Ground-state properties of of 2D hard-core bosons in superfluid phase within second-order spin wave theory

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An analytical expression for zero-temperature thermodynamic potential of the hard-core bosons on a square and triangular lattices in the superfluid phase is derived using the spin-wave theory. We go beyond the standard linear spin-wave approximation calculating corrections due to spin-wave interaction. The model takes into account the hopping of the particles, the nearest neighbor repulsion, and next nearest neighbor interaction which can be of any sign. The internal energy, superfluid density, boson density and compressibility are calculated for different sets of the system parameters. It is shown that even at small particle density the second order corrections to the linear spin-wave approximation are significant at high enough interparticle interactions.

We compare our analytical results for the internal energy, boson density, and superfluid density with a number of numerical data for hard-core bosons on square[1] and triangular[2,3] lattices. In all the cases quite good agreement is obtained.

1. L. Dang, M. Boninsegni, and L. Pollet, Phys. Rev. B **78**, 132512 (2008).
2. S. Wessel and M. Troyer, Phys. Rev. Lett. **95**, 127205 (2005).
3. M. Boninsegni, J. Low Temp. Phys., **132**, 39 (2003).