Q 11: Präzisionsmessungen und Metrologie 2

Time: Monday 14:00–16:00 Location: V7.03

Group Report Q 11.1 Mon 14:00 V7.03

Technology development in Hannover for the space-based gravitational wave detector LISA — •Michael Tröbs, Simon Barke, Johanna Bogenstahl, Iouri Bykov, Christian Diekmann, Juan Jose Esteban, Oliver Gerberding, Joachim Kullmann, Maike Lieser, Jens Reiche, Gerhard Heinzel, and Karsten Danzmann — AEI Hannover

Laser Interferometer Space Antenna (LISA) is a future space-based gravitational wave detector consisting of three satellites. LISA shall act as a Michelson interferometer and measure distance variations between free-floating test masses inside the satellites. Currently, the main optical instrument (the optical bench) comprising the interferometers and the electronic device to read out the phase changes (the phasemeter) are being developed.

We give a brief overview on programmatics and report on the progress in Hannover in the optical bench and the phasemeter development.

Group Report Q 11.2 Mon 14:30 V7.03

Status of the GEO600 gravitational-wave detector — •Mirko Prijatelj and for the Geo600 Team — Albert-Einstein Institut, Hannover, Germany

The german-british project GEO600 is the only gravitational wave detector currently in operation. The VIRGO and LIGO detectors have recently started to undergo extensive upgrade programs. The GEO-HF upgrade program to GEO600 is approaching completion. Its goal is to enhance the sensitivity of GEO600 mainly at high frequencies above 500Hz. Several major elements of this program have already been completed, namely a change of the signal recycling mirror, the switch to a DC readout scheme and an increase in laser power. Furthermore we implemented an output mode cleaner as a fully automated subsystem and implemented a new laser system making great strides towards a planned overall tenfold laser power increase. The implementation of an automated system for squeezed vacuum injection into the interferometer gives us an additional stable improvement at high-frequency sensitivity. Future improvements to the laser system and a thermal compensation system will further improve sensitivity. I will present the challenges and rewards of upgrades to GEO600 as well as the current state of the detector.

Q 11.3 Mon 15:00 V7.03

Status of the AEI 10m Prototype facility for interferomtry studies — •Tobias Westphal for the AEI 10m prototype — Max-Planck Institute for Gravitational Physics (Albert-Einstein-Institut) and Centre for Quantum Engineering and Space-Time Research, Leibniz University Hannover

A 10 m Prototype facility for interferometry studies is currently being set up at the AEI in Hannover, Germany. Among the main objectives are the demonstration of novel techniques for future generations of GW detectors, as well as building an instrument operating at and beyond the standard quantum limit of interferometry for 100 g test masses. Inside a large (ca. 100 m^3) ultra-high vacuum envelope, three passively seismically isolated optical tables provide a pre-isolated platform for experiments. The differential motion of these tables will be stabilized via a set of Mach-Zehnder interferometers. All relevant optical components will be mounted on top of these isolated tables by means of multiple-cascaded pendulum suspensions. A suspended triangular ring cavity with a finesse of ca. 7300 will, in conjunction with a molecular iodine reference, serve as a frequency reference for the stabilization of the 35 W Nd:YAG laser. The main instrument is a 10 m Michelson interferometer with Fabry-Perot cavities in the arms. The end mirrors will be made of Khalili-style Fabry-Perot cavities to minimise the effective coating thermal noise. The design of the interferometer is done such that the sum of all classical noises lies well below the sum of quantum noise in a frequency band around 100 Hz. The layout, status, and progress of the AEI 10m prototype will be given in this talk.

Q 11.4 Mon 15:15 V7.03

Key Optical Metrology Technologies for LISA — •Martin Gohlke[1,2], Thilo Schuldt[3], Ulrich Johann[2], Achim Peters[1], Claus Braxmaier[2,3], and Dennis Weise[2] — [1]Humboldt University, Berlin, Germany — [2]Astrium GmbH, Friedrichshafen, Germany — [3]University of Applied Sciences Konstanz, Germany

To support and complement the formulation of the LISA (Laser Interferometer Space Antenna) mission, we develop and validate experimentally selected key technologies for the realization of LISA's optical metrology system. Over the last few years, we have developed a possible realization of the test mass optical readout interferometry, which reaches now a verified end-to-end noise floor of $2\,\mathrm{pm}/\sqrt{\mathrm{Hz}}$ in translation measurement and – through the use of differential wavefront sensing – sub-nrad/$\sqrt{\mathrm{Hz}}$ in tilt measurement. Throughout the LISA measurement band from 3×10^{-5} Hz and 1 Hz, this system is close to compliance with the measurement requirements defined within the LISA mission formulation, where meanwhile the limiting noise-contributors are to a large extent well understood.

This high accuracy interferometric device has been the foundation for recent new advances in various technological elements of the LISA payload. For detection of intra-spacecraft beat signals, low-noise RF quadrant photodetectors have been developed and validated, offering an RF bandwidth of 2 to 20 MHz. For μcycle accuracy phase measurement in this frequency range, an FPGA-based phasemeter on the basis of a digital PLL is under test. We will give an overview on the current performance and latest results of all of these developments.

Q 11.5 Mon 15:30 V7.03

Testing the optical bench for LISA — •Maike Lieser, Christian Diekmann, Johanna Bogenstahl, Michael Tröbs, Gerhard Heinzel, and Karsten Danzmann — Max Planck Institute for Gravitational Physics (Albert-Einstein-Institut), Leibniz University Hannover

The Laser Interferometer Space Antenna (LISA) is a space-based gravitational wave detector constituted of three satellites. It is built to detect gravitational waves in the low frequency band by measuring distances between free falling test masses inside the satellites. The prototype of the so called optical bench, the main optical part of the satellites, will be completed soon and performance tests will be done in laboratory. For the testing a telescope simulator is needed to simulate the far interferometer beam coming from another satellite five million kilometers away. Here it will be focused on the test bed for the optical bench and the performance tests for the actuators on the telescope simulator. The latter are needed to align the beams and to simulate test mass motions and have to satisfy the LISA stability requirements.

Q 11.6 Mon 15:45 V7.03

Seismic isolation for the 10m Prototype — •Gerald Bergmann for the AEI 10m Prototype Team — Leibniz Universität Hannover und MPG für Gravitationsphysik (AEI),

A 10m arm length prototype interferometer is currently being setup at the AEI in Hanover, Germany. This facility will not only be used for developing novel techniques for future gravitational wave detectors but will also provide a platform for high precision experiments such as measuring the standard quantum limit (SQL). To achieve a suitable environment for these experiments, a very good isolation from the surrounding, especially from seismic motion, is required.

In this talk, the basic isolation stage will be introduced which is realized as a set of passive attenuation tables. These are based on the Advanced Ligo HAM-SAS design; geometric anti-spring filters provide vertical isolation, attenuation in the horizontal direction is provided by inverted pendulum legs. In first experiments, seismic attenuation of about 60dB at low frequencies could be shown by pure mechanical passive isolation. Several sensors and a Suspension Platform Interferometer will further be used to measure table motion signals. It will be fed back to actuators which will actively damp eigenmodes and position the tables in DC.