Hanbury Brown–Twiss effect in finite-sized Bose gases

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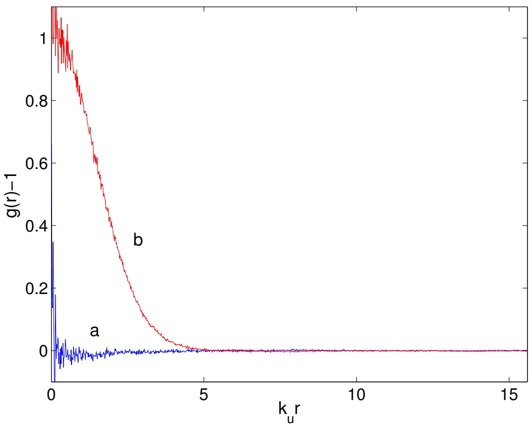
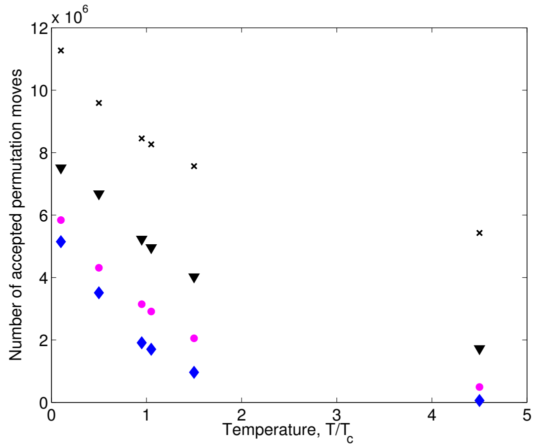
In 1956 Hanbury Brown and Twiss reported [1] elevated photon correlation in *light* emitted by a chaotic source demonstrating that photons obey Bose-Einstein statistics. The same effect has also been detected for massive *subatomic particles*, pions [2]. The first experiment of an *atomic* analogue has carried out in 1996 [3]; the original optical experiment was repeated but with a laser-cooled atomic beam. The temporal correlation of two atoms successively hitting the detector also exhibited a peak around the origin.

We investigate the Hanbury Brown-Twiss effect in a homogeneous, ultracold, spinless Bose gas using the Path Integral Monte Carlo technique [4, 5]. The pair correlation function, $g(r)$ is computed in $d = 1$, 2, and 3 dimensions for temperatures both below and above the critical temperature of Bose condensation. The plot of $g(r)$ exhibits a "bump" at small inter-atomic distances which is a hallmark of bunching.

The configuration space is sampled by: single particle, bisection [4] and permutation updates [6]. The latter is crucial for bunching. Without permutations, $g(r)$ would be a horizontal line corresponding to an ideal Maxwell-Boltzmann gas (see figure).



Pair correlation of an ideal boson gas without (a) and with permutations (b) at $T = 4.5T_c$.



$N = 64$ and symbols: 3d ideal (●); 3d non-ideal, $\gamma = 0$ (♦), 2d ideal (▼); 1d ideal (×).

At a fixed temperature finite-size systems exhibit some deviation from the thermodynamic limit. In lower dimensions the quantum effects are more pronounced. The presence of repulsive interactions suppresses bunching of the bosons, as evidenced by the decrease in number of permutations.

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