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Strangeness S = −3 and S = −4 baryon-baryon interactions in relativistic chiral effective field theory

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The strangeness S = −3 and −4 baryon-baryon interactions are investigated in the relativistic chiral effective-field theory at leading order. First, the 12 tree-level low-energy constants contributing to the S = −1 hyperon-nucleon interaction are fixed by fitting to the 36 hyperon-nucleon scattering data. Then the S = −3 and −4 baryon-baryon interactions are derived from that of S = −1 assuming that the corresponding low-energy constants are related to each other via SU(3) flavor symmetry. The comparison with the state-of-the-art lattice QCD simulations, show, however, that SU(3) flavor symmetry-breaking effects cannot be neglected. To take into account these effects, we redetermine two sets of low-energy constants by fitting to the lattice QCD data in the XiSigma and XiXi channels, respectively. The fitting results demonstrate that the lattice QCD S-wave phase shifts for both channels can be described rather well. Without any additional free low-energy constants, the predicted phase shifts for the 3D1 channel and the mixing angle ε1 are also in qualitative agreement with the lattice QCD data for the S = −3 channel, while the results for the S = −4 channel remain to be checked by future lattice QCD simulations. With the so-obtained low-energy constants, the S-wave scattering lengths and effective ranges are calculated for these two channels at the physical point. Finally, in combination with the S = 0 and −2 results obtained in our previous works, we study the evolution of the irreducible representation "27"in the baryon-baryon interactions as a function of increasing strangeness. It is shown that the attraction decreases dramatically as strangeness increases from S = 0 to S = −2, but then remains relatively stable until S = −4. The results indicate that the existence of bound states in the XiSigma and XiXi channels is rather unlikely.

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