Q 52: Floquet Engineering and Topology

Time: Thursday 14:30–16:30 Location: E001

Invited Talk Q 52.1 Thu 14:30 E001

Nonperturbative Floquet engineering and Floquet-dissipative state preparation — •Francesco Petiziol — Technische Universität Berlin, Institut für Theoretische Physik, Hardenbergstraße 36, 10623 Berlin, Germany

Time-periodic driving of quantum systems is a powerful tool for realizing effective Hamiltonians with desired properties (so-called "Floquet engineering") and, thus, for quantum simulation. Typical Floquet engineering techniques rely on perturbative approximations and can be categorized into "continuous" or "digital", depending whether they employ continuous time-dependent modulations, or stepwise evolutions with time-independent Hamiltonians. I will present a hybrid continuous-digital approach that allows one to engineer local coupling terms (such as three- and four-body couplings) in a nonperturbative and scalable fashion. This approach allows for the robust engineering of Kitaev's toric-code Hamiltonian, the paradigmatic model of a topological spin liquid, which involves purely four-spin interactions. I will, moreover, discuss how eigenstates of an effective Floquet-engineered Hamiltonian can be prepared and stabilized by coupling the system to artificial baths in superconducting circuits, by generalizing approaches of reservoir engineering. In particular, I will discuss the preparation of ground states of bosonic ladders with artificial magnetic flux.

Q 52.2 Thu 15:00 E001

Preparing and probing bosonic Chern-insulator analogs using Mott states or disorder — •Isaac Tesfaye[1], Botao Wang[2], and André Eckardt[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Université Libre de Bruxelles

Mimicking fermionic Chern insulators with bosons has drawn a lot of interest in experiments by using, for example, cold atoms [1,2] or photons [3]. Here we present a scheme to prepare and probe a bosonic Chern insulator analog by using (a) an ensemble of randomized bosonic states and (b) an initial Mott state configuration. By applying a staggered superlattice, we can identify the lowest band with individual lattice sites. The delocalization over this band in quasimomentum space is then achieved by introducing on-site disorder or local random phases (a). Switching off the interactions and adiabatically decreasing the superlattice then gives rise to a bosonic Chern insulator, whose topologically non-trivial property is further confirmed from the Laughlin-type quantized charge pumping. Adding to this, we propose a detection scheme allowing for the observation of the bosonic quantized charge pump using a feasible number of experimental snapshots. Our protocol provides a useful tool to realize and probe topological states of matter in quantum gases or photonic systems.

[1] M. Aidelsburger, M. Lohse, C. Schweizer, et al., Nature Physics 11, 162 (2015), [2] N. R. Cooper, J. Dalibard, and I. B. Spielman, Rev. Mod. Phys. 91, 015005 (2019), [3] T. Ozawa, H. M. Price, A. Amo, et al., Rev. Mod. Phys. 91, 015006 (2019).

Q 52.3 Thu 15:15 E001

Observation of a dissipative time crystal — •Phatthamon Kongkhambut[1], Hans Kessler[1], Jim Skulte[1], Ludwig Mathey[1], Jayson G. Cosme[2], and Andreas Hemmerich[1] — [1]Zentrum für Optische Quantentechnologien and Institut für Laser-Physik, Universität Hamburg, 22761 Hamburg, Germany. — [2]National Institute of Physics, University of the Philippines, Diliman, Quezon City 1101, Philippines.

We are experimentally exploring the light-matter interaction of a Bose-Einstein condensate (BEC) with a single light mode of an ultra-high finesse optical cavity. The key feature of our cavity is the small field decay rate ($\kappa/2\pi$ = 3.5 kHz), which is in the order of the recoil frequency ($\omega_{rec}/2\pi$ = 3.6 kHz). This leads to a unique situation where cavity field evolves with the same time scale as the atomic distribution. If the system is pumped transversally with a steady state light field, red detuned with respect to the atomic resonance, the Hepp-Lieb superradiant phase transition of the open Dicke is realized [1]. Starting in this self-ordered density wave phase and modulating the amplitude of the pump field, we observe a dissipative discrete time crystal, whose signature is a robust subharmonic oscillation between two symmetry broken states [2].

[1] J. Klinder et al., PNAS 112, 3290-3295 (2015).

[2] H. Keßler et al., PRL 127, 043602 (2021).

