Design and development of a suspension platform interferometer for the AEI 10 m Prototype Interferometer

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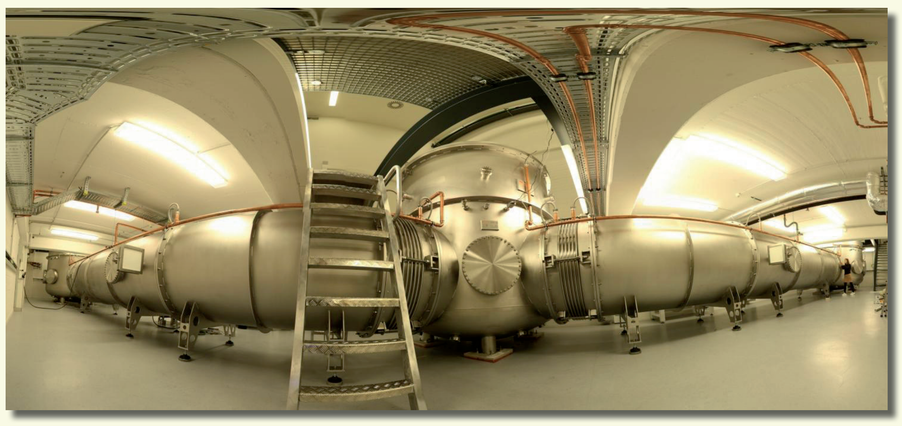
The AEI 10 m Prototype

