Q 17: Quantum gases (Bosons) III

Time: Tuesday 14:00–16:00 Location: e214

Q 17.1 Tue 14:00 e214

Implanting fermionic ^{6}Li impurities in a Bose-Einstein condensate of ^{133}Cs — •Eleonora Lippi[1], Binh Tran[1], Manuel Gerken[1], Lauritz Klaus[1], Bing Zhu[1,2], Moritz Drescher[3], Tilman Enss[3], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China — [3]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 19, 69120, Heidelberg, Germany

Fermionic ^{6}Li impurities in a ^{133}Cs Bose-Einstein condensate (BEC) realizes a very well controllable version of the Bose polaron, a quasiparticle emulating the Fröhlich polaron problem of solid-state physics. The large mass imbalance between the two species represents the key ingredient to access intriguing aspects of both dynamics and ground-state properties of the Bose polaron. Nevertheless, the large differential gravitational sag between Li and Cs makes its preparation quite challenging.

I will describe the experimental realization of a stable BEC of Cs atoms at high magnetic field (>880 G), where, a broad Feshbach resonance between Li and Cs allows to control the kind and the strength of interactions. Sympathetic cooling has also been observed with Li playing the role of coolant for Cs. A tightly confining movable optical dipole trap at the tune out wavelength of 880.25 nm for Cs allows to confine a cloud of Li in a small volume inside the BEC without imposing additional confinement to Cs.

Q 17.2 Tue 14:15 e214

Bragg scattering of ultracold erbium atoms off a standing wave tuned to near a narrow-line transition — •Roberto Röll, David Helten, Daniel Babik, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Deutschland

We report on the status of an ongoing experiment aiming at investigating the fractional quantum Hall effect with ultracold bosonic erbium atoms by phase imprinting via position dependent optical Raman manipulation. In recent work, we have observed Bragg scattering of an atomic erbium Bose-Einstein condensate off a standing wave tuned into the vicinity of the $J = 6 \to J' = 7$ narrow-line transition (8 kHz natural linewidth) of the erbium atoms near 841 nm wavelength. Despite the small linewidth of this transition, a clear Bragg diffraction signal of the rare earth atoms is experimentally observed. Both current experimental work as well as future plans will be reported.

Q 17.3 Tue 14:30 e214

Witnessing bosonic and fermionic features in quantum transport — •Giulio Amato[1], Alberto Rodriguez[1,2], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität-Freiburg — [2]Departamento de Física Fundamental, Universidad de Salamanca

The transport behavior of non-interacting quantum particles through a one-dimensional lattice is governed by the bias between the reservoirs and no clear cut differences between fermionic and bosonic carriers can be observed studying single particle observables. Differences emerge in the two particle observables, due to the underlying discrepancy between fermionic and bosonic many-particle interference phenomena [1]. We explore such differences while providing a method to clearly witness and discriminate the nature of the particles involved in a quantum transport experiment.

[1] F. Schlawin, N. Cherroret and A. Buchleitner, EPL 99, 14001 (2012)

Q 17.4 Tue 14:45 e214

Statistical Transmutation in One Dimension — •Martin Bonkhoff[1], Kevin Jägering[1], Nicholas Sedlmayr[2], Sebastian Eggert[1], and Axel Pelster[1] — [1]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany — [2]Institute of Physics, M. Curie-Sklodowska University, Lublin, Poland

We compare two different concepts of fractional exchange statistics in one dimension, which have independently been discussed in the literature [1,2]. In the continuum limit both concepts are described by variants of the Lieb-Liniger model, for which we compare their experimental signatures. For instance, we analyze how the Friedel oscillations in the density change with the statistical parameter. The corresponding discretized versions of both concepts are given by the Bose-Hubbard model, where the on-site interaction strength plays the role of the statistical parameter, and by free bosons with a density-dependent Peierl's phase, respectively. Note that such a density dependent Peierl's phase has recently been implemented in optical experiments [3,4]. We study the lattice realizations of both concepts numerically with DMRG calculations and analytically with the bosonization method as well as with the Bogoliubov approximation.

[1] T. Keilmann et al., Nat. Commun. **2**, 361 (2011).
[2] T. Posske et al., Phys. Rev. B **96**, 195422 (2017).
[3] F. Götz et al., Nat. Phys. **15**, 1161 (2019).
[4] C. Schweizer et al., Nat. Phys. **15**, 1168 (2019).

