Charge-4e superconductivity in a Hubbard model

Martina Ondina Soldini,
Mark H. Fisher, Titus Neupert.

University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland

msoldi@physik.uzh.ch

A phase of matter in which fermion quartets form a superconducting condensate, rather than the paradigmatic Cooper pairs, is a recurrent subject of experimental and theoretical studies. However, a comprehensive microscopic understanding of charge-4e superconductivity as a quantum phase is lacking. Here, we study a two-orbital tight-binding model with attractive Hubbard-type interactions. Such a model naturally provides the Bose-Einstein condensate as a limit for electron quartets and supports charge-4e superconductivity, as we show by mapping it to a spin-1/2 chain in this perturbative limit. Using infinite density matrix renormalization group calculations for the one-dimensional case, we further establish that the ground state is indeed a superfluid phase of 4e charge carriers and that this phase can be stabilized well beyond the perturbative regime. Importantly, we demonstrate that 4e condensation dominates over 2e condensation even for nearly decoupled orbitals, which is a more likely scenario in electronic materials. Our model paves the way for both experimental and theoretical exploration of 4e superconductivity and provides a natural starting point for future studies beyond one dimension or more intricate 4e states.

Figures

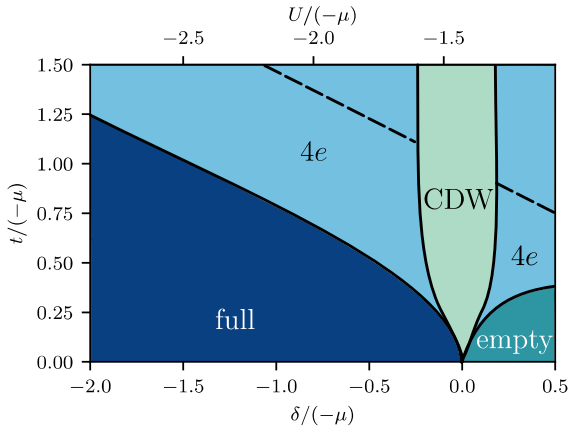

Figure 1: Phase diagram for the one-dimensional model that displays charge-4e superconductivity. In two of the regions the ground state is either the fully empty or fully occupied state, the central region has a charge density wave (CDW), and the intermediate regions realise a charge-4e superconducting phase.