LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Development of Novel Lock Acquisition Procedures at the Caltech 40m Interferometer

Masha Baryakhtar
Mentors: Rana Adhikari and Alan Weinstein

California Institute of Technology
LIGO Project, MS 18-34
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project, Room NW22-295
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
Route 10, Mile Marker 2
Richland, WA 99352
Phone (509) 372-8106
Fax (509) 372-8137
E-mail: info@ligo.caltech.edu

LIGO Livingston Observatory
19100 LIGO Lane
Livingston, LA 70754
Phone (225) 686-3100
Fax (225) 686-7189
E-mail: info@ligo.caltech.edu

http://www.ligo.caltech.edu/

Abstract

1 Background and Motivation

The Caltech LIGO 40m interferometer prototype gravitational wave detector, operated by the LIGO Laboratory, is designed for optimizing techniques and modeling the performance of the LIGO detectors and for developing and testing new elements for the Advanced LIGO design. Prior to operation of the detector, the system is in an uncontrolled state; in order to collect data, the optical elements must be brought close to resonance and locked. When the system is locked, feedback signals to the optics maintain each degree of freedom (DOF) of the detector at the operating point. Currently, the random motion of the test masses is relied on to bring them close enough to lock. It is important that the time required for lock acquisition is short, such that the time the detector is available for taking data is not significantly affected[1]. To achieve this, the process must be made more robust and deterministic. The lock acquisition work at the 40m interferometer will determine how the Advanced LIGO interferometers are locked.

The current method of lock acquisition is based on a procedure in which the five different DOF of the system (Figure 1) are sequentially brought to resonance[4]. As the states of the DOF cannot be independently measured in the output signals available, it is difficult to calculate the required feedback from this information. Mathematically, solving the lock acquisition problem means dynamically finding the inverse of the sensing matrix $\mathbf{G}$, defined by the equation $O = \mathbf{G}D$, where D is the vector of the displacement of the DOF and O the detectable output signals[4]. In order to make the process more reliable, it is important to diagonalize the matrix $\mathbf{G}$ as much as possible.

1.1 Outline

The first section of this paper describes the technique and impementation of cancelling phase noise due to transferring laser light over long distances through a fiber. This is necessary for our method of lock acquisition, as the stable stable PSL reference must be transferred to the end stations 4km away for Advanced LIGO. The characteristics of the fiber noise (will be) presented. The technique for phase cancellation described in [5] is altered and implemented for a 40m fiber and the results are described.

The second section of the paper describes the frequency shifted PHD scheme for auxiliary locking rpoposed in [**?**], and (hopefully) the proposed improvements to the method and its implementation at the 40m.

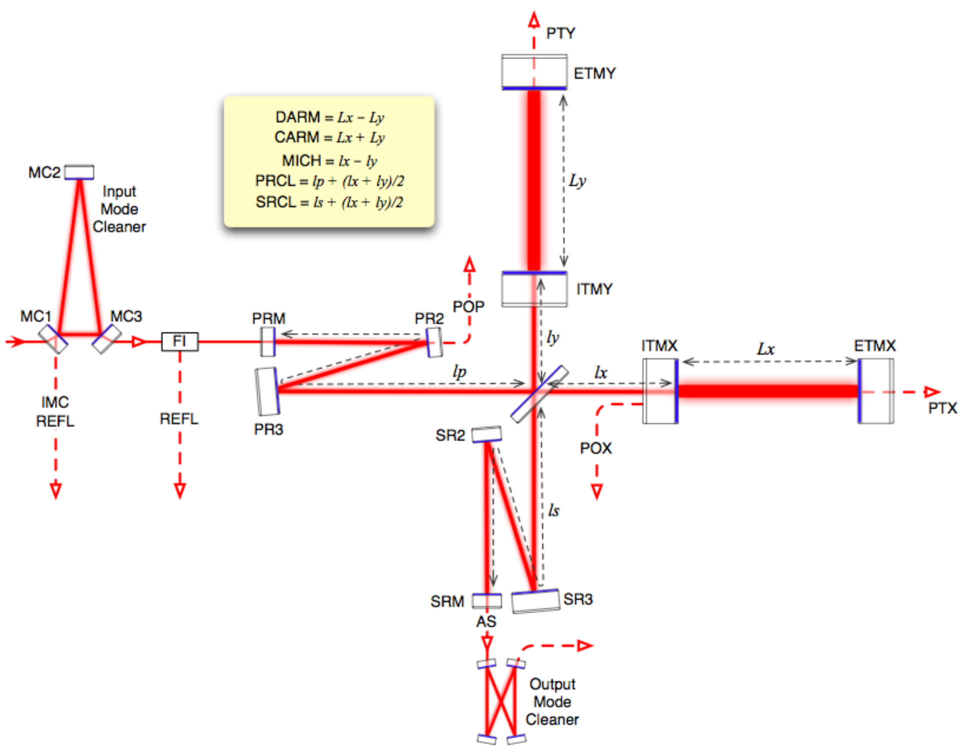

Figure 1: LIGO interferometer[1].

2 Fiber Stabilization

To improve the lock acquisition procedure, auxiliary laser locking will be used - a novel approach in which auxiliary laser light, distinct from the main laser beam, is injected into the interferometer to obtain better length sensing signals to aid in lock acquisition. The light will be injected through the end test masses (ETMs) into the arm cavities (Figure 1). In order to obtain a stable frequency reference at the end stations, the laser light sent through a fiber from the PSL will be used. As sending stabilized light by optical fiber over 4 km greatly increases the amount of phase noise, it is necessary to use noise cancelling techniques [5].

2.1

3 Auxiliary Locking

4 Summary and Conclusion

5 Methods

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