Q 1: Precision Measurements and Metrology I (with A)

Time: Monday 11:00–12:45 Location: a310

Q 1.1 Mon 11:00 a310

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

Direct traceability to the SI definition of the meter and the capability to generate synthetic wavelengths from the optical to the microwave regime make broadband optical frequency combs highly promising sources for future length metrology with high precision as required in engineering, geodesy and surveying.

In this contribution we want to present the development of a novel 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 and 250 MHz repetition rate is used as a seed laser. By cavity filtering two coherent combs of different mode spacings in the GHz band are generated and subsequently used as local oscillator and measurement beam. The deployed filtering duplet with tunable spacing and Pound-Drever-Hall stabilization scheme will be presented as well as the electronic filtering unit for phase detection. Furthermore, we want to discuss the current progress on the interferometer head setup and show preliminary results of first length measurements.

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 1.2 Mon 11:15 a310

Squeezed light and self-induced transparency in mercury-filled hollow core photonic crystal fibers — •Ulrich Vogl[1,2], Nicolas Y. Joly[1,2], Philip St.J. Russell[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]University Erlangen-Nuremberg, Erlangen, Germany

We recently demonstrated that the use of atomic mercury vapour allows greatly improved loading of an atomic gas into hollow core photonic crystal fibres (PCFs), leading to high and constant vapour pressure in the fibre core [1]. The kagomé-PCFs used guide light not by the photonic band gap effect, but by a two-dimensional version of anti-resonant reflection, and offer much broader windows of transmission, typically over 1000 nm. The generation of squeezed states of light, using pulses that fulfil the self-induced transparency (SIT) condition, was proposed in 1989 [2]. We successfully demonstrate SIT of optical pulses in the mercury-filled PCF system and its use in the generation of squeezed states of light. In the first experiments we observed squeezing below the shot noise limit upon launching short nanosecond pulses into the fibre and using a measurement in direct difference detection. Future prospects include phase-sensitive detection of SIT solitons with temporally shaped local oscillator forms to investigate the phase and number uncertainty of the generated states.

[1] U. Vogl, Ch. Peuntinger, N. Y. Joly, P. St.J. Russell, Ch. Marquardt, and G. Leuchs. Optics Express **22**, 29375 (2014).
[2] K. Watanabe, et. al. Phys. Rev. Lett. **62**, 2257 (1989).

Q 1.3 Mon 11:30 a310

Dilatometer Setup to Characterize Dimensionally Stable Materials by the Coefficient of Thermal Expansion at a Temperature Range from 100 K to 325 K — •Ines Hamann[1], Ruven Spannagel[1], Thilo Schuldt[1], Jose Sanjuan[1], Martin Gohlke[1], Ulrich Johann[2], Dennis Weise[2], and Claus Braxmaier[1,3] — [1]DLR German Aerospace Center, Institute of Space Systems, 28359 Bremen, Germany — [2]Airbus Defence & Space, 88039 Friedrichshafen, Germany — [3]University of Bremen, ZARM Center of Applied Space Technology and Microgravity, 28359 Bremen, Germany

Space missions with the aim of high precision optical measurements are often limited by the dimensional stability of the instrument which can be exposed to high temperature fluctuations, due to the environment of the space probe. To minimize the change of the geometric dimension due to temperature changes, highly dimensionally stable materials are needed at the specific environmental temperatures. Materials like glass ceramics offer a minimal coefficient of thermal expansion (CTE) but they are also very heavy. Composite materials like CFRP or SiC offer also a very low CTE but with a lower weight and are more and more used for such applications. To characterize such low expansion materials we use a laser dilatometer with a heterodyne interferometer to measure length variations of the sample caused by an applied temperature variation. Using a cryocooler in combination with a heating system, we are able to determine CTEs at the 10 ppb/K level within a temperature range from 100 K to 325 K. In this talk, we present improvements of our setup and recent sample measurements.

Q 1.4 Mon 11:45 a310

Precision rubidium spectroscopy in space — •Vladimir Schkolnik[1], Markus Krutzik[1], Achim Peters[1,2], and The FOKUS Team[1,2,3,4,5] — [1]Institut für Physik, Humboldt- Universität zu Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin — [3]ILP, Universität Hamburg — [4]Institut für Physik, JGU Mainz — [5]Menlo Systems, Martinsried

Frequency stabilized lasers are one of the key elements in high precision instruments such as atom interferometers and atomic clocks. Accordingly, future space missions for tests of the equivalence principle require robust and compact lasers with high mechanical and frequency stability.

In this talk, we present the first Doppler free spectroscopy on rubidium in space, performed during the flight of the sounding rocket mission TEXUS 51. We present the spectroscopy payload, the autonomous stabilization scheme and the experimental results of the flight. The frequency of the stabilized laser was compared to a microwave reference using a fiber based frequency comb during launch and microgravity phase. This frequency measurement can be interpreted as a test of the local position invariance and paves the way for future high precision experiments in space.

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Q 1.5 Mon 12:00 a310

Coating Thermal Noise Interferometer — •Janis Wöhler for the AEI 10m Prototype Team — MPG for Gravitational Physics Hannover

Thermal noise in the coatings of highly reflective mirrors is becoming a limiting noise source in interferometers used for the detection of gravitational waves. It is caused by mechanical losses of the thin films used in the coatings. A way to reduce the noise is to use crystalline coatings due to their inherently lower mechanical losses. Crystalline AlGaAs-coatings are a promising candidate and their noise properties will be measured before using them in a quantum limited Michelson interferometer. For the measurement, all other noise sources, especially seismic noise and acoustic disturbances, have to be reduced below the thermal noise level. The AEI 10 m Prototype facility is probably the best suited environment for this kind of experiment.

In this talk the setup of the Thermal Noise Interferometer will be presented, which can measure thermal noise in a frequency band from 10Hz to 50kHz, limited from below by seismic noise and from above by photon shot noise. Furthermore prospects of using crystalline coatings in large scale gravitational wave detectors will be discussed.

Q 1.6 Mon 12:15 a310

Enhancing quantum sensing sensitvity and spectral resolution by a quantum memory — •Sebastian Zaiser, Torsten Rendler, Ingmar Jakobi, Samuel Wagner, Philipp Neumann, and Jörg Wrachtrup — 3. Physikalisches Institut, Universität Stuttgart, Deutschland

Measurement of the phase accumulation of a quantum state is central to quantum sensing. Typically, the sensor coherence time (here $400\mu s$) limits the timescale for this phase accumulation and hence the energy resolution. Processes occuring on larger timescales can indeed be observed[1]. We employ a small nuclear spin quantum register to store quantum information on timescales of the sensors longitudinal relaxation time (here $5ms$). This allows us an increase in frequency resolution by more than one order of magnitude while keeping the full measurement signal. We show that the measurement signal is strongly correlated to the amount of quantum information on the memory qubit by gradually disentangling sensing and memory qubit before the sensing step. We further apply our quantum sensor-memory couple for high resolution NMR spectroscopy of single ^{13}C nuclear spins.

[1] A. Laraoui et al., Nature Communica- tions 4, 1651 (2013), arXiv: 1305.1536

Q 1.7 Mon 12:30 a310

Spectroscopic tests of Lorentz and CPT invariance — •Ralf Lehnert — Indiana University Center for Spacetime Symmetries, Bloomington, USA — Leibniz Universität Hannover, Hannover, Germany

Various approaches to new physics allow for the possibility of small departures from Lorentz and CPT symmetry. This talk provides a brief discussion of the identification of suitable experimental tests for these ideas. Emphasis is placed on low-energy high-precision spectroscopic measurements.