Q 11: Precision Measurements: Gravity I

Time: Monday 17:00–19:00 Location: E214

Q 11.1 Mon 17:00 E214

a testbed for Tilt-To-Length coupling and Differential-Wavefront-Sensing performance in LISA — •Alvise Pizzella, Miguel Dovale, and Gerhard Heinzel — AEI Hannover, Germany

The LISA mission aims at measuring gravitational waves (GWs) in the sub-Hz band using inter-spacecraft interferometry. It consists in a constellation of three satellites in triangle formation with 2.5 Gm-long arms following an Earth-like heliocentric orbit. The target sensitivity of pm/Hz^1/2 presents unprecedented technical challenges; such as minimal detected power levels, causing shot noise, and the coupling of the angular jitter of the spacecraft and test masses to the interferometrically-measured longitudinal displacement (Tilt-To-Length (TTL) coupling). TTL is forecasted to be the second highest noise entry in LISA. In order to readout from the heterodyne interference beatnote the length and angular signals, necessary for respectively GWs detection and maintaining the interferometer*s alignment, LISA implements Differential-Wavefront-Sensing (DWS), combining the individual phase readouts from the four segments of a Quadrature PhotoDiode (QPD). An ultra stable interferometer testbed representative of the Optical Bench (OB) of a LISA spacecraft has been developed in order to validate the critical interferometric techniques for LISA. The testbed features steering mirrors that can induce synthetic tilts between the beams to simulate spacecraft or test mass motion. This experiment has been used to demonstrate optical reduction of TTL by using imaging. Current work is focusing on developing a new method to readout the DWS and achieving nrad DWS noise levels.

Q 11.2 Mon 17:15 E214

Dual balanced readout for scattered light noise suppression in gravitational wave detection — •André Lohde, Daniel Voigt, and Oliver Gerberding — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany

Gravitational wave interferometers are highly sensitive to scattered light noise. This is due to the interfering character of straylight backscattered into the interferometer that is potentially modulated at moving surfaces. Today's interferometers, such as LIGO, Virgo and KAGRA are already limited by scattered light noise in the low frequency domain. Future detectors, however, such as the Einstein Telescope, depend upon advanced scattered light mitigation to fulfill design requirements.

Here, I present the technique of implementing two balanced homodyne detectors for the readout of a Michelson interferometer. This technique promises to allow partial subtraction of scattered light noise by simple arithmetic operations and thus improval of the sensitivity of gravitational wave detectors.

Q 11.3 Mon 17:30 E214

A Free-Beam Backlink for the Space-Based Gravitational Wave Detector LISA — •Daniel Jestrabek[1,2], Lea Bischof[1,2], Melanie Ast[1,2], Jiang Ji Ho Zhang[1,2], and Gerhard Heinzel[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany — [2]Leibniz Universität Hannover, Hannover, Germany

The Laser Interferometer Space Antenna (LISA) will be the first Gravitational Wave Detector in space, consisting of three satellites forming an equilateral triangle of 2.5 million kilometers distance. The challenge introduced by the relative movements of the satellites can be overcome by the implementation of steerable optical benches to compensate for these changes. This makes an optical connection necessary that links the moving benches so that the gravitational wave signal can be extracted in post-processing. One possible solution for such an optical connection (also called "Backlink") is the use of mirrors that guide the light in free space between the benches. The mirrors must be actively steered to keep this Free-Beam Backlink stable. Control electronics were developed, tested, and implemented for the Free-Beam Backlink within a LISA-like test bed, the Three-Backlink Experiment. This test bed consists of two separate, rotatable benches in between which light is exchanged through three optical connections: the free-beam link and two fiber-based solutions.

We present here the working principle of the Free-Beam Backlink and its optimization, enabling stable heterodyne interference over separated optical benches with a low noise contribution.

Q 11.4 Mon 17:45 E214

Compact Laser Interferometer for Testmass Readout in Gravitational Wave Detectors — •Wanda Vossius, Meenakshi Mahesh, Tobias Eckhardt, Leander Göbbels, and Oliver Gerberding — Institut für Experimentalphysik, Geb. 68 Z. 21-21c, Luruper Chaussee 149, 22761 Hamburg, Deutschland

In order to realise the sensitivity required for future gravitational wave detectors, there is a need for an increase of three orders of magnitude for the precision of the testmass readout. This would decrease the noise at frequencies below 10Hz and allow for the detection of gravitational waves of lower amplitude. Local displacement sensors in gravitational wave detectors have to be both compact and stable without the need for readjustment while the detector is running.

We present the plan and current status on a compact readout sensor in the form of an interferometer. This interferometer is only 3 cm long with an armlength of about 5 cm. It contains a single quasimonolithic optic which results in an unequal armlength Michelson interferometer with a dual port readout. In order to reduce the coupling of electronic noise and ghostbeams into the readout, we plan to use a Deep Frequency Modulation on the laser. To ensure the stability criteria, the optical components will be glued onto a titanium carrier.

