Subject: Science

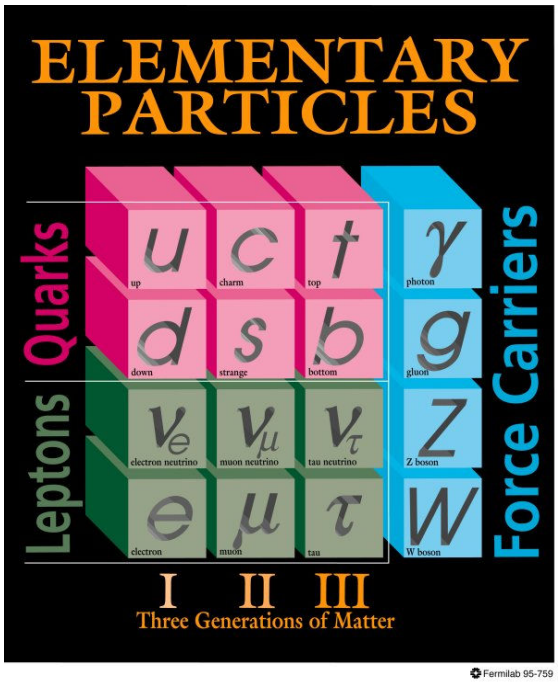
Article: 4

Particles and Anti-Particles

Doç. Dr. Haluk Berkmen

In 1932 Paul Dirac (1902–1984) proposed that there "should exist" electrons with opposite charge and equal mass. Since an electron has a negative charge its antiparticle, the positron, should have a positive charge. The discovery of the positron the same year by Carl Anderson (1905-1991) started a search for antiparticles. In 1955 the antiproton and the antineutron were discovered. We now know that all (or most) particles in the universe have their anti partner.

Particles and antiparticles annihilate each other into a pair of photons or a pair of particles. According to the present Standard Model there are two types of particles. A) **Matter particles** and B) **Force carrier particles**, as shown on the Table below.



The Quarks are responsible for Strong Interactions and the Leptons for Weak Interactions. According to this model all matter particles have their antiparticle, but force carriers are their own antiparticle. Thus the antiparticle of the photon and of the Graviton does not exist.

In our universe all particles move slower than light. According to the Special Theory of Relativity the ultimate speed that a particle can attain is the speed of light. No material particle or force carrier particle can move faster than the speed of light. But recently scientists at CERN have detected neutrinos travelling at a speed faster than the speed of light. They calculated that the neutrinos traveled faster than the speed of light by a fraction 20 parts per million. This means that neutrinos were travelling 299,798,454 m/s instead of 299,792,458 m/s, which is the speed of light.

Antineutrinos are created during the decay of a free neutron together with an electron and a proton, as shown below.

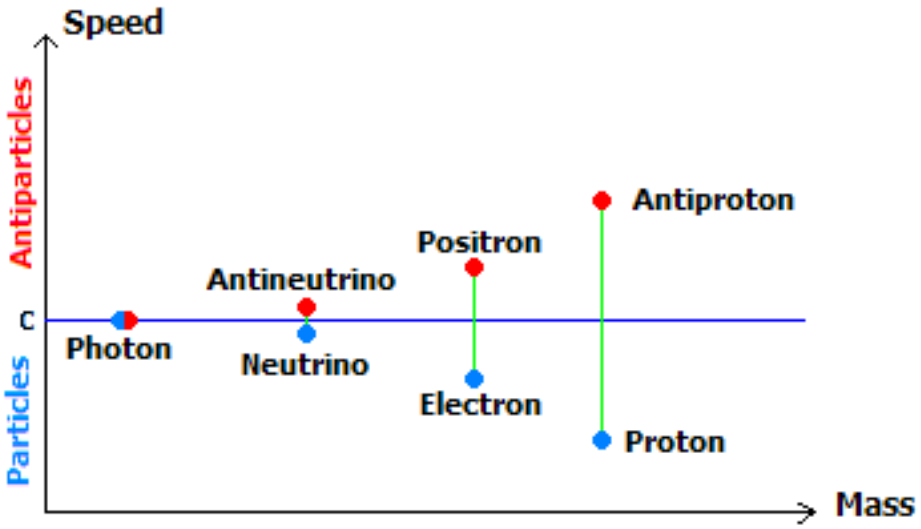
$$n \rightarrow p + e + \tilde{n}_e \ ,$$

