Chez Pierre

Presents ...

Monday, September 22, 2025
12:00 pm - 1:00 pm
Duboc room – 4-331

Chez Pierre Seminar

Daniel Kaplan, Rutgers University

”Designing crystal structures with stacking and light”

The nascent 2D revolution in condensed matter has immense promise for the design of tunable quantum matter. In this talk, I will show new theoretical advances that permit robust and reversible manipulation of quantum materials , through stacking-tuning and light-matter interaction.
Starting with the famous example of multiferroicity, in which quantum materials exhibit competing phases of ferrimagnetism and ferroelectricity, I will present a theory of mutliferroic switching in 2D van der Waals layers (vdW) using light pulses. I will explain how many-body effects can be incorporated using time-dependent density functional theory. The result is a method for switching polar and magnetic order that is reversible and ultrafast, as it is driven by electrons and directly couples to their band properties (the quantum metric).
Next, I will show how light-matter coupling can permit Floquet engineering of quantum materials by combining nonlinear phonon-phonon interactions and a solid-state analogue of parametric resonance. Above a dissipation-set threshold, I will demonstrate that energy is coherently transferred to pairs of low-energy excitations which exist at finite frequency *as well as finite momentum*. This momentum can be controlled by detuning the resonance with which light interacts in the solid. The resultant out-of-equilibrium order, — which couples to phonons, magnons, and other low-energy quasiparticles — is shown to be fundamentally robust to temperature and disorder.
Combining insights from the chemistry of 2D vdW layers, I will show that a stacking-driven topological transition can be controlled by phonons, leading to realization of out-of-equilibrium topological invariants. Using a concrete example, a pnicitide bilayer, I will demonstrate two scenarios: adiabatic driving leading to a time-varying Z_2 invariant and a rapid quench which leads to topological defects and a Moir\’e -like network of trivial and topological domains.