Thermal Corrective Devices for Advanced Gravitational Wave Interferometers

M. Kasprzack[1], J. Ramette[2]

[1]Louisiana State University, Baton Rouge, LA, USA
[2]Hillsdale College, Hillsdale, MI, USA

Abstract

The advanced gravitational wave detectors require injecting a high continuous power laser into the optical cavities of the interferometers to reach their design sensitivity. To mitigate the thermal aberrations created by absorption of this high power load into the various optical elements, thermally actuated devices are installed at strategic places in the instruments, like ring heaters correcting the thermal focal lengths [1], while development of even more sophisticated tools such as high order mode optical aberrations is on-going [2] to anticipate the runs at the maximum laser power.

COMSOL Multiphysics® software is a support tool in designing, testing and commissioning our thermal devices. In this talk, I will give you an overview of some recent applications. To apply a correct thermal compensation with the ring heaters at any time, we need to accurately know the thermal load it delivers into the test masses as well as the amount of the main beam absorbed. We were able to derive a simple analytical model of the ring heater compensation [3] and COMSOL software was our reference simulation to test our simple model.

Furthermore, we performed COMSOL simulations of the influence functions of a thermally deformable mirror [4], which is a device aiming at correcting beam-wavefront distortions for applications where classical mechanical methods are precluded by noise considerations. This helped us in designing the actuation pattern and demonstrate the ability of our device to correct high order modes.

Reference

[1] R. Lawrence et al. "Active correction of thermal lensing through external radiative thermal actuation." Optics letters, 29.22, (2004)

[2] M. Arain, W. Korth, L. Williams, R. Martin, G. Mueller, D. Tanner, and D. Reitze, “Adaptive control of modal properties of optical beams using photothermal effects,” Opt. Express 18, 2767–2781 (2010).

[3] J. Ramette, et al. "Analytical model for ring heater thermal compensation in the Advanced Laser Interferometer Gravitational-wave Observatory." Applied optics 55.10 (2016): 2619-2625.

[4] M. Kasprzack, et al. "Performance of a thermally deformable mirror for correction of low-order aberrations in laser beams." Applied optics 52.12 (2013): 2909-2916.