Thermodynamics and nonlocal pair correlations in 1D Bose gases

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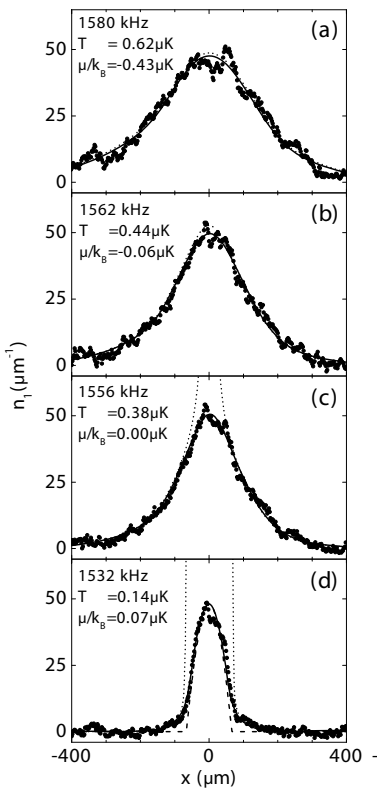
Reducing the dimensionality of a quantum system can have dramatic consequences. For example, the 1D Bose gas with repulsive δ-function interactions exhibits a surprisingly rich variety of physical regimes that is not present in 2D or 3D. The 1D Bose gas model is of particular interest because exact solutions for the many-body eigenstates can be obtained using a Bethe ansatz [1]. Furthermore, the finite-temperature equilibrium can be studied using the Yang-Yang (YY) thermodynamic formalism [2]. The experimental achievement of ultracold atomic Bose gases in the 1D regime has attracted renewed attention to the 1D Bose gas problem and is providing previously unattainable opportunities to test the YY thermodynamics. In 2008 we have made progress on several fronts in the study of 1D Bose gases.

We have established a collaboration with the van Druten group in Amsterdam who have been studying the thermodynamics of 1D Bose gases. They have made measurements of the density profiles of their system over a range of temperatures, and we have shown [3] that the measured density profiles are very well described by a model based on exact solutions obtained using the YY thermodynamic formalism. The figure on the right shows the linear (1D) atomic density obtained from *in situ* absorption images at different temperatures (T) and chemical potentials (μ). Solid lines are fits using YY thermodynamic solutions. Dotted lines are the ideal Bose gas density profiles showing divergence for $\mu(x) = 0$. Dashed line in (d) is a quasi-condensate density profile with the same peak density as the experimental data.



In collaboration with Raizen's experimental group (University of Texas, Austin) and D. M Gangardt (University of Birmingham), we have analytically calculated the spatial nonlocal pair correlation function for a uniform 1D Bose gas at finite T [4]. The summary of the results is given in the ACQAO Annual Reports for 2007. We are currently combining these results with the numerical calculation of the pair correlation function in the crossover regimes where the analytic approaches do not work [5].

References

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