SURF Progress Report Two: Non-Gaussian Beams for Interferometric Gravitational Wave Detectors

John Miller
University of Glasgow, U.K.
Mentor: Dr. R DeSalvo

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Abstract

Thermal noise forms a significant part of the noise budget of interferometric gravitational wave (GW) detectors. This investigation is concerned with a novel method of suppressing thermal noise by reshaping laser beams and mirrors. Developments over the last month are discussed along with plans for future work

1 Follow-up

Further to last months progress report, the algorithm for the design of the mode-matching telescope was refined. We were subsequently able to optimise both input waist size and position. Many possible solutions were mooted and a simplified one lens design was selected. Although the coupling efficiency to the fundamental mode shall not be as high as is achievable with a two lens system it is believed that practical benefits shall outweigh any losses.

2 Work this month

Due to a number of works carried out in our laboratory, experimental work was slow this month. Work continued on fine tuning the optical set-up and alignment of the cavity.

A computer was destroyed and data acquisition software was lost. An improved package was written with an integrated spectral analysis facility. We are now in a position to identify resonances within our system and possibly eliminate them.

3 Results

We have been able to lock to higher order modes with relative ease [See Fig.1].

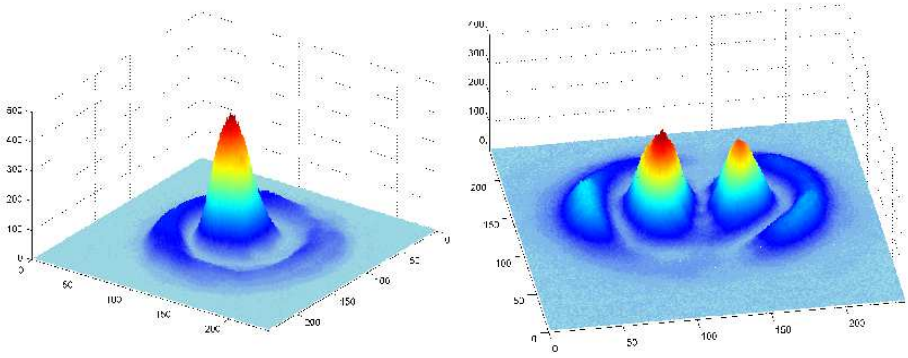

Figure 1: Higher order modes

However, we are still experiencing difficulties in locking to the fundamental mesa mode. Nevertheless we have demonstrated that a similarity exists between the simulated higher order modes with, for example, tilt errors and those witnessed experimentally. Fig.2 below shows a simulation of the 00-mode experiencing a tilt of 5 μrad and a profile captured from our cavity.

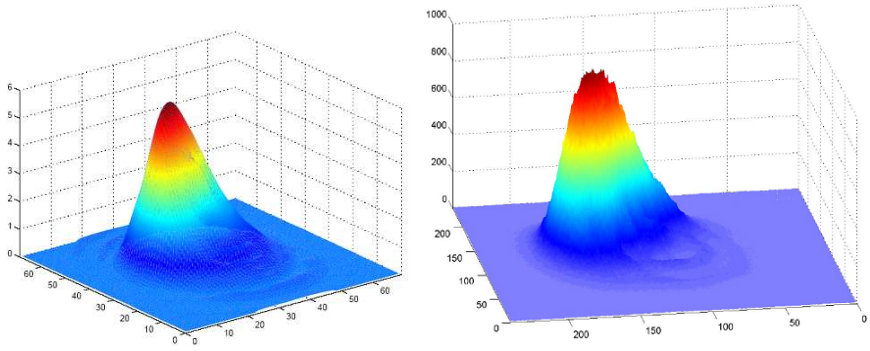

Figure 2: Comparison between simulated (left) and observed (right) mesa modes

4 Current work

Due to the problems experienced locking to the 00 mesa mode it was postulated that our flat input and folder mirrors in fact had a large (but non-negligible) radius of curvature. To this end and interferometric study was made of each mirror's surface.

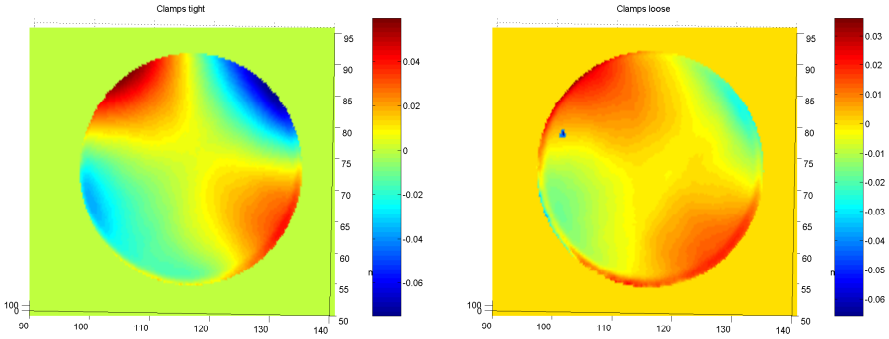

Figure 3: Variation of surface deformation with tightness of mounts

We found that the mirror mountings were exerting a force on the substrates thus causing a deformation of the coated surface. Loosening the micrometric screws was found to alleviate the problem to some degree [See Fig.3]

This analysis agrees with experience in the lab. Every time the cavity was re-aligned the observed profiles were worse. This is thought to have been caused by an increase in the surface deformation of the mirrors caused by a tightening of the screws with each alignment.

A revised mount has been designed and is due to be implemented this week.

5 Further work

Research goals for the coming month include:

- Implementing the new mode-matching telescope and associated optics
- Accounting for know resonances within the system
- producing a stable 00 mesa mode within the experimental cavity
- obtaining quantitative data on the sensitivity of mesa beams beam to known tilts, translations and figure errors of the mirror
- extending the investigation to other MH mirrors to define the principal design criteria for full-scale implementation of mesa beam technology to long baseline GW detectors

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