Few Body Systems in Effective Field Theory

H. W. Grießhammer[a]

[a]Institut für Theoretische Physik, Physik-Department der Technischen Universität München, D-85747 Garching, Germany

e-mail: hgrie@physik.tu-muenchen.de

Effective Field Theory describes the few nucleon system at low energies and allows for simple, model independent, systematic and rigorous computations of the properties of nuclear systems with an error estimate. After explaining the main ingredients, the talk focuses on nuclear two and three body properties:

At very low energies, pions do not have to be treated as explicit degrees of freedom, and high precision calculations are performed with relative ease. As an example of this version, an analytic calculation of the differential cross section for elastic Compton scattering on the deuteron at photon energies ω in the range of $25-50$ MeV is presented to next-to-next-to-leading order, i.e. to an accuracy of $\sim 3\%$ [1]. The iso-scalar, scalar electric and magnetic nucleon polarisabilities α_0 and β_0 enter as free parameters with a theoretical uncertainty of about 20% and can easily be determined. The real and imaginary parts of the phase shifts in nd scattering for centre-of-mass momenta of up to 300 MeV were calculated, using both perturbative pions and an approach in which pions are integrated out [2,3]. The results suggest that pion effects are small even at high momenta. All calculations demonstrate convergence and agree with both phase shift analyses and potential model calculations (as available), but extend to a higher, so far untested momentum régime above the deuteron breakup point. From the computational point of view, the numerics involved is considerably simpler and faster than potential model calculations without loss of accuracy. The role of three body forces is touched upon.

In the version in which the pion is treated as a perturbation of the forces binding the deuteron, the pion deuteron scattering length and π^0-electroproduction off the deuteron are also addressed [4,5]. In this approach, knowledge of the pion nucleon interactions does not suffice to determine the pion deuteron interaction completely. Rather, short distance effective interactions coupling two nucleons to two pions or to one pion and one photon enter with unknown strengths. Besides the pion electro-production mechanism on one nucleon and by pion-rescattering effects, we predict therefore that contact interactions between the pion, photon and two nucleons are effects of the order of 30%. With the aid of pion deuteron data from PSI and MAMI, the sizes of these counter terms can be estimated to be of the predicted range. These findings are compared to the EFT variant in which pion contributions are iterated.

References

1. H.W. Grießhammer and G. Rupak: nucl-th/0012096.
2. P.F. Bedaque and H.W. Grießhammer: Nucl. Phys. **A671**, 357 (2000).
3. F. Gabbiani, P.F. Bedaque and H.W. Grießhammer: Nucl. Phys. **A675**, 601 (2000).
4. B. Borasoy and H.W. Grießhammer, to be published.
5. B. Borasoy and H.W. Grießhammer, to be published.