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Deep Frequency Modulation Readout noise limitations and algorithms

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Ground based gravitational wave detectors are limited at low frequencies by seismic noise and other related technical noise sources.
In order to overcome these limitations, we study the use of interferometry based, local displacement sensors as part of the active seismic noise mitigation at the pendulum-suspensions of these detectors.
Our idea is to use so called "Deep-Frequency-modulated"interferometers which allow for a highly compact design of the sensor while providing accuracies of below 10^{-14} m/Sqrt{Hz} over a large dynamic range. In order to assess the achievable precision of these new sensors, we use the Cramer-Rao-lower-bound from statistical analysis and compare it for different types of laser interferometers to calculate a fundamental limit of the readout.
Our results show that the "Deep-Frequency-modulated"scheme performs within a factor of \sqrt{2} of other interferometry based sensors and might even outperform some of them at specific scenarios.
We also find that in principle a fringe-scanning (deep modulation) scheme can be even more sensitive when combined with an optical resonator topology.
The calculated fundamental readout limits show that DFM-Interferometers can reach very high accuracies with a small physical footprint and seem to be a promising candidate for local displacement sensors for current and future gravitational wave detectors.

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