Chiral symmetry and the two-nucleon interaction

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The longest-range part of the strong nucleon-nucleon interaction is the well-established one-pion exchange (OPE) force. Next in range is the two-pion exchange (TPE) force, the formulation of which has been a long-standing problem, both in field theory and in dispersion theory. In recent years, it has been argued that the key to the solution is the chiral symmetry of QCD, and that the long-range parts of the TPE potential can be derived model-independently by a systematic expansion of the effective chiral Lagrangian.

In this talk, I will review the progress in this direction. Specifically, I will discuss the study of the long-range chiral TPE force in the proton-proton [1] and neutron-proton [2] interactions, where its presence and importance have been shown unambiguously. The OPE and TPE forces were derived from the effective chiral Lagrangian. In leading order, the TPE interaction contains the planar- and crossed-box diagrams and the triangle and bubble diagrams with the nonlinear Weinberg-Tomozawa (seagull) interaction. In subleading order, additional triangle diagrams appear, with the chiral coupling constants c_i ($i = 1, 3, 4$). These coupling constants were determined from the proton-proton and neutron-proton data. Good agreement was found with the values extracted previously from the pion-nucleon scattering amplitudes [3]. This demonstrates, for the first time, that the long-range NN and the low-energy πN interactions are governed by the same chiral Lagrangian.

These results provide a big success for chiral symmetry. It is the first time that this theoretically well-founded and model-independent chiral TPE has been unambiguously shown to be present in the two-nucleon interaction. This again has important implications for TPE three-nucleon forces [4].

References

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