Q 60: Materiewellen und Technologie

Time: Friday 10:30–12:00 Location: V53.01

Q 60.1 Fri 10:30 V53.01

Multi-spatial-mode amplitude squeezing on a single beam. — •Matthew Turnbull, Plamen Petrov, Vincent Boyer, and Kai Bongs — University of Birmingham, Birmingham UK.

A method is presented here to generate a beam of light with amplitude fluctuations below the standard quantum limit across multiple spatial modes.

Four-wave-mixing in hot Rubidium vapour has previously been shown to generate twin-beams that demonstrate quantum correlations in spatially correlated regions, that is to say entanglement between multiple spatial modes. This next step combines these beams with the result being a single beam with reduced amplitude fluctuations across an equal number of modes.

The key to the process is the level of gain achievable on a single pass through the Rb cell which negates the need for a cavity, typically required in a squeezing setup, hence also removing the cavity-mode-limited nature of the squeezing.

Included in this talk will be a description of the theory underlying this process along with the current status of the experiment being performed and a selection of possible uses for such a beam, e.g. storing quantum information with greater coherence or ultra-low-noise quantum imaging.

Q 60.2 Fri 10:45 V53.01

Advanced laser systems for matter-wave interferometry in microgravity — •Christoph Grzeschik[1], Achim Peters[1], and the QUANTUS Team[1,2,3,4,5,6,7,8,9,10] — [1]Institut für Physik, HU Berlin — [2]Institut für Quantenoptik, LU Hannover — [3]Institut für Laserphysik, Uni Hamburg — [4]ZARM, Uni Bremen — [5]Institut für Quantenphysik, Uni Ulm — [6]MPQ, München — [7]Institut für angewandte Physik, TU Darmstadt — [8]Midlands Ultracold Atom Research Centre, University of Birmingham, UK — [9]FBH, Berlin — [10]DLR Institut für Raumfahrtsysteme, Bremen

We present a robust and compact laser system for dual-species atom interferometry with rubidium and potassium in microgravity in the context of the QUANTUS and LASUS project. The system is built around a set of hybrid-integrated master oscillator power amplifiers (MOPA), which allow for outputpower in the Watt range, while preserving the spectral characterisics of the DFB laser diode. Results from several catapult launches at the ZARM droptower in Bremen showing the stability of the frequency locks and fiber coupling efficiencies as well as the ruggedness of the complete system will be presented. Finally, an outlook on even more sophisticated lasersystems for missions in a sounding rocket within the MAIUS project as well as perspectives for fundamental physics in space will be given.

The QUANTUS and LASUS project are supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number (DLR 50WM 1131-1137, 0937-0940).

Q 60.3 Fri 11:00 V53.01

Compact atom chip based source of ultra-cold atoms with high flux — •Waldemar Herr[1], Ernst Maria Rasel[1], and the QUANTUS-TEAM[2,3,4,5,6,7,8,9] — [1]Institut für Quantenoptik, LU Hannover — [2]ZARM, Universität Bremen — [3]Institut für Physik, HU Berlin — [4]Institut für Laser-Physik, Universität Hamburg — [5]Institut für Quantenphysik, Universität Ulm — [6]Institut für angewandte Physik, TU Darmstadt — [7]MUARC, University of Birmingham — [8]FBH, Berlin — [9]MPQ, Garching

Atom chips enable compact and robust apparatuses for matter-wave interferometry and condensed matter physics. Usually these setups are limited in the total number and the flux of atoms. In this talk we present the QUANTUS-II apparatus, which uses a combination of a chip-based atom trap with a pre-cooling stage. This apparatus allows to collect $>3{\cdot}10^9$ atoms within 3 seconds in a mesoscopic chip MOT. This is an excellent starting point towards the realisation of a high precision matter-wave interferometer.

The QUANTUS project is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM1131.

Q 60.4 Fri 11:15 V53.01

Thick-film technology for ultra-high vacuum interfaces of micro-structured traps — •Delia Kaufmann, Thomas Collath, M. Tanveer Baig, Peter Kaufmann, Eman Asenwar, Michael Johanning, and Christof Wunderlich — Universität Siegen, NT Fakultät, Dept. Physik, 57072 Siegen, Deutschland

Miniaturized traps for ions or neutral atoms are useful tools in quantum information science. For operation, they typically need a large number of control voltages or currents, and rf or microwave fields. Furthermore, an ultra-high vacuum environment is needed for operating such traps.

In order to produce custom made ultra-high vacuum compatible interfaces for a large number of electrical signals, we adopt the thick-film technology [1]. These interfaces permit voltages of hundreds of volts and currents of several amperes and allow for very compact vacuum setups. Such printed circuits can also be useful as pure in-vacuum devices. We demonstrate a specific interface, which provides eleven current feedthroughs, more than 70 dc feedthroughs and a feedthrough for radio frequencies. We achieve a pressure in the low 10^{-11} mbar range and demonstrate the full functionality of the interface by trapping chains of cold ytterbium ions, which requires the presence of all of the above mentioned signals.

[1] D. Kaufmann, T. Collath, M. T. Baig, P. Kaufmann, E. Asenwar, M. Johanning, C. Wunderlich, arXiv:1107.4082v1 [quant-ph] (Appl. Phys. B, in print)

Q 60.5 Fri 11:30 V53.01

Mechanical stability of laser system components — •Kai Lampmann[1], Achim Peters[1], and the QUANTUS Team[1,2,3,4,5,6,7,8,9] — [1]Institut für Physik, HU Berlin — [2]Institut für Quantenoptik, LU Hannover — [3]Institut für Laserphysik, Uni Hamburg — [4]ZARM, Uni Bremen — [5]Institut für Quantenphysik, Uni Ulm — [6]MPQ, München — [7]Institut für angewandte Physik, TU Darmstadt — [8]Midlands Ultracold Atom Research Centre, University of Birmingham, UK — [9]FBH, Berlin

We present stability tests of laser system components for atom interferometry in microgravity within the QUANTUS and LASUS projects. Special challenges in the construction of the laser system are posed by the vibrations and accelerations found during the launch phase of sunding rockets or in droptower experiments. Compact subcomponents and an integrated subsystem consisting of a fiber coupled master-oscillator power amplifier (MOPA) have been tested under extreme conditions to investigate their mechanical stability. These tests are especially crucial for developing a laser system for further experiments in space.

The QUANTUS and LASUS project are supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant number DLR 50WM 1131-1137 and 0937-0940.

Q 60.6 Fri 11:45 V53.01

Strong continuous-variable EPR-steering with a detection efficiency above 96% — •Sebastian Steinlechner, Jöran Bauchrowitz, Melanie Meinders, Tobias Eberle, Vitus Händchen, and Roman Schnabel — Institut für Gravitationsphysik, Leibniz Universität Hannover and Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Callinstr. 38, 30167 Hannover

In 1935, Einstein, Podolsky, and Rosen reported a *gedanken experiment* which became famous as the EPR-paradox. In the same year, Schrödinger introduced the terms *entanglement* and *steering* in order to describe the underlying effect that a measurement on subsystem A of a certain class of entangled states may apparently allow for a remote steering of the measurement outcome at subsystem B, without the presence of a physical interaction between the subsystems. In this work we report on the observation of unprecedented strong EPR-steering in the gaussian regime, quantified by an EPR co-variance product of about $0.04 < 1$, where 1 is the critical value. Together with a high detection efficiency of more than 96%, our result is an important milestone towards applications of gaussian entanglement distribution.