Chiral Symmetry of Baryons

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Chiral symmetry plays an important role in hadron physics. At low energies as in the present world, it is spontaneously broken and the associated massless Nambu-Goldstone pions strongly dictates the structure and interactions of hadrons. Knowing detailed and precise information of hadrons is indeed important since it serves a basis for the research of richer aspects of strong interaction physics from hadronic to quark matter, or from symmetry breaking to restoration.
In this contribution, we would like to discuss the role of chiral symmetry especially for baryons. To do this, it is important to know how the baryon states are classified according to the chiral symmetry group, when their building blocks, quarks, belong to the fundamental representations of chiral symmetry. This is not a trivial question, when chiral symmetry is spontaneously broken. In such a case, the pion renormalizes the baryon fields and its chiral symmetry nature is hidden, just as in the non-linear realization of chiral symmetry. If, on the other hand, it is still valid to consider that baryons remains to be linear representations of chiral symmetry, it serves interesting information for baryon properties.
From a group theoretical point of view, we have found that two chiral representations are allowed for baryons [1,2,3]. Consider the two helicity states of baryons, ψ_r and ψ_l, and $SU(2)_R \times SU(2)_L$ chiral symmetry group. In one assignment which we have called naive, we assume that $\psi_r \to SU(2)_R$ and $\psi_l \to SU(2)_L$. In this case, the axial coupling takes a value $g_A = +1$. In the other assignment which we have called *mirror*, it is assumed that $\psi_r \to SU(2)_L$ and $\psi_l \to SU(2)_R$ and the axial coupling takes a negative value $g_A = -1$. Such a different assignment becomes relevant when we consider negative parity states together with the positive parity states. Effective lagrangians for the two cases were used to point out some distinguished features of the two chiral assignments [2,3].
We have also proposed experiments in order to distinguish the two assignments, when a pair of positive and negative parity states are the ground state nucleon $N(939)$ and the first negative parity state $N(1535)$, photo or pion induced reactions for pion and eta productions from the nucleon [3].
Chiral group representations can be extended to include more excited baryons such as deltas. We discuss possible consequences when baryon excited states are classified by the chiral symmetry group.

References

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