# Q 8: Quantum Gases (Bosons) II

Time: Monday 16:30–18:30 Location: Q-H10

Q 8.1 Mon 16:30 Q-H10

**Floquet-heating-induced non-equilibrium Bose condensation in a dissipative optical lattice** — •Alexander Schnell[1], Ling-Na Wu[1], Artur Widera[2], and André Eckardt[1] — [1]Technische Universität Berlin, Institut für Theoretische Physik, 10623 Berlin, Germany — [2]Department of Physics and State Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

We investigate theoretically a mixture of two weakly interacting species of bosonic quantum gases, where the parameters are such that an open-system description in terms of a Floquet-Born-Markov master equation applies. One component, the system, is a non-interacting gas in a one-dimensional optical lattice potential, the other component, the bath, is a three-dimensional weakly-interacting BEC. Interestingly, by additionally time-periodically driving the system at one lattice site, a nonequilibrium steady state that features Bose condensation can be induced in the system. Condensation can occur at bath temperatures well above equilibrium condensation temperature as well as in excited single-particle states. An intuitive explanation is that the Floquet drive induces a large inflow of heat that can be avoided by the system by condensing in a mode that decouples from the driving site. The model should be realizable with state of the art quantum gas experiments.

Q 8.2 Mon 16:45 Q-H10

**Driving a 1D Bose Gas into Non-Equilibrium by Particle Losses** — Anja Seegebrecht and •Carsten Henkel — Universität Potsdam, Institut für Physik und Astronomie

Low-dimensional Bose gases form a model system where comparison to a portfolio of theories (Lieb-Liniger, Luttinger liquid, stochastic Gross-Pitaevskii equation [1]) is possible. Being a nearly integrable system, long-lived non-equilibrium states appear while particles are lost [2]. We perform stochastic simulations for loss processes also involving 2-, or 3-body collisions. The thermometers we developed give different readings as the system evolves, that can be given heuristic interpretations and compared to experiments. Particular large discrepancies appear due to the "shot noise" that arises from the information gain due to particle loss [3].

[1] N. Proukakis, S. Gardiner, M. Davis, and M. Szymańska, *Quantum Gases: Finite Temperature and Non-Equilibrium Dynamics*, Series Cold Atoms vol. 1 (Imperial College Press 2013).
[2] A. Johnson, S. Szigeti, M. Schemmer, and I. Bouchoule, " Long-lived non-thermal states realized by atom losses in one-dimensional quasi-condensates," Phys. Rev. A **96** (2017) 013623.
[3] P. Grišins, B. Rauer, T. Langen, J. Schmiedmayer, and I. E. Mazets, "Degenerate Bose gases with uniform loss," Phys. Rev. A **93** (2016) 033634; I. Bouchoule, M. Schemmer, and C. Henkel, "Cooling phonon modes of a Bose condensate with uniform few body losses," SciPost Phys. **5** (2018) 043.

Q 8.3 Mon 17:00 Q-H10

**Experimental realization of a 3D random hopping model** — •Patrick Mischke, Carsten Lippe, Jana Bender, Tanita Klas, Thomas Niederprüm, and Herwig Ott — Department of Physics and research center OPTIMAS, Technische Universität Kaiserslautern, Germany

We present experimental results from a Rydberg system described by the XY-model Hamiltionian with random couplings.

While systems with disordered potentials have already been studied in detail, experimental investigations on systems with disordered hopping are still rare. Small amounts of disorder can dramatically change the transport properties of a system compared to the underlying simple model. We present an experimental study of a dipole–dipole-interacting three-dimensional Rydberg system described by the XY transport model for spin-$\frac{1}{2}$ particles $\hat{H}_{XY} = \sum \frac{J_{ij}}{2}\left(\hat{\sigma}_i^x \hat{\sigma}_j^x + \hat{\sigma}_i^y \hat{\sigma}_j^y\right) + \sum \varepsilon_i \hat{\sigma}_i^z$. We observe spectroscopic agreement with theoretical models and discuss emerging localization phenomena.

The presented Rydberg platform allows for high control over the microscopic parameters and will allow to further study transport processes and localization phenomena in random hopping models.

Q 8.4 Mon 17:15 Q-H10

**Experimental characterization of a dissipative phase transition in a multi-mode system** — •Marvin Röhrle, Jens Benary, Christian Baals, Erik Bernhart, Jian Jiang, and Herwig Ott — Department of Physics and Research Center OPTIMAS, Erwin-Schrödinger-Straße 46, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We experimentally investigate the behavior of a driven-dissipative Bose-Einstein condensate of weakly interacting $^{87}$Rb atoms in a 1-D optical lattice. The dissipation is induced by a scanning electron microscope setup, which allows us to observe a single site time resolved. Tunneling from the neighboring sites makes up the driving force.

