Low-lying Odd-parity Nucleon Resonances in Hamiltonian Effective Field Theory

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Recent lattice QCD results for the first two low-lying odd-parity excitations of the nucleon have revealed that they have magnetic moments consistent with constituent-quark-model expectations [1]. Thus, in constructing a basis of states to describe scattering in this channel, one should not represent both odd-parity excitations by a single three-quark basis state. Two single-particle basis states are required to accommodate these two quark-model-like states. This contrasts previous studies where it has been assumed that both low-lying negative-parity states observed on the lattice are part of the finite-volume spectrum associated with the N(1535) resonance [2]. Using Hamiltonian Effective Field Theory (HEFT), we represent these constituent-quark-like states by including two single-particle basis states in the Hamiltonian, mixing through meson-baryon scattering channels. By constraining the parameters of HEFT using S-wave pion-nucleon scattering data, we perform the first calculation of the finite-volume energy spectrum for this system using multiple single-particle basis states. By extending these calculations to unphysical pion masses, we are able to make connection between finite-volume energy eigenstates from world-leading lattice QCD results, and experimental scattering data. By analysing the composition of these states in HEFT, we can develop a new understanding of the structure of the odd-parity nucleon resonances.

[1] Finn M. Stokes, Waseem Kamleh, and Derek B. Leinweber. *Elastic Form Factors of Nucleon Excitations in Lattice QCD* Phys. Rev. D, 102(1):014507, 2020

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