Triggering coherent quantum many-body dynamics in antiferromagnetic oxides

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The strongest interaction between microscopic spins in magnetic materials is the exchange interaction J_{ex}. Because J_{ex} emerges from the Pauli principle and the electrostatic Coulomb repulsion between electrons, it is sensitive to purely nonmagnetic perturbations. This fact implies novel possibilities for the ultrafast control of magnetism which in recent years led to intense experimental and theoretical studies on the optical control of J_{ex}. Beyond the control of J_{ex} itself, here we present recent theoretical work elucidating the potential to exploit the control of J_{ex} to trigger coherent quantum many-body dynamics in antiferromagnetic oxides on ultrafast timescales. In particular, we discuss the description of the impulsive excitation of magnon pairs by ultrafast control of J_{ex}. This was recently observed experimentally and leads to coherent longitudinal oscillations of the antiferromagnetic order parameter [1]. By introducing magnon-pair operators, we show that these oscillations can be understood as a coherence between two magnon-pair states, which suggest that the oscillations are a macroscopic manifestation of entanglement between pairs of magnons [2]. Moreover, by extending existing Floquet theory for the control of J_{ex} to multi-band Hubbard systems [3], we discover a novel many-body spin-charge coupling. For special driving frequencies this coupling can even dominate over the control of J_{ex}, linking pairs of local spin states with pairs of doublon-holon states, both of which are gapped with respect to the first excited Hubbard band. Therefore, unlike normal photo-doping causing irreversible charge dynamics within the Hubbard bands, the system remains coherent suggesting potential for optical access to coherent many-body charge dynamics.

[1] J. Zhao et al., Phys. Rev. Lett 93, 107203 (2004), D. Bossini et al., Nat. Commun. 7, 10645 (2016)
[3] D. Bossini, J.H. Mentink, E.V. Gomonay, et al., in preparation (2017)
[4] M. Barbeau, M. Eckstein, M.I. Katsnelson and J.H. Mentink, in preparation (2017)