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Coherence Properties and Excitation Spectrum of Weakly Interacting Bose Gases across the Superfluid--Bose-glass Transition

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Abstract:

Due to the high degree of control they offer, ultracold atomic gases have emerged as a powerful tool to explore the physics of disordered quantum systems. While pioneering experiments focused on the observation of Anderson localization in a regime of negligible interactions, more recent ones turned to a systematic investigation of the effects of disorder in interacting systems [1-3]. In Bose systems, disorder may destroy superfluidity even at zero temperature and trigger a phase transition to an insulator called Bose glass. To date, some aspects of this transition are not fully understood, even in the one-dimensional geometry [4-6]. Here we examine the coherence properties and the excitation spectrum of weakly interacting disordered bosons at zero temperature. The asymptotic behavior of the one-body density matrix which characterizes (quasi-)long-range order and the density of excited states are analyzed numerically within the framework of an extended Bogoliubov theory that correctly accounts for phase fluctuations in low-dimensional systems [7,8]. We use our approach to delineate the zero-temperature phase diagram in 1D and 2D, as a function of interaction strength, disorder strength and disorder correlation.

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