Q 49: Ultra-cold Atoms, Ions and BEC IV (joint session A/Q)

Time: Thursday 11:00–13:00 Location: F303

Invited Talk Q 49.1 Thu 11:00 F303

Trapping Ions and Ion Coulomb Crystals in a 1D Optical Lattice — •Daniel Hoenig[1], Fabian Thielemann[1], Joachim Welz[1], Wei Wu[1], Thomas Walker[1], Leon Karpa[2], Amir Mohammadi[1], and Tobias Schaetz[1] — [1]Albert-Ludwigs Universität, Freiburg, Germany — [2]Leibniz Universität, Hannover, Germany

The long-range Coulomb interaction between ions and the dependence of the trapping potential on the internal electronic state of the ions make optically trapped ion Coulomb crystals an interesting platform for quantum simulations. Optical lattices further extend this platform by providing arrays of individual microtraps for the ions.

In the past, we reported the successful trapping of a single ion in a one-dimensional optical lattice as well as of ion Coulomb crystals in a single-beam optical dipole trap. In this talk, we present recent advancements in trapping 138Ba+ ions in a one-dimensional optical lattice at a wavelength of 532nm and the first successful trapping of linear ion Coulomb crystals ($N \leq 3$) in such a trap array. The observed eigenfrequencies of the ions in the lattice and the increased robustness against axial electric fields provide evidence for the single-site confinement of the ions at individual lattice sites.

As optical lattices are extendable in size and dimension, they might allow for the realization of ion-microtrap structures in 2D and 3D. Additionally, the absence of micromotion in optical traps could give them an edge over rf-traps in applications, where heating and decoherence induced by micromotion become limiting factors, as for example, the study of atom-ion interactions at ultracold temperatures.

Q 49.2 Thu 11:30 F303

Catalyzation of supersolidity in binary dipolar condensates — •Daniel Scheiermann[1], Luis Ardila[2], and Luis Santos[3] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [2]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

reakthrough experiments have newly explored the fascinating physics of dipolar quantum droplets and supersolids. The recent realization of dipolar mixtures opens further intriguing possibilities. We show that under rather general conditions, the presence of a second component catalyzes droplet nucleation and supersolidity in an otherwise unmodulated condensate. For miscible mixtures, droplet catalyzation results from the effective modification of the relative dipolar strength, and may occur even for a surprisingly small impurity doping. We show that different ground-states may occur, including the possibility of two coexisting interacting supersolids. The immiscible regime provides a second scenario for double supersolidity in an array of immiscible droplets. In addition, we will discuss how the superfluidity of this mixture can be tested.

Q 49.3 Thu 11:45 F303

Controlling superfluid flows using dissipative impurities — •Martin Will[1], Jamir Marino[2], Herwig Ott[1], and Michael Fleischhauer[1] — [1]University of Kaiserslautern-Landau, Germany — [2]Johannes Gutenberg University Mainz, Germany

We propose and analyze a protocol to create and control the superfluid flow in a one dimensional, weakly interacting Bose gas by noisy point contacts. Considering first a single contact in a static or moving condensate, we identify three different dynamical regimes: I. a linear response regime, where the noise induces a coherent flow in proportion to the strength of the noise, II. a Zeno regime with suppressed currents, and III. a regime of continuous soliton emission. Generalizing to two point contacts in a condensate at rest we show that noise tuning can be employed to control or stabilize the superfluid transport of particles along the segment which connects them.

Q 49.4 Thu 12:00 F303

Atom-number enhancement by shielding atoms from losses in strontium magneto-optical traps — •Vasiliy Makhalov[1], Jonatan Höschele[1], Sandra Buob[1], Antonio Rubio[1], and Leticia Tarruell[1,2] — [1]ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — [2]Pg. Lluís Companys 23, 08010 Barcelona, Spain

Strontium offers many exciting opportunities for ultracold-atom experiments. For example, the most precise atomic clocks to date utilize the ultra-narrow clock transition of ^{87}Sr. Strontium also finds applications in atom quantum computing, interferometers, superradiant lasers, the generation of continuous-wave BEC, and quantum simulations. Most of these applications can benefit from a higher number of atoms.

