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Quantum Monte Carlo (QMC) Methods for strongly correlated Bose and Fermi Systems

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I will give two examples where the fluctuations probed by QMC highlight the novel physics of strongly correlated systems. In the first example of bosons in optical lattices, we find in addition to the sound mode, evidence for extra gapped modes in the correlated superfluid phase [1]. We also calculate the effect of thermal and quantum fluctuations, including vortices, on the superfluid density and condensate fraction and compare with recent experiments in optical lattices [2]. In the second example, we calculate the pairing and superfluid properties of a dilute gas of fermions in 3-dimensions with attractive interactions tuned to the unitarity point [3]. From the growth of the density correlations for unequal spins, we identify the pseudogap crossover temperature scale $T^* \approx 0.7E_F$ below which pairing correlations develop. The pseudogap phase is characterised by the temperature dependence of spin susceptibility and compressibility. We estimate the critical temperature for condensation $T_c \approx 0.24E_F$ from a finite size scaling analysis of the superfluid density.

[1] C. Menotti and N. Trivedi, preprint.
[2] Y. Kato, N. Kawashima, and N. Trivedi, preprint.
[3] V. Akkineni, N. Trivedi, D.M. Ceperley, cond-mat/0608154.