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Hyperon-nucleon coupling from QCD sum rules

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In understanding the dynamics of kaon-nucleon scattering or the strangeness content of the nucleon using hadronic models, it is important to know the hadronic coupling constants involving the kaons. Among them, $g_{NK\Lambda}$ and $g_{NK\Sigma}$ are the most relevant coupling constants. To determine these couplings using the QCD sum rules [1] one can follow two different approaches: a) the two-point function, where the nucleon and hyperon fields are sandwiched between the vaccum and kaon states, or b) the three-point function where three interpolating fields are sandwiched between vacuum states.

In the case of the pion-nucleon coupling constant, in a pioneer calculation [2] both approaches showed to reproduce the phenomenological value fairly well. However, in this first study the continuum contribution was neglected and since then many calculations were done including higher order terms in the operator product expansion (OPE) and the continuum contribution [3], going beyond the soft-pion limit and including also pole-continuum transitions [4].

For the nucleon-kaon-hyperon coupling constant there are also QCD sum rules calculations based on the two- and three-point functions [5–7]. The advantages of the three-point function calculation is that it allows for the calculation of the form factors at the hadronic vertices.

In the strange sector, the nucleon-kaon-hyperon form factors are used, for instance, to evaluate the strange radius of the nucleon using the kaon cloud [8] and, therefore, a theoretically founded evaluation of these form factors is wellcome.

We will calculate the g_{NKY} coupling constant using the three-point function

$$A(p,p',q) = \int d^4x\, d^4y\, e^{ip'x}\, e^{-iqy} \times \langle 0|T\{\eta_Y(x) j_5(y)\overline{\eta}_N(0)\}|0\rangle \qquad (1)$$

where $j_5 = \bar{s}i\gamma_5 u$.

As it is well known from two-point sum rules for baryons, there is a continuum of choices for the baryon interpolating fields. Of course the results should be independent of the choice of the current, if we considered an infinity number of terms in the OPE and if we had a perfect model for the continuum contribution in the phenomenological side. However, the OPE has to be truncated and we work with a very simple model for the continuum contribution. Therefore, the results do depend on the choice of the currents. For the proton Λ and Σ we can write general currents as [9]

$$\eta_P = 2\varepsilon_{abc}[(u_a^T C d_b)\gamma_5 u_c + b(u_a^T C\gamma_5 d_b)u_c]\,, \qquad (2)$$

$$\eta_Y = 2[\eta_{Y_1} + b\eta_{Y_2}]\,, \qquad (3)$$

where b is a parameter and

$$\eta_{\Lambda_1} = \frac{1}{\sqrt{6}}\varepsilon_{abc}[2(u_a^T C d_b)\gamma_5 s_c + (u_a^T C s_b)\gamma_5 d_c - (d_a^T C s_b)\gamma_5 u_c]\,, \qquad (4)$$