1.8: Mesons, Leptons and Neutrinos

In 1934 Yukawa introduces a new particle, the pion (π), which can be used to describe nuclear binding. He estimates it's mass at 200 electron masses. In 1937 such a particle is first seen in cosmic rays. It is later realised that it interacts too weakly to be the pion and is actually a lepton (electron-like particle) called the μ. The π is found (in cosmic rays) and is the progenitor of the μ's that were seen before:

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

The next year artificial pions are produced in an accelerator, and in 1950 the neutral pion is found,

$$\pi^0 \rightarrow \gamma\gamma.$$

This is an example of the conservation of electric charge. Already in 1938 Stuckelberg had found that there are other conserved quantities: the number of baryons (n and p and $\ldots$) is also conserved!

After a serious break in the work during the latter part of WWII, activity resumed again. The theory of electrons and positrons interacting through the electromagnetic field (photons) was tackled seriously, and with important contributions of (amongst others) Tomonaga, Schwinger and Feynman was developed into a highly accurate tool to describe hyperfine structure.

Experimental activity also resumed. Cosmic rays still provided an important source of extremely energetic particles, and in 1947 a "strange" particle (K^+ was discovered through its very peculiar decay pattern. Balloon experiments led to additional discoveries: So-called V particles were found, which were neutral particles, identified as the Λ^0 and K^0. It was realised that a new conserved quantity had been found. It was called strangeness.

The technological development around WWII led to an explosion in the use of accelerators, and more and more particles were found. A few of the important ones are the antiproton, which was first seen in 1955, and the Δ, a very peculiar excited state of the nucleon, that comes in four charge states Δ^{++}, Δ^+, Δ^0, Δ^-.

Theory was develop-ping rapidly as well. A few highlights: In 1954 Yang and Mills develop the concept of gauged Yang-Mills fields. It looked like a mathematical game at the time, but it proved to be the key tool in developing what is now called "the standard model".

In 1956 Yang and Lee make the revolutionary suggestion that parity is not necessarily conserved in the weak interactions. In the same year "madam" CS Wu and Alder show experimentally that this is true: God is weakly left-handed!

In 1957 Schwinger, Bludman and Glashow suggest that all weak interactions (radioactive decay) are mediated by the charged bosons $W^\pm$. In 1961 Gell-Mann and Ne'eman introduce the "eightfold way": a mathematical taxonomy to organise the particle zoo.

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