By changing the tunnel coupling $J$ of the lattice, a dissipative phase transition from a coherent super fluid phase to an incoherent phase can be seen. In the vicinity of the phase transition, both branches coexist in a meta stable region depending on the initial state. Measuring the relaxation rates between the two states allows us to approximate the adiabatic decay rate and find the critical point. In every individual realization of the experiment, the filling of the site shows a digital behavior, which is visible as pronounced jumps in the site occupation. We find that the switching between both states takes only a few tunneling times despite hundreds of atoms tunneling. Furthermore, starting from an initially filled site, the losses induce a super fluid current which keeps the site filled. This complete extinction of a matter wave within a medium indicates the onset of coherent perfect absorption.

Q 8.5 Mon 17:30 Q-H10

**High signal to noise imaging of potassium at high magnetic fields** — •Maurus Hans, Celia Viermann, Marius Sparn, Nikolas Liebster, Helmut Strobel, and Markus K. Oberthaler — Kirchhoff-Institut für Physik, Universität Heidelberg, Deutschland

In 39K a broad Feshbach resonance at 560G allows for the tuning of the atomic interaction over a wide range. To detect the in-situ atomic density with high spatial resolution, direct imaging at this field is necessary. However, for the F=1 ground state manifold a closed optical transistion does not exist. In this talk, we present an imaging scheme that utilises four atomic levels and two laser frequencies to get an approximately closed optical cycle [1]. It allows for a drastic enhancement of the number of scattered photons. We demonstrate the extraction of the atomic column density of a 39K Bose-Einstein condensate with absorption imaging and show the suitability of the scheme for fluorescence imaging of few atoms per detection volume.

[1] Hans, M. et al., Rev. Sci. Instrum. 92, 023203 (2021)

Q 8.6 Mon 17:45 Q-H10

**Disorder in topological Floquet engineered systems.** — •Christoph Braun[1,2,3], Raphaël Saint-Jalm[1,2], Alexander Hesse[1,2], Monika Aidelsburger[1,2], and Immanuel Bloch[1,2,3] — [1]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 the systems parameters, has proven as a powerful experimental tool for the realization of quantum systems with exotic propertiest that are otherwise not accessible in static realizations. Our experimental system consists of bosonic atoms in a periodically driven honeycomb lattice. Depending on the driving parameters several topological phases can be realized, including genuine out-of-equilibrium topological phases without any static analog [1]. Recently, we have added a random optical potential to study localization in topological bands. To this end we are investigating the real-space evolution of an initially localized wavepacket after release from a tightly-focused optical tweezer. In general, disorder will drive a transition to a topologically trivial phase. The interplay between topology and disorder in driven systems, however, was further predicted to give rise to exotic disorder-induced topological phases, such as the anomalous Floquet Anderson insulator.

Q 8.7 Mon 18:00 Q-H10

**A Kapitza Pendulum for Ultracold Atoms** — •Erik Bernhart, Jian Jiang, Marvin Röhrle, Jens Benary, Marvin Beck, Christian Baals, and Herwig Ott — Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We present the experimental realization of a Kapitza pendulum for ultacold $^{87}$Rb atoms.

Our experiment shows how a periodic modulation of the potential can lead to dynamical stabilization of the atomic motion in an otherwise unstable potential. While the time average of the modulated potential vanishes, the corresponding Floquet Hamiltonian results in an effective time independent potential, which traps the atoms.

In our experiment we create the Kapitza pendulum by two time modulated Gaussian shaped laser beams, which generate an attractive and repulsive potential. We analyze the lifetime and the stability of the trap, depending on the driving frequency of the potentials.

Q 8.8 Mon 18:15 Q-H10

**Quantum phases of a dipolar gas of bosons in an one-dimensional optical lattice** — •Rebecca Kraus[1], Titas Chanda[2,3], Jakub Zakrzewski[2,4], and Giovanna Morigi[1] — [1]Theoretical Physics, Saarland University, Saarbrücken, Germany — [2]Institute of Theoretical Physics, Jagiellonian University, Kraków, Poland — [3]ICTP, Trieste, Italy — [4]Mark Kac Complex Systems Research Center, Jagiellonian University, Kraków, Poland

We present a theoretical analysis of the phase diagram of ultracold bosons in a lattice and interacting with long-range forces decaying with the inter-particle distance. The theoretical model is an extended Bose-Hubbard model and describes the dynamics of ultracold atoms in optical lattices realised in present experimental platforms. We determine the ground state in one dimension using numerical programs based on tensor networks. We focus in particular on parameters for which quantum fluctuations compete with the interaction-induced correlated hopping between lattice sites. We analyse the phases emerging from the competition of these two mechanisms. For larger densities we identify the parameters where correlated hopping and quantum fluctuations destructively interfere. This quantum interference leads to insulating phases at relatively large kinetic energies, where one would otherwise expect superfluidity. For unit density our results predict that correlated tunnelling can significantly modify the parameter range where the topological phase is found. At vanishing values of the onsite interactions, moreover, correlated tunnelling promotes here the onset of a phase separation.