Q 22: Precision Measurements and Metrology III (with A)

Time: Tuesday 11:00–12:45 Location: G/gHS

Group Report Q 22.1 Tue 11:00 G/gHS

Laser Ranging Interferometer for GRACE Follow-On — •Christina Bogan, Gerhard Heinzel, and On behalf of the LRI team — Max-Planck-Institute for Gravitational Physics, Hannover, Germany

The GRACE satellite mission is measuring the earth's gravity field and its temporal variations since March 2002. What was planned to be a five year mission is still collecting data which show e.g. the drastic climate change all over the planet. However, the fuel of the two satellites is limited and anytime soon they will have to stop operations. Therefore, it was decided to launch a following mission as soon as possible, GRACE Follow On (GFO), with a scheduled launch date of August 2017. Like GRACE the GFO mission is a joint US/German project. This new mission will be an almost identical copy of the former mission but with an additional science instrument on board. The Laser Ranging Interferometer (LRI) will demonstrate for the first time the high precision inter-satellite distance measurement using a heterodyne interferometer. This will increase the accuracy of the distance measurement compared to the main science instrument which uses microwave radiation by a factor of 25. In this talk we will present the concept of the LRI, introduce the different subsystems and give an overview about the current status.

Q 22.2 Tue 11:30 G/gHS

Test-bed development to experimentally investigate tilt-to-length coupling for eLISA — •Sönke Schuster[1], Ewan Fitzsimons[2], Gerhard Heinzel[1], Christian Killow[3], Maike Lieser[1], Michael Perreur-Lloyd[3], David Robertson[3], Michael Tröbs[1], Henry Ward[3], and Karsten Danzmann[1] — [1]Albert-Einstein-Institute — [2]Airbus Defence and Space — [3]University of Glasgow

eLISA (evolved Laser Interferometer Space Antenna) is a planned space-based GW detector consisting of three satellites separated by millions of kilometers. It measures with laser interferometry distance variations between free-floating test masses inside the satellites to detect gravitational waves. The coupling from angular misalignment between the satellites, laser links and test masses into the pathlength readout (tilt-to-length coupling) is currently the second largest entry in the eLISA metrology error budget (after shot noise). Here we give an overview over a test-bed development to experimentally investigate tilt-to-length coupling and test if suitable imaging systems can suppress this coupling to the required level.

Q 22.3 Tue 11:45 G/gHS

An optical testbed for the eLISA Phasemeter — •Thomas Schwarze, Germán Fernández Barranco, Gerhard Heinzel, and Karsten Danzmann — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) und Institut für Gravitationsphysik der Leibniz Universität Hannover

The planned spaceborne gravitational wave detector eLISA 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 for the phase readout system of these interferometers (Phasemeter) was developed in the scope of an ESA technology development project by a collaboration between the Albert Einstein Institute, the Technical University of Denmark and the Danish industry partner Axcon Aps. This project was completed successfully fulfilling all performance requirements in an electrical two-signal test. Here we present the planning and advances in the implementation of an optical testbed for the Phasemeter. It is based on an ultra-stable hexagonal optical bench. This bench allows the generation of three unequal heterodyne beatnotes, thus providing the possibility to probe the Phasemeter for non-linearites in an optical three-signal test. The final goal is to show 1 microcycle/sqrt(Hz) performance between 2 and 25 MHz with a dynamic range of 10 orders of magnitude. Furthermore, other components of the eLISA metrology chain can be tested in this setup. This includes clock noise transfer and removal, inter-satellite ranging and communication, as well as laser frequency control and acquisition.

Q 22.4 Tue 12:00 G/gHS

Highspeed multiplexed heterodyne interferometry — •Katharina-Sophie Isleif, Oliver Gerberding, Sina Köhlenbeck, Gerhard Heinzel, and Karsten Danzmann — Albert-Einstein-Institut Hannover, Max-Planck-Institut für Gravitationspyhsik und Institut für Gravitationsphysik der Universität Hannover

Digitally enhanced heterodyne interferometry is a promising new metrology technique for high-precision displacement measurements using free beams [Shaddock, 2007]. This technique uses pseudo-random noise codes for modulating the phase of the laser light. A digital decoding mechanism allows us to isolate multiple interferometric signals from the same beam based on their propagation delay. This results in more flexibility in optical layouts and finds application in multi-channel interferometry and spatial investigation of stray light. Since space-based interferometers require compact optical set-ups, this technique is an attractive alternative for future missions like eLISA and LISA Pathfinder.

This talk presents the current status of the digital interferometer experiments at the AEI. Using a high modulation rate of 1.25GHz we are able to demonstrate multiplexing between targets separated by only 36cm and we achieve a displacement measurement noise floor of <3pm/sqrt(Hz) at 10 Hz for the distance between two targets along the same beam axis. A source of excess low frequency noise was identified and is probably caused by the finite bandwidth of our experimental set-up. An additional delay lock loop was implemented to reduce this noise by one order of magnitude.

Q 22.5 Tue 12:15 G/gHS

Characterization and stabilization of a high-power fiber amplifier — •Patrick Oppermann, Fabian Thies, and Benno Willke — Max-Planck-Institut für Gravitationsphysik und Leibniz Universität Hannover (AEI)

We present a detailed beam characterization of continuous-wave single frequency fiber amplifier with an output power of more than 180 W at a wavelength of 1064 nm. The power noise, frequency noise, beam pointing fluctuations and spatial beam quality were measured with an optical ring resonator. The results are compared with the Advanced LIGO Pre-Stabilized Laser system. The advantage of this laser system is the use of new actuators for power stabilization of each amplifier stage with a power-shunt and an EO-AM to modulate the seed laser. First, stabilization of the pre-amplifier with 20 W to an over all relative power noise of 1*10e-8/sqrt(HZ) is shown. Then the main amplifier is stabilized with a second power-shunt.

Q 22.6 Tue 12:30 G/gHS

iSense: A portable ultracold atom based gravimeter — •Lingxiao Zhu, Jonathan Malcolm, Clemens Rammeloo, Michael Holynski, Vincent Boyer, and Kai Bongs — West Midlands Ultracold Atom Research Centre, School of Physics and Astronomy, University of Birmingham, UK

The iSense project aims to be a bridge between the latest developments in ultracold atom science and practical applications, turning laboratory-based experiments into portable and robust quantum sensors. Expertise from the iSense consortium has been brought together to achieve significant reductions in the size and power consumption of all major components. The integrated device, iSense, will form a portable compact gravity sensor. This is under construction at the University of Birmingham. The current status and recent results are presented.

The iSense consortium is comprised of:
University of Birmingham;
University of Nottingham;
Ferdinand-Braun-Institut;
Centre national de la recherche scientifique;
Università degli Studi di Firenze;
Leibniz Universität Hannover;
Universität Hamburg;
Österreichische Akademie der Wissenschaften;
Institute d'Optique Graduate School;
Observatoire de Paris - SYRTE