Q 17.5 Tue 15:00 e214

Spectroscopy of dense xenon ensembles - Towards Bose-Einstein condensation of vacuum-ultraviolet photons — •Thilo vom Hövel, Christian Wahl, Frank Vewinger, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, D-53115 Bonn

Coherent light sources cover wide ranges of the optical spectrum. In the vacuum-ultraviolet regime (VUV, 100 - 200 nm), however, constructing a laser is difficult, as excited state lifetimes scale as ω^3, resulting in the need of very high pump powers to achieve population inversion. We propose an experimental approach for the realization of a coherent light source in the VUV based on Bose-Einstein condensation of photons. In our group, Bose-Einstein condensation of visible photons is investigated using a liquid dye solution as thermalization medium in a wavelength-sized optical microcavity, the latter providing a non-trivial low-energy ground state the photons condense into.

Conveying these principles into the VUV, a replacement for the dye molecules has to be found, as they dissociate under VUV irradiation. We consider xenon atoms a potential candidate, with absorption re-emission cycles on the transition from the ground state ($5p^6$) to the lowest electronically excited state ($5p^5 6s$) for thermalization. We here report on the results of current spectroscopic measurements, investigating VUV line profiles of dense xenon ensembles. Both absorption and emission profiles are presented at pressures up to 180 bar. We also report on VUV spectral profiles of xenon recorded in the liquid phase.

Q 17.6 Tue 15:15 e214

Breaking continuous time-translation symmetrie in a cavity-BEC-system — •Hans Kessler, Jayson G. Cosme, Christoph Georges, and Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg, Germany

We propose an experimental realization of a time-crystal using an atomic Bose-Einstein condensate in a high-finesse optical cavity pumped with laser light detuned to the blue side of the relevant atomic resonance [1]. By mapping out the dynamical phase diagram, we identify regions in parameter space showing stable limit cycle dynamics. Since the model describing the system is time-independent, the emergence of a limit cycle phase indicates the breaking of continuous time-translation symmetry. Employing a semiclassical analysis to demonstrate the robustness of the limit cycles against perturbations and quantum fluctuations, we establish the emergence of a time crystal.

[1] Emergent limit cycles and time crystal dynamics in an atom-cavity system H Keßler, JG Cosme, M Hemmerling, L Mathey, A Hemmerich Physical Review A 99 (5), 053605

Q 17.7 Tue 15:30 e214

Superradiant multimode Floquet polaritons — •Christian Johansen, Johannes Lang, and Francesco Piazza — Max Planck Institut für Physik Komplexer Systeme

Optically trapped driven ultracold atoms in cavities present a highly tunable system for exploring many-body physics. Using near-planar cavities the transversal modes (TMs) are typical distanced by several hundreds megahertz. As such the atoms will dominantly interact only with the resonant TM of the cavity. This interaction between atoms and the cavity gives rise to the well known superradiant instability. New confocal experimental setup have shown that when multiple modes becomes relevant then the nature of the unstable mode changes. In this project we theoretically investigate a system where the pump laser's phase is periodically modulated. This modulation puts higher-order transversal modes closer to resonance in a way that is easily implemented in current near-planar cavity setups Using non-equilibrium field theory we find that this modulation affects both the threshold of the instability and the unstable mode's nature.

Q 17.8 Tue 15:45 e214

Pulse Delay Time Statistics in a Superradiant Laser with Calcium Atoms — •Torben Laske, Hannes Winter, and Andreas Hemmerich — Institut für Laserphysik, Hamburg, Deutschland

Cold samples of calcium atoms are prepared in the metastable $^3P_1$ state inside an optical cavity resonant with the narrow band (375 Hz) $^1S_0 \leftrightarrow {}^3P_1$ intercombination line at 657 nm. We observe a superradiant emission of hyperbolic secant shaped pulses into the cavity with an intensity proportional to the square of the atom number, a duration much shorter than the natural lifetime of the $^3P_1$ state, and a delay time fluctuating from shot to shot in excellent agreement with theoretical predictions [1]. Our incoherent pumping scheme to produce inversion on the $^1S_0 \leftrightarrow {}^3P_1$ transition should be extendable to allow for continuous wave laser operation.

[1] T. Laske, H. Winter, A. Hemmerich, Phys. Rev. Lett. 123, 103601 (2019).