Three-body physics with finite-range potentials

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Three-body Efimov physics is relevant for the understanding of both dynamics and stability of ultracold gases. Efimov predicted the existence of an infinite sequence of three-body bound states, of which many properties scale universally, at diverging scattering length for a zero-range interaction potential. Experiments with ultracold atoms using Feshbach resonances have found some universal features, however, not everything is as universal as predicted from the simple interaction models. For smaller scattering lengths also non-universal features appear in the Efimov spectrum. These are linked to the finite-range nature of the interactions, and to the widths of the Feshbach resonances used. We model these effects by considering the off-the-energy-shell two-body T-matrix which is present in the three-body Faddeev equations, and analyze the corresponding separable expansions that are needed to solve these equations. We find for instance that strong d-wave interactions lower the energy of the second Efimov state and therefore prevent this Efimov state from merging with the atom-dimer threshold. We also show that precise calculations of the three-body parameter corresponding to the potential resonances of deep square well potentials require many terms in the expansion the off-shell two-body T-matrix.