A 5: Precision Measurements and Metrology: Gravity (with Q)

Time: Monday 14:30–16:30 Location: P 104

Group Report A 5.1 Mon 14:30 P 104

The Laser Ranging Interferometer on GRACE Follow-On - current status and outlook — Germán Fernández Barranco, Alexander Görth, •Christoph Mahrdt, Vitali Müller, Daniel Schütze, Gunnar Stede, Gerhard Heinzel und Karsten Danzmann — Albert-Einstein-Institut (AEI), Hannover

The Gravity Recovery and Climate Experiment (GRACE) is able to observe the Earth's dynamic gravitational field on a global scale. Changes due to mass transport within the Hydrosphere and Cryosphere, with unprecedented precision have been observed with a temporal resolution of one month. Long term monitoring of these changes is important for a better understanding of the processes causing these time variations. GRACE has been flying for nearly 15 years now, tripling it's targeted design lifetime. Due to the increasing risk of failure a rebuild of GRACE has been build and is currently under test for an anticipated launch as early as spring 2018. GRACE Follow-On carries an additional laser ranging interferometer as technology demonstrator for future gravity field missions which has the potential to enable improved spatial resolution. This talk will give an overview of the architecture of the laser ranging interferometer, a status update, and outlook towards the launch.

A 5.2 Mon 15:00 P 104

Precise measurement of pW laser powers for inter-satellite laser interferometry applications — •Sebastian Schreiber, Alexander Görth, Christoph Vorndamme, Nils Christopher Brause, Oliver Gerberding, Thomas Schwarze, Gerhard Heinzel, and Karsten Danzmann — Albert-Einstein-Institut Leibniz Universität Hannover

Future space missions like the Laser Interferometer Space Antenna (LISA) or the Gravity Recovery and Climate Experiment Follow-on mission (GRACE-FO) will make use of laser interferometry to measure precise distance changes between the spacecraft.

The huge distances between the SC reduce the received laser power to a few nW or even pW. To ease the alignment procedure of the SC an acquisition sensor will be installed on each SC.

To ensure the correct functionality of those sensors it is necessary to measure such light intensities on ground. Noise sources such as residual, scattered or reflected light as well as electronic readout noise are actually limiting the achievable results from common instruments.

This talk will present a general overview and first ideas of building a measuring instrument which is able to directly measure such low intensities. The focus lies on AC measurement techniques that involve optical chopper wheels or heterodyne interferometey

A 5.3 Mon 15:15 P 104

Deep Frequency Modulation Interferometry — •Christoph Vorndamme[1], Oliver Gerberding[2], Katharina-Sophie Isleif[1], Thomas S. Schwarze[1], Moritz Mehmet[2], Gerhard Heinzel[2], and Karsten Danzmann[1,2] — [1]Albert Einstein Institute, Leibniz Universität Hannover — [2]Max Planck Institute for Gravitational Physics (Albert Einstein Institute)

Here we present the latest developments for the deep frequency modulation interferometry (DFMI) technique at the AEI. This technique is based on a Michelson setup with unequal armlength and a strong, or deep, frequency modulation applied to the input laser. The unequal armlength converts the laser frequency modulation into an effective deep phase modulation in the measurement arm, thus encoding the measurement phase in complex amplitudes of the modulation frequency harmonics. Unlike in a phase modulated setup, which already provides high precision and high dynamic range, the frequency modulated setup can be implemented with very compact optical heads for a scalable amount of degrees of freedom. This is due to the laser frequency modulation and reference noise measurement being kept seperate from the part of the optics that need high thermal and mechanical stability. Futhermore, the effective modulation depth includes the total delay in the measurement arm, thus yielding the possibility for absolute ranging. The presented efforts include the construction of optical hardware like a glued ultra-stable reference interferometer as well as the developement of fast phase readout electronics (phasemeter) based on a system on chip (SoC).

A 5.4 Mon 15:30 P 104

Interferometrischer Messkopf zur dynamischen Laser-Entfernungsmessung — •Oliver Mandel[1,2], Thilo Schuldt[2,3], Michael Chwalla[1], Dennis Weise[1], Ulrich Johann[1] und Claus Braxmaier[2,3] — [1]Airbus DS GmbH, Friedrichshafen — [2]Zentrum für angewandte Raumfahrttechnologie und Mikrogravitation (ZARM), Bremen — [3]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Bremen

Die Laserinterferometrie gilt in der Raumfahrt als vielversprechende Technologie zur dynamischen Abstandsmessung zwischen Satelliten, besonders im Hinblick auf Missionen zur Erdbeobachtung, Detektion von Gravitationswellen und Formationsflügen. Verschiedene Konzepte für ein heterodynes, dynamisches Laser-Entfernungsmessgerät mit Nanometergenauigkeit wurden auf ihre Nutzbarkeit für Gravitations-Missionen der nächsten Generation untersucht und hinsichtlich ihrer Messgenauigkeit, Baugröße, Flexibilität und Komplexität verglichen. Darauf aufbauend wird ein monostatisches Instrumentendesign vorgestellt, bei dem sich die Laserstrahlen auf der direkten Sichtverbindung zwischen den Satelliten ausbreiten, wobei innerhalb des Instruments eine bi-statische Strahlführung Anwendung findet. Die tatsächliche Leistungsfähigkeit soll in einer eigens dafür entwickelten Testumgebung vermessen werden. Zur leichteren Unterbringung in zukünftigen Satellitenmissionen ermöglicht das Instrumentendesign einen frei wählbaren Abstand vom Messkopf zum Phasenzentrum und kann vollständig auf einer kompakten optischen Bank integriert werden. Zuwendung des DLR mit Mitteln des BMWi unter dem Förderkennzeichen 50EE1409.