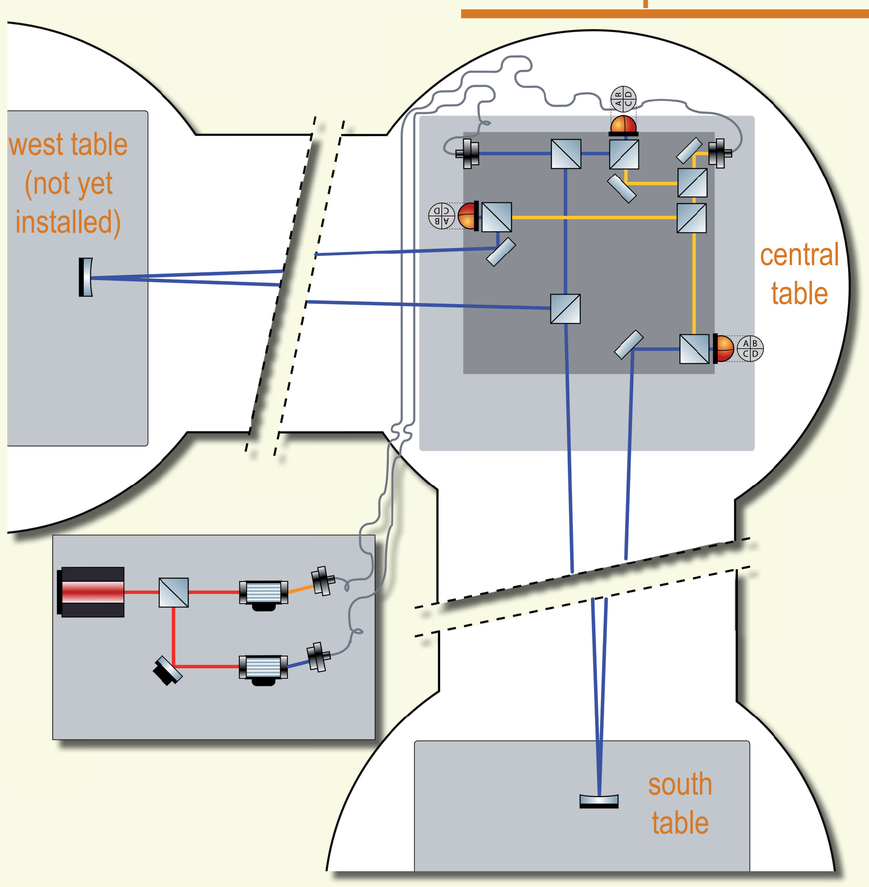
Aim

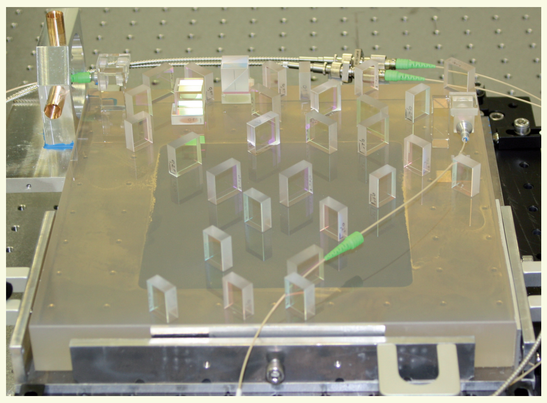
- To test novel techniques for advanced gravitational wave detectors
- To probe the Standard Quantum Limit, and go beyond

Excellent seismic isolation is required.



Principle and status of the optical layout





Overview

- Clearceram-Z HS base plate
- Heterodyne frequency: 15 kHz
- Iodine stabilized Laser
- Components are bonded, glued, or optically contacted onto the base plate
- Monolithic fiber injectors

Status

- Diagnostic, Reference, and South interferometers are operational

SPI in a nutshell

Three suspended optical tables are housed in a UHV System. The relative position and alignment of these tables is measured and controlled by the SPI.

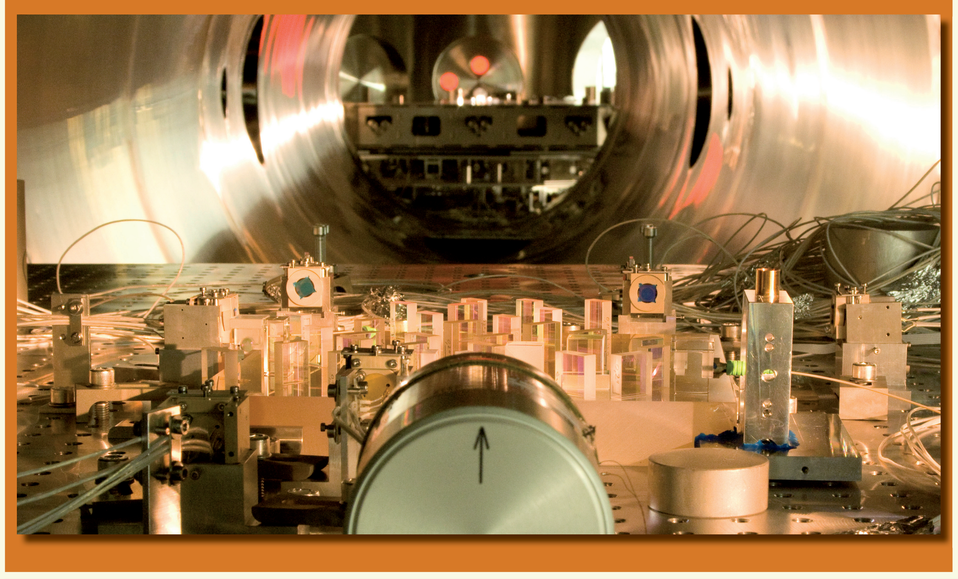
- Measures the position of the three tables relative to each other in five degrees of freedom
- Uses heterodyne Mach-Zehnder interferometers to monitor the longitudinal displacement
- Differential wave front sensing (DWS) is used for angular displacement measurements
- Power monitoring with quadrant photo diodes (QPD) for adjustment of the tables
- Broad measurement range in excess of 5mm in the longitudinal degree of freedom
- Longitudinal and DWS signal are used for feedback
- Feedback control with aLIGO's Control and Data System

