LSC Six-Month Progress Report

Organization University of Florida Physics Department LIGO Group (UFLG)

Report Date 08/15/1999

Attachment A - LIGO I

Item - Task 7 - IOO

Installation on the 2 km Input Optics continues. All of the seven suspension towers have been placed in vacuum. These optics have been rough aligned using alignment tooling and locked down. Ancillary in vacuum optics have also been placed, aligned, and locked. The optics layout on the PSL table has converged to its final configuration and, after determining some spurious RFAM noise sources, will undergo final alignment. Measurements of the beam size for mode matching into the mode cleaner have been used to position the mode cleaner mode matching lenses on the PSL table.

During the course of the installation, the IOO group and the Core Optics Group determined that the protocols for preparing the optics for suspension was flawed. The process of bonding, baking, and cleaning the optics lead to roughly one to two epoxy joint failures per optic after the final cleaning was performed, due to weakening of the joint from exposure to heated detergent solution. Determining the cause of these failures and developing a new protocol caused ~ 2 months delay. The new protocol has proven successful.

A method for measuring interferometer mode matching has been prototyped and demonstrated with detection efficiency better than 0.1% in power based on heterodyne detection of higher order transverse cavity modes. Calculations are complete for transferring this to the LIGO 2K interferometer and demodulation circuits are undergoing retrofitting for LIGO 2k modulation frequencies.

Preparation for installation on the LLO 4k interferometer is underway. The small optics suspensions have been shipped to LLO, along with PSL optics.

Plan for Aug. 99 - Feb. 00

During the next 6 month period, we expect to complete the installation of the 2k Input Optics including final alignment of the PSL table, final alignment of the mode cleaner, length locking of the mode cleaner, alignment sensing and locking of the mode cleaner, and measurements of MC noise performance.

Installation will begin on the Livingston 4k Input Optics,

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including the IOO PSL table optics, suspended optics preparation, and installation and alignment of the suspended optics.

Item - Task 8 - End to End

The UF group is responsible for simulation of the LIGO Input Optics. The IO simulation program is a part of the End-to-End simulation software which is using primitive, object-oriented modules to describe the LIGO detector components. The UF group develop and test a set of the End-to-End primitive modules to describe the IO system.

In addition to the modules we have developed, we added two more modules - iris (a) and thermo-lens (b), and updated the mode-cleaner module (c).
a) The iris module describes a limited aperture of a laser beam. In addition to the intensity loss it causes in the generation of high order Gaussian modes. This module can be used to describe the Electro-Optics Modulators in the IO system.
b) The thermo-lens module represents a thick lens with the thermo-lensing effect - variations of the optical length due to heating of the lens's medium. This variations result in perturbation of a laser beam.
c) We developed the mode-cleaner cavity module which takes into account large static displacement of mirrors.

Plan for Aug 99 - Feb 00

We plan to work on the development of the simulation program for Hanford 2k interferometer (a) and documentation (b).
