A model-independent study of the QCD sum rule for the πNN coupling constant and a projected correlation function approach

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We reinvestigate the QCD sum rule for the πNN coupling constant, g, starting from the vacuum-to-pion matrix element of the correlation function of the interpolating fields of two nucleons. We study in detail the physical content of the correlation function without referring to the effective theory. First, we consider the invariant correlation functions by splitting the correlation function into different Dirac structures. We show that the coefficients of the double-pole terms are proportional to g but that the coefficients of the single-pole terms are not determined by g. In the chiral limit the single-pole terms as well as the continuum terms are not well defined in the dispersion integral. Therefore, naive QCD sum rules obtained from the invariant correlation functions are not well defined. A possible procedure to avoid this difficulty is discussed. Secondly, we consider the projected correlation function by taking the matrix element of the correlation function with respect to the nucleon spinors. In the chiral limit the double-pole term survives but the single-pole term and the continuum term are well defined in the dispersion integral. Then, we construct a QCD sum rule for the πNN coupling constant from the projected correlation function without taking the chiral limit. We calculate the Wilson coefficients of the OPE and obtain the Borel sum rule up to $O\left({M_B}^{-4}\right)$ and $O\left(m_\pi\right)$ where M_B and m_π are the Borel mass and the pion mass, respectively. The new sum rule is expected to incorporate $O(m_\pi)$ corrections. The numerical result is in reasonable agreement with the empirical value.