Development of a DC adaptive actuator for optical aberration correction in future gravitational wave detectors

Aiello L[1,2,3], Bonora S[4], Cesarini E[2,5], Fafone V[1,2,3], Goracci G[3], Lorenzini M[1,6], Lumaca D[2,3], Minenkov Y[2], Nardecchia I[2,3], Rocchi A[2]

[1] Gran Sasso Science Institute, Viale Francesco Crispi 7, I-67100, L'Aquila, Italy
[2] INFN - Roma Tor Vergata, Via della Ricerca Scientifica 1, I-00133, Roma, Italy
[3] Dipartimento di Fisica, Università di Roma Tor Vergata, Via della Ricerca Scientifica 1, I-00133, Roma, Italy
[4] IFN - CNR, Via Trasea 7, I-35131, Padova, Italy
[5] Centro Studi e Ricerche Enrico Fermi, Piazza del Viminale 1, I-00184, Roma, Italy
[6] INFN - Laboratori Nazionali del Gran Sasso, Via Giovanni Acitelli 22, I-67100, Assergi, Italy

Corresponding author: lorenzo.aiello@roma2.infn.it

Abstract

The sensitivity of the present gravitational-wave detectors is strongly dependent on the quality of the cavity mirrors, which is limited by the fabrication process. Surface figure errors, inhomogeneity of the substrate refractive index, non-uniform coating absorption, all arise from the mirror's manufacturing and typically induce non-axisymmetric aberrations.
The performances of the advanced detectors are affected by these imperfections that also lead to a reduction of the stability and then of the duty cycle.
The Thermal Compensation Systems [1] responsible for the correction of the optical aberrations have so far comprised methods to properly compensate the non axi-symmetric wavefront distortions, based on scanning laser systems [2] or static beam shaping techniques. The compensation is performed by shining a proper heating pattern provided by CO_2 lasers [3] on auxiliary optics placed in the recycling cavity, close to the test masses.
The scanning system can introduce noise in the sensitive bandwidth of the detector, depending on its characteristic frequency, through several coupling mechanisms.
This contribution describes a new solution for the compensation of non-axisymmetric aberrations exploiting a MEMS (Micro-Electro Mechanical System) deformable mirror, which is able to modify the phase of an impinging Gaussian laser beam and to convert its intensity profile into the desired one. This has the advantage of the DC operation and the flexibility to adaptively modify the corrective pattern.

References

[1] T. Accadia et al., *A Thermal Compensation System for the Gravitational Wave Detector Virgo*, Proceedings of the 12th Marcell Grossmann Meeting ed T Damour, R T Jantzen and R Ruffini (Singapore: World Scientific) (2011).

[2] R.C. Lawrence, Ph.D. thesis, MIT, LIGO-P030001-00-R (2003)

[3] A. Rocchi, E. Coccia, V. Fafone, V. Malvezzi, Y. Minenkov, L. Sperandio *Thermal effects and their compensation in Advanced Virgo* Journal of Physics: Conference Series **363**, 012016 (2012)