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LISA Optical Bench Testing

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Abstract. 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. Currently, an elegant bread board of the optical bench is developed for the European Space Agency (ESA) by EADS Astrium, TNO Science and Technology, University of Glasgow and the Albert Einstein Institute. To test the optical bench the two interferometers mentioned above must be completed by an external simulator, the test mass and telescope simulator. We give an overview of the simulator layout and performance predictions.

1. Telescope simulator optical layout

Figure 1(left) shows the layout of test mass and telescope simulator. It will be mounted on the LISA optical bench by Zerodur legs to achieve pm/$\sqrt{\text{Hz}}$ pathlength stability. The test mass simulator consists of optical components TMSim1 and Mtm. The latter uses a reflective gold coating and is placed on a tilt actuator and linear actuator to simulate the test mass movements.

All other components on the Zerodur baseplate belong to the telescope simulator: The mainly s-polarised output beam from the Fibre Injector Optical Subassembly (FIOS) Telsim in the upper right corner is reflected from polarising beam splitter PBS101 to clean the polarisation. Beam splitter BS101 splits the beam into two equal parts. One part is magnified by lens1 and lens2 to 5 mm diameter and reflected by mirrors M4 and M3 (45° angle of incidence). Beam combiner BS6 reflects 1% of the power towards the out-of-plane mirror Mup that sends the RX beam towards the science interferometer on the optical bench. M4 and M3 are mounted in actuator assemblies. They are used to align the RX beam to the science interferometer. The other part of the beam is reflected by mirrors M101 and M102 (41.5° angle of incidence) and directed to beam combiner BS103. There, the beam from the Telsim FIOS interferes with a fraction of the TX beam from the optical bench. One percent of the p-polarised TX beam is reflected by BS6, shrunk in diameter by lens2 and lens1, transmitted through PBS102 and rotated to s polarisation by half-wave plate HWP1. The interference signals of TX beam and RX beam are detected by photo detectors PD1 and PD2. Mirrors M101 and M102 are used to align the transponder interferometer.

A second FIOS, FIOS COM, is used for commissioning of the telescope simulator. Its s-polarised output beam is split by BS104 into two parts. The reflected part propagates towards BS6. For commissioning a mirror and quarter-wave plate will be placed between M3 and BS6, that reflect all light back and rotate its polarisation by 90°, such that it is transmitted through PBS102 and interferes at BS103 with light from FIOS TELSIM. The part transmitted through BS104 is interfered at BS106 with light from FIOS TELSIM. The interference signals in this commissioning interferometer are detected by photo detectors PD3 and PD4. For commission-

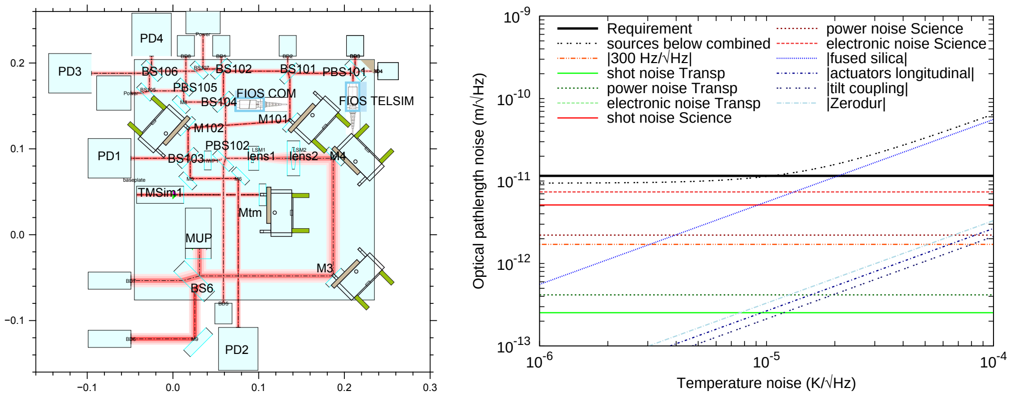

Figure 1. Left: Optical design of telescope simulator with commissioning interferometer, right: Performance prediction for optical bench and telescope simulator as function of temperature noise

ing, the beam path between BS102 and BS104 has to be blocked. This will be achieved by insertion of a mirror that reflects the light coming from FIOS TELSIM to the space between beam dumps BD1 and BD2 where an additional beam dump will be placed.

2. Performance prediction

Figure 1 (right) shows a performance prediction for optical bench and telescope simulator as function of temperature noise. For temperature noise below 10^{-5} K/ $\sqrt{\text{Hz}}$ the combined noise is below the requirement. For higher temperature noise thermo-optic noise in fused silica is the dominant noise source followed by electronic noise and shot noise in the science interferometer.

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