Q 52.4 Thu 15:30 E001

Time-periodic Lindblad master equations for quantum systems with engineered interactions and dissipation — •Simon B. Jäger, Jan Mathis Giesen, Christoph Dauer, Imke Schneider, and Sebastian Eggert — Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, D-67663, Kaiserslautern, Germany

Floquet engineering enables the creation of exotic and correlated many-body quantum states by using time-periodic driving. However, driving usually generates heat in the quantum system which can eventually lead to thermalization and loss of coherence on long timescales. A pathway to circumvent these detrimental effects can be engineered dissipation that drains away part of the introduced energy and stabilizes the quantum system far away from equilibrium. One possibility to engineer dissipation and also interactions within the quantum system is by coupling it to bosonic modes. We will show how one can quite generally eliminate the bosonic modes in such a scenario and achieve a Lindblad master equation which includes the mediated interactions and dissipation. We apply this procedure to the time-periodic dissipative Dicke model, a workhorse for the recently observed dissipative time crystals, and confirm its validity. Our results pave the ways towards the theoretical description of many-body quantum systems with mediated interaction and dissipation in presence of periodic driving.

Q 52.5 Thu 15:45 E001

Unveiling heating suppression regimes in a periodic driving Bose gas using a spacetime mapping — •Etienne Wamba[1,2], Axel Pelster[1], and James Anglin[1] — [1]Physics Department and Research Center OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, Germany — [2]Faculty of Engineering and Technology, University of Buea, Buea, Cameroon

We consider a Floquet-engineered model of many-body systems with rapid driving and map the evolutions of the model onto those of relatively slow processes. Such a mapping between rapid and slow evolutions allows us to investigate non-equilibrium many-body dynamics and examine how rapidly driven systems may avoid heating up, at least when mean-field theory is still valid. The fact that the fast time evolution of the system can be mapped exactly onto that of an almost static system suggests that rapid periodic driving does not automatically cause heating, because the system may have a kind of hidden adiabaticity.

Q 52.6 Thu 16:00 E001

Probing boundaries in interacting topological systems — •Marius Gächter, Zijie Zhu, Anne-Sophie Walter, Konrad Viebahn, and Tilman Esslinger — ETH, Zurich, Switzerland

Boundaries between topologically distinct materials give rise to gapless edge modes whose robustness against perturbations makes them promising candidates for technological applications. Therefore, it is crucial to gain a better understanding of topological edge states, especially regarding their response to interparticle interactions. In our experiment, we study quantised bulk Hall drifts of interacting ultracold fermions in the presence of a harmonic confinement. We discovered that quantised drifts halt and reverse in the opposite direction at the topological boundary which emerges due to the harmonic confinement. In the absence of interactions this reflection can be understood as a transfer of atoms between bands with opposite Chern numbers C = +1 and C = -1 via a gapless edge mode, in agreement with the bulk-edge correspondence. Interestingly, this reflection can be used to study the edge in an interacting system since a non-zero repulsive Hubbard U leads to the emergence of an additional edge in the system, which is purely interaction-induced.

Q 52.7 Thu 16:15 E001

Observation of edge states in topological Floquet systems — •Alexander Hesse[1,2], Christoph Braun[1,2,3], Raphaël Saint-Jalm[1,2], Johannes Arceri[1,2], Immanuel Bloch[1,2,3], and Monika Aidelsburger[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), München, Germany —

[3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Floquet engineering, i.e., periodic modulation of a system's parameters, has proven as a powerful tool for the realization of quantum systems with exotic properties that have no static analog. In particular, the so-called anomalous Floquet phase displays topological properties even if the Chern number of the bulk band vanishes. [1]

Our experimental system consists of bosonic atoms in a periodically driven honeycomb lattice. Depending on the driving parameters, several out-of-equilibrium topological phases can be realized, including an anomalous phase. [2]

As the bulk-boundary correspondence relates the properties of the bulk bands to the number of topologically protected edge modes, special interest lies in studying the behavior of them. We are investigating the real-space evolution of a wavepacket close to the edge after the release from a tightly-focused optical tweezer. This way, we observe the chiral nature of the edge state, even in the anomalous Floquet phase, thereby directly revealing the topological nature of this phase.

[1] Rudner et al., Phys. Rev. X 3, 031005 (2013)
[2] Wintersperger et al., Nat. Phys. 16, 1058-1063 (2020)