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Absence of spin order in a two-dimensional orbital optical lattice[1]

ZHENYU ZHOU, George Mason University, University of Pittsburgh, VINCENT LIU, University of Pittsburgh, ERHAI ZHAO, George Mason University — Mott insulators with both spin and orbital degeneracy are pertinent to a family of transition metal oxides. The intertwined spin and orbital fluctuations can lead to exotic phases such as quantum spin-orbital liquids. Here we consider two-component spin 1/2 fermionic atoms with strong repulsive interaction on the p-band of the square optical lattice. We derive the spin-orbital exchange for quarter filling of the p-band in the Mott limit, and show it frustrates the development of long range spin order. Exact diagonalization indicates a spin-disordered ground state with ferro-orbital order. The system dynamically decouples into individual Heisenberg spin chains, each realizing a Luttinger liquid accessible at higher temperatures compared to atoms confined to the s-band. Our model serves as an example of how orbital order enhances quantum fluctuations to prevent spin order and leads to dimension reduction in a quantum gas system.

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