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Deformable mirrors for mitigation of non-axisymmetric optical defects for the future gravitational wave detectors

In the context of gravitational wave detectors, optical aberrations primarily arise from laser absorption in coatings and production process defects in the various optics along the laser path. If uncorrected, these distortions can significantly deviate the detector from its optimal working point, making the interferometer unmanageable and drastically reducing its sensitivity. Therefore, the Thermal Compensation System (TCS), designed to detect and compensate for these optical aberrations, is crucial for ensuring the proper operation of the detector. The TCS primarily exploits the thermo-optic effect to correct wavefront deformations by illuminating on-path optics with a shaped CO2 laser beam. Future generations of gravitational wave detectors, such as ET-HF, are expected to achieve unprecedented levels of intracavity optical power, which will amplify the effects of optical aberrations, including non-axisymmetric ones. We are currently investigating Deformable Mirrors (DMs) as a versatile solution to mitigate these non-axisymmetric optical defects. Indeed, DMs can adapt the reflective surface to match a selected phase pattern and reproduce a desired intensity profile. Additionally, DMs do not introduce frequency-dependent noises in the detector's band due to the static nature of the correction. We employed a Modified Gerchberg-Saxton (MoG-S) algorithm to determine the phase corrections required for intensity compensation on the image plane. This study includes the characterization of a DM equipped with 192 magnetic actuators and investigates phase correction approaches based on the MoG-S algorithm.

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