Contribution ID: **53** Contribution code: **P#45** Type: **Poster**

All-polarisation beamsplitters for advanced quantum noise mitigation schemes

Tuesday, May 7, 2024 6:15 PM (1 minute)

The design sensitivity of future gravitational-wave detectors like Einstein Telescope is fundamentally limited by quantum noise over a wide frequency range. Speedmeters can overcome this semi-classical sensitivity limit, because they probe a quantum non-demolition observable. Polarisation-based speedmeters are a class of speedmeters that do not require large infrastructure changes compared to current detector topologies and are therefore favourable for potential detector upgrades. However, they do require the main interferometer to be controlled for two orthogonal polarisations of light at the same time. Here, we investigate properties of beamsplitter samples with all-polarisation coatings, i.e. 50/50 beamsplitters that are designed to perform for both orthogonal polarisations of light at the same time. We specifically investigate the phase shift that the central beamsplitter introduces between p-polarised and s-polarised light at the dark port of the Michelson interferometer configuration. We use different analysis methods, including correlation and ellipse fitting, to extract the phase from the data of a scanning Michelson table-top experiment. We also present a method to calculate the effect of this dark fringe offset on the quantum-noise limited sensitivity of a polarisation-circulation speedmeter.

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Session Classification: Posters

Track Classification: Instrument Science Board (ISB)