Families of dark solitons in the superfluid Fermi gas across the BCS-BEC crossover

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Abstract:

Fermionic superfluids of ultra-cold atomic gases provide a unique opportunity to study nonlinear waves throughout the transition from a weakly-interacting quantum gas to a strongly-correlated quantum liquid. Here, we numerically find families of solutions of the time-dependent Bogoliubov-de Gennes (TDBdG) equation corresponding to moving dark solitons. The TDBdG equation presents the mean-field theory for the superfluid Fermi gas through the BEC-BCS crossover. We calculate the soliton energy as a function of velocity and determine the critical velocity below which solitons can propagate. Consequences for soliton oscillation in harmonically trapped gases are discussed.