A 37: Precision measurements and metrology IV (with Q)

Time: Thursday 14:00–16:00 Location: F 128

Group Report A 37.1 Thu 14:00 F 128

A prototype optical bench for the Laser Interferometer Space Antenna — •Michael Tröbs and the LISA Optical Bench Team — Albert Einstein Institute, Callinstrasse 38, 30167 Hannover, Germany

The Laser Interferometer Space Antenna (LISA), aims to detect gravitational-waves at mHz frequencies. It consists of three spacecraft forming an equilateral triangle in an Earth-like orbit around the sun. Drag-free test masses define the arms of a Michelson interferometer that is implemented by mutual laser links between the satellites in a transponder configuration. Each LISA satellite carries optical benches, one for each test mass, that measure the distance to the local test mass and to the remote optical bench on the distant satellite. In addition, the optical bench includes an acquisition sensor and mechanisms for laser redundancy switching.

Currently, an elegant bread board of the optical bench is developed and will be characterized. This requires to complete externally the two interferometers mentioned above by simulators – a test mass simulator and a telescope simulator. We will give an overview of the test infrastructure including the simulators, the interferometer readout, the laser systems and the data acquisition.

A 37.2 Thu 14:30 F 128

Micro-Newton thruster and test facility development — •Franz Georg Hey[1,2], Andreas Keller[1], Ulrich Johann[1], Claus Braxmaier[1,3,4], Martin Tajmar[2], and Dennis Weise[1] — [1]Astrium GmbH - Satellites — [2]Technische Universität Dresden — [3]Universität Bremen — [4]Deutsches Zentrum für Luft- und Raumfahrt

For future space missions especially with multi satellite configuration like the New Gravitational Wave Observatory, a highly precise attitude control system is required. The High Efficiency Multistage Plasma Thruster (HEMP-T) could be an adequate attitude actuator for these mission scenarios. In parallel to the development of suitable thrusters, also the setup of suitable test infrastructure for measurement of μN thrust noise levels is of crucial importance to understand such systems.

We present the development status of the micro-Newton HEMP-T as well as the status of the developed micro-Newton thrust balance. The developed, integrated and tested thrust balance consists of an optical read out, a calibration device, and the measurement pendulum itself. A heterodyne interferometer is used as optical read out. To measure the tilt of the pendulum, differential wave front sensing is used. The whole interferometer- and the mechanical balance setup is in a total symmetric configuration to enable a common-mode rejection of different noise sources. The calibration was accomplished with an electro static comb. The developed thrust balance has a resolution of $10\,\mu\mathrm{N}/\sqrt{Hz}$ by a measured pendulum translation of few nanometers. Moreover we present the results of an experimental comparison of different HEMP-T configurations.

A 37.3 Thu 14:45 F 128

Ground-based characterisation of the LISA Pathfinder optical measurement system — •Andreas Wittchen, Martin Hewitson, Heather Audley, Natalia Korsakova, Gerhard Heinzel, and Karsten Danzmann — Max-Planck Institut/AEI Hannover

A space-based gravitational wave detector, the laser interferometer space antenna (LISA), is currently being developed. LISA consists of three identical satellites, forming an equilateral triangle with million kilometre armlengths. To develop and test key technologies required, a test satellite, LISA Pathfinder, will be launched. This satellite contains a pair of free-floating test masses. The distance between the test masses will be precisely measured interferometrically. One of the key components of the measurement system is the optical bench, consisting of four interferometers. An engineering model optical bench is available at the Albert Einstein Institute, Hannover. It is currently used for system characterisation experiments, and will be integrated in a ground based test bed for use during in-flight operations. In this contribution the optical bench will be introduced and the current preparations for the mission are explained.

