetime of 10^{31} to 10^{32} years, far older than the age of the **universe**.

The proton is made of two up **quarks** and a down quark, so if the proton decayed it would be due to the decay of one of the component quarks. In the Standard Model, decay of an up quark must result in a down quark in the final state, and vice versa. However, both cases are forbidden by **conservation of energy**. If the lone down quark decayed to an up quark, the resulting particle is called a $(Delta)^{++}$, which has a higher **mass** than the proton; therefore, this decay violates conservation of **energy** and is not allowed. If one of the up quarks decayed to a down quark, the resulting particle would simply be a **neutron**, but the mass of the neutron is slightly greater than that of the proton, so this decay is also not allowed. Therefore, in the Standard Model, the proton is absolutely stable and cannot decay.

Some GUTs, or Grand Unified Theories, predict interactions which allow quarks to decay to purely leptonic final states (that is, states with no quarks). In these theories, the proton is not stable and can decay. The simplest GUT, called SU(5), predicts a maximum lifetime of 10^{30} years, so it is ruled out as a possible theory. More complicated GUTs predict longer lifetimes and are therefore possible.