Q 10: Ultra-cold atoms, ions, and BEC II (joint session A/Q)

Time: Monday 14:00–16:00 Location: f303

Invited Talk Q 10.1 Mon 14:00 f303

Reducing their complexity and miniaturise BEC interferometers — •Waldemar Herr[1], Hendrik Heine[1], Alexander Kassner[2], Christoph Künzler[2], Marc C. Wurz[2], and Ernst M. Rasel[1] — [1]Institut für Quantenoptik, Leibniz Universität, Hannover, Germany — [2]Institut für Mikroproduktionstechnik, Leibniz Universität, Hannover

Matterwave interferometry with Bose Einstein Condensates (BEC) promises exciting prospects in inertial sensing and research on fundamental physics both on ground and in space. By now, we can create BECs very efficiently by using atom chips and compact realisations have already been shown, e.g. by creating the first BEC in space on a sounding rocket mission. However, for in-field or satellite-borne applications, it is vital to further reduce the complexity in order to lower size, weight and power demands and to transform BEC interferometers to easy-to-use devices.

In this talk, different aspects ranging from interferometry schemes, sensor fusion concepts and results on a magneto optical trap and sub-Doppler cooling using only a single beam of light in combination with an optical grating on an atom chip will be discussed.

Q 10.2 Mon 14:30 f303

Quantum fluctuations and uncertainty relations in NLS solitons and breathers — •Oleksandr Marchukov[1,2], Boris Malomed[2], Maxim Olshanii[3], Vanja Dunjko[3], Randall Hulet[4], and Vladimir Yurovsky[2] — [1]Technische Universität Darmstadt, Darmstadt, Germany — [2]Tel Aviv University, Tel Aviv-Yaffo, Israel — [3]University of Massachusetts Boston, Boston, MA, USA — [4]Rice University, Houston, TX, USA

We consider the quantum fluctuations of the macroscopic variables associated with a breather, a second-order soliton solution of nonlinear Schrödinger equation. Linearizing the evolution of the bosonic quantum field around the Bose condensate in a breather state, we express the quantum fluctuations of the macroscopic variables through the fluctuations of the full quantum field. We compare two models for the state of the quantum field of fluctuations surrounding the classical field of the Bose-Einstein condensate: a conventionally used, computationally convenient "white noise", and a correlated noise which assumes that the breather has been created from a fundamental soliton, by means of the application of the factor-of-four quench of the nonlinearity strength. We evaluate the initial quantum uncertainties of the macroscopic parameters and their time evolution. This approach is well suited for the description of Bose gas with large number of atoms and suggests the possibility for experimental observation of macroscopic quantum fluctuations.

Q 10.3 Mon 14:45 f303

Rogue waves in a selfgravitating BEC — •Sandro Gödtel[1], Claus Lämmerzahl[1], and Domenico Giulini[1,2] — [1]ZARM, University of Bremen, Germany — [2]ITP, Leibniz University Hannover, Germany

The coupling between gravity and quantum mechanics is still an open question in physics. For this, we investigate an approach to increase possible gravitational effects within a quantum system such as a Bose-Einstein condensate. We show that the theoretical description by the well-known Gross-Pitaevskii equation leads to an interesting nonlinear phenomenon, namely rogue waves. Originally observed in ocean waves these waves locally increase the density and are often modeled by the Peregrine soliton or the so called multi-rogue wave solutions. By including a gravitational self-interaction we estimate the impact on the condensate with typical experimental values and specify the regime where it may become significant and observable.

Q 10.4 Mon 15:00 f303

Guided Atom Interferometry with Bose-Einstein Condensates in Painted Optical Potentials — •Sebastian Bode, Knut Stolzenberg, Alexander Herbst, Henning Albers, Ernst M. Rasel, and Dennis Schlippert — Institute of Quantum Optics - Leibniz University Hannover

Inertial navigation allows for the positioning in space diminishing the dependency on global navigation satellite systems. Guided atom interferometers are a candidate for compact inertial measurement units with outstanding accuracy and stability in harsh environments.
We utilize a 2D-acousto-optic deflector (AOD) in the beam path of an optical dipole trap in combination with a software defined radio (SDR) RF-source for the creation of time-dependent arbitrary potentials. The experimental setup facilitates the creation of ^{87}Rb BECs with large atom numbers and subsequent guided atom interferometry. For the splitting, holding, and recombination of the atom cloud during the interferometric sequence the confining potential is modified resulting in multiple distinct potential minima with well defined atom populations. We report on first results in absolute and differential measurements and discuss various future configurations.

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Q 10.5 Mon 15:15 f303

Josephson effects in coupled anisotropic Bose-Einstein condensates — •Marc Momme, Yuriy Bidasyuk, and Michael Weyrauch — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Josephson effects can manifest in a bose-condensed atomic gas with two components, if the phase of both components remains (mostly) coherent. That way, many experimental and theoretical studies of bosonic Josephson effects have been conducted to gain insight about the nature of macroscopic quantum coherence. The common theoretical description for such systems is the two-mode model, which relies on the assumption that the coupling between two components is much weaker then the energy required to create excitations inside each condensate. However if the Josephson oscillations couple with the longitudinal modes of the trap, the two-mode approximation is no longer valid.

The present study focuses on one system where such a coupling can occur: the bosonic equivalent of a long Josephson junction. Thereby a BEC is put in a cigar-shaped trap with the barrier parallel to the long axis of the trap. Effectively, two coupled quasi one-dimensional condensates are formed. We compare the results of mean-field numerical simulations with predictions of simplified effective models. We show how collective excitations influence the population dynamics of the condensates.

Q 10.6 Mon 15:30 f303

Josephson junction dynamics in an ultracold two-dimensional Bose gas — •Vijay Singh and Ludwig Mathey — Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany

We investigate the Berezinskii-Kosterlitz-Thouless (BKT) scaling of the critical current of Josephson junction dynamics across a barrier potential in a two-dimensional (2D) Bose gas, motivated by recent experiments by Luick *et al.* arXiv:1908.09776. Using classical-field dynamics, we determine the dynamical regimes of this system, as a function of temperature and barrier height. As a central observable we determine the current-phase relation, as a defining property of these regimes. In addition to the ideal junction regime, we find a multimode regime, a second-harmonic regime, and an overdamped regime. For the ideal junction regime, we derive an analytical estimate for the critical current, which predicts the BKT scaling. We demonstrate this scaling behavior numerically for varying system sizes. The estimates of the critical current show excellent agreement to the numerical simulations and the experiments. Furthermore, we show the damping of the supercurrent due to phonon excitations in the bulk, and the nucleation of vortex-antivortex pairs in the junction.

Q 10.7 Mon 15:45 f303

Dynamical control of conductivity in a bosonic Josephson junction — •Beilei Zhu[1], Vijay Pal Singh[1], Junichi Okamoto[2], and Ludwig Mathey[1,3] — [1]Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, Hamburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

We propose to demonstrate dynamical enhancement of conductivity in a bosonic Josephson junction composed of two weakly coupled one dimensional condensates. A current is induced by a periodically modulated potential difference between the condensates, giving access to conductivity of the junction. We propose to control the conductivity via parametric driving of the tunneling energy. We demonstrate that the low frequency conductivity of the junction can be enhanced or suppressed, depending on the choice of the driving frequency. The experimental realization of this proposal constitutes a quantum simulation of recently proposed mechanism for optically induced superconductivity in pump-probe experiments.