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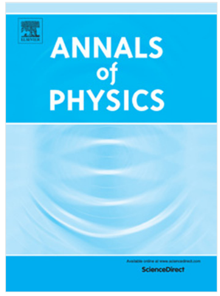

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Boosted one dimensional fermionic superfluids on a lattice

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Abstract

We study the effect of a boost (Fermi sea displaced by a finite momentum) on one dimensional systems of lattice fermions with short-ranged interactions. In the absence of a boost such systems with attractive interactions possess algebraic superconducting order. Motivated by physics in higher dimensions, one might naively expect a boost to weaken and ultimately destroy superconductivity. However, we show that for one dimensional systems the effect of the boost can be to strengthen the algebraic superconducting order by making correlation functions fall off more slowly with distance. This phenomenon can manifest in interesting ways, for example, a boost can produce a Luther-Emery phase in a system with both charge and spin gaps by engendering the destruction of the former.

1. Introduction

An electrical current set up in a superconductor continues to flow even in the absence of a driving electric field [1–3]. Such a persistent current is equivalent to an imbalance in the number of carriers moving along and opposite to the direction of the current, i.e. a boost. In a 1D system, a boost can be realized with different chemical potentials for left and right movers. The magnitude of the boost or the current cannot be arbitrarily large and there is a critical value above which the superconducting state is destroyed. This phenomenon is analogous to the destruction of a superfluid when its flow velocity is larger than the critical velocity. The critical value of the boost can be calculated from the Bogoliubov- de Gennes equations for a superfluid [4] and superconductor [5, 7].

A natural question is about the fate of superconductors, which do not have long range order (and hence order parameter equal to zero) upon the application of a boost. The most common example of such a system is a one dimensional system of fermions with attractive interactions [8, 10–12]. Such one dimensional superconductors have recently come to the fore as they possess interesting topological properties such as the existence of Majorana edge modes under appropriate conditions [13–15]. Experiments to detect these modes typically involve driving a current through the superconductor [16, 17] and hence it is germane to ask how large the critical current in these systems can be. Moreover, such systems have also been realized in cold atomic gases where it has been possible to make the system left-right asymmetric thereby producing a boost [20–22]. The critical velocity of a clean one dimensional superconductor has been calculated in mean-field theory and was found to be smaller that the standard Landau critical velocity due to a pre-emptive

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