Meetings of the Belgian Quantum Physics Initiative

Colloquium

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Synthetic gauge fields with ultracold atoms

Topological phases of matter exhibit remarkable electronic properties. A prominent example is the robust quantization of the Hall conductivity in quantum Hall insulators. A widespread technique for generating topological band structures in synthetic quantum systems, such as ultracold atoms in optical lattices, is Floquet engineering. This method relies on the periodic modulation of the system's parameters to emulate the properties of a non-trivial static system. The rich properties of Floquet systems, however, transcend those of their static counterparts. The associated quasienergy spectrum can exhibit a non-trivial winding number, which leads to the appearance of anomalous chiral edge modes even in situations where the bulk bands have zero Chern numbers.
Here, I report on the realization of such an anomalous Floquet topological system in a periodically-modulated hexagonal optical lattice and show how wavepacket dynamics can be used to study the bulk and edge topological properties of the system. The novel properties of topological Floquet phases open the door to exciting new many-body topological phases without any static analog.
In parallel, we have constructed a new Cs quantum gas microscope which offers exciting alternative experimental possibilities to realize topological many-body phases in state-dependent optical potentials.

The success of Floquet engineering triggered new efforts to build on this vast toolbox and realize non-trivial matter-gauge couplings – a central ingredient for the simulation of so-called lattice gauge theories (LGTs). LGTs play a fundamental role in a variety of areas including high-energy physics and topological quantum computation. So far successful experimental implementations, however, were limited due to the complex local structure of the theory. We are currently developing a new scheme based on correlated tunneling of fermionic atoms and local state-dependent control using optical tweezers to realize a scalable platform for the simulation of U(1) LGTs, relevant for quantum electrodynamics.

Thursday 5th MAY 2022 AT 2 P.M.

COFFEE AND TEA WILL BE SERVED AT 3 P.M.

Two short talks will follow:

4:00pm: Timour Ichmoukhamedov (Antwerp)

Path integral treatment of quadratic systems with general memory: Application to the Bose polaron

4:30pm: Anton Potocnik (IMEC)

Building scalable superconducting quantum processors

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