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Precision Mechanical Loss Measurement & Noise Characterisation: E-TEST Cryogenic Prototype

Tuesday 7 October 2025 10:00 (15 minutes)

The ETEST prototype, designed for the Einstein Telescope, a next-generation gravitational-wave observatory, employs a 100-kg test mass cooled to 20–25 K via radiative cooling to minimise thermal noise while maintaining effective seismic isolation below 10 Hz. The system integrates active isolation to suppress low-frequency seismic disturbances and incorporates cryogenic sensors and electronics for precise monitoring of vibrational dynamics within the penultimate cryogenic stage.

As a critical R&D platform, ETEST advances suspension technologies vital to the Einstein Telescope's technical design. This study also assesses the performance of electrostatic actuators and examines the influence of air damping under cryogenic conditions. It addresses challenges associated with the use of huge monocrystalline silicon test mass, including anisotropic mechanical losses influenced by crystalline orientation, manufacturing processes, and impurity levels, and loss due to suspension. Additionally, an adapted method for determining the mechanical quality factor, closely linked to thermal noise is experimentally explored. This approach involves driving the resonator at resonance with constant amplitude to measure the required drive amplitude, enabling continuous, real-time quality factor assessment with improved signal stability compared to conventional free-decay methods. These developments underscore E-TEST's significant role in enhancing the performance of future gravitational-wave detectors.

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