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A testbed for Tilt-To-Length coupling and Differential-Wavefront-Sensing performance in LISA

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The LISA mission, which has been accepted by ESA as the ESA-L3 Gravitational Wave Mission, aims at measuring gravitational waves in the sub-Hz band using inter-spacecraft interferometry. LISA consists in a constellation of three satellites in triangle formation with 2.5 Gm-long arms following along an Earth-like heliocentric orbit. The ambitious sensitivity of pm/Hz$^{1/2}$ presents many technical challenges; one of the main issues is the coupling of the angular jitter of the spacecraft and test masses to the interferometrically-measured longitudinal displacement (Tilt-To-Length coupling, or TTL), which can be of geometric origin if the tilt causes an optical pathlength change, or it can be non-geometric, e.g., caused by wavefront curvature mismatches between the interfering beams. To readout length and angular signals, LISA implements the Differential-Wavefront-Sensing (DWS) method, that combines 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 critical interferometric techniques for the LISA mission. The testbed features a pair of 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 systems to image the point of rotation of the beams into the detector plane. Current work is focusing on developing a new method to readout the DWS signals from the QPDs.

Primary authors: Mr PIZZELLA, Alvise (Albert Einstein Institute Hannover); DOVALE ALVAREZ, Miguel (Albert Einstein Institute Hannover)

Presenter: Mr PIZZELLA, Alvise (Albert Einstein Institute Hannover)

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