Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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CFEL Seminar room III, Bldg. 99

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Ultracold Fermions in Optical Lattices as a Testbed for Dynamically Driven Complex Materials

Complex quantum many-body systems are ubiquitous in nature, but their behaviour often remains very challenging to predict with analytical or numerical calculations - especially when it comes to dynamics. However, using ultracold atoms in optical lattices it is possible to create precisely tunable, yet very accessible artificial solids, which can be probed with a large arsenal of observables. Using this experimental set-up, we demonstrate how a periodically modulated lattice can be described by an effective Floquet-Hamiltonian on longer time scales - even when driving the system far from equilibrium. This allows for implementing Haldane's model for a topological insulator, and mapping out its topological transitions, by applying an oscillating force to a honeycomb lattice. Using an oscillating magnetic field gradient, we also engineer spin-dependent bands. By adding interactions to the optical lattice system, we create a pure realisation of the Hubbard model and study how the distribution of anti-ferromagnetic correlations therein depends on the geometry of the lattice. We investigate how fast correlations can re-arrange, by deforming the lattice geometry on time-scales ranging from the sudden to the adiabatic regime. Finally, we explore how an oscillating force applied to this interacting system may be used to tune and enhance the magnetic exchange energy beyond the regimes accessible within the Hubbard model.

Host: Andrea Cavalleri

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