IMPLICIT AND EXPLICIT RENORMALIZATION OF THE NUCLEAR FORCE

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We consider a simple toy model for the two-body nuclear force and perform a complete study in the framework of the similarity renormalization group (SRG). The idea is to investigate the infrared limit of the SRG with both Wilson's and Wegner's generators as well as the Block Diagonal ones which the unitary version of the $V_{\rm lowk}$ approach. In the limit $\lambda \to 0$, the resulting effective Wilson and Wegner interactions is purely diagonal and free of any off-shell ambiguities. However, this region is very dificult to access with phenomenological or chiral nucleon-nucleon potentials since the numerical evolution of the SRG flow equations for $\lambda < 2$ fm^{-1} is extremely stiff. Our toy model is constructed so that the main two-nucleon observables are reasonably described with a short-range interaction, which makes the SRG evolution towards the infrared region much more practical. We then use the resulting diagonal effective interactions to compute observables such as the binding energies of the deuteron, triton and helium and the pairing BCS gap. Given the simplicity of the model, our results show an impressive qualitative description of the limit $\lambda \to 0$ for both Wilson's and Wegner's generators, suggesting advantageous simplifications in the few and many body nuclear problem. We also describe to what extent and the corresponding scales where $V_{\rm lowk}$ potentials can be implicitly described by low energy parameters without explicitly solving the always complicated SRG equations.

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