I. Introduction

We develop a dual-heterodyne laser interferometer without DWS (Differential-front Sensing) which can measure picometer-level linear displacement and nano-radian-level angular displacement simultaneously. Due to a highly-symmetric optical path configuration, this dual-heterodyne laser interferometer has reduced sensitivity to the low-frequency noise mainly caused by the environmental fluctuations by means of common-mode noise rejection. This dual-heterodyne laser interferometer offers potentials for optical readout system of proof mass attitude metrology in space borne gravitational wave detection.

II. Experiment Setup

The experiment system is composed mainly of three parts:


II. Optical bench: two fiber collimators, five beam splitters, one mirror, three photodetectors (PD)

III. Calibration system: 6-Axis Nano-Position system, autocollimator

The translational displacement of two parallel measurement points on the testing mirror (M1) is measured, so information of two degrees of freedom of M1 is known: translational displacement along the measurement laser axis and tilt in the laser plane.

A dual-heterodyne laser interferometer with displacement resolution of picometer-level translation and nano-radian-level tilt are demonstrated. It can be used as optical readout system prototype for proof mass attitude metrology.

III. Results

A. Noise Level

The noise levels of the linear and angular displacements measurements are 50 pm/√Hz and 50 nrad/√Hz at 10 mHz, respectively. The noise with frequency above 6 Hz is likely attributable to mechanical vibrations.

B. Calibration

Translation Calibration
- Actuator: 6-Axis Miniature Hexapod
- Calibration: Miniature Hexapod
- Square Mode: 10 nm @ T=4s
- Step Mode: 100 nm @ T=4s
- Nonlinearity: < 1%
- Travel Range: > 200nm

Tilt Calibration
- Actuator: 6-Axis Miniature Hexapod
- Calibration: Miniature Hexapod, Autocollimator
- Square Mode: 10 urad @ T=4s
- Step Mode: 100 urad @ T=4s
- Nonlinearity: < 1%
- Travel Range: > ± 100 urnrad

IV. Future Work

A dual-heterodyne laser interferometer with displacement resolution of picometer-level translation and nano-radian-level tilt are demonstrated. It can be used as optical readout system prototype for proof mass attitude metrology.

IV. Future Work

A dual-heterodyne laser interferometer with displacement resolution of picometer-level translation and nano-radian-level tilt are demonstrated. It can be used as optical readout system prototype for proof mass attitude metrology.

Challenges:
- Desired resolution (@ 10 mHz): 10 pm/√Hz, 10 nrad/√Hz
- Cross-Coupling effects between six DOFs
- Compact packaging of 6-DOF Optical Readout System

Reference: