Spin and charge orders of the two-dimensional electron gas in external triangular and honeycomb moiré potentials

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Strongly interacting electronic phases are being discovered at an astonishing pace in moiré materials. In the past few years, generalized Wigner crystal (GWC), fractional Chern insulator (FCI), Kondo heavy fermion and kinetic magnetism have all been realized in transition metal dichalcogenide (TMD) bilayer devices. Fundamentally semiconductor junctions, these devices host electrons confined in 2D, which can be accurately modeled as a two-dimensional electron gas (2DEG). We explore the charge and spin orders of TMD moiré materials by solving the 2DEG under the influence of an external moiré potential [1]. In this talk, I will describe the model, methods, and interesting physics one can find. By tuning the shape of the potential and the form of the electron-electron interaction, we find evidence of generalized Wigner crystals (GWC) with noncollinear spin texture, ferromagnetic (FM) semimetal, and charge density wave phases. I will also briefly mention our efforts in using machine learning tools to uncover unusual properties of the 2DEG.

[1]: Y. Yang, M.A. Morales, S. Zhang, "Metal-Insulator Transition in a Semiconductor Heterobilayer Model," Phys. Rev. Lett. **132**, 076503 (2024).