The upcoming LISA Pathfinder (LPF) mission will test the gravitational reference sensor (GRS) and the disturbance reduction system (DRS) for a future LISA-like space mission. While LPF will show that the technology for LISA exists and meets the LISA requirements, it is likely that LPF will also reveal areas where future improvements can be made and might be necessary. Some of these are already well known (such as the discharging system). After all, the technology for LISA pathfinder was frozen about 10 years ago or about 30 years before a LISA-like mission will be launched. The need for continued testing and development of the technology is obvious. The University of Florida is currently building a torsion pendulum-based test facility to explore new techniques and also to develop a base in the US for state-of-the-art GRS technologies.

Abstract

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Space-Based Gravitational Wave Detectors

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Pendulum Facility

The UF Torsion Pendulum is a LISA technology development facility aimed at exploring new technologies for a gravitational reference sensor. It currently consists of:

- Crossbar structure suspended from 1 m tungsten fiber
- Includes two GRS prototypes: each reads out position of TM

For a detailed description of the facility, see Ryan Shelley’s poster.

Capacitive Sensing Scheme for the GRS

- 100 kHz signal “injected” through the red electrodes
- Pickup in green electrodes depends on TM position
- Differential sensing scheme, similar to LTP/Trento
  - Fewer electrodes
  - Expansion planned later

Analog Readout Electronics

- Simplified version of LPF flight electronics
  - No resonant bridge
  - Actuation applied directly to electrodes at DC: filtered out of readout
  - Expected ~nm/√Hz performance

Digital Readout Electronics

- Simple I-Q demodulation scheme
- CIC filters downsample/LPF data
- Acquisition handled by Ni DAQ card
- Demodulation phase varied until entirety of the signal in I

Future Work: Interferometric Readout Scheme

- Polarization-multiplexed heterodyne interferometer
  - Blue and red laser signals oppositely polarized, offset by heterodyne frequency.
  - Blue laser gathers phase information from TM
  - Red laser provides reference
  - Beat signal acquired on PD-bench
  - Expected 10 pm/√Hz sensitivity
  - Expansion to alignment sensing via wavefront sensing planned

Current Status and Preliminary Results

- Pendulum suspended and in vacuum, with two GRS prototype sensors (“Delta” and “Gamma”) active.
- Measurement made with pendulum roughly centered inside GRS prototypes
- Fiber unwinding limits continuous observation time
  - Relieves stress which adds noise
  - Takes time to reach lower noise level
- Electronics only limit pendulum above measurement band...but perform ~10x worse than expected
- Could limit performance at lower frequencies eventually. Requires more investigation!

For a detailed description of the facility, see Ryan Shelley’s poster.

Preliminary!