A 8: Precision measurements and metrology II (with Q)

Time: Monday 14:00–15:45 Location: F 128

Group Report A 8.1 Mon 14:00 F 128

Miniaturized laser systems for precision measurement applications — •Markus Krutzik[1], Achim Peters[1,2], Andreas Wicht[2], Ernst Rasel[3], Klaus Sengstock[4], and The LASUS Team[1,2,3,4] — [1]Institut für Physik, HU Berlin — [2]Ferdinand-Braun-Insitut, Leibniz Institut für Höchstfrequenztechnik, Berlin — [3]Institut für Quantenoptik, LU Hannover — [4]Institut für Laserphysik, U Hamburg

Rapid progress in the field of ultra cold quantum gases has led to the development of new measurement tools with unprecedented precision such as high performance optical clocks and matter wave interferometers. Their ultimate performance can only be reached in space by providing access to unperturbed long evolution times and low-noise environments, altogether leading to outperform existing inertial sensors in accuracy and precision. Space-borne experiments in particular, but also those instruments targeting practical applications on ground, depend to a large degree on the availability of robust, compact and energy-efficient laser system technology. We present the development of a new generation of compact laser systems specifically optimized for precision applications on sounding rockets and satellites.

This work is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant numbers DLR 50 WM 1131-1137, 1237-1240, 1141 and 50QT1201.

A 8.2 Mon 14:30 F 128

High resolution Sagnac atom interferometer — •Gunnar Tackmann, Peter Berg, Sven Abend, Teresa Feld, Katja Baxmann, Paul Kaebert, Christian Schubert, Wolfgang Ertmer, and Ernst M. Rasel — Institut für Quantenoptik, Leibniz Universität Hannover

We present a compact dual source cold-atom gyroscope with flat parabolic atomic trajectories in which an area of 19 mm^2 is realised on a baseline of 13.7 cm. This gyroscope resolves a rotation rate of $5.3{\cdot}10^{-7}$ rad/s at one second, mainly limited by inertial noise, and reaches a final sensitivity of $3{\cdot}10^{-8}$ rad/s. We introduce ways to further improve the stability of the device and to increase its sensitivity to the 10^{-9} rad/s regime by monitoring the rotational noise with auxiliary seismic sensors.

This work is supported by the DFG, the cluster of excellence QUEST, and IQS.

A 8.3 Mon 14:45 F 128

High sensitivity temperature measurements on the nanometer scale — •Philipp Neumann[1], Florian Dolde[1], Ingmar Jakobi[1], Gerald Waldherr[1], Rolf Reuter[1], Junichi Isoya[2], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart — [2]Graduate School of Library, Information and Media Studies, University of Tsukuba, Japan

Here we demonstrate a novel method to measure temperatures with a sensitivity of ~ 10 mK/$\sqrt{Hz}$ and nanometer spatial resolution. Its temperature application range is at least from 120 K to 600 K and includes ambient conditions. It is therefore interesting for material and lifescience. We employ a single optically active paramagnetic defect in a nanometer size diamond, namely the nitrogen-vacancy center. More precisely the spin state can be read out optically and its energy levels depends on temperature among others. We have developed a novel technique to circumvent the main detrimental effects to achieve the stated sensitivity.

A 8.4 Mon 15:00 F 128

Spectroscopy of the clock transition in ^{171}Yb with a transportable setup — •Tobias Franzen, Charbel Abou Jaoudeh, Gregor Mura, Axel Görlitz, Heiko Luckmann, Alexander Nevsky, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, HHU Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

Optical lattice clocks based on elements with two valence electrons are strong competitors in the quest for next generation time and frequency standard. While promising results have already been obtained on several stationary setups using Sr and Yb, transportable clocks are desirable for both performance evaluation and applications.

In the framework of the Space Optical Clocks 2 project, we are developing a transportable Yb lattice clock demonstrator. Our setup is based on diode and fiber lasers and features an intra-vacuum enhancement resonator to allow the formation of a large volume lattice using moderate laser power.

Here we present first results of spectroscopy of the $^1S_0 \rightarrow {}^3P_0$ transition in ^{171}Yb confined in an one dimensional optical lattice, a first evaluation of systematics and ongoing work towards competitive clock operation as well as more compact and robust subsystems.

A 8.5 Mon 15:15 F 128

Compact mode-locked diode laser system for highly accurate frequency comparisons — •Heike Christopher[1,2], Evgeny Kovalchuk[1], Achim Peters[1,2], and the LASUS Team[1,2,3,4] — [1]Institut für Physik, HU Berlin — [2]Ferdinand-Braun-Insitut, Leibniz-Institut für Höchstfrequenztechnik Berlin — [3]Institut für Quantenoptik, LU Hannover — [4]Institut für Laserphysik, Universität Hamburg

We have developed a compact mode-locked diode laser system designed to generate an optical frequency comb spanning the wavelength range from 767 nm to 780 nm. It will thus allow highly accurate frequency comparisons in microgravity experiments testing the Einstein equivalence principle (EEP) for Rubidium and Potassium quantum gases.

The passively mode-locked semiconductor laser system is configured as an extended-cavity laser, allowing for high flexibility in optimizing performance parameters to match the application requirements. The intra-cavity output of the two-section ridge-waveguide (RW) laser diode, consisting of a short saturable absorber and a long gain section, is collimated and reflected by a dielectric mirror. The group velocity dispersion (GVD) of this mirror can be adjusted to provide optimal performance by compensating the laser diode dispersion. Here we present the current status of our work and discuss options for further improvements.

This 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 50WM1237-1240.

A 8.6 Mon 15:30 F 128

Broadband femtosecond filtering cavities for quantum limited projective metrology — •Roman Schmeissner, Valerian Thiel, Jonathan Roslund, Claude Fabre, and Nicolas Treps — Laboratoire Kastler Brossel, 4 Place Jussieu, 75252 Paris cedex 05, France

We have shown theoretically that balanced homodyne detection with a temporally shaped local oscillator extracts timing information and any other parameter of femtosecond(fs)-pulses with ultimate sensitivity [1]. To reach limits predicted by information theory, the scheme requires a laser beam that is quantum-limited in amplitude and phase. We propose to use optical cavities: they are intrinsic, passive low-pass filters that address frequency scales difficult to reach with active feedback mechanisms. Similar systems are used for broadband spectroscopy [2,3]. We construct and characterize a readily implementable filtering cavity that is simultaneously resonant over 100nm. This exceptional broadband property enables a wide range of applications from parameter estimation to ultra-precise spectroscopy. When seeded with a 25fs frequency comb, intensity and phase noise are reduced by up to 10dB at and below the relaxation oscillation band at 1MHz. Furthermore, noise quadrature interconversion enables qualitative identification of phase noise at sidebands above 100kHz. In conclusion, a frequency comb that is quantum limited in amplitude and phase for frequencies larger than 500kHz is obtained from a commercial Ti:Sa laser system.

[1] B. Lamine et al., Phys. Rev. Lett. 101, 2008, 123601, 1-4 [2] Ch. Gohle et al., Phys. Rev. Lett. 100, 2008, 1-4 [3] M.J. Thorpe et al., Optics Express 16, 2008, 2387-2397