where $\tilde{n}_e$ denotes an electron-antineutrino. As shown on the table above, we see that there are three types of neutrinos: The Electron-neutrino, the Muon-neutrino and the Tau-neutrino. The neutrino can oscillate between these three types. The probability of measuring a particular type of neutrino varies periodically in time as it propagates. We now realize that the oscillations of the neutrinos happen not only among types, but also in the vicinity of the speed of light. Neutrinos have a very small mass which is different than zero. The fact that the neutrino oscillations have been experimentally proven, is a clear indication that neutrinos have a non-zero mass.

A possible explanation of these facts is by accepting that particles are coupled to their antiparticle and that they are mirror images of each other. The particles can only move slower than light and their anti-partners can only move faster than light. We can measure faster-than-light particles if the total light-energy allows them to appear as pairs. This is because the speed of light is like a boundary between the two realms; the realm of the slower-than-light (STL) particles and the realm of faster-than-light (FTL) particles. Below we see a graph of this idea. The speed of light c is constant and the photon which sits at the boundary is it's own antiparticle. This is why we don't observe an "antiphoton". The graph is not at scale. As the mass of the particle increases, its distance, **in terms of speed**, to its antiparticle increases too.

Now we have symmetry between particles and antiparticles. The graph below shows that as the mass increases, it becomes more and more difficult to obtain a particle-antiparticle pair. The CERN scientists could observe the neutrino moving faster than light because neutrinos have a mass very close to zero and also because its speed is very close to the speed of light. The speed of light c acts as a boundary between the two realms. Now, we can explain why no **independent** antiparticle is detected in the laboratory. This is because any particle is coupled to its antiparticle and one can only create and annihilate them in pairs. The result of this coupling is charge conservation. From E = mc^2 mass is equivalent to energy. As the total mass (or total energy) of the particle-antiparticle pair

increases the natural average speed of the particle decreases while the natural speed of the corresponding antiparticle increases above the speed of light.



The charge conservation of any interaction can be explained in a different manner. Because particles and antiparticles are coupled to each other, they must have a certain property that is **fixed and is opposite**. That property is called the "electric charge". All particles in our universe have the same charge as the electron, because they are all STL particles. Similarly all antiparticles have an equal and opposite charge of their STL counterpart. The same applies for neutral particles. The Neutron is made out of Quarks and the Antineutron is made out of Antiquarks. This approach gives us a logical explanation why the electric charge exists and why it is fixed for all particles.

Particles moving faster than light are called **Tachyons**. So, all FTL particles (or antiparticles) are in fact Tachyons. According to the present Big Bang model the universe expanded much faster than the speed of light in its first inflationary period that lasted for 10^{-32} seconds. Expansion created a larger space, and this resulted in an Adiabatic cooling which created a pair of mirror-image particles. This explanation is not in contradiction with the universe model proposed in the previous chapter since the Klein bottle has a region of contraction and a region of expansion. In Quantum mechanics the number of different states at a particular energy level is called the "level's degeneracy", and this phenomenon is generally known as a **quantum degeneracy**. Since mass is proportional to the energy, each energy level degenerates into a particle and its antiparticle.

There are as many Tachyons as there are STL particles. This means that there are two universes, the universe of the Tachyons and our universe. They co-exist in thermodynamic equilibrium but we can observe and measure only one of them, namely the universe of the STL particles. But each has a Tachyon twin that exists in the **Tachyon Universe**.

The next chapter will deal with the characteristics of Tachyons.