Q 38: Quantum Gases: Bosons V

Time: Wednesday 14:30–16:45 Location: P 204

Q 38.1 Wed 14:30 P 204

Observation of Quantum Criticality and Luttinger Liquid in One-dimensional Bose Gases — •Bing Yang[1,3], Yang-Yang Chen[2], Yong-Guang Zheng[1,3], Hui Sun[1,3], Han-Ning Dai[1,3], Xi-Wen Guan[2,4], Zhen-Sheng Yuan[1,3], and Jian-Wei Pan[1,3] — [1]Hefei National Laboratory for Physical Science at Microscal and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China — [2]State Key Laboratory of Magnetic Resonance and Atomic and Molecular Physics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Science, Wuhan 430071, Wuhan — [3]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [4]Department of Theoretical Physics, Research School of Physics and Engineering, Australian National University, Canberra ACT 0200, Australia

We report an observation of quantum criticality and the TLL in a system of ultracold ^{87}Rb atoms within 1D tubes. The universal scaling laws are measured precisely and the characteristic critical temperatures are determined by the double-peak structure of specific heat, confirming the existence of three phases: classical gas, quantum critical region and the TLL. The Luttinger parameter estimated from the observed sound velocity approaches the measured Wilson ratio (WR), which reveals the collective nature of the TLL and the quantum fluctuations.

Q 38.2 Wed 14:45 P 204

Spatial first-order correlations of a trapped two-dimensional photon gas — •Tobias Damm, David Dung, Frank Vewinger, Julian Schmitt, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, D-53115 Bonn

Bose-Einstein condensation was observed for ultracold atoms, polaritons, and more recently with photons in a dye-filled optical microcavity. In the latter experiment, the used short cavity provides a low frequency cutoff with a quadratic dispersion relation. Photons thermalize by repeated absorption and emission processes on dye molecules.

Here we report measurements of the first-order spatial coherence of the thermalized photon gas trapped in the dye microcavity, both in the classical Boltzmann regime as well as in the condensed phase. The dye microcavity emission is analyzed with a Michelson interferometer utilizing a cat eye retroreflector replacing one of the plane reflecting mirrors. Below condensation threshold correlations are determined by the thermal de Broglie length. We observe the expected $1/\sqrt{T}$ dependence with temperature, which verifies the thermal character. The onset of Bose-Einstein condensation agrees with the assumption that quantum statistical effects emerge when the thermal de Broglie wavepackets overlap, a property so for verified only for material gases. Above this critical phase-space-density we observe long range order, with the correlation length eventually exceeding the size of the condensate.

Q 38.3 Wed 15:00 P 204

Thermalized Light in Variable Micropotentials and Coupled Photon Condensates — •David Dung[1], Christian Kurtscheid[1], Tobias Damm[1], Erik Busley[1], Fahri Emre Öztürk[1], Julian Schmitt[1], Frank Vewinger[1], Jan Klärs[2], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Universität Bonn — [2]Institut für Quantenelektronik, ETH Zürich

We report work creating multiple coupled photon condensates in a single microcavity setup at room-temperature. In general, Bose-Einstein condensation has been observed for cold atomic gases, solid state quasiparticles as exciton-polaritons, and more recently with photons. The latter can be realized in a dye-filled optical microcavity. Number-conserving thermalization of photons in the dye-microcavity is achieved by multiple absorption and fluorescence processes on dye-molecules.

The microcavity creates a suitable ground state for condensation, equivalent to a non-vanishing effective photon mass. By locally thermo-optically changing the refractive index inside the microcavity an effective trapping potential for photons can be induced. For this, a focused external control laser beam locally heats an absorbing layer below one of the cavity mirror coatings, leading to a local refractive index change of a thermo-responsive polymer mixed with the dye solution. We show that Bose-Einstein condensation can be realized in such a micropotential. Moreover a thermo-optical photon self interaction is observed. Finally we show measurements on the coupling of two microsites in a double well potential for light, showing both hybridization of Eigenstates and coherent oscillations.

Q 38.4 Wed 15:15 P 204

Droplet Formation in Quantum Ferrofluids in Ring Trap Geometry — •Antun Balaž[1] and Axel Pelster[2] — [1]Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research center OPTIMAS, Technical University of Kaiserslautern, Germany

In the recent experiment [1], the Rosensweig instability was observed in a quantum ferrofluid of a strongly dipolar BEC, leading to a formation of atomic droplets. In Ref. [2] it was demonstrated that the stability of such droplets is due to quantum fluctuation correction of the ground-state energy [3,4]. Here we extend this previous theoretical description and develop a full Bogoliubov-Popov theory, which also takes into account the condensate depletion due to quantum fluctuations. We apply this approach to study the droplet formation in a ^{164}Dy BEC in ring trap geometry where, after a sudden reduction of the scattering length, the dipolar quantum gas creates a droplet ring. We use extensive numerical simulations in order to study various properties of the emerging droplets, such as their number, size, and distribution. We also study how a phase imprinting affects the droplet formation process.

[1] H. Kadau, et al., Nature **530**, 194 (2016).
[2] L. Chomaz, et al., Phys. Rev. X **6**, 041039 (2016).
[3] T. D. Lee, K. Huang, and C.N. Yang, Phys. Rev. **106**, 1135 (1957).
[4] A.R.P. Lima and A. Pelster, Phys. Rev. A **84**, 041604(R) (2011); Phys. Rev. A **86**, 063609 (2012).