A 37.4 Thu 15:00 F 128

MAIUS - a rocket-based matter-wave interferometer — •Stephan Tobias Seidel[1], Ernst Maria Rasel[1], and The Quantus-Team[1,2,3,4,5,6,7,8,9] — [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

A central goal of modern physics is the test of fundamental principles of nature with ever increasing precision. One of these contains of a differential measurement on freely falling ultra-cold clouds of two atomic species and thus using atom interferometry to test the weak equivalence principle in the quantum domain. By performing such an experiment in a weightless environment the precision of the interferometer can be considerably increased. With the QUANTUS experiments operating in the drop tower Bremen we were able to realize the first BEC based interferometer in microgravity. As a next step towards the transfer of such a system in space, either on board the ISS or as a dedicated satellite mission, a chip-based atom interferometer operating on a sounding rocket is currently being built. The success of this project would mark a major advancement towards a precise measurement of the equivalence principle with a space-born atom interferometer.

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A 37.5 Thu 15:15 F 128

Breadboard model of the LISA Phasemeter — •Oliver Gerberding, Simon Barke, Joachim Kullmann, Ioury Bykov, Juan Josè Esteban Degaldo, Gerhard Heinzel, and Karsten Danzmann — Max-Planck-Institute for Gravitational Physics (Albert-Einstein-Institute) and Leibniz University of Hannover, Callinstraße 38, 30167 Hannover, Germany

The detection of gravitational waves in the sub-Hz regime will allow insight into the dynamics of galactic objects, like mergers of ultramassiv black holes. For this purpose the space-born gravitational wave detector LISA is planned, which uses precision heterodyne laser interferometry as main measurement technology.

A breadboard model for the phase readout system of these interferometers (Phasemeter) is currently under development as an ESA project by a collaboration between the Albert-Einstein Institute, the Technical University of Denmark and Axcon Aps. The breadboard is designed to demonstrate all functions for operating a complete LISA-like metrology system, to meet all performance requirements for a future mission and to study the effort of bringing the design to space qualification.

Here we will present a system overview and the current status of testing and development of the breadboard. This includes phase readout with $1\mu\mathrm{cycle}/\sqrt{\mathrm{Hz}}$ performance, clock noise transfer, inter-satellite ranging and communication, laser frequency control and acquisition.

A 37.6 Thu 15:30 F 128

Laser frequency stabilisation for the AEI 10m Prototype Interferometer — •Manuela Hanke for the AEI 10 m Prototype team — Leibniz Universität Hannover und MPG für Gravitationsphysik (AEI)

The 10 m Prototype facility, currently being set up at the AEI Hannover, will provide a testbed for very sensitve interferometric experiments. One ambitious goal of this project is to reach and subsequently even surpass the standard quantum limit in a detection band around 200 Hz with a 10 m arm length Michelson interferometer. In order to pursue such an avenue, the laser source must be extremely well stabilised. The laser source was chosen to be one of the 35 W lasers used to drive the km-scale gravitational wave observatories, LIGO and GEO 600. A fully suspended triangular ring cavity of finesse ca. 5000 will be used as a frequency reference for the stabilisation of the laser. The aim of this project, the so-called frequency reference cavity, is to reach a level of laser frequency fluctuations of better than 10^{-5} Hz/sqrt(Hz) in the detection band, centered around 200 Hz. Therefore we need to reduce the frequency noise by a factor of 10^7. The main goal is to make a sufficiently stabilised laser beam available for the AEI 10 m Prototype Interferometer, with a duty cycle that is not limiting the operation of the core instrument by any means. In this talk I will show the motivation for a frequency stabilisation and present the layout and the status of the reference cavity.

A 37.7 Thu 15:45 F 128

Development of photoreceivers for space-based interferometry — •Germán Fernández, Gerhard Heinzel, and Karsten Danzmann — Max Planck Institute for Gravitational Physics/AEI, Hannover

The photoreceiver is a basic element in laser interferometry systems presented in space-based missions such as Lisa Pathfinder or GRACE. The special requirements demaded by those systems rule out any commercial solution for the photoreceiver. Therefore, new photoreceiver designs have been developed and characterized in the Max Planck Institute for Gravitational Physics, Hannover, focusing the efforts on the bandwidth and noise performance. Additionally, a high-accuracy measurement system was configured to perform scans of the photodiodes' surface, which allow a real understanding of the spatial response of those devices.