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Effective theory for few-body physics in the Gaudin-Yang model

A topic of high interest in the field of cold atoms and molecules is the crossover from a Bardeen-Cooper-Schrieffer (BCS) superfluid with loosely bound Cooper pairs to a Bose-Einstein condensate (BEC) of tightly bound dimers (molecules). While the crossover can be investigated experimentally near Feshbach resonances, there is a lack of analytical solutions providing insights into the crossover physics [1]. Considering a one-dimensional spin-1/2 Fermi gas, the exactly solvable Gaudin-Yang (GY) model can describe the BCS-BEC crossover in the form of a transition from a (BCS-like) gas of loosely bound fermion pairs to a Tonks-Girardeau gas of tightly bound fermion pairs (dimers) [2]. We note, however, that already the exact Bethe-ansatz (BA) solution of the GY model without external potential becomes complicated rapidly for increasing number of particles whereas the GY model is not even exactly solvable if external potentials are present. Due to this, most investigations considering the experimentally relevant case of an external potential are numerical [3]. We propose to use the effective field theory (EFT) framework to reduce the complexity of the GY model solution to the most relevant physics and possibly 'enable'analytical insights for the GY model with external potential. To achieve this goal, we set up an effective theory for fermions and dimers by investigating the few-body physics of fermion-dimer and dimer-dimer scattering within the BA-solution of the GY model.

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