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Strong decays of excited baryons in Large N_c QCD

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Abstract. We present the analysis of the strong decays widths of excited baryons in the framework of the $1/N_c$ expansion of QCD. These studies are performed up to order $1/N_c$ and include both positive and negative parity excited baryons.

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We consider here some application of the $1/N_c$ expansion of QCD[1, 2] to the study of the strong decays of excited baryons belonging to the **70**-plet of negative parity and the **56**-plet of positive parity. For simplicity we consider here only the non-strange baryons of those multiplets. The ℓ_P partial wave decay width into a ground state (GS) baryon and a pseudo-scalar meson with isospin I_P is given by

$$\Gamma^{[\ell_P, I_P]} = \frac{k_P}{8\pi^2} \frac{M_{B^*}}{M_B} \, \frac{|B(\ell_P, I_P, S, I, J^*, I^*, S^*)|^2}{\sqrt{(2J^*+1)(2I^*+1)}}, \tag{1}$$

where $B(\ell_P, I_P, S, I, J^*, I^*, S^*)$ are the reduced matrix elements of the baryonic operator. Such operator admits an expansion in $1/N_c$ that has the general form:

$$B^{[\ell_P, I_P]}_{[\mu,\alpha]} = \left(\frac{k_P}{\Lambda}\right)^{\ell_P} \sum_q C_q^{[\ell_P, I_P]}(k_P) \sum_m \langle \ell, m; j, j_z \mid \ell_P, \mu\rangle \; \xi^\ell_m \; \left(\mathcal{G}^{[j, I_P]}_{[j_z,\alpha]}\right)_q , \tag{2}$$

The factor $\left(\frac{k_P}{\Lambda}\right)^{\ell_P}$ is included to take into account the chief meson momentum dependence of the partial wave. For definiteness, the scale Λ is taken to be equal to 200 MeV. The operator ξ^ℓ_m drives the transition from the $(2\ell+1)$-plet to the singlet $O(3)$ state, and the spin-flavor operators $\left(\mathcal{G}^{[j, I_P]}_{[j_z,\alpha]}\right)_q$ give transitions within the

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spin-flavor representations in which the excited and GS baryons reside. The label j denotes the spin of the spin-flavor operator while its isospin obviously coincides with the isospin of the emitted meson. The dynamics of the decays is encoded in the effective dimensionless coefficients $C_q^{[\ell_P, I_P]}(k_P)$. The relevant list of independent operators $\mathcal{G}$ for the decays we are interested as well as the corresponding fits and calculated widths in can be found in Refs.[3,4]. From those results we observe that, in general, the LO operators already provide a reasonable description of the decay widths. Exception to this are the D-wave decays of the $(1^-, \mathbf{70})$-plet where the NLO corrections play some role in improving the results. Another interesting observation that points to the consistency of the framework based on the approximate $O(3) \times SU(2N_f)$ symmetry is that the predicted suppression of the η channels in the decays positive parity baryons is clearly displayed by the observed decays. This represents a strong experimental confirmation that those excited baryons do belong primarily into a symmetric representation of $SU(2N_f)$. In the case of the negative parity baryons the η channel is not suppressed and is indeed very important. This implies that these states belong primarily into the mixed-symmetric representation of $SU(2N_f)$. Thus, η channels serve as a selector of the spin-flavor structure of excited baryons.

To conclude, the $1/N_c$ expansion provides a systematic approach to the properties of the excited baryons. In the case of the negative parity $(1^-, \mathbf{70})$-plet and the positive parity $(2^+, \mathbf{56})$ baryons it successfully describes the existing data and, to the order considered, also makes numerous testable predictions.

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