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Mitigation of point defects and residual non-axysimmetric aberrations on the high-reflectivity surface: challenges for the future generation test-masses

The increasing power levels injected into interferometric gravitational wave detectors have highlighted the impact of localized defects on the high-reflectivity (HR) surfaces of the main optics. These defects, originating from coating inhomogeneities, substrate imperfections, or localized absorbers, can degrade detector performance by introducing aberrations in the optical wavefront, leading to mode mismatches, loss of stored power, and reduced interferometer sensitivity.

As next-generation detectors such as ET-HF aim for circulating powers of up to 3 MW, addressing these issues requires an advanced wavefront control system capable of directly compensating for distortions on the HR surface. Building on studies carried on within the Advanced Virgo detector, a new actuator has been developed to correct axisymmetric aberrations and other residual distortions on the mirror surface, providing a more flexible and comprehensive approach compared to previous correction methods. The system modifies a binary mask responsible for generating the corrective pattern, allowing for precise compensation of a broad range of optical defects.

This talk will present an overview of wavefront distortions caused by localized defects, the design and operational principles of the new actuator, and its potential applications in future gravitational wave detectors. Initial results from correction tests carried on at the TeTIS facility at Roma Tor Vergata will be discussed, along with future challenges and strategies to further improve interferometer performances.

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