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Two-fluid coexistence in a spinless fermions chain with pair hopping

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In order to enrich the understanding of pairing mechanisms in one-dimensional quantum systems, we studied the ground state properties of a spinless fermions chain with single-particle and pair hopping terms in the Hamiltonian [1,2]. We discovered an unusual behaviour of the system with regard to the transition to a pairing phase as the pair hopping parameter strength is increased. The ground state properties are incompatible with previous works on pairing transitions in one-dimensional spinless fermions systems [3,4] and demonstrate that the phenomenology of pairing transitions is even richer than expected.
By examining entanglement, correlation and local kinetic properties of the ground state computed via DMRG simulations, we show the presence of an intervening coexistence phase in which a single-particle Luttinger liquid coexists with a Luttinger liquid of pairs.
The emergence of such an intermediate phase characterized by the simultaneous presence of two gapless bosonic modes is justified by the consequences drawn from a phenomenological two-fluid model; the latter allows to interpret the transitions to/from the coexistence phase as continuous Lifschitz phase transitions associated to the appearence/disappearence of a pair of gapless points in the excitation spectrum of the system.
Our work has been accepted to appear in PRL.

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[4] L. Gotta, L. Mazza, P. Simon, and G. Roux, Phys. Rev. Research 3, 013114 (2021).

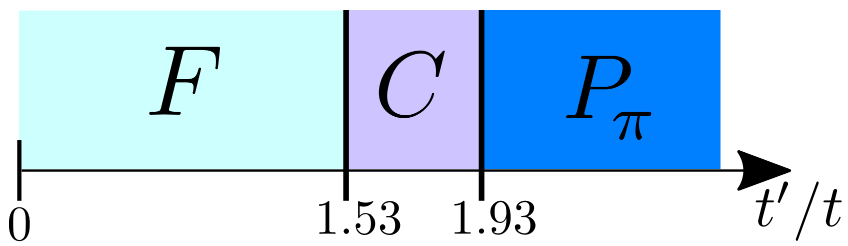

Figure 1 : phase diagram of the model Hamiltonian as a function of the ratio between the pair hopping and the single-particle hopping amplitude in the considered parameter regime. The standard Luttinger liquid phase (F) is separated from the Luttinger liquid of pairs (P) by a coexistence phase (C) of paired and unpaired low energy degrees of freedom.