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Towards a solution for the weak radiative hyperon decays puzzle

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Abstract It is proposed that all radiative hyperon decays occur due to the variation of a new quantum number associated to quarks which for the transition $s \to d\gamma$ is always equal to $+1$.

Keywords Weak radiative hyperon decays, Hyperon decays, Hyperons

1. Introduction

The weak radiative hyperon decays problem is a long standing puzzle of about 50 years. It has its origin in the results of experiment [1] which showed a large asymmetry in the $\Sigma^+ \to p\gamma$ decay, violating, thus, Hara's theorem [2] which, at the hadron level, states that *Parity-violating amplitude A of the $\Sigma^+ \to p\gamma$ decay vanishes in exact SU(3)-flavor symmetry.* This means that for a nonzero parity-conserving amplitude B^{PC}, the decay asymmetry

$$A_\gamma = \frac{2\,\mathrm{Re}\left(A^{PV*}B^{PC}\right)}{\left|A^{PV}\right|^2 + \left|B^{PC}\right|^2} \tag{1}$$

is expected to be small because SU(3) is weakly broken. In the above expression PC and PV stand, respectively, for parity-conserving and parity-violating.

Within the Standard Model there are some important articles in the literature dealing with this old puzzle, among them the papers by Dubovik et al. [3,4,5], and Zenczykowski [6,7,8,9]. The development of the experimental data along time has shown a convergence of the asymmetries A_γ for the decays $\Xi^0 \to \Lambda\gamma$ and $\Xi^0 \to \Sigma^0\gamma$ towards -0.7 because in 2006 PDG [10] reports for these decays, respectively, $A_\gamma = -0.78 \pm 0.19$ and $A_\gamma = -0.63 \pm 0.09$, while in 2012 PDG reports for these same decays $A_\gamma = -0.704 \pm 0.083$ and $A_\gamma = -0.69 \pm 0.06$. It is important to notice that these A_γ values are close to that one of the decay $\Sigma^+ \to p\gamma$, which is $A_\gamma = -0.76 \pm 0.08$ [10]. Therefore, the three asymmetries have roughly the same value and, thus, should have a common origin.

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2. The hidden selection rule obeyed by weak radiative hyperon decays

Considering that quarks are composite particles de Souza [12, 13] has shown that quarks have a new quantum number associated to them, as presented on Table 1. It is important to point out that, as shown in reference [12], all weak decays of hadrons follow definite patterns directly related to variations of Σ_3. As the weak radiative hyperon decays occur due to the decay $s \to d\gamma$, its selection rule is $\Delta\Sigma_3 = 0-(-1) = +1$. Thus, we expect to have about the same asymmetry for all weak radiative hyperon decays, and we can predict that the future experiments will find for the weak radiative hyperon decays $\Lambda^0 \to n\gamma$ and $\Xi^- \to \Sigma^-\gamma$ values for A_γ close to -0.7.

Table 1. The quantum numbers Σ_3 associated to quarks.

Quarks	Σ_3
c,t	+1
u	0
d	0
s,b	-1

3. Discussion of results and conclusion

Hara's theorem is valid within the quark model, and its violation for weak radiative hyperon decays is due to the substructure of quarks because these decays obey selection rules directly related to such substructure. Due to this selection rule about the same asymmetry A_γ is expected for all weak radiative hyperon decays.

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