Poster-2-8

Simulating 2D-1D dimensional crossover with ultracold atoms

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As a function of dimensionality, in quantum physics we have access to a broad range of phenomena. In this presentation, we describe the dimensional crossover along two integer dimensionalities, namely 2D to 1D, in strongly interacting ultracold atomic gases as a function of the transverse confining potential V_y. We showcase the analytical tools that can be used to describe the large V_y case where the system is well described by weakly-coupled chains, such as *bosonization* [1]. In this regime, we use a mean-field approach to decouple the chains and study the temperature at which we expect the crossover to occur and its scaling as a function of V_y. We extend the analysis to a broader range of V_y by meaning of QMC simulations [2] and study the superfluid fraction and the evolution of the one-body density matrix $g_1(x)$ by comparing with experiment [3]. These results allow us to define in the V_y - $k_b T$ plane a phase diagram which ranges from BKT physics to 1D Luttinger liquid going through a distinct intermediate phase.

[1] G. Bollmark et al. "Solving 2D and 3D lattice models of correlated fermions-combining matrix product states with mean-field theory". Phys. Rev. X 13, 011039 (2023).

[2] H. Yao, L. Pizzino, T. Giamarchi, "Strongly-interacting bosons at 2D-1D dimensional crossover". SciPost Phys. 15, 050 (2023).

[3] Y. Guo et al. "Observation of the 2D-1D crossover in strongly interacting ultracold bosons". Nat. Phys. (2024).