Spectroscopy of correlated electronic magnetism in semiconductor moiré materials

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Since the discovery of magic-angle twisted bilayer graphene, moiré bilayers consisting of two monolayers of van der Waals materials have emerged as a highly-tunable platform for accessing novel correlated phases of matter. A small twist angle and/or a lattice mismatch between the constituting monolayers in these structures gives rise to a superlattice potential that breaks the electronic bands into a series of flat moiré minibands, which in turn sizably enhances the stability of correlated electronic phases. Recently, this approach has led to the observation of a plethora of exotic electronic states, ranging from Mott-Wigner crystals to fractional Chern insulators.

In this talk, I will describe our low-temperature spectroscopic experiments on magnetism of electrons in the vicinity of a Mott insulating state in angle-aligned, AA-stacked $MoSe_2/WS_2$ heterobilayer [1]. Owing to a strong, triangular moiré superlattice potential, the electrons forming a Mott state in such a structure are deeply localized within their moiré lattice sites, which renders their exchange interactions to be vanishingly small. However, as soon as the Mott state is doped with electrons that form doublons at already-occupied sites, the system begins to exhibit prominent ferromagnetic correlations, with the corresponding Curie-Weiss temperature being proportional to the number of doublons. As proven by our density-matrix-renormalization-group (DMRG) calculations, this ferromagnetism is not driven by inter-electron exchange interactions, but by the minimization of the kinetic energy of doublons through the Nagaoka mechanism. Such a kinetic origin of ferromagnetic correlations in our system is further confirmed a sizable drop in critical temperature that we observe at 4/3 filling factor of the moiré lattice, where the doublons form a Mott-Wigner state in which their mobility is strongly suppressed. These observations constitute a direct evidence for kinetic Nagaoka magnetism in an extended, two-dimensional system.

[1] L. Ciorciaro, T. Smoleński, I. Morera, N. Kiper, S. Hiestand, M. Kroner, Y. Zhang, K. Watanabe, T. Taniguchi, E. Demler, A. Imamoğlu, Kinetic Magnetism in Triangular Moire Materials. Nature **623**, 509 (2023)