Q 28: Präzisionsmessungen und Metrologie 4

Time: Tuesday 14:00–16:00 Location: V47.02

Q 28.1 Tue 14:00 V47.02

Passive Ring-Laser Stabilization to Sub-kHz Linewidths with Whispering Gallery Mode Resonators — •Michele C. Collodo[1,2], Benjamin Sprenger[3], Florian Sedlmeir[1,2], Sergiy Svitlov[2], Harald G. L. Schwefel[1,2], and L. J. Wang[4] — [1]Max Planck Institut für die Physik des Lichts, Erlangen, Deutschland — [2]Universität Erlangen-Nürnberg, IOIP, Erlangen, Deutschland — [3]Humboldt-Universität zu Berlin, Institut für Physik, AG Nanooptik, Berlin, Deutschland — [4]Physics Department and Joint Inst. of Measurement Science (JMI), Tsinghua University, Beijing, 100084 China

A dielectric whispering gallery mode (WGM) resonator is able to confine light due to total internal reflection at its dielectric interface. In order to achieve high quality (Q) factors in the range of 10^8 and above we use crystalline CaF_2 disk resonators, which provide very low intrinsic absorption losses. Such an evanescently coupled millimeter sized WGM disk resonator can be used as a passive filtering element in an erbium-doped fiber ring laser. This system sustains single mode lasing without the usage of active stabilization techniques.

The resulting lasing linewidth is determined via a three-cornered-hat measurement. We record the beat notes resulting from the combination of all the three different lasing sources working around 1530nm; two self-built WGM resonator lasers and a commercial laser. An evaluation utilizing the Allan Deviation yields a relative frequency stability of 3.28×10^{-12} after 16μs integration time. This corresponds to a lasing linewidth of 643Hz.

Q 28.2 Tue 14:15 V47.02

Präzise interferometrische Frequenzstabilisierung für durchstimmbare Laser und Vergleich mit Frequenzkamm — •Thomas Kinder[1], Thomas Müller-Wirts[1], Hannes Brachmann[2] und Kai Dieckmann[2,3] — [1]TEM Messtechnik GmbH — [2]Max- Planck-Institut für Quantenoptik, Garching — [3]Centre for Quantum Technologies - National University of Singapore

Oft erfordert die Anwendung von Lasern eine hochpräzise Messung und Stabilisierung der Laserfrequenz, z.B. für Spektroskopie oder Abstandsmessung. Wir stellen dazu ein interferometrisches Verfahren zur Stabilisierung durchstimmbarer Laser vor. Hierbei wird die Differenz zwischen der Interferenzphase (die ein Maß für die optische Frequenz ist) und einem computergenerierten Sollwert in einer analogen Regelschleife auf den Laser zurückgegeben. Auf diese Weise kann die Frequenz auf beliebige, auch variable (!) Werte innerhalb des Durchstimmbereiches des Lasers stabilisiert werden, also auch während eines Scans. Der Scanbereich ist dabei nicht prinzipiell beschränkt. Nach einer Kalibration konnten wir mit diesem Verfahren einen Diodenlaser im Wellenlängenbereich 750nm bis 795nm mit einer Absolutgenauigkeit besser 6MHz (1,6MHz RMS) auf beliebige Frequenzen stabilisieren. Der Nachweis der Genauigkeit und Wiederholbarkeit erfolgte durch Vergleich mit einem Frequenzkamm.

Q 28.3 Tue 14:30 V47.02

Arbitrarily frequency shifting optical frequency combs — Erik Benkler[1], •Felix Rohde[2], and Harald R. Telle[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig — [2]Cosingno, Imagine Optic Spain S.L.,Mediterranean Technology Park av. Canal Olimpic s/n 08860 Castelldefels (Barcelona)

A novel optical frequency shifter based on an appropriately driven electro-optic modulator will be presented. It is universally applicable to optical frequency combs corresponding to periodic trains of pulses. The method comprises well-directed optical carrier phase shifting between subsequent pulses without intrusion into or modification of the comb generator. It offers both wide optical bandwidth (many THz) and agile tuneability (10 THz/s), allowing the lines to be continuously swept from one comb end to the other, following a target temporal frequency evolution.

Q 28.4 Tue 14:45 V47.02

Correlated Impact of the Feedback Loops on the Noise Properties of an Optical Frequency Comb — •Vladimir Dolgovskiy, Nikola Bucalovic, Christian Schori, Pierre Thomann, Gianni Di Domenico, and Stéphane Schilt — Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland

An optical frequency comb is characterized by two parameters, the repetition rate of the pulses f_{rep} and the carrier-envelop offset frequency f_{CEO}. A fully stabilized comb is generally obtained by phase-locking these two parameters to a stable frequency reference, using two feedback loops acting on the laser cavity length (for f_{rep}) and on the pump power (for f_{CEO}). However, these two actuators have a simultaneous influence on the two comb parameters, leading to some cross-coupling between the two servo loops. Here, we present the first study of the impact of this coupling onto an optical comb mode in an Er:fiber frequency comb, based on experimental measurements and on a theoretical model. An extensive experimental characterization of the comb was performed in terms of f_{CEO} and f_{rep} dynamic response, frequency noise and total loop transfer functions. We observed a more than 10-fold improved frequency noise power spectral density of an optical comb line at 1.56 μm in a wide Fourier frequency range, resulting from this coupling, compared to a hypothetical modeled case with no coupling. The model is validated by experimental data showing a very good agreement. We also predict a significant comb linewidth reduction at a wavelength around 2 μm.

Q 28.5 Tue 15:00 V47.02

Digital unterstützte heterodyn Interferometrie — •Sina Köhlenbeck für das AEI 10m Prototypinterferometerteam — Leibniz Universität Hannover und Max-Planck-Institut für Gravitationsphysik (AEI)

Das 10m Prototypinterferometer wird momentan am AEI in Hannover gebaut und stellt eine Testumgebung für die Entwicklung neuer Techniken für bestehende und zukünftige Gravitationswellendetektoren da. Ebenso wird es konstruiert um das Standard Quanten Limit zu erreichen und schließlich sogar zu unterschreiten. Um dies zu erreichen wird eine extrem ruhige Arbeitsplattform benötigt, die sich aus drei seismisch isolierten optischen Tischen zusammensetzt. Die Abstände der Tische zueinander werden durch mehrere heterodyn Interferometer vermessen und daraufhin stabilisiert, sodass die drei Tische eine optische Bank bilden. Die digital unterstützte heterodyne Interferometrie ist eine Weiterentwicklung der heterodynen Interferometrie. In einen Arm eines Interferometers wird durch Phasenmodulation eine Pseudozufallszahlenfolge auf den optischen Träger aufgebracht. Unterschiedliche Laufwege des Laserlichts innerhalb eines optischen Aufbaus können nun durch die Decodierung mit derselben, zeitlich versetzten Pseudozufallszahlenfolge entschlüsselt und isoliert werden. Diese Isolierung durch digitale Decodierung erlaubt das Auslesen mehrerer optischer Komponenten mit nur einem Detektor und ermöglicht zusätzlich die Unterdrückung gemeinsamer Rauschquellen.

In diesem Vortrag wird der Aufbau eines ersten Experiments mit digital unterstützter heterodyn Interferometrie am AEI vorgestellt.

Q 28.6 Tue 15:15 V47.02

A gas-tight prestressed piezo cavity as a tunable optical frequency reference for LISA and for future cavity enhanced spectroscopy applications — •Katharina Möhle, Klaus Döringshoff, Moritz Nagel, Evgeny V. Kovalchuk, and Achim Peters — Humboldt Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin

We set up different types of piezo tunable high finesse cavities in the context of the gravitational wave detector LISA, where a tunable frequency prestabilization is desired. The implementation has so far been done by gluing the piezo directly between mirror and spacer of the cavity. These tunable cavities fulfill all LISA requirements for a tunable prestabilization and show a relative stability of 10^{-14}.

Since the piezo actuator can not withstand excessive tensile and shear forces, prestressing of the piezo is of interest to handle, e.g., vibrations during the launch of a space mission. Therefore we designed a new tunable cavity where the piezo is prestressed with 0.5 to 1 MPa by being clamped between the Zerodur parts of the cavity spacer.

At the same time the cavity can be made gas-tight and is bonded in a way such that the piezo has no contact to the intracavity volume. Thus the newly designed piezo tunable cavity is a useful tool for cavity enhanced spectroscopy of week narrow reference lines aiming for the implementation of new types of molecular standards.

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Q 28.7 Tue 15:30 V47.02

Highly Reproducible Sub-Nanometer Surface Characterisation of Laser Mirrors for Satellite-to-Satellite Picometer Metrology — •Harald Kögel[1], Martin Gohlke[1,3], Thilo Schuldt[2], Ulrich Johann[1], Claus Braxmaier[1,2], and Dennis Weise[1] — [1]Astrium GmbH - Satellites, Friedrichshafen, Germany — [2]University of Applied Sciences Konstanz, Germany — [3]Humboldt-Universität zu Berlin, Germany

Within the alternative payload concept IFP (In-Field Pointing) for the LISA (Laser Interferometer Space Antenna) space mission seasonal angular changes in the triangular formation of the three spacecraft are compensated by changing the line of sight of their telescopes with a small actuated mirror, the IFP-Mechanism. This mechanism is located in a pupil plane of each telescope. During actuation the laser beam is scanning over the surface of the optical components in its path. This leads to changes in optical path length due to their surface roughness and could negatively influence the targeted picometer-sensitivity of the optical metrology system. We present a measurement setup developed to characterise the surface of laser mirrors within sub-nanometer accuracy at a high level of reproducibility. As measuring device a heterodyne interferometer is used. The optical components are accommodated in a pendulum specifically designed for this purpose that is suspended on a monolithic hinge and driven by a linear piezo-stepping actuator. With this pendulum the optical components can be precisely moved through the laser beams of the interferometer whereby the surface is measured highly reproducible with a deviation < 0.2nm (rms).

Q 28.8 Tue 15:45 V47.02

Towards a compact atom chip based gravimeter — •Holger Ahlers[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 provide a promising atomic source for matter-wave interferometry in compact setups. They combine tight traps, low power requirements and integrated control features for cold atom experiments. In this talk we present our efforts to demonstrate a gravimeter using bragg scattering in our chip-based QUANTUS-I apparatus. We use the chip to prepare sub-recoil thermal atoms or a BEC in the $F = 2, m_F = 2$ state and transfer to the $m_F = 0$ state via a chip-delivered RF adiabatic passage. The momentum width of the atomic ensemble is reduced by an intermediate δ-kick cooling step, leading to improved Bragg transfer efficiencies and better distinction between the spatially resolved interferometer output ports. First results using the Chip as a retroreflector for the bragg-beams are presented.

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