Angular Sensor with a Coupled Cavity for Gravity Gradient Sensing

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Introduction

TOrsion-Bar Antenna (TOBA) is a highly sensitive gravity gradient sensor using torsion pendulums [1]. The resonant frequency of torsional motion is ~1 mHz, therefore TOBA has good design sensitivity in low frequencies (0.1 – 10 Hz). A prototype detector Phase-III TOBA with a 35 cm-scale pendulum is under development to demonstrate noise reduction [2]. The target sensitivity is set to 10^{-15} /√Hz at 0.1 Hz. Phase-III TOBA can detect earthquakes with magnitude 7 or larger within 10 seconds from 100 km distance, therefore Phase-III TOBA is useful for gravity-based earthquake early warning [3]. To achieve our target sensitivity, we need to measure the pendulum rotation precisely. We propose a coupled wavefront sensor as an angular sensor for Phase-III TOBA. We show the principle and experimental demonstration status of a coupled wavefront sensor.

Method

For a conventional wavefront sensor, we build a linear cavity with two mirrors (FIG. 1. Top). When a mirror tilts, a part of the zero-order Hermite-Gaussian (HG) modes converts into the first-order HG modes. We detect it as angular signal. In the cavity, the first-order HG modes are anti-resonant since they get non-zero Gouy phase shift compared to the zero-order HG modes.

A coupled wavefront sensor is a new wavefront sensor using an optical coupled cavity. In our method, we put one more mirror behind a main cavity and build an auxiliary cavity (FIG. 1. Bottom). An auxiliary cavity can compensate Gouy phase of main cavity, therefore the zero-order and the first-order HG modes are resonant simultaneously. As a result, angular signal is enhanced in the main cavity.

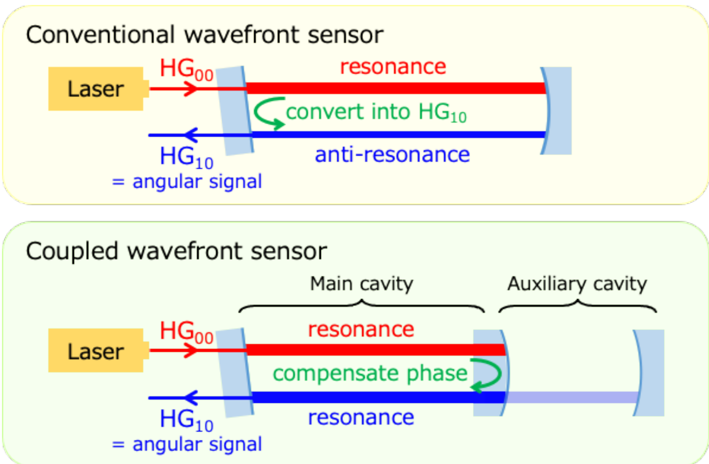

FIG. 1. Top: The schematic of a conventional wavefront sensor. Bottom: The schematic of a coupled wavefront sensor.

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Reference

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