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Erratum

The pion-nucleon scattering lengths from pionic deuterium

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In the paper [1] we have studied the pion-deuteron scattering length within low-energy effective theories of QCD. In particular, in the section 4.3 of this article we give an estimate of the uncertainty in this scattering length, coming from the presence of the 6-particle low-energy constant (LEC) – referred to as f_0. Unfortunately, in this estimate, which has yielded $\Delta a_{\pi d}/a_{\pi d} \simeq 12\%$, an incorrect value for the deuteron wave function at the origin in the Weinberg approach $\tilde{\Phi}_0(\Lambda) = [0.487; 0.434]\ \mathrm{fm}^{-3/2}$ with the cutoff mass from the interval $\Lambda = [450; 650]$ has been used (normalization error). Using the corrected value $\tilde{\Phi}_0(\Lambda) = [0.137; 0.122]\ \mathrm{fm}^{-3/2}$ downsizes the error (only due to the above-mentioned source) to a much more comfortable $\Delta a_{\pi d}/a_{\pi d} \simeq 1\%$, which, in addition, fits better to the *a priori* estimates, based on the Weinberg power counting. Thus, the results of the high-precision calculations of Ref. [2] have been independently confirmed.

This result has far-reaching consequences. In particular, we have to re-think the equivalence between the Weinberg [2] and Heavy-Pion Effective Field Theory (HPEFT) [3] approaches to the pion-deuteron scattering at low energy. The arguments remain the same, but the big change in the estimated uncertainty leads to the conclusion that now this equivalence is realized in a slightly different manner. As before, the success of the modified power counting [2] unambiguously indicates that HPEFT is a physically equivalent tool for describing pion-deuteron interactions near threshold. Furthermore, the sole input which HPEFT imports from the Weinberg approach are the values of LECs, determined through the matching procedure. As it is discussed in Ref. [1], these LECs in general acquire contributions from two different momentum regions: $M_\pi < p < \Lambda$ and $p > \Lambda$. Whereas the former can in principle be expressed through the wave functions, etc – and is thus calculable in terms of the known parameters of the theory, the latter represents a genuinely high-energy contribution, which at the present stage can only be included in the error estimate. What follows from our corrected calculations is that this high-energy contribution is small and does not preclude a high-precision determination of the pion-nucleon scattering lengths from the combined analysis of the pionic hydrogen and pionic deuterium data by Pionic Hydrogen collaboration at PSI [4]. We wish to emphasize once more that the strong predictive power is a result of a subtle balance between HPEFT, which at the end allows for constructing multiple scattering series in terms of observables (scattering lengths, etc) and the Weinberg approach, which enables one to evaluate the LECs of HPEFT with a high precision.

Several remarks are in order. First, we wish to mention that our error estimate, which is carried out by using dimensional arguments or resonance saturation hypothesis, is complementary to the study of the scale dependence of the calculated pion-deuteron scattering length. Obviously, the investigations should proceed from both ends. As mentioned in Ref. [1], a weak scale dependence would indicate that the uncertainty might be small and not that it must be small. Finally, the fact that the short-range interactions do not introduce large uncertainty in the calculated value of the pion-deuteron scattering length, might stimulate further activity in calculating various small contributions, with an aim to determine this scattering length as precise as possible. Using the above-mentioned equivalence between the Weinberg and HPEFT approaches could enable one to carry out these calculations in a simpler setting.

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