Investigating an Optimal Backlink Candidate for LISA

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The future detection of Gravitational waves with the Laser Inteterferometer Space Antenna (LISA) will expand the observable frequency range to the mHz regime. The three satellites, forming an equilateral triangular, follow orbits that cause an angular change between the arms by 3° over a year. This angular change needs to be compensated with two moving optical sub-assemblies per spacecraft, requiring two, independently moving, optical benches. Laser frequency noise limits the readout of the spacecraft separations but can be suppressed in data post-processing by time-delay interferometry. This requires a precise phase comparison between the two local lasers on each optical bench that is realized by a phase reference distribution system or backlink. Here the differential (non-reciprocal) phase fluctuations are critical because they directly enter the measurement. Realizing such a backlink connection with a fiber was proven to be working within the requirements by adding post-corrections like balanced detection and attenuation stages. This, however, is not an ideal solution, motivating the search for other, more optimal schemes. In the Three-Backlink Experiment (TBE) three promising candidates are going to be compared in one quasi-monolithic set-up with regards to the non-reciprocity, required to be below $6\frac{\mu\mathrm{rad}}{\sqrt{\mathrm{Hz}}}$. This requires a precise alignment and construction progress which is ongoing by the use of precise beam-alignment measurements using a coordinate measurement machine and optimized procedures. In the experiment itself, two optical benches rotate with a sinusoidal motion of a 12h period, simulating a LISA-like test-bed. Chosen to be tested are a fiber connection, a frequency separated fiber-based backlink and a free beam connection. The working principle of the Free-Beam Backlink solution was successfully demonstrated in a pre-experiment. The optical benches of the TBE are under construction while its laboratory infrastructure is extended. The experimental design, the knowledge from pre-experiments and simulations and the optimized construction process are presented.

References

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