Self-consistent multi-soliton solutions in Bogoliubov-de Gennes systems

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The Bogoilubov-de Gennes (BdG) equation and the gap equation (the self-consistent condition) describe spatially inhomogeneous states in various kinds of condensed matter systems, such as superconductors, polyacetylene [1], and ultracold atomic Fermi gases. The equivalent equations also appear in the mean field theory of the Gross-Neveu model in high-energy physics [2]. It is generally a difficult problem to obtain a self-consistent exact solution satisfying not only the BdG equation but also the gap equation, and only a few analytic examples were known so far such as the one- and two-kink (polaron in polyacetylene) [1-3] and the kink-crystal [4]. In our presentation, we show the most general condition for the multi-soliton solutions to satisfy the gap equation [5]. We show that the occupation numbers of bound states around each of solitons determine the soliton's phase shift, which must be discretized. We also show a new result on the self-consistent condition of the system consisting of only right-movers.

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Section: QG - Quantum gases

Keywords: Bogoliubov-de Gennes equation, gap equation, self-consistent solution