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The Three-Backlink Experiment

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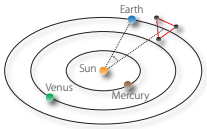
Introduction

Arm breathing & TDI require a backlink

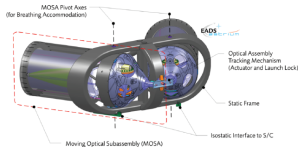


The current design of LISA has non-common mode armlength changes which result in the coupling of laser frequency to phase. It can be supressed in data post-processing by using the Time Delay Interferometry (TDI) algorithm that requires the differential phase noise of the TX lasers within one satellite to be negligible.

Due to the arm breathing, the angle within the spacecraft constellation varies up to ±1.5°/yr. The beam directions of the laser from the distant spacecraft and the local laser change significantly. Using two optical benches (OBs), following the incoming beams, can compensate for the angular deviation. These OBs must be **optically connected via backlink** for the TDI algorithm to exchange their local oscillators. Three backlinks are planned to be tested in one optical set-up: The **stabilized fibre backlink**, the **frequency separated fibre backlink** and the **free beam backlink**. The non-common mode pathlength change between both directions of a backlink, the so called **non-reciprocity**, is required to be below 1pm/√Hz.

MOSAs

Movable Optical Sub Assembly



The **optical assembly pointing** is one approach to compensate the breathing of the arms. Two separated MOSAs per satellite are rotatable around their pivot axes that allows to compensate the angle deviations via a control loop. One of the two OBs planned in the 3-backlink experiment will be movable to analyse the influence of the bench motion on the backlink connection making it similar to the MOSA configuration.

Stabilized fibre backlink

Already tested, used as reference in the 3-backlink experiment

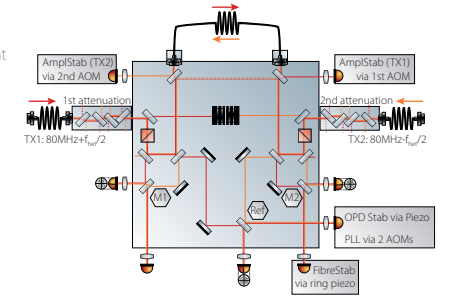
Experimental set-up

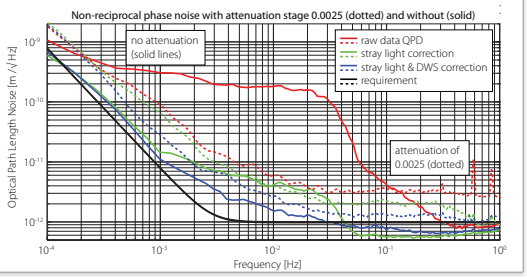
- Nd:YAG laser (1064nm, idione stabilized)
- f_{het} = 17.854kHz
- length stabilization of backlink fibre on ring piezo
- stray light attenuation via beam splitter stages behind both fibre couplers

Results

- stray light suppression via attenuation
- stray light correction via **balanced detection**
- **differential wavefront sensing** (DWS) correction

Attenuation is a valid method to decrease the stray light influence on the measured phase that is generated from the fibres providing the laser light. However, it is unattractive as backlink solution for LISA since it yields a huge loss of laser power in the measurement interferometers.



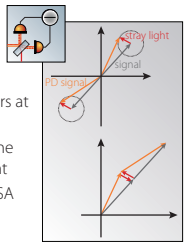


Stray light

Sources, possible correction & attenuation

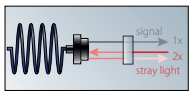
Sources of stray light are direct reflections at the lenses of the fibre couplers or at the fibre interface. Due to Rayleigh scattering, the main part of back reflected light is generated in the fibre core.

Correction via balanced detection



- assumption: stray light enters at one beam splitter port
- subtraction delivers twice the nominal signal, no stray light
- loss of PD redundancy in LISA

Attenuation via beam splitter stages



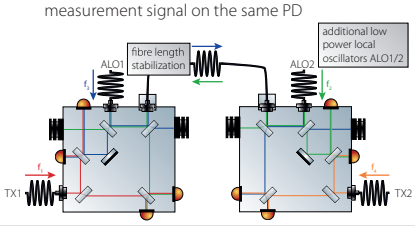
- stray light is attenuated once more than the light coming from the fibre
- loss of laser power

Two backlink alternatives

Frequency separated fibre backlink & Free beam backlink

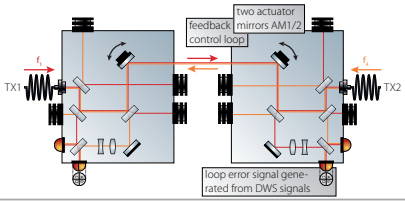
Frequency separated fibre backlink

- stray light is frequency shifted with respect to the measurement signal on the same PD



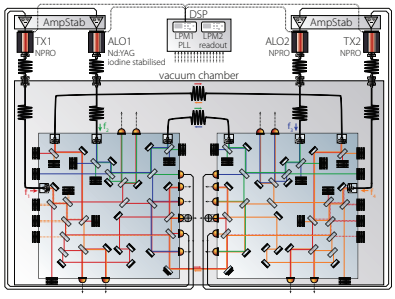
Free beam backlink

- stray light only from fibres providing the lasers TX1 and TX2
- compensation of the movement of one bench against the other of about ±1.5° with 2 movable mirrors
- imaging systems decouple the movement of one actuator of the DWS signal on the distant bench



Overview set-up

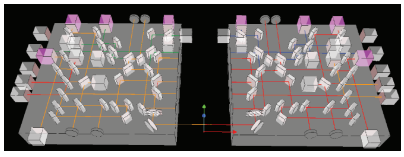
Three backlinks in one experiment



Design status

IfoCad simulation & current layout

The 3-backlink solutions will be tested in one experimental set-up consisting of 2 OBs. The simulation allows to find useful imaging systems for the free beam backlink, correct laser powers and stray light estimations.



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