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sigma

The pion-nucleon sigma term, characterizing the mass component of Higgs origin related to u and d quarks inside the nucleon, is investigated within relativistic baryon chiral perturbation theory at leading two-loop order using the extended-on-mass-shell renormalization scheme. The two-loop representation of the sigma term is derived from the nucleon mass via the Feynman-Hellmann theorem and verified through a direct calculation of the forward isoscalar-scalar nucleon matrix element. We apply the derived chiral expression to extract the physical pion-nucleon sigma term by extrapolating $N_f = 2 + 1$ lattice quantum chromodynamics (QCD) data at unphysical quark masses. We find that, at the two-loop level, the long-standing tension between lattice QCD and dispersive determinations can be naturally resolved, owing to the incorporation of intermediate $\pi\pi$ rescattering effects that begin to contribute at two-loop order. Our final result for the nucleon sigma term based on recent lattice QCD calculations is $\sigma_{\pi N} = 55.9(2.5)$~MeV. It is compatible with the result of the Roy-Steiner equation analysis and thus provides a satisfactory resolution to the previous debate between lattice QCD and phenomenological determinations.

Primary author(s) : LIANG, Ze-Rui

Presenter(s) : LIANG, Ze-Rui