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Three Nucleons at Very Low Energies

In a plethora of processes relevant e.g. for big-bang nucleo-synthesis and stellar evolution, the typical energy scale lies below 10 MeV. There, pion dynamics "freezes out" into strengths of point-like interactions between the only hadronic degrees of freedom left, namely the nucleons. In Effective Field Theory, this low-energy expansion of observables yields a model-independent and systematic approach with an error estimate. Often, three-body forces are irrelevant and high-accuracy calculations performed with ease. In the doublet S wave (triton/^{3}He) channel however, the problem is sensitive to physics at very short distances if three-body forces are discarded. Using the requirement that physical low-energy observables are insensitive to details of the short distance treatment, the power counting for the three-body system was systematised to all orders in the low-energy expansion in [1]. Two simple observables like the triton binding energy and scattering length suffice to determine the three-body forces for wave functions accurate to $\sim 1\%$. This yields a limit cycle for the three-body force, and explains the Phillips line as well as the Efimov- and Thomas-effects. The rapidly converging results agree well with phase shift analysis and more sophisticated potential model calculations. Electro-magnetic interactions (triton form factor, effects on ^{3}He binding) are also discussed. Other applications include the atomic Helium trimer, loss rates in Bose-Einstein condensates, and a neutral atom close to a charged wire.

[1.] Bedaque, Grießhammer, Hammer and Rupak: Nucl. Phys. **A714** (2003), 589 [nucl-th/0207034].