Readout

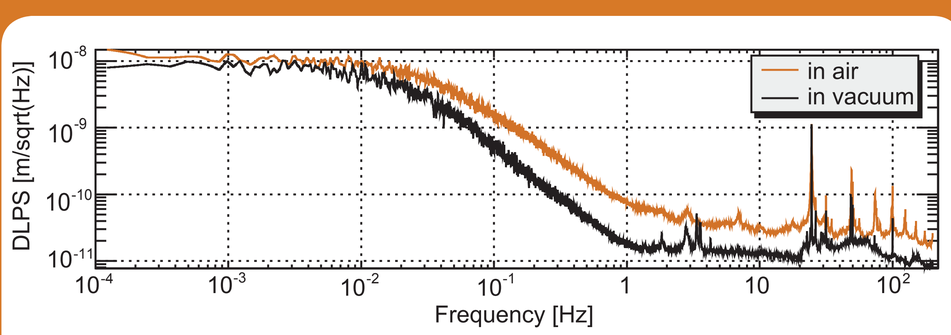
- FPGA based phasemeter developed for LISA Pathfinder mission

Design sensitivity

- Angular: 10 nrad/√Hz @ 10 mHz
- Longitudinal: 100 pm/√Hz @ 10 mHz



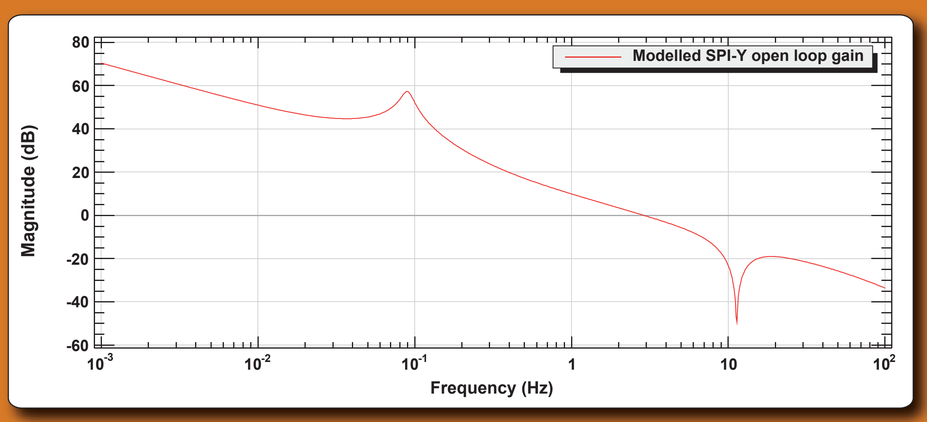
Current Status



Katrin Dahl. *From design to operation: a suspension platform interferometer for the AEI 10m prototype*. PhD thesis, Fakultät für Mathematik und Physik der Gottfried Wilhelm Leibniz Universität Hannover, 2013.

Performance of the Diagnostic Interferometer (left)

- The longitudinal Signal of the Reference Interferometer was subtracted from the Diagnostic Interferometer
- Small vector noise limits the performance



Feedback Control

- Feedback control is currently under commissioning
- SPI Signals were used to stabilize the differential length between the central and south table (figure to the right)
- The modelled open loop gain is shown in the upper right corner
- Suppression of up to three orders of magnitude

Out of Loop measurement

- One Geophone on each table
- Geophone signals are not valid below ~1 Hz, due to table tilt

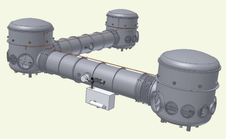
Results

- Geophone and SPI signals agree at a few Hz, where both signals are valid
- Differential motion is reduced
- RMS motion in the longitudinal degree of freedom is of the order of one nm

Further Steps

- Implement the feedback control for the angular degrees of freedom
- Implement blending filters for all sensors and actuators in the tables that will be used for control
- Finalize the SPI model
- Set up a test interferometer to verify SPI measurements
- Install the west interferometer

AEI 10 m Prototype Group
http://10m-prototype.aei.uni-hannover.de



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