Q 1: Ultra-cold Atoms, Ions and BEC I (joint session A/Q)

Time: Monday 11:00–13:00 Location: HS 1010

Invited Talk Q 1.1 Mon 11:00 HS 1010

Exploring the Supersolid Stripe Phase in a Spin-Orbit Coupled Bose-Einstein Condensate — •Sarah Hirthe, Vasiliy Makhalov, Rémy Vatré, Craig Chisholm, Ramón Ramos, and Leticia Tarruell — ICFO - The Institute of Photonic Sciences, Castelldefels, Spain

Spin-orbit coupled Bose-Einstein condensates, where the internal state of the atoms is linked to their momentum through optical coupling, are a flexible experimental platform to engineer synthetic quantum many-body systems. In my talk, I will present recent work where we have exploited the interplay of spin-orbit coupling and tunable interactions in potassium BECs to observe and characterize the supersolid stripe phase. By optically coupling two internal states of potassium-41 using a two-photon Raman transition, we engineer a single particle dispersion relation with characteristic double-well structure. When the intrawell interactions dominate over the interwell ones, both minima are occupied and their populations interfere, leading to a system with a modulated (striped) density profile. The BEC then behaves as a supersolid: a phase that spontaneously breaks both gauge and translation symmetry, and which combines the frictionless flow of a superfluid and the crystalline structure of a solid. Using a matter-wave lensing technique, we magnify the density profile of the cloud and measure in situ the contrast and spacing of the stripes. Furthermore, we characterize the collective modes of the system and their dependence on interactions and coupling strength.

Q 1.2 Mon 11:30 HS 1010

Determination of the dissipative response of a circularly driven atomic erbium quantum Hall system — •Franz Richard Huybrechts, Arif Warsi Laskar, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn

Cold atomic gases are attractive systems for the study of topological states and phases. Here we report on experimental work studying the dissipative response of a synthetic atomic erbium quantum Hall system to two different handed modes of circular shaking. In general, the dissipative response of a topological system, expressed by its circular dichroism, is linked to the transport properties by a Kramers-Kronig relation. In our experiment, for a cold cloud of erbium atoms a quantum Hall geometry is realised in a two-dimensional state space, consisting of one spatial and one synthetic dimension, with the latter being encoded in the Zeeman quantum number of erbium atoms in the ground state. Our measurements give evidence for a difference in the excitation rates between left and right handed driving. The current status of this ongoing experiment will be reported.

Q 1.3 Mon 11:45 HS 1010

Drude weight and the many-body quantum metric in one-dimensional Bose systems — •Grazia Salerno[1], Tomoki Ozawa[2], and Päivi Törmä[1,2] — [1]Department of Applied Physics, Aalto University School of Science, FI-00076 Aalto, Finland — [2]Advanced Institute for Materials Research (WPI-AIMR), Tohoku University, Sendai 980-8577, Japan

We study the effect of quantum geometry on the many-body ground state of one-dimensional interacting bosonic systems. We find that the Drude weight is given by the sum of the kinetic energy and a term proportional to the many-body quantum metric of the ground state. Notably, the many-body quantum metric determines the upper bound of the Drude weight. We validate our results on the Creutz ladder, a flat-band model, using exact diagonalization at half and unit densities. Our work sheds light on the importance of the many-body quantum geometry in one-dimensional interacting bosonic systems.

Q 1.4 Mon 12:00 HS 1010

Shapiro steps in driven atomic Josephson junctions — •Vijay Singh[1], Juan Polo[1], Ludwig Mathey[2], and Luigi Amico[1] — [1]Quantum Research Centre, Technology Innovation Institute, Abu Dhabi, UAE — [2]Zentrum für Optische Quantentechnologien and Institut für Quantenphysik, Universität Hamburg, 22761 Hamburg, Germany

We study driven atomic Josephson junctions realized by coupling two two-dimensional atomic clouds with a tunneling barrier. By moving the barrier at a constant velocity, dc and ac Josephson regimes are characterized by a zero and nonzero atomic density difference across the junction, respectively. Here, we monitor the dynamics resulting in the system when, in addition to the above constant velocity protocol, the position of the barrier is periodically driven. We demonstrate that the time-averaged particle imbalance features a step-like behavior that is the analog of Shapiro steps observed in driven superconducting Josephson junctions. The underlying dynamics reveals an intriguing interplay of the vortex and phonon excitations, where Shapiro steps are induced via suppression of vortex growth. We study the system with a classical-field dynamics method, and benchmark our findings with a driven circuit dynamics.

