A 2: Ultracold atoms and BEC - I (with Q)

Time: Monday 14:30–16:30 Location: N 1

Invited Talk A 2.1 Mon 14:30 N 1
Towards Atomtronic Interferometry — •Wolf von Klitzing — Institute of Electronic Structure and Laser, FORTH, 71110 Heraklion, Crete, Greece

Atom interferometers are some of the most sensitive instruments available to date. In order to avoid unwanted perturbations, most of the matterwave interferometers use atoms in free fall. This is largely due to the lack of appropriatly coherent matterwave guides. Here, we present a novel Sagnac interferometer based on state-dependent manipulation of atoms in waveguides using time-averaged adiabatic potentials (TAAP) [1,2]. In this clock-type matterwave interferometer the atoms are in different internal states in the two arms of the interferometer and can thus be manipulated nearly independently. In analogy to the magic frequency of the strontium lattice clocks, by carefully tuning the confining potential a magic-field strength can be found such that the linear dependence on the potential vanishes [3].

We will report the use of adiabatic potentials in the creation of ultra-bright atom lasers. And present initial experimental results towards the realization of this interferometer. Most notably the state-dependent manipulation and guiding of the atoms.

[1] P. Navez et al. N.J.Phys. **18**:7 075014 (2016)
[2] I. Lesanovsky and W. von Klitzing PRL **99**:8 083001 (2007)
[3] P. Treutlein et al. PRL **92**:20 203005 (2004)

A 2.2 Mon 15:00 N 1
Towards coherent beam splitting in a TAAP ring atom waveguide — •Hector Mas[1,2], Saurabh Pandey[2,3], Giannis Drougakis[2,3], Patrick Navez[1], Konstantinos Poulios[2], Georgios Vasilakis[2], Thomas Fernholz[4], and Wolf von Klitzing[2] — [1]Department of Physics, University of Crete, Heraklion 70113, Greece — [2]IESL-FORTH, Heraklion 70013, Greece — [3]Department of Materials, Science and Technology, University of Crete, Heraklion 70113 — [4]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom

Trapped atom interferometers are promising candidates for improving the sensitivity of cold atom based sensing devices by means of increasing the interaction time and decreasing the size of the devices. We present progress towards a Sagnac clock type interferometer employing the two hyperfine states (F=1 and F=2) of Rubidium 87 (Rb87) in a state-dependent time averaged adiabatic potential (TAAP) ring shaped waveguide. We report on experimental advances leading to the implementation of the full interferometric sequence with a focus on achieving coherent splitting, guiding and recombination of the atomic cloud inside the waveguide. A number of decoherence processes may arise during the interferometric cycle, e.g. fluctuations in the magnetic fields or rf/microwave excitation. We will introduce and discuss preliminary measurements on both the ring waveguide characterisation and the spectroscopy of cold atoms in TAAP potentials, focusing on the search for a magic frequency that will allow for much improved coherence times.

A 2.3 Mon 15:15 N 1
QUANTUS-2 - Ultra Low Expansion Atomic Source for Matter Wave Interferometry in Extended Free Fall — •Peter Stromberger[1], Alexander Grote[1], Andre Wenzlawski[1], Patrick Windpassinger[1], and the QUANTUS-Team[1,2,3,4,5,6,7] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz — [2]Institut für Physik, Humboldt-Universität zu Berlin — [3]Ferdinand-Braun-Institut, Leibniz Institut für Höchstfrequenztechnik Berlin — [4]Institut für Quantenoptik, Leibniz-Universität Hannover — [5]ZARM, Universität Bremen — [6]Institut für Quantenphysik, Universität Ulm — [7]Institut für angewandte Physik, TU Darmstadt

QUANTUS-2 is a mobile high-flux rubidium BEC source used for experiments under microgravity in the drop tower in Bremen. To further decrease the expansion rate of the BEC, magnetic lensing - also known as delta-kick cooling - is crucial for observations after long evolution times in the range of seconds. Long evolution times are desirable, because the sensitivity of atom interferometers enhances quadratically with the interrogation time. Here we present our results of a lens, which leads to an observability of the BEC of up to 2.7 s after free expansion. This expansion rate is equivalent to an expansion rate of a thermal ensemble with a temperature below 100 pK in all three dimensions.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economic Affairs and Energy under grant numbers DLR 50 WM 1552-1557.

