2. A Brief History of Particle Physics

1930

Status:

Elementary particles:

proton (p), electron (e^-) and photon (γ)

Quantum Mechanics and Special Relativity are well established.

P.Dirac (1929):

... The general theory of Quantum Mechanics is now almost complete, the imperfections that still remain being in connection with the fitting of the theory with relativity ideas ...

As a novel feature of a quantum description of particles that conformed with special relativity, creation and annihilation of matter emerges:

- P.Dirac interprets the solutions of the Dirac equation with negative energy as a particle, the positron (e^+), which is exactly like a electron just with opposite charge. It is the first example of antimatter. $\Rightarrow$ Requirement of Lorentz invariance leads to completely novel idea !

- In the Dirac theory the magnetic moment of the electron is

$$|\vec{\mu}_e| = \frac{1}{2} g_e \frac{e}{2m_e}$$

with the *Lande* factor $g_e = 2$ which was in agreement with the experiment (actually g_e is not exactly 2 (QED)).

W.Pauli suggests the neutrino to explain the continuous energy spectrum for β decay:

- In 1914 J.Chadwick discovered the continuous energy spectrum of beta "rays" (=electrons).

  Was it directly due to primary electrons emitted from the nucleus ?

- In 1927 Ellis and Wooster measured the total energy in the calorimeter of the decay ${}^{210}_{83}Bi \overset{\beta^-}{\rightarrow} {}^{210}_{84}Po$ to be the mean energy of the electrons. It proved that the electrons indeed came from the primary process and that the spectrum cannot be explained by secondary processes in the calorimeter.

Two possibilities:
Either energy is not conserved or there is a new particle which carries away energy but escapes detection in the calorimeter (this a great example for how the belief in fundamental principles led to the prediction of a new particle/interaction).

W.Pauli:

"*... I have hit upon a desperate remedy to save ... the law of conservation of energy. Namely, the possibility that there could exist in the nuclei electrically neutral particles, that I wish to call neutrons, ...*" [E.Fermi: neutrinos].