Q 1.5 Mon 12:15 HS 1010

Collisional dynamics between an ion and a Rydberg *S*-state — •Moritz Berngruber[1], Daniel Bosworth[2], Óscar Andrey Herrera Sancho[1], Viraatt Anasuri[1], Jennifer Krauter[1], Nicolas Zuber[1], Frederic Hummel[2], Florian Meinert[1], Robert Löw[1], Peter Schmelcher[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We report on the onset dynamics of a collision between an ion and a Rydberg atom in a highly excited S-state. Due to a large number of avoided crossings in the pair state potential, the dynamics can be quite complex but also provides a lot of possibility to manipulate and control the collision rates by changing the adiabaticity of the system. In our setup we can create Rb^+ ions and highly excited Rydberg sates independently. Owed to a very precise control of electric stray fields, we can conduct our measurements without the need of an additional ion trap, preventing micromotion in our experiments. By using a high-resolution ion microscope, we can directly observe the ions and Rydberg atoms in a cold thermal cloud in real space with a resolution of 200 nm. This allows us not only to directly map out the C4 pair interaction potential but also to directly observe the onset of the collisional dynamics. Finally, the experimental results are compared to a multi-channel model based on a Landau-Zener approach, which agrees very well with the experimental results.

Q 1.6 Mon 12:30 HS 1010

Systematic analysis of relative phase extraction in 1D Bose gases interferometry — •Taufiq Murtadho[1], Marek Gluza[1], Nelly Ng[1], Arifa Khatee Zatul[1,2], Sebastian Erne[3], and Jörg Schmiedmayer[3] — [1]Nanyang Technological University, Singapore — [2]University of Wisconsin-Madison, Madison, USA — [3]Technische Universität Wien, Vienna, Austria

Matter-wave interference upon free expansion enables spatially resolved relative phase measurements of two adjacent 1D Bose gases. However, longitudinal dynamics is typically ignored in the analysis of experimental data. We provide an analytical formula showing a correction to the readout of the relative phase due to longitudinal expansion and mixing with the symmetric phase. Furthermore, we assess the error propagation to the estimation of temperature and correlation of the gases with numerical simulation. Our analysis also incorporates experimental systematic errors such as diffraction, recoil, and shot noise from the imaging devices. This work characterizes the reliability and robustness of interferometric measurements, directing us to the improvement of existing phase extraction methods necessary to observe new physical phenomena in cold-atomic quantum simulators.

Q 1.7 Mon 12:45 HS 1010

Quantum phases of hardcore bosons with repulsive dipolar density-density interactions on two-dimensional lattices — •Jan Alexander Koziol[1], Giovanna Morigi[2], and Kai Phillip Schmidt[1] — [1]Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany — [2]Theoretical Physics, Saarland University, Campus E2.6, D-66123 Saarbrücken, Germany

We analyse the ground-state quantum phase diagram of hardcore Bosons interacting with repulsive dipolar potentials. The bosons dynamics is described by the extended-Bose-Hubbard Hamiltonian on a two-dimensional lattice The ground state results from the interplay between the lattice geometry and the long-range interactions, which we account for by means of a classical spin mean-field approach. This extended classical spin mean-field theory accounts for the long-range density-density interaction without truncation. The mean-field analysis is limited by the size of the considered unit cells. We consider three different lattice geometries: square, honeycomb, and triangular. In the limit of zero hopping the ground state is always a devil's staircase of solid (gapped) phases. Such crystalline phases with broken translational symmetry are robust with respect to finite hopping amplitudes. At intermediate hopping amplitudes, these gapped phases melt, giving rise to various lattice supersolid phases, which can have exotic features with multiple sublattice densities. Our results are of immediate relevance for experimental realisations of self-organised crystalline ordering patterns, e.g., with ultracold dipolar atoms in an optical lattice.