Q 55: Quantum Effects III

Time: Thursday 14:00–15:30 Location: Q-H13

Q 55.1 Thu 14:00 Q-H13

Observation of long-lived metastable structures in a quantum gas with long-range interactions — •Simon Hertlein[1], Alexander Baumgärtner[1], Carlos Máximo[1], Tom Schmit[2], Giovanna Morigi[2], Davide Dreon[1], and Tobias Donner[1] — [1]Institute for Quantum Electronics, Eidgenössische Technische Hochschule Zürich, 8093 Zurich, Switzerland — [2]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany

We study relaxation of a quantum gas after quenches across a phase transition and in the presence of competing long-range interactions. The interactions are mediated by two cavity modes, which induce competing spatial ordering. The quenches are implemented by changing the detuning between an external laser frequency and the cavity resonances. Using the real-time access to the order parameters provided by the leaking cavity fields, we observe metastability for a large range of parameters. The atoms remain frozen in the initial pattern with lifetimes that exceed any natural time scale of the system before relaxing to the stable configuration. From an ab- initio treatment we derive a Vlasov equation. We show that its fixed points are the metastable configurations, which can be understood as quasi-stationary states due to the long-range interactions. By this mean we theoretically reproduce the character- istic time scale of relaxation and their dependence on the physical parameters. We attribute the observed metastability to the competing global range interactions.

Q 55.2 Thu 14:15 Q-H13

Characterisation of lasing from cold trapped Yb atoms — •Saran Shaju, Dmitriy Sholokhov, and Jürgen Eschner — — Universität des Saarlandes, Germany

We observe optical gain and laser emission from a medium of a few thousand Ytterbium-174 atoms which are magneto-optically trapped (MOT), using their $^1S_0 \rightarrow {}^1P_1$ transition at 399 nm, inside a 5-cm long high-finesse cavity. The cavity output is observed as continous wave lasing on the $^1S_0 \rightarrow {}^3P_1$ intercombination line at 556 nm when the atoms are laser-pumped on the same transition. The physics behind the observation is understood as a multi-photon lasing mechanism involving the MOT transition [1]. By heterodyne analysis, we analyse the frequency characteristics of the system versus pump and cavity detuning. By cooling the atoms near the Doppler limit of the intercombination transition, we observe an increase in atomic density and a corresponding reduction of the laser threshold.

[1] H. Gothe, D. Sholokhov, A. Breunig, M. Steinel, and J. Eschner. Phys. Rev. A, 99, 013415, 2019.

Q 55.3 Thu 14:30 Q-H13

Emergent atom pump in a non-hermitian system — •Alexander Baumgärtner, Davide Dreon, Simon Hertlein, Xiangliang Li, Tilman Esslinger, and Tobias Donner — Institute for Quantum Electronics, Eidgenössische Technische Hochschule Zürich, 8093 Zürich, Switzerland

The time evolution of a quantum system can be strongly affected by dissipation. Although this mainly implies that the system relaxes to a steady state, in some cases it can make new phases appear and trigger emergent dynamics. In our experiment, we study a Bose-Einstein Condensate dispersively coupled to a high finesse resonator. The cavity is pumped via the atoms, such that the sum of the coupling beam(s) and the intracavity standing wave gives an optical lattice potential. When the dissipation and the coherent timescales are comparable, we find a regime of persistent oscillations where the cavity field does not reach a steady state. In this regime the atoms experience an optical lattice that periodically deforms itself, even without providing an external time dependent drive. Eventually, the dynamic lattice triggers a pumping mechanism. We show complementary measurements of the light field dynamics and of the particle transport, proving the connection between the emergent non-stationarity and the atomic pump.

Q 55.4 Thu 14:45 Q-H13

Anisotropy of multiple quantum fluorescence signals — •Friedemann Landmesser[1], Ulrich Bangert[1], Lukas Bruder[1], Edoardo Carnio[1,2], Mario Niebuhr[1], Vyacheslav Shatokhin[1,2], Andreas Buchleitner[1,2], and Frank Stienkemeier[1] — [1]Institute of Physics, University of Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, University of Freiburg, Germany

We investigate collective effects in thermal atomic alkali vapors by multiple-quantum coherence experiments, where multiphoton processes can be separated from one-photon transitions and can be assigned to specific particle numbers [1, 2]. The technique is sensitive enough to reveal weak interparticle interactions, despite the thermal motion and the spatial separation of the atoms in the micrometer-range [3]. We experimentally investigate the dependence of such signals on the laser polarization, which was previously predicted theoretically for a similar physical system [4].

[1] L. Bruder et al., Phys. Rev. A 92, 053412 (2015).
[2] S. Yu et al., Opt. Lett. 44, 2795 (2019).
[3] L. Bruder et al., Phys. Chem. Chem. Phys. 21, 2276 (2019).
[4] B. Ames et al., J. Chem. Phys. 155, 44306 (2021).

Q 55.5 Thu 15:00 Q-H13

Characterization of a localization transition in a power-law interacting spin model without disordered potentials — •Adrian Braemer[1] and Martin Gärttner[1,2,3] — [1]Physikalisches Institut, Heidelberg, Deutschland — [2]Kirchhoff-Institut für Physik, Heidelberg, Deutschland — [3]Institut für Theoretische Physik, Heidelberg, Deutschland

The impact of disorder on quantum many-body systems has been studied extensively over the past decade. Disorder commonly takes the form of random potentials which leads to localized eigenstates at sufficiently high disorder strength. Here we study the localization transition in a Heisenberg XXZ spin chain, where the disorder is exclusively due to random spin-spin couplings, arising from power-law interactions between randomly positioned sites. We use established spectral and eigenstate properties and entanglement entropy to show that there is indeed a transition from an ergodic to a localized regime. We identify strongly interacting pairs as emergent local conserved quantities in the system, leading to an intuitive physical picture consistent with our numerical results.

Q 55.6 Thu 15:15 Q-H13

Does a disordered Heisenberg spin system thermalize? — •Titus Franz[1], Adrien Signoles[2], Adrian Braemer[3], Renato Ferracini Alves[1], Sebastian Geier[1], Annika Tebben[1], André Salzinger[1], Nithiwadee Thaicharoen[1,4], Clément Hainaut[1,5], Gerhard Zürn[1], Martin Gärttner[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Heidelberg University, Germany — [2]Pasqal, France — [3]Kirchhoff-Institut für Physik, Heidelberg University, Germany — [4]Research Center for Quantum Technology, Chiang Mai University, Thailand — [5]Université de Lille, CNRS, UMR 8523 - PhLAM, France

The far-from-equilibrium dynamics of generic disordered systems is expected to show thermalization, but this process is yet not well understood and shows a rich phenomenology ranging from anomalously slow relaxation to the breakdown of thermalization. While this problem is notoriously difficult to study numerically, we can experimentally probe the relaxation dynamics in an isolated spin system realized by a frozen gas of Rydberg atoms. The long-time magnetization as a function of a transverse external field shows striking features including non-analytic behavior at zero field. These can be understood from mean-field, perturbative, and spectral arguments. The emergence of these distinctive features seems to disagree with Eigenstate Thermalization Hypothesis (ETH), which indicates that either a better theoretical understanding of thermalization is required or ETH breaks for the here studied quench in a disordered spin system.