Q 38.5 Wed 15:30 P 204

Observation of parametric resonances in 1D shaken optical lattices — •Karen Wintersperger[1,2], Jakob Näger[1,2], Martin Reitter[1,2], Ulrich Schneider[3], and Immanuel Bloch[1,2] — [1]Ludwig-Maximilians-Universität München, Schellingstr. 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching — [3]University of Cambridge, Cambridge, UK

We study a BEC of 39K with tunable interactions in a shaken 1D optical lattice. Due to the interplay between the external drive and interactions dynamical instabilities arise [1]. The short-time dynamics can be captured by parametric resonances within Bogoliubov theory, which should lead to a fast decay of the BEC. At long times, the behavior will be dominated by collision processes described by a Fermi's Golden rule approach that slow down the decay. Varying the shaking parameters and interactions, we observe the transition between the two heating regimes. Moreover, we can identify the onset of the parametric instabilities at short times by analysing the 2D quasimomentum distribution of the excited atoms.

[1] S. Lellouch et al., arXiv: 1610.02972v1 (2016)

Q 38.6 Wed 15:45 P 204

Observation of scaling in the coarsening dynamics of a quenched one-dimensional spinor Bose-Einstein condensate — •Maximilian Prüfer, Christian-Marcel Schmied, Philipp Kunkel, Daniel Linnemann, Anika Frölian, Helmut Strobel, Thomas Gasenzer, and Markus K. Oberthaler — Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg

Coarsening dynamics features a scaling behaviour of the characteristic length scale as a function of time. Accessing experimentally the corresponding scaling exponent, we employ a Bose-Einstein condensate of ^{87}Rb in the $F = 1$ hyperfine manifold with ferromagnetic interaction. We prepare the system in the polar phase and quench it into the symmetry broken ferromagnetic phase. After a build-up of excitations in the transversal spin, as predicted by Bogoliubov theory, we observe a self-similar coarsening evolution with a characteristic power-law behaviour for long evolution times. By rescaling the spatial correlation functions we determine the scaling exponent z describing the temporal evolution of the characteristic length scale.

Q 38.7 Wed 16:00 P 204

Towards a Photon Bose-Einstein Condensate in the Vacuum-Ultraviolet Spectral Regime — •Christian Wahl, René Nettekoven, Julian Schmitt, Frank Vewinger, and Martin Weitz — University of Bonn, Germany

We propose an experimental approach for photon Bose-Einstein condensation in the vacuum-ultraviolet spectral regime, based on the thermalisation of photons in a noble gas filled optical microcavity. Our current experiments realizing photon Bose-Einstein condensates operate in the visible spectral regime with organic dyes as a thermalisation medium [1]. To reach the vacuum-ultraviolet spectral regime, we propose to replace the dye medium by high pressure xenon or krypton gas with absorption re-emission cycles on the transition from the ground to the lowest electronically excited state of the noble gases for thermalisation. In order to achieve sufficient spectral overlap between the atomic absorption and the di-atomic excimer emission noble gas pressures of up to 60 bar will be created inside the cavity. Using the heavy noble gases xenon and krypton, emission wavelengths in the 120-160 nm regime seem feasible. Current experimental work focuses on verifying the fulfillment of the thermodynamic Kennard-Stepanov frequency scaling between absorption and emission for the dense noble gas medium. The current status of experimental work will be reported. References: [1]: J. Klaers et al. Nature **468**, 545-548 (2010)

Q 38.8 Wed 16:15 P 204

Fluctuation-dissipation relations in a Bose-Einstein condensed photon gas coupled to a dye reservoir — •Fahri Emre Ozturk, Tobias Damm, David Dung, Frank Vewinger, Julian Schmitt, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Wegelerstraße 8, 53115 Bonn, Germany

Bose-Einstein condensation, the phase transition of bosons to a macroscopically occupied ground state at low temperature, has been observed e.g. in cold atomic gases and semiconductor exciton-polaritons. We have previously observed Bose-Einstein condensation of a two dimensional photon gas in a dye filled optical microcavity [1]. The photon condensate shows grand canonical statistical behavior as the condensate exchanges both energy and particles with the dye reservoir. This results in photon number fluctuations, which can be as large as the average condensate photon number [2]. In thermal equilibrium, such fluctuations are related to the linear response of the system to a weak perturbation and thermal energy $k_B T$. This relation, expressed by the fluctuation-dissipation theorem, also explains e.g. the Brownian motion of suspended microscopic particles. Fluctuation-dissipation relations based on particle number fluctuations have not been studied previously in Bose-Einstein condensates. Here, we report on the status of current experimental work aiming at a study of the fluctuation-dissipation theorem for a condensed photon gas coupled to a dye reservoir.

[1] Klaers et al., *Nature* **468**, 545 (2010)
[2] Schmitt et. al., *Phys. Rev. Lett.* **112**, 030401 (2014)

Q 38.9 Wed 16:30 P 204

Quantum Gases in Microgravity: Activities at ZARM — •Lisa Woerner[1], Jens Grosse[1], Michael Elsen[1], Norman Guerlebeck[1], Claus Braxmaier[1,2], and the QUANTUS collaboration[1,2,3,4,5,6] — [1]ZARM, University of Bremen — [2]DLR — [3]Humboldt University Berlin — [4]Leibniz University Hanover — [5]Ferdinand-Braun Institute — [6]Johannes Gutenberg University Mainz

This paper shall give a summary on the recent and future developments of the experiments with quantum gases in microgravity and space. The current status of the ongoing activities will be presented, possible applications explained, and further opportunities and plans introduced.

Ever since the experimental realization of the first Bose-Einstein condensate in 1995, various experiments have been developed to study the resulting cloud of atoms. Especially interest in matter wave interferometry has risen recently. The atoms are subjected to diffraction gratings and the resulting states are measured.

At ZARM different approaches to perform atom interferometry in microgravity are investigated. First experiments were performed using the drop-tower at ZARM. Succeeding these successful campaigns, the capsule containing the atom interferometer has been adapted to fit a sounding rocket.