A 5.5 Mon 15:45 P 104

A backlink for LISA: Pre-experiment and optical design — •Lea Bischof[1], Katharina-Sophie Isleif[1], Oliver Gerberding[2], Daniel Penkert[2], Stefan Ast[2], Gerhard Heinzel[2], Michael Winter[1], Jens Reiche[2], and Karsten Danzmann[1,2] — [1]Institut für Gravitationsphysik, Leibniz Universität Hannover — [2]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut)

The Laser Interferometer Space Antenna (LISA) is a planned space-based gravitational wave detector with arm-lengths of several million kilometers. To suppress laser frequency noise in this detector two or more arms have to be compared to synthesize a quasi Michelson interferometer. This is non-trivial due to an orbit induced breathing of the angle between the arms, which requires an adaptable link (so-called backlink) between two optical benches in one satellite. Therefore, a new experiment is currently being set-up at the AEI in Hannover to compare three different methods: a 'fiber backlink', a 'free beam backlink' and a 'frequency separated backlink'. All bonded on two baseplates that are fixed on two rotary stages to simulate a LISA like motion. We will present the current status of this, so called '3Backlink-experiment', the stray light mitigation strategies and the actual implementation of a pre-experiment that will analyze key issues for the free beam backlink. Highlights include first results with a free beam backlink, including angular steering control, and the IfoCAD based design of the highly complex three backlink interferometer.

A 5.6 Mon 16:00 P 104

Experiment to investigate collinear back-reflections of optical components — •Michael Winter[1], Oliver Gerberding[2], Katharina-Sophie Isleif[1], Daniel Penkert[2], Stefan Ast[2], Lea Bischof[1], Gerhard Heinzel[2], Jens Reiche[2], and Karsten Danzmann[1,2] — [1]Albert Einstein Institute Hannover, Leibniz Universität Hannover — [2]Max Planck Institute for Gravitational Physics (Albert Einstein Institute)

The Laser Interferometer Space Antenna (LISA) is a planned space-based gravitational wave detector with arm lengths of some million kilometres. Due to orbital dynamics the angle between the arms changes. Thus an adaptable link (backlink) between the two optical benches inside each spacecraft is required. Previous experiments have shown that a fiber solution is limited by collinear ghost beams. Additional optical components can be used to avoid them or make them irrelevant, e.g. Faraday Isolators or AOMs. Collinear back-reflections of the components are designated to be the new limiting factors.

To investigate these back-reflections a simple cavity-like setup is used, whereby the component to be examined forms one half of an ultra-low finesse cavity. Deep Frequency Modulation (DFM) interferometry is then applied to generate self-interference at AC-frequencies for a quasi heterodyne detection.

This talk will give an overview of the operating principle and the characterization of the setup. Thereby the focus lies on reconciling theory and experiment to connect obtained signal and power reflectivity of the device-under-test, revealing collinear back-reflection properties.

A 5.7 Mon 16:15 P 104

Optical three-signal test for the LISA phasemeter — •Germán Fernández Barranco, Daniel Penkert, Thomas Schwarze, Oliver Gerberding, and Gerhard Heinzel — Max Planck Institute for Gravitational Physics, Callinstraße 38 30167 Hannover

The planned spaceborne gravitational wave detector LISA will allow the detection of gravitational waves at frequencies between 0.1 mHz and 1 Hz. It uses high-precision heterodyne laser interferometry as the main measurement technology. A breadboard model of the interferometric phase readout system (phasemeter) was developed in the scope of an ESA technology development project. This project was completed successfully fulfilling all performance requirements in an electrical two-signal test. Here we present the advances of an optical testbed for the phasemeter as well as measurements. The testbed is based on an ultra-stable hexagonal optical bench. This bench allows the generation of three unequal heterodyne beatnotes, thus enabling us to probe the phasemeter for nonlinearities in an optical three-signal test. The final goal is to show a performance in the microcycle/sqrt(Hz) regime for the upper part of the LISA measurement band (5 mHz to 1 Hz) with a dynamic range of about 7 orders of magnitude using beatnotes between 5 and 25 MHz. The measurements presented here fulfill this requirement down to 100 mHz including dynamic and beatnote ranges. Once full performane is achieved, other components of the LISA arm metrology chain (clock noise transfer and removal, inter-satellite ranging and communication) can be tested in this setup.