Q 6: Ultra-cold Plasmas and Rydberg Systems I (joint session A/Q)

Time: Monday 11:45–12:45 Location: N 1

Invited Talk Q 6.1 Mon 11:45 N 1

Experimental investigation of strongly interacting quantum fluids of light in rydberg atoms — •Amar Bellahsene, Tom Bienaimé, and Shannon Whitlock — Université de Strasbourg, CESQ-ISIS, Strasbourg, France

Photons are ideal quantum systems - easy to generate, manipulate, and detect - but their absence of mutual interactions limits their use for many-body physics and quantum simulation. A powerful approach to engineer strong and tunable photon-photon interactions is to propagate light through an ultracold atomic gas coupled to Rydberg states under electromagnetically induced transparency (EIT). This medium provides strong light-matter coupling and collectively enhanced nonlinearities, allowing photons to acquire an effective mass and interact, forming a platform for quantum fluids of light. My PhD work explores this regime using ultracold potassium 39 atoms in a Magneto-optical trap. We characterize how atomic nonlinear media mediate interactions between photons by measuring the Kerr nonlinearity in a two-level system and comparing it to the large enhancement achieved in a three-level Rydberg-EIT configuration. The nonlinear phase shifts are extracted with a Mach-Zehnder interferometer, providing a sensitive probe of interaction-induced optical response. By combining spatial structuring of the light field, strong Rydberg interactions, and interferometric detection, the goal is to demonstrate a quantum nonlinear medium where photons behave as interacting quasiparticles - opening the way toward the realization of a quantum fluid of light.

Q 6.2 Mon 12:15 N 1

Orientation of Trilobite Rydberg Molecules in Electric Fields — •Richard Blättner, Markus Exner, and Herwig Ott — RPTU Kaiserslautern-Landau

Rydberg molecules consist of a Rydberg atom bound to a ground state atom. The binding mechanism is based on the scattering interaction between the Rydberg electron and the ground state atom. Trilobite molecules are a subclass of high-l Rydberg molecules that exhibit a huge permanent electric dipole moment and are therefore highly sensible to electric fields. We report on the observation of trilobite molecules oriented by an electric field. We excite these molecules within a cloud of ultracold ^{87}Rb atoms using a three-photon excitation scheme. We make the molecules orientation visible on the 2D detector of a reaction microscope taking advantage of state changing collisions.

Q 6.3 Mon 12:30 N 1

Signatures of emerging kinetic constraints in a weakly interacting dissipative Rydberg gas — •Viktoria Noel[1] and Igor Lesanovsky[1,2] — [1]Institut für Theoretische Physik and Center for Integrated Quantum Science and Technology, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany — [2]School of Physics and Astronomy and center for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

We investigate the relaxation dynamics of a weakly interacting, dissipative Rydberg gas, and identify subtle signatures typically associated with kinetic constraints in more strongly interacting settings. We access mesoscopic one- and two-dimensional systems and resolve the dynamical features underlying this behaviour using the truncated Wigner approximation, also supported by exact benchmarks on smaller systems. We observe a weak slowdown in temporal correlations relative to a simple relaxation, while spacetime snapshots show prolonged excitation patches signalling dynamical heterogeneity. We trace these features to the interplay of coherent driving, interactions, and dissipation, which in part restricts relaxation pathways. Our results highlight that the onset of kinetic constraints may occur before the strongly interacting regime is reached, establishing weakly interacting Rydberg arrays as a promising platform for studying emergent slowed dynamics out of equilibrium.