Strongly-correlated ultracold bosons in one dimension

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Reduced dimensions have dramatic effects on the dynamics of many-body quantum systems. For instance, in one dimension, the interactions as well as the interference effects are strongly enhanced compared to higher dimensions. It has fundamental consequences, such as the enhancement of quantum correlations in extreme dilute systems, the fermionization of Bose gases, and the emergence of diverging susceptibilities at characteristic length scales. The latter is responsible for a novel superfluid-insulator transition in infinitely small periodic potentials, known as the pining transition. Recently, there has been a huge amount of activity in the quantum simulation of such systems with ultracold quantum gases.

In this contribution, I report recent results of ours on Lieb-Liniger bosons subjected to external potentials. On the one hand, I discuss the behaviour of the Tan contact of the Lieb-Liniger gas under harmonic confinement for arbitrary temperature, number of particles, interaction strength, and trap frequency [1]. We show that it can be written as a universal function of only two scaling parameters and derive the scaling function. Importantly, we show that the contact realizes an unequivocal signature of the fermionization effect in the trapped system and provide quantitative evidence that this effect can be extracted from the general behaviour of momentum distributions as measured routinely in epxeriments. On the other hand, I discuss recent developments on the pinning transition [2]. In particular, we show that the quantum critical line is significantly affected by strong renormalization of the Luttinger parameter induced by an even weak periodic potential. This results are found using exact quantum Monte Carlo calculations and confirmed in quantum simulators realized with ultracold Bose gas with controled interactions.

[1] H. Yao, D. Clément, A. Minguzzi, P. Vignolo, and L. Sanchez-Palencia, Tan's contact for trapped Lieb-Liniger bosons at finite temperature, *to appear*, arXiv:1804.XXXXX.

[2] G. Boéris, L. Gori, M. D. Hoogerland, A. Kumar, E. Lucioni, L. Tanzi, M. Inguscio, T. Giamarchi, C. D'Errico, G. Carleo, G. Modugno, and L. Sanchez-Palencia, Mott transition for strongly interacting one-dimensional bosons in a shallow periodic potential, Phys. Rev. A **93**, 011601(R) (2016).