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Update on Deep Frequency Modulation Interferometry

Deep Frequency Modulation Interferometry (DFMI) offers a powerful approach to achieve precise displacement readout as well as absolute ranging with reduced complexity and compact sensing heads. Minimizing local sensing noise is crucial to reduce controls noise in e.g. active suspension damping and therefore DFMI will be a crucial technology to achieve the low-frequency sensitivity of future ground-based detectors like the Einstein Telescope. Here we present the status of our work on developing such compact sensors and on testing them in an in-house experiment for local test-mass readout.

The sensor, called Compact Balanced Readout Interferometer (COBRI), is only 35 mm in length and small enough to fit inside a half-inch mirror mount. It employs a single quasi-monolithic optic, forming an unequal-arm Michelson interferometer with dual-port balanced detection. Our target sensitivity is below 100 fm/ $\sqrt{\text{Hz}}$ in the 0.1–10 Hz band, and our current work is focused on characterizing and optimizing performance of our latest prototypes while preparing their series production.

Implementing an analytic readout algorithm for DFMI signals, we are aiming for a readout frequency of ~64 kHz compatible with systems such as LIGO CDS and allowing us to run fast feedback loops.

For our Interferometer Displacement Sensor Testbed (IDiST), consisting of two HRTS suspensions monitored with our local sensors, we are working on the laser preparation and stabilization. Additionally, we are installing an in-vacuum seismometer for active seismic isolation.

Regarding our experiment called Resonantly enhanced DMFI (ReDFMI), we believe to have identified the high noise source between our two IFOs and are working on a solution. We also purchased new mirrors to increase the finesse, aiming to achieve sub-fm readout noise performance.

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