Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Effective magnetic interactions in spin-orbit coupled d4 Mott insulators[1] NANDINI TRIVEDI, CHRISTOPHER SVOBODA, MOHIT RANDERIA, Ohio State Univ - Columbus — Transition metal compounds with the $(t_{2g})^4$ electronic configuration are expected to be nonmagnetic atomic singlets due to spin-orbit coupling for both weak and strong interactions . However, starting with the full multi-orbital electronic Hamiltonian, we show the low energy effective magnetic Hamiltonian contains isotropic superexchange spin interactions but anisotropic orbital interactions. By tuning the ratio of superexchange to spin-orbit coupling $J_{\mathrm{SE}/\lambda}$, we obtain a phase transition from nonmagnetic atomic singlets to novel magnetic phases depending on the strength of Hund's coupling, the crystal structure and the number of active orbitals. Spin-orbit coupling plays a non-trivial role in generating a triplon condensate of weakly interacting excitations at antiferromagnetic ordering vector $\vec{k} = \vec{\pi}$, regardless of whether the local spin interactions are ferromagnetic or antiferromagnetic. In the large $J_{\mathrm{SE}/\lambda}$ regime, the localized spin and orbital moments produce anisotropic orbital interactions that are frustrated or constrained even in the absence of geometric frustration. Orbital frustration leads to frustration in the spin channel opening up the possibility of spin-orbital liquids with both spin and orbital entanglement.

[1]We acknowledge the support of the CEM, an NSF MRSEC, under grant DMR-1420451

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Date submitted: 11 Nov 2016 Electronic form version 1.4