Coherence properties of a 2D trapped Bose gas around the superfluid transition with and without disorder

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We measure the momentum distribution of a two-dimensional trapped Bose gas and observe the increase of the range of coherence around the Berezinskii-Kosterlitz-Thouless (BKT) transition [1]. We quantitatively compare our observed profiles to both a Hartree-Fock mean-field theory and quantum Monte Carlo simulations. In the normal phase, the momentum distribution is observed to sharpen well before the phase transition. We then experimentally study the effect of disorder in the vicinity of the superfluid phase transition [2]. The disorder correlation length is of the order of the Bose gas characteristic length scales (thermal de Broglie wavelength, healing length) and disorder thus modifies the physics at a microscopic level. We analyze the coherence properties of the cloud through measurements of the momentum distributions for two disorder strengths as a function of its degeneracy. For moderate disorder, the emergence of coherence remains steep but is shifted to a lower entropy. In contrast, for strong disorder, the growth of coherence is hindered. Our study is an experimental realization of the dirty boson problem in a well controlled atomic system suitable for quantitative analysis [3, 4].

[1] T. Plisson, B. Allard, M. Holzmann, G. Salomon, A. Aspect, P. Bouyer, and T. Bourdel Phys. Rev. A **84**, 061606(R) (2011).

[2] B. Allard, T. Plisson, M. Holzmann, G. Salomon, A. Aspect, P. Bouyer, and T. Bourdel Phys. Rev. A **85**, 033602 (2012).

[3] T. Bourdel, Phase diagrams of 2D and 3D disordered Boses gases in the local density approximation, Phys. Rev. A, **86**, 063626 (2012).

[4] G. Carleo, G. Boéris, M. Holzmann, and L. Sanchez-Palencia, Phys.Rev.Lett.,**111**,050406 (2013).