



Deriving the Density Form Factor for the Strongly Interacting ($c \rightarrow \infty$) 1D-Bosons in Lieb-Liniger Model

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Interacting bosons in one dimension (1D) are described by the exactly solvable Lieb-Liniger (LL) model, which satisfies the Bethe Ansatz equations. The dynamical structure factor (DSF) is given by the Fourier transform of the time-dependent density-density correlation function. This study aims to obtain a simplified analytical expression for the density form factor (DFF), which is currently unavailable due to the complexity of the calculation related to the density-density correlation function. The DFF is a function that describes how energy eigenstates are distributed in space. As a first step, the excited momentum of the boson particle in the ground state was approximated up to $1/c$, where c is the coupling constant, based on the momentum of the ground state. The DFF was then expanded using the Lehmann representation, and each term in the expansion was simplified separately using mathematical techniques such as the Cauchy determinant, in terms of energy eigenstates. Finally, a simplified analytical expression was derived for the DFF, and the result was confirmed by numerical results and the dispersion relation. The dispersion relation for 1D strongly interacting bosons in the LL model was obtained considering a large system with constant density. Furthermore, this study helps to gain knowledge about the significant excitation of the system based on the sum rule.

Keywords: Dispersion relation, Dynamical form factor, Lieb-Liniger model