Q 11.5 Mon 18:00 E214

Postprocessing subtraction of tilt-to-length noise in LISA — •Sarah Paczkowski[1,2], Roberta Giusteri[1,2], Martin Hewitson[1,2], Nikolaos Karnesis[3], Ewan Fitzsimons[4], Gudrun Wanner[1,2], and Gerhard Heinzel[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-30167 Hannover, Germany — [2]Leibniz Universität Hannover, D-30167 Hannover, Germany — [3]Department of Physics, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece — [4]The UK Astronomy Technology Centre, Royal Observatory, Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, United Kingdom

The space mission LISA aims to observe gravitational waves over a frequency range from 0.1 mHz to 1 Hz. LISA is characterised by its three satellites which form a nearly equilateral triangle with a 2.5 million km arm length. Laser interferometers will measure the distance between free-falling test masses hosted in each satellite with picometer precision down to mHz frequencies. To reach this performance, several noise sources have to be kept under control.

One of these is the coupling of an angular jitter into the interferometric phase readout, called TTL coupling. This cross-coupling arises, for example, from misalignments within the optical system. Unless mitigated, this noise source is expected to affect the scientific performance of LISA. In this talk, I will present a method to calibrate and subtract TTL noise that has no impact on LISA science operations. Selected proof-of-principle simulation results will demonstrate the performance based on the current design configuration of LISA.

Q 11.6 Mon 18:15 E214

Status of the AEI 10m Prototype: a gravitational wave detector prototyping facility — Matteo Carlassara[1,2], Firoz Khan[1,2], Philip Koch[1,2], Johannes Lehmann[1,2], Harald Lück[1,2], Juliane von Wrangel[1,2], Janis Wöhler[1,2], and •David S. Wu[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-30167 Hannover, Germany — [2]Leibniz Universität Hannover, D-30167 Hannover, Germany

The current status will be presented on the Albert Einstein Institute (AEI) 10 m Prototype facility in Hannover, where new technologies and techniques for full scale gravitational wave detectors (GWDs) are developed and tested. A particular area of focus is the investigation of techniques to surpass the standard quantum limit (SQL) of interferometry by providing a test bed interferometer to experimentally test these techniques in a low noise GWD-like environment. Current activities are focussed on getting the Sub-SQL Interferometer online and commissioned to it's designed sensitivity. These activities range from new motion sensors, seismic isolation techniques, precision optics, and scattered light mitigation.

Q 11.7 Mon 18:30 E214

Toward testing LISA post-processing pipeline under realistic circumstances with experimental data. — •Narjiss Messied —

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Laser Interferometer Space Antenna (LISA) is a space-based mission that aims to detect gravitational waves in the mHz range with heterodyne interferometry. Gravitational wave signals encoded in a beam phase are extracted by a phasemeter. Raw phase data from this core device is dominated by various noise sources, for example, laser frequency noise, clock noise, etc. Hence, LISA requires the initial noise reduction pipeline (INReP), a set of complex data post-processing algorithms, in order to dig up gravitational wave signals from such noise-dominant data. Any research on this pipeline has relied on synthetic data produced by numerical LISA simulators so far, which can not cover all realistic features of actual phasemeter outputs during the mission. In this talk, we present the latest efforts toward the verification of this pipeline with experimental data from our on-ground testbed called the Hexagon, which acts as a miniature-scale LISA with three beam sources and three independent phasemeters.

Q 11.8 Mon 18:45 E214

The Three-Backlink Experiment for the first space-based gravitational wave detector LISA — •Jiang Ji Ho Zhang[1,2], Lea Bischof[1,2], Daniel Jestrabek[1,2], Melanie Ast[1,2], Michael Born[1,2], Katharina-Sophie Isleif[3], Stefan Ast[4], Nicole Knust[1,2], Daniel Penkert[1,2], and Gerhard Heinzel[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Hannover, Germany — [2]Leibniz Universität Hannover, Hannover, Germany — [3]Deutsches Elektronen-Synchroton (DESY) Zeuthen, Hamburg, Germany — [4]DLR-Institute for Satellite Geodesy and Inertial Sensing, Hannover, Germany

The Laser Interferometer Space Antenna (LISA) will be the first gravitational wave detector in space, aiming to use laser interferometry to detect gravitational wave signals in the 0.1 mHz to 1 Hz band. It consists of three satellites forming a near-equilateral triangle with 2.5 million km arms. Due to the orbital mechanics, the inter-satellite distances and angles vary by about 1% and 1.5% per year, respectively. Each satellite features two moving optical sub-assemblies (MOSAs) that compensate for the angular dynamics. They both carry one optical bench, which in turn are connected via a flexible optical link. This is the so-called Backlink. The noise of the optical pathlength difference between two counter propagating beams along the Backlink is required to reach 1 pm/sqrt(Hz) stability. The Three-Backlink Experiment is a trade-off study between different designs of the Backlink: two fiber-based and one free beam. Here, we report on the design and technical aspects of the experiment, the current status and the ongoing work.