A 2.4 Mon 15:30 N 1
Selfbound quantum droplets — •Matthias Wenzel, Matthias Schmitt, Fabian Böttcher, Carl Bühner, Igor Ferrier-Barbut, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Self-bound many-body systems are formed through a balance of attractive and repulsive forces and occur in many physical scenarios. Liquid droplets are an example of a self-bound system, formed by a balance of the mutual attractive and repulsive forces that derive from different components of the inter-particle potential. On the basis of the recent finding that an unstable bosonic dipolar gas can be stabilized by a repulsive many-body term, it was predicted that three-dimensional self-bound quantum droplets of magnetic atoms should exist.

Here we report on the observation of such droplets, with densities 10^8 times lower than a helium droplet, in a trap-free levitation field. We find that this dilute magnetic quantum liquid requires a minimum, critical number of atoms, below which the liquid evaporates into an expanding gas as a result of the quantum pressure of the individual constituents. Consequently, around this critical atom number we observe an interaction-driven phase transition between a gas and a self-bound liquid in the quantum degenerate regime with ultracold atoms.

A 2.5 Mon 15:45 N 1
Quantum droplets in one-dimensional dipolar Bose-Einstein condensates — •Daniel Edler, Falk Wächtler, and Luis Santos — Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

Recent experiments on dipolar Bose-Einstein condensates have reported the formation, due to quantum fluctuations, of a novel form of ultra-dilute stable droplets. We will show that in one-dimensional geometries these fluctuations lead to peculiar momentum dependence of the dipole-dipole interactions inducing an anomalous density dependence of the beyond-mean-field corrections. Further we will discussion the density distribution for different system parameters and the behaviour for included three-body losses.

A 2.6 Mon 16:00 N 1
Purity oscillations in coupled Bose-Einstein condensates — •Jonathan Stysch, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart, Germany

We investigate the many-body dynamics of two three-mode Bose-Einstein condensates (BECs) forming a six-mode system. Both three-mode subsystems are initially prepared as isolated, fully coherent BECs and are then rendered open systems by coupling them together. The dynamics induced by this coupling leads to a periodic loss and restoration of the coherence in each subsystem which is quantified by the purity of the single-particle density matrices of the respective subsystems. We show that these purity oscillations correspond with oscillations in the average contrast in interference experiments and are therefore linked to a quantity accessible in experiment.

A 2.7 Mon 16:15 N 1
Dynamical Instabilities in Trapped Bose-Einstein Condensates — •Torsten Victor Zache[1], Valentin Kasper[2], and Jürgen Berges[1] — [1]Institut für Theoretische Physik, Philosophenweg 16, 69120 Heidelberg — [2]Physics Department, Harvard University, Cambridge MA 02138, USA

We study the nonlinear phenomenon of secondary instabilities (secondaries), which was proposed in the context of inflationary particle production, with ultracold atom systems. Specifically, we consider a one-dimensional two-component Bose gas that can be realized in different experimental setups and show analytically that it exhibits a primary instability characterized by exponentially growing occupation numbers of certain momentum modes. The primary instability is triggered by initial quantum fluctuations and leads to an amplified occupation of primarily stable modes at later times. We demonstrate the existence of these secondary instabilities in trapped Bose-Einstein condensates numerically employing the classical-statistical approximation. The process underlying the generation of secondaries can be identified with a nonlinear loop correction, which leads to an interpretation in terms of Feynman diagrams and allows us to analytically estimate the secondary growth rates to be integer multiples of the primary one.