In my talk, I will present a method to enhance the atom number in a 461-nm MOT of strontium without increasing the experimental complexity. This is achieved via saturation of the $^1S_0 \rightarrow ^3P_1$ intercombination-line transition with intense resonant light. This continuously populates a short-living reservoir in the $^3P_1$ state and shields part of the atoms from the intrinsic losses of the 461-nm MOT cooling cycle. Such enhancement approximately doubles the atom number of the MOT of bosonic (^{88}Sr and ^{84}Sr) or fermionic (^{87}Sr) isotopes. Most of the strontium experiments can readily apply this technique without changes in the apparatus. I will also discuss the application of the shielding mechanism to other atomic species.

Q 49.5 Thu 12:15 F303

From single to binary dipolar supersolids: a platform offering possibilities beyond imagination — •Albert Gallemi — Institut für Theoretische Physik, Leibniz Universität Hannover

Recent breakthrough experiments on dipolar condensates have reported the creation of supersolids. Supersolids have been observed both in elongated and oblate geometries, where they display themselves as 1D and 2D array of quantum droplets. In a single-component dipolar system, two main parameters (the ratio between dipolar and contact interactions and the density) can trigger different ground state configurations, in terms of different density patterns. As a result, apart from droplet arrays, one can observe the formation of honeycomb patterns and other kind of structure subject to randomness under the presence of an external confinement providing finite-size effects.

When two dipolar components coexist, the miscible-immiscible transition (which now depends on the dipole-dipole interaction) and the quantum number m_F corresponding to the condensed components (both in modulus and sign) play a role. We will analyse the different paths that open thanks to these extra degrees of freedom. We will also comment about the particular case of coherently Rabi-coupled dipolar mixtures, where polarization becomes a key observable. Rabi coupling also provides an intriguing power to the beyond-mean-field Lee-Huang-Yang correction, which can make the physics of droplets and supersolids to behave in a dramatically different way.

Q 49.6 Thu 12:30 F303

Quantum fluctuations in one-dimensional supersolids — •Chris Bühler, Tobias Ilg, and Hans Peter Büchler — Institute for Theoretical Physics III and Center for Integrated Quantum Scienceand Technology, University of Stuttgart, DE-70550 Stuttgart, Germany

In one-dimension, quantum fluctuations prevent the appearance of long-range order in a supersolid, and only quasi long-range order can survive. We derive this quantum critical behavior and study its influence on the superfluid response and properties of the solid. The analysis is based on an effective low-energy description accounting for the two coupled Goldstone modes. We find that the quantum phase transition from the superfluid to the supersolid is shifted by quantum fluctuations from its mean-field prediction. However, for current experimental parameters with dipolar atomic gases, this shift is not observable and the transition appears to be mean-field like.

Q 49.7 Thu 12:45 F303

Supersolidity and Bloch oscillations in dipolar quantum gases — •Manfred Mark — Institut für Experimentalphysik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Austria

Since strongly dipolar quantum gases made from lanthanide atoms were successfully brought to degeneracy 10 years ago, they have proven to be a rich source of new and fascinating phenomena arising from the long-range and anisotropic dipole-dipole interactions. Here, we will present the latest results from our erbium and dysprosium quantum gas experiments in Innsbruck. Following the recent discovery of supersolid states, we have studied its lifecycle from the formation to its death [1]. We also discuss our latest observation of supersolidity in two dimensions [2]. Finally, we investigated the properties of strongly dipolar gases within an array of two-dimensional traps [3] using Bloch oscillations and detected a transition to a stable self-focusing state which occupies only a single lattice plane, and predict the possibility of preparing dipolar solitons.

[1] M. Sohmen et al., Phys. Rev. Lett. 126, 233401 (2021) [2] M. A. Norcia et al., Nature 596, 357-361 (2021) [3] G. Natale et al., Commun. Phys., 5, 227 (2022)