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# Cryogenic Interferometric Inertial Sensors for next-generation Gravitational-Wave Detectors

The Lunar Gravitational-wave Antenna payload will be composed of an array of seismic stations in a permanently shadowed crater. Highly sensitive cryogenic inertial sensors will be deployed at seismic stations to detect the difference between the elastic response of the Moon and the motion of the suspended inertial sensor proof mass induced by gravitational waves. This talk presents the first experimental validation of a vertical and a horizontal interferometric inertial sensor designed for operation in low vibration cryogenic environments relevant to next generation gravitational-wave detectors such as the ET-LF and the LGWA. The sensor targets 10 fm/√Hz displacement sensitivity from 2-3 Hz, while operating at temperatures down to a few kelvin. We report on the characterization of key subsystems under cryogenic conditions, including the interferometric readout, suspensions, and mechanics. The homodyne quadrature interferometric readout achieves sub picometer resolution above 0.4Hz at 17K, with performance limited by shot noise at higher frequencies and temperature fluctuations at low frequencies. The sensors are then characterized in a dedicated low-vibration cryogenic environment to demonstrate their operation at temperatures down to 5.12K. These results confirm the operation and robustness of interferometric inertial sensing at cryogenic temperatures, and set the building blocks for LGWA soundcheck.

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