Hyperons as collective excitations of chiral solitons

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ABSTRACT

The description of baryons as soliton configurations in effective meson theories is studied for the case of three flavors[1]. In the collective approach the soliton configuration is equipped with baryon quantum numbers by canonical quantization of the coordinates describing the flavor orientation. The baryon spectrum is obtained by exactly diagonalizing the Hamiltonian for the collective coordinates. The resulting eigenstates are identified as the the low–lying $\frac{1}{2}^+$ and $\frac{3}{2}^+$ baryons. Such model computations constitute a comprehensive picture of hyperons, in particular the complete incorporation of flavor symmetry breaking effects in the baryon wave–functions makes possible the analysis of symmetry breaking effects on baryon properties. In particular their variation with the strength of flavor symmetry breaking is investigated. For example, it is observed that current matrix elements like $\langle N|\bar{s}(\gamma_5)\gamma_3 s|N\rangle$ diminish quickly as the symmetry breaking increases; contrary matrix elements like $\langle N|\bar{s}s|N\rangle$ exhibit only moderate variations. These nucleon matrix elements are compared with those entering the phenomenologically successful Cabbibo scheme for the semi–leptonic hyperon decays, like $\langle p|\bar{s}(\gamma_5)\gamma_3 u|\Lambda\rangle$. It is found that these strangeness changing matrix elements are significantly less sensitive to symmetry breaking than the strangeness current matrix elements of the nucleon. In the context of the semi–leptonic hyperon decays the effect of symmetry breaking is small. However, it is sizable for the strangeness conserving nucleon matrix elements. This casts some doubts on the application of flavor–$SU(3)$–relations when analyzing the axial current matrix elements in the context of the *proton spin puzzle.* Turning to other hyperon properties it is especially shown that the observed deviation from the U–spin symmetry of the hyperon magnetic moments requires the shape of the soliton to account for symmetry breaking.

Having completed these conceptional discussions on the collective quantization, realistic models are employed to make quantitative predictions on baryon properties. These models constitute various extensions of the Skyrme model by *e.g.* including vector mesons or explicit quark degrees of freedom. For example, the vector meson model predicts the axial singlet current matrix element of the nucleon to be 0.3. This result appears to be robust against permissible variations of the model parameters. The explicit inclusion of quark fields provides a tool to compute various nucleon structure functions at a low momentum scale. In the $SU(3)$ model even the contributions of strange quarks to the structure functions can be separated.

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[1]These studies have recently been reviewed in: H. Weigel, Intl. J. Mod. Phys. **A11** (1996) 2419. An exhaustive list of references is also supplied in that article.