Q 39: Precision Measurements and Metrology V (with A)

Time: Wednesday 11:00–12:30 Location: C/HSO

Q 39.1 Wed 11:00 C/HSO

Compact mode-locked diode laser system for high precision frequency comparison experiments in space — •Heike Christopher[1,2], Evgeny Kovalchuk[1,2], Andreas Wicht[1,2], Götz Erbert[2], Günther Tränkle[2], and Achim Peters[1,2] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik Berlin

We present a compact mode-locked diode laser system designed to generate an optical frequency comb in the wavelength range around 780 nm. It will be used for precision experiments in space which will test the universality of free fall (UFF) by employing light pulse atom interferometry for rubidium and potassium ultra-cold quantum gases.

The passively mode-locked extended-cavity diode laser contains an AlGaAs ridge-waveguide diode chip, collimation aspheric micro-optics, and an external nearly zero group velocity dispersion (GVD) dielectric mirror. Reverse biasing a short section of the two section laser diode enables the passive mode-locking process. Highly stable pulse performance is realized at a repetition rate of about 4 GHz where a free running full-width-at-half-maximum (FWHM) RF linewidth of about 100 Hz (resolution bandwidth 50 Hz) was achieved. We present the current status of our work and discuss options for further improvements, e.g. extending the wavelength range and active stabilization of the repetition rate.

This project is supported by the German Space Agency DLR, with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant numbers 50WM1237-1240.

Q 39.2 Wed 11:15 C/HSO

Frequency stabilized laser systems for sounding rockets - towards precision measurements in space. — •Vladimir Schkolnik[1], Max Schiemangk[1,2], Aline Dinkelaker[1], Achim Peters[1,2], The LASUS Team[1,2,3,5], and The KALEXUS Team[1,2,4,5] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]FBH Berlin — [3]ILP Hamburg — [4]JGU Mainz — [5]IQO Hannover

Lasers with stable and accurate output frequencies are the key element in high precision experiments such as atom interferometers and atomic clocks. Moreover, future space missions, including quantum based tests of the equivalence principle or the detection of gravitational waves, require such robust and compact lasers with high mechanical and frequency stability.

We present two laser systems that fulfill these requirements. First, a micro-integrated distributed feedback laser (DFB) stabilized to a rubidium transition which will operate together with a frequency comb on the TEXUS 51 sounding rocket mission scheduled for April 2015. The second laser system contains two narrow linewidth extended cavity diode lasers (ECDLs) for potassium spectroscopy, including a redundancy architecture for reliable operation. The system will be integrated together with control and driver electronics within a pressurized payload module and operate autonomously on the TEXUS 53 mission.

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Q 39.3 Wed 11:30 C/HSO

Utilizing weak pump depletion to stabilize squeezed vacuum states — •Timo Denker[1], Maximilian H. Wimmer[1], Dirk Schütte[1], Trevor A. Wheatley[2], Elanor Huntington[3], and Michèle Heurs[1] — [1]Albert-Einstein-Institut (Max-Planck-Institut für Gravitationsphysik), Hannover, Deutschland — [2]The University of New South Wales, Canberra, Australia — [3]The Australian National University, Canberra, Australia

We propose and demonstrate a pump-phase locking technique that makes use of weak pump depletion (WPD) – an unavoidable effect that is usually neglected – in a sub-threshold optical parametric oscillator (OPO). We show that the phase difference between seed and pump field is imprinted on pump and seed light by the non-linear interaction in the crystal and can be read out without disturbing the squeezed output. In our experimental setup the input of the OPO is 0.55 mW of 1064 nm and it is pumped with 67.8 mW of 532 nm laser light to observe squeezing levels of 1.96 ± 0.0085 dB, with an antisqueezing level of 3.78 ± 0.0150 dB. Our new locking technique allows the first experimental realisation of a pump-phase lock by read-out of the phase information pre-existing in the pump field. There is no degradation of the detected squeezed states.

Q 39.4 Wed 11:45 C/HSO

Line-shape manipulation for x-ray frequency-comb generation — •Stefano M. Cavaletto, Zuoye Liu, Zoltan Harman, Christian Ott, Christian Buth, Thomas Pfeifer, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

Optical frequency combs had a revolutionary impact on precision spectroscopy and metrology. This was recently enabled at extreme-ultraviolet frequencies via methods based on high-harmonic generation (HHG). We put forward a three-level Λ-type scheme in which the absorption spectrum of a short pulse, tuned to an x-ray transition, is manipulated by an optical-frequency-comb laser which couples the excited state to a nearby level [S. M. Cavaletto *et al.*, *Nature Photonics* **8**, 520 (2014)]. The comb structure displayed by the x-ray absorption spectrum might eventually represent an alternative scheme for x-ray frequency-comb generation, overcoming the limitations of present HHG-based methods. We then present related line-shape-manipulation schemes in rubidium atoms, whose $5s\,^2S_{1/2} \to 5p\,^2P_{1/2}$ (794.76 nm) and $5s\,^2S_{1/2} \to 5p\,^2P_{3/2}$ (780.03 nm) transitions are simultaneously excited by pump/probe optical pulses centered at 780 nm. We model the atomic system via a three-level V-type scheme, in order to connect the absorption line shape of the two excited transitions for different time delays to the quantum evolution (in amplitude and phase) of the atomic state.

Q 39.5 Wed 12:00 C/HSO

Frequency comb-based heterodyne many-wavelength interferometry — •Jutta Mildner, Karl Meiners-Hagen, and Florian Pollinger — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig

Up-to-date long distance metrology in engineering, geodesy and surveying ask for relative measurement uncertainties of better than 10^{-7}. A promising tool to push optical-based measurement techniques into this regime are broadband optical frequency combs. In this contribution we want to present a novel concept of a comb-based many-wavelength interferometer in which a direct heterodyne phase detection of individual comb lines is aimed at. To this end a single fiber-based optical frequency comb with CEO-stabilization is used as a seed laser. By cavity filtering two coherent combs of different mode spacing are generated and subsequently used as local oscillator and measurement beam. Based on this scheme, a complete chain of synthetic wavelengths from the optical to the microwave range can be realized in theory, making full phase unwrapping possible without additional high accuracy information. Development and demonstration of a prototype filtering unit with tunable spacing will be presented, including simulations and experiments on positioning sensitivity. Furthermore, we want to discuss the deployed stabilization schemes as well as current progress on optimization measures. This project is performed within the joint research project SIB60 'Surveying' of the European Metrology Research Programme (EMRP). The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

Q 39.6 Wed 12:15 C/HSO

Dispersive Qubit Measurement by Interferometry with Parametric Amplifiers — •Shabir Barzanjeh, David DiVincenzo, and Barbara Terhal — Institute for Quantum Information, RWTH Aachen University, 52056 Aachen, Germany

We perform a detailed analysis of how an amplified interferometer can be used to enhance the quality of a dispersive qubit measurement, such as one performed on a superconducting transmon qubit, using homodyne detection on an amplified microwave signal. Our modeling makes a realistic assessment of what is possible in current circuit-QED experiments; in particular, we take into account the frequency-dependence of the qubit-induced phase shift for short microwaves pulses. We compare the possible signal-to-noise ratios obtainable with (single-mode) SU(1,1) interferometers with the current coherent measurement and find a considerable reduction in measurement error probability in an experimentally-accessible range of parameters.