Rutherford Laboratory

Technical leaflet

UNITARY SYMMETRY

The situation confronting elementary particle physicists to-day is similar to that faced by the chemists of the 19th century when the complexities of the elements were being reduced to order by the periodic table. To-day a pattern is emerging in the equally complex field of elementary particles. The most important development in this direction was the scheme of Unitary Symmetry, proposed in 1961 by Gell Mann and Ne'eman by which many of the particles known as HADRONS may be classified. The hadrons are elementary particles which interact through the strong nuclear force and include the class of heavy particles known as BARYONS and the lighter MESONS.

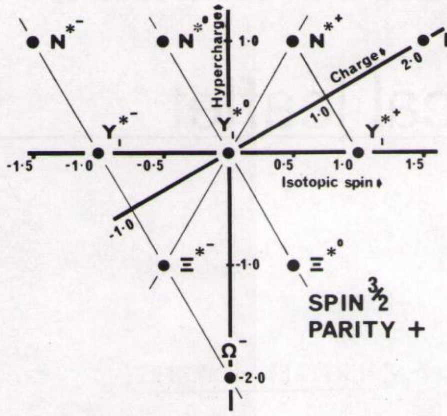
Certain particles are simply different charge states of the same entity, for example, the pion occurs in the three states π^+, π^0 and π^- which have charges + 1, 0 and -1. Similarly the proton and neutron can be regarded as states of the nucleon with charges +1 and 0. Multiple charged states may be conveniently described with the aid of the concept of ISOTOPIC SPIN I which is mathematically analagous to ordinary spin. The quantum unit of isotopic spin is $\frac{1}{2}$ so with I = 1 the pion forms an isotopic spin multiplet with three components $I_c = +1$, 0 and -1 corresponding to the π^+, π^0 and π^-. Likewise the nucleon forms an isotopic spin multiplet with $I = \frac{1}{2}$ and components $I_c = +\frac{1}{2}$ and $-\frac{1}{2}$ corresponding to the proton and neutron.

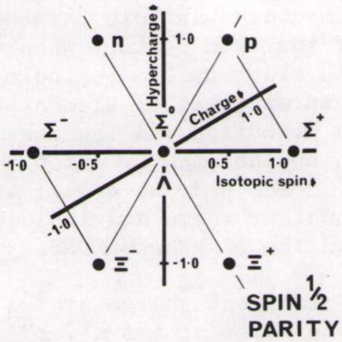
The charge Q and isotopic spin component I_c are related by the equation $Q = I_c + \frac{1}{2}Y$ where Y is known as the hypercharge. Thus the pion has Y = 0 whilst the nucleon has Y = 1. This relation is expressed by the oblique charge axis on the accompanying diagrams.

In the Unitary Symmetry scheme isotopic spin multiplets are grouped together into larger sets involving 8 or 10 particles. The particles are labelled by their isotopic spin component I_c and hypercharge Y. Not all of the known hadrons can be fitted into similar groups, a fact which suggests that many more elementary particles have still to be discovered.

The simplicity of the diagrams reflects the underlying mathematical theory, and may be interpreted as indicating the existence of even more elementary entities, sometimes called 'quarks', from which the so-called elementary particles are built.

BARYONS





MESONS