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E-TEST: Seismic Isolation and Thermal Noise Reduction for Next-Generation Observatories

The E-TEST prototype, developed for the Einstein Telescope—a next-generation gravitational-wave observatory, utilises a 100-kg test mass cooled to 20–25 K using radiative cooling techniques. This system achieves effective seismic isolation below 10 Hz while minimising thermal noise, a key challenge for high-precision measurements. Active isolation successfully mitigates low-frequency seismic disturbances, while the integration of cryogenic sensors and electronics allows for the monitoring of vibrational dynamics in the penultimate cryogenic stage.

Serving as a crucial research and development platform, E-TEST advances suspension technologies essential for the Einstein Telescope's technical design. The study also examines the performance of electrostatic actuators in this context and explores the impact of air damping at cryogenic temperatures. Furthermore, an adapted method for determining the mechanical quality factor, which is related to thermal noise, is presented. This method drives the resonator at resonance with constant amplitude to measure the required drive amplitude for estimating the quality factor, offering a continuous, real-time assessment with stable signal-to-noise ratio, unlike traditional free-decay techniques. These advancements highlight E-TEST's contribution to improving future gravitational-wave detectors.

Primary author: SINGH, Hemendra

Presenter: SINGH, Hemendra

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