Q 52: Ultra-cold Plasmas and Rydberg Systems II (joint session A/Q)

Time: Thursday 11:00–13:00 Location: N 2

Invited Talk Q 52.1 Thu 11:00 N 2

Long-lived giant circular Rydberg atoms at room temperature — •Fabian Thielemann, Einius Pultinevicius, Aaron Götzelmann, Christian Hölzl, and Florian Meinert — 5 . Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Germany

Atoms in Rydberg states feature long-lived coherent electronic excitations and strong dipolar interactions, making them an attractive platform for quantum simulation and computation. Spinning them up to their maximum allowed angular momentum, to so called circular Rydberg states (CRS), can significantly enhance these desirable properties, e.g. boosting their lifetime from micro- to millisecond timescales. In our experiment we prepare ^{88}Sr atoms in CRS and optically trap them within a room-temperature capacitor structure made from indium-tin-oxide-coated glass. The capacitor inhibits blackbody radiation with wavelengths longer than twice its plate distance, thus significantly suppressing transitions between neighboring CRS with large principal quantum number n. Here, we coherently link CRS with n ranging from 79 up to 101 and demonstrate a capacitor-enhanced lifetime of 10ms [1]. We further show that, owing to their divalent structure, the ^{88}Sr in high angular momentum Rydberg states can be trapped in regular optical tweezers with trapping times exceeding 100ms.

[1] Pultinevicius et al., arXiv:2510.27471 (2025)

Invited Talk Q 52.2 Thu 11:30 N 2

Dynamical decoupling in a dipolar Rydberg gas — •Meny Menashes, Eduard Braun, Matthias Lotze, Maharshi Pran Bora, Gerhard Zürn, and Matthias Weidemüller — Physikalisches Institut, Heidelberg, Germany

We present our ongoing effort to measure out-of-time-order correlators (OTOCs) in a disordered, dipolar Rydberg gas. Building on our recent time-reversal experiments in a dipolar quantum many-body spin system and advances in microwave Hamiltonian engineering, we aim to realize a novel dynamical decoupling protocol based solely on microwave control. This approach enables precise time reversal and suppression of higher-order interactions, providing a clean platform to study information scrambling and quantum dynamics. Via state-selective ionization field tomography reconstruction of the global magnetization is measured, granting access to both global and local observables. The experiment represents a step toward controlled investigations of thermalization, localization, and dynamical quantum phase transitions in isolated long-range interacting spin systems

Q 52.3 Thu 12:00 N 2

Stabilizing a Dissipative Non-Equilibrium Phase Transition — •Patrick Mischke, Herwig Ott, and Thomas Niederprüm — Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau

We experimentally investigate the facilitation dynamics in an ultracold Rydberg system. In the facilitation ($\equiv$ anti-blockade) regime, a non-equilibrium phase transition emerges from the interplay between driving and excitation decay.

In an off-resonantly driven cloud of atoms, the strong dipole-dipole interactions between two Rydberg states compensates the laser detuning for a specific interatomic distance, allowing resonant excitations to occur. At sufficiently high atomic densities, this facilitation process leads to the spreading of excitations, forming an active phase, whereas at low densities excitations decay faster than they can propagate, resulting in an absorbing phase. Rydberg excitations that decay to ions are lost from the system and observed at our detector. In order to stabilize the system, this loss must be balanced by a gain process. We implement such gain by optically pumping atoms from a different hyperfine state, allowing us to tune the steady-state density. This stabilization enables measurements of the system dynamics, including correlation functions, over time scales orders of magnitude longer than previously accessible, allowing a systematic characterization of the associated dissipative non-equilibrium phase transition.

Q 52.4 Thu 12:15 N 2

Cryogenic Strontium Quantum Processor — •Xintong Su, Roberto Franco, Valerio Amico, Jonas Drotleff, and Christian Gross — Physikalisches Institut, Eberhard Karls Universität Tübingen, Germany

With the increasing perfection in the control of quantum mechanical many-body systems, first steps for the realization of simple quantum computers have been made. Various physical systems can serve as a basis for such quantum computers. Neutral Rydberg atoms in optical tweezers are among the most promising technologies in the race to build a quantum computer. This platform unites fundamentally indistinguishable qubits and precise control via light fields with scalability in the size of the qubit register. In our project, we work with fermionic 87Sr. The qubit states are defined on two hyperfine sublevels of the ground state. Our goal is to combine the optical tweezer technology with a carefully designed cryogenic setup at 4K. This will result in exceptionally long coherence and lifetime of the atoms in the optical tweezer array and forms the basis for scalability to large atom numbers. Furthermore, the intensity of black-body radiation is strongly reduced in cryogenic environments. Therefore, detrimental coupling between neighbouring Rydberg states, a potential source for collective decoherence in a quantum processor, is suppressed. Finally, the cryogenic environment enables the usage of superconducting coils, which offers outstanding passive stability of the magnetic field and thereby increases the qubit coherence.

Q 52.5 Thu 12:30 N 2

Entanglement of mechanical oscillators mediated by a Rydberg tweezer chain — •Chris Nill[1,2], Cedric Wind[2], Julia Gamper[2], Samuel Germer[2], Valerie Mauth[2], Wolfgang Alt[2], Igor Lesanovsky[1,3], and Sebastian Hofferberth[2] — [1]Institut für Theoretische Physik, University of Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]Institute for Applied Physics, University of Bonn, Wegelerstraße 8, 53115 Bonn, Germany — [3]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

Mechanical systems provide a unique test bed for studying quantum phenomena at macroscopic length scales. However, realizing quantum states that feature quantum correlations among macroscopic mechanical objects remains an experimental challenge. Here, we propose a quantum system in which two micro-electromechanical oscillators interact through a chain of Rydberg atoms confined in optical tweezers [1]. We demonstrate that the coherent dynamics of the system generate entanglement between the oscillators. Furthermore, we utilize the tunability of the radiative decay of the Rydberg atoms for dissipative entanglement generation. Our results highlight the potential to exploit the flexibility and tunability of Rydberg atom chains to generate nonclassical correlations between distant mechanical oscillators.

[1] C. Wind, C. Nill et al., arXiv:2510.08371 (2026).

Q 52.6 Thu 12:45 N 2

Probing localization in a bond-disordered power-law interacting system using time-reversal based protocols — •Eduard Jürgen Braun, Matthias Lotze, Adrian Braemer, Gerhard Zürn, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Quantum thermalization raises intriguing questions about the fate of isolated many-body systems. In conventional one-dimensional systems at finite system size, many-body localization (MBL) appears to defy thermalization, often understood through the emergent integrability encoded in local integrals of motion (LIOMs). However, in systems with long-ranged power-law interactions, the standard LIOM picture is not expected to hold, and recent studies in a bond-disordered model have revealed level statistics markedly different from standard MBL systems. Here, we investigate whether time-reversal-based methods, such as Loschmidt echoes, can uncover distinctive signatures of localization in these bond-disordered power-law interacting systems. Our results suggest that localization in such systems is qualitatively different from conventional MBL, providing new insights into the interplay of disorder and long-ranged interactions.