Momentum distribution of a weakly interacting quasi-1D Bose gas

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In this work we study the finite temperature behavior of the weakly interacting quasi-1D Bose gas. This system exhibits a crossover between nearly ideal gas and a quasi-condensate regime, which is characterised by the presence of both density and phase fluctuations. Experiments in this regime were recently reported by van Amerongen *et al.* [1] and provided the first quantitative test of the Yang-Yang thermodynamic formalism [2] (also known as thermodynamic Bethe ansatz) using the measured position density profiles. Those experiments also measured the momentum distribution using a novel focussing technique, however, these measurements were not explained theoretically as the construction of the momentum distribution using the known Bethe ansatz and the Yang-Yang thermodynamic formalism is a challenging problem yet to be solved.

In this work we develop alternative theoretical techniques to describe the momentum distribution of a quasi-1D Bose gas in a harmonic trap [3]. We show that (*i*) the width w of the momentum distribution can be determined generally using the Yang-Yang thermodynamic formalism by calculating the kinetic energy per particle $E_{\rm kin}/N = \hbar^2 w^2/2m$ (see Fig. 1), and that (*ii*) the Stochastic Gross-Pitaevskii Equation (SGPE) provides a full description of the momentum distribution in the weakly interacting limit (Fig. 2). Using these theories we provide the first quantitative description of the momentum distribution measurements presented in [1].

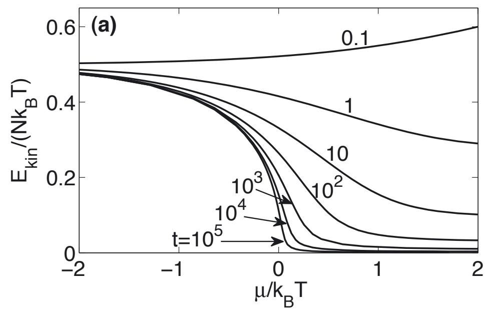

Figure 1. Kinetic energy per particle of a purely 1D uniform Bose gas as a function of the chemical potential μ (all in units of k_BT), for different values of the dimensionless temperature parameter $t = 2k_BT\hbar^2/mg^2$, where g is the 1D coupling constant.

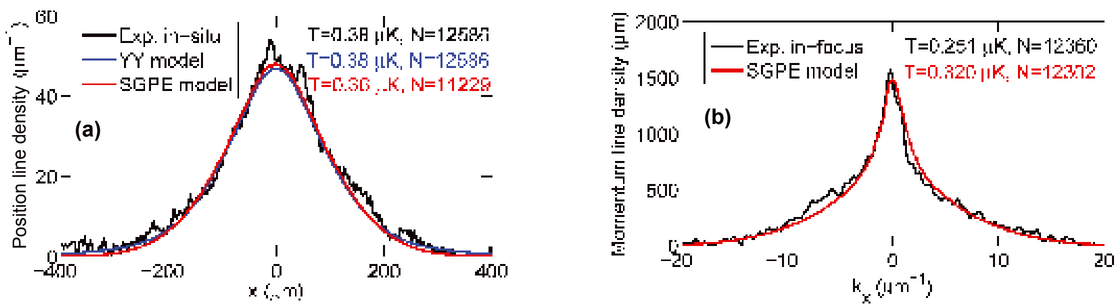

Figure 2. (a) Position-space density profiles from the Yang-Yang thermodynamic formalism (blue), SGPE approach (red), and the experiment (black). (b) Momentum distribution from the SGPE approach (red) and the experiment (black).

References

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