Q 58: Precision Measurements and Metrology (Gravity and Miscellaneous) (joint session Q/A)

Time: Thursday 10:30–12:00 Location: K 2.013

Q 58.1 Thu 10:30 K 2.013

A high-flux BEC source for the transportable Quantum Gravimeter QG-1 — •Jonas Matthias, Nina Grove, Maral Sahelgozin, Jan Philipp Barbey, Sven Abend, Waldemar Herr, and Ernst M. Rasel — Inst. f. Quantenoptik, LU Hannover

Absolute inertial sensors based on atom interferometry will benefit in two ways from using Bose-Einstein condensates (BEC). First, their low expansion rate reduces the leading order systematic uncertainties of current generation sensors. Second, the per-shot sensitivity will be increased by a higher interferometer contrast and by implementing higher-order Bragg diffraction compared to Raman diffraction used with thermal ensembles. However, formerly the application of BECs was hindered by the size and repition rate of typical BEC experiments, which usually fill a laboratory and have a repetition rate on the order of several ten seconds.

These limitations have been overcome by atom-chip-based BEC sources, which allow compact apparatuses and achieve a high flux at the same time. The source for the transportable Quantum Gravimeter QG-1 consists of a 2D$^+$ MOT and a mirror MOT on a three-layer atom chip as published by Rudolph et al, 2015. The atoms will be evaporatively cooled to quantum degeneracy in a magnetic trap and released from the trap for atom interferometry in free fall. In this talk we will present the current progress on atom cooling and Bose-Einstein condensation.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG) as part of project A01 within the SFB 1128 geo-Q.

Q 58.2 Thu 10:45 K 2.013

Pre-stabilized laser system for future gravitational-wave detectors at a wavelength of 1550nm — •Fabian Thies, Nico Koper, and Benno Willke — Max Planck Institute for Gravitational Physics, Hannover, Germany

To reduce thermal noise in future gravitational-wave detectors(GWDs)[1] and in updated current detectors[2] the use of cryogenic test masses is proposed. Silicon is a promising material for these test masses, because of its high mechanical quality factor and the good thermal conductivity at cryogenic temperatures. The use of silicon requires a laser source at a wavelength of 1550nm or longer.

Currently commercial available laser systems do not fulfill the demanding requirements concerning the laser power, frequency and intensity noise and the spatial beam profile of future GWDs.

We will use a low noise laser at the wavelength of 1550nm as a seed for erbium-ytterbium fiber amplifiers, to get into the range of the proposed laser power levels. To reach the demanded noise levels active stabilizations are necessary in such a laser system for GWDs.

Here we present the results of the characterization of several possible seed lasers and of a fiber ring cavity as an in-fiber frequency sensor.

[1]ET Science Team, ET conceptual design document ET-0106C-10, http://www.et-gw.eu/index.php/etdsdocument

[2]LIGO Scientic Collaboration, Instrument Science White Paper, https://dcc.ligo.org/public/0113/T1400316/004/T1400316-v5.pdf

Q 58.3 Thu 11:00 K 2.013

Sensor noise measurements for an improved active seismic isolation of the AEI 10m-Prototype — •Robin Kirchhoff — Albert-Einstein / Max-Planck Institut für Gravitationsphysik Hannover, Callinstraße 38, 30167 Hannover

Large scale, ground based interferometric gravitational wave detectors use a combination of passive isolation and active control loops to reduce the coupling of seismic motion into the Michelson interferometer. The active isolation is limited by the self-noise of the in-loop sensors and a precise characterization of this noise is needed to optimize the control loops. In the Albert-Einstein-Institute in Hannover, the Sub-SQL (standard quantum limit) interferometer is under construction, which is a 10 m Michelson interferometer designed to be limited by quantum noise for prototyping techniques to surpass the SQL. To reach the quantum noise limit, all classical and technical noise sources, including seismic noise, must be suppressed below quantum noise levels. The seismic attenuation system (AEI-SAS) provides the required seismic pre-isolation of an optical platform using both passive and active techniques. Several huddle tests were performed using these seismically isolated platforms to precisely measure the noise of different inertial sensors and their amplifier electronics. The initially installed Sercel L-22D geophones were measured to have a higher self-noise compared to Sercel L-4C geophones. The geophones were therefore exchanged and the resulting improvement of the active isolation performance of the AEI-SAS was verified.

