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Locked cavity scan - using heterodyne detection with a phase camera

Increasing the optical circulating power in gravitational-wave detectors is a straightforward way of increasing detection sensitivity. However, current detectors are limited in the amount of achievable circulating power far below the design values. Optical absorption in the test masses and main optics leads to thermal effects that shift the eigenmodes of the optical cavities and cause control issues such as parametric instabilities.

Here we present the experimental results of a technique using optical injection to perform a scan of the higher-order modes of a cavity and extract the modal weights. We use a phase camera in transmission to confirm the mode basis and image modes up to order 9. We showcase as well the capability of the phase camera to determine the optical phase between carrier and co-resonating higher-order modes, which can be used for optical suppression of parametric instabilities. Finally, we test the scheme's capability of tracking the cavity g-factor while locked. This could find application in gravitational-wave detectors to track in real-time the thermal transient in the arm cavities due to the optical absorption.

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