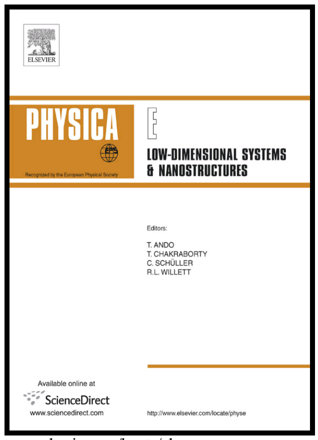


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# The one step fermionic ladder

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**Abstract**

The one step fermionic ladder refers to two parallel Luttinger Liquids (poles of the ladder) placed such that there is a finite probability of electrons hopping between the two poles at a pair of opposing points along each of the poles. The many-body Green function for such a system is calculated in presence of forward scattering interactions using the powerful non-chiral bosonization technique (NCBT). This technique is based on a non-standard harmonic analysis of the rapidly varying parts of the density fields appropriate for the study of strongly inhomogeneous ladder systems. The closed analytical expression for the correlation function obtained from NCBT is nothing but the series involving the RPA (Random Phase Approximation) diagrams in powers of the forward scattering coupling strength resummed to include only the most singular terms with the source of inhomogeneities treated exactly. Finally the correlation functions are used to study physical phenomena such as Friedel oscillations and the conductance of such systems with the potential difference applied across various ends.

*Keywords:* Luttinger Liquid, Bosonization, Green's functions

## 1. Introduction

One dimensional systems occupy a special position when it comes to inter-particle interactions which are totally different from their higher dimensional counterparts, leading to a state described as Luttinger Liquid (LL) [1]. The primary goal of many-body physics is to obtain the "N-point Green functions" of a system of many mutually interacting particles in the thermodynamic limit. For fermions in one dimension, the well known analytical method to do so goes under the name 'g-ology' (see e.g. Giamarchi [2]) which works well in translationally invariant systems and also in weakly inhomogeneous systems. A non-conventional approach has been recently developed which easily deals with a particular class of strongly inhomogeneous systems, viz. one with a finite number of barriers and wells clustered around an origin [3]. In the present work, the same approach, known as the 'Non Chiral Bosonization technique' or NCBT, has been employed to obtain the Green functions for the well-studied one-step fermionic ladder. It is based on a non-standard harmonic analysis of the rapidly varying parts of the density fields appropriate for the study of such strongly inhomogeneous systems. This method provides analytical expressions for the most singular part of the asymptotic Green functions without having to use renormalization group (RG) or numerical techniques. The system under consideration is described in Fig. 1 in the form of a caricature.

The Luttinger Liquid theory [1] which is based on the linearization of the dispersion relations of the constituent particles finds its applications in a variety of 1D systems, prominent among them are carbon nanotubes [4], quantum wires [5], organic conductors [6], ultra cold atoms [7], spin ladder sytems [8], etc. A clean Luttinger liquid (without any impurity) behaves as a perfect conductor and the inter-particle interactions in such systems are handled well using conventional bosonization techniques [2]. But the introduction of even a weak impurity can bring about drastic changes in the system which can be as extreme as the 'cutting the chain' phenomenon in the case of repulsive mutual interactions, which was first studied in the seminar paper by Kane and Fisher [9]. This phenomenon is seen more directly using the conductance formula obtained from the correlation functions calculated using the non-chiral bosonization technique [3]. A variant of this system is the one-step ladder i.e. Luttinger Liquids (two "poles") lying close to each other with a non-zero hopping probability from one pole to another at a specific location on each pole.

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