Q 58.4 Thu 11:15 K 2.013

Fabrication Process Control of Wire Grid Polarizers for the Deep Ultraviolet- by Transmission Spectroscopy in the Visible Spectral Range — •Walter Dickmann[1], Thomas Siefke[2], Johannes Dickmann[3], Carol Bibiana Rojas Hurtado[3], and Stefanie Kroker[1,2] — [1]Technische Universität Braunschweig, LENA Laboratory for Emerging Nanometrology — [2]Friedrich-Schiller-Universität Jena, Institute of Applied Physics — [3]Physikalisch-Technische Bundesanstalt Braunschweig

Wire grid polarizers (WGPs) are periodic nano-optical metasurfaces which act as polarizing elements. In the deep ultraviolet (DUV) region the performance of metallic WGPs is poor whereas wide bandgap semiconductors are promising materials for this spectral range. RCWA calculations provide extinction ratios (ERs) of up to 10^4. However, so far fabricated titanium dioxide WGPs achieved only ERs which are almost two orders of magnitude smaller than the simulated values. This is mainly due to surface roughness and deterministic structural deviations resulting from the fabrication process and approaching the size range of the structural features for short application wavelengths. In this contribution we present a method to characterize deterministic structural deviations of DUV polarizers at the nanometer scale by transmission spectroscopy in the visible spectral range. The achieved results lay the foundation for an in situ fabrication process control.

This research is supported by the DFG within research training group 'Metrology for Complex Nanosystems' (GrK 1952/1) and within project 'PolEx' (KR4768/1-1).

Q 58.5 Thu 11:30 K 2.013

Thickness uniformity measurements of crystalline AlGaAs mirror coatings — •Philip Koch — MPI für Gravitationsphysik, Hannover, Deutschland

Beside quantum noise, the sensitivity of the current generation of gravitational wave detectors is limited by coating Brownian noise of the interferometer mirrors. This arises from thermal fluctuations of the molecules in the coating itself. Coating Brownian noise is dependent on the mechanical loss angle of the coating materials. AlGaAs mirror coatings are crystalline dielectric coatings which have higher Q factors (lower loss) and thus a ten-fold reduction of coating Brownian noise compared to the commonly used amorphous silica-tantala coatings. A homogenous surface figure is needed in the high precision interferometry to avoid optical losses. A method to measure the surface homogeneity of mirror coatings will be presented with an accuracy of below 0.05 nm. This method was used to measure a 0.5 nm RMS thickness homogeneity across a 5 cm diameter AlGaAs coating provided by Crystalline Mirror Solutions.

Q 58.6 Thu 11:45 K 2.013

Feasibility and Possibility of Testing Non-Classical Features of Gravity in a Double-slit-Type Experiment — •Sahar Sahebdivan — Atominstitut, TU Wien, Stadionallee 2, 1020 Wien

In this presentation, we are exploring the feasibility of observing non-classical features of gravity in a low-energy regime in a quantum optics experiment.

If gravity has an underlying quantum nature, it should hold the most fundamental quantum characteristics such as superposition principle and entanglement. Despite the weakness of gravity, in principle there is a chance, to observe such a quantum signature of the gravity by exploiting the quantum optical techniques, without direct observation of graviton.

We are investigating a new dynamical scheme called, gravitational quantum regime, in which the source of gravity is a quantum particle, and its centre of mass is subject to the spatial superposition. In a Gedankenexperiment, a test particle is gravitationally interacting with a quantum nanoparticle in a double-slit setup. Possible entanglement or superposition of the fields is investigated.

We are looking for the corresponding deviation of the classical description of gravity despite being far from Planck scale. Any experimental interrogation which reveals that gravitational field obeys the quantum superposition principle would be the first recognition of quantumness of gravity. This study will show how feasible it is to search for a non-classical feature of gravity in such regime of motion.