Contribution ID: **57** Type: **Contributed Talk**

Probing higher order correlations in the thermodynamic limit a finite temperature doped $t - J$ model

Wednesday 8 October 2025 10:10 (15 minutes)

In strongly correlated systems, the interplay between mobile dopants and the antiferromagnetic (AFM) background plays a central role in emergent phenomena such as the pseudogap and the strange metal at finite temperature. In this particular regime, we investigate the microscopic structure of correlators of the nature of two-point and beyond, in the doped $t - J$ model at the thermodynamic limit using infinite projected entangled pair states down to temperatures $T/t \approx 0.1$. We compute bulk thermodynamic observables — specific heat, uniform spin susceptibility, and charge compressibility — and identify characteristic temperature and doping regimes where short-range magnetic order and electronic compressibility exhibit nontrivial features. These macroscopic signatures guide our microscopic analysis of spin and charge correlations. Our analysis of dopant-dopant-spin-spin (four-point) correlators reveals that two closely spaced holes enhance this ferromagnetic reordering over an extended spatial region, suggesting that holes may attract via the formation of ferromagnetic clusters - a precursor to stripe order. Our findings provide quantitative evidence of a nontrivial, spatially dependent reorganization of spin order induced by dopants in the thermodynamic limit and offer benchmarks for ultracold atom experiments trying to reach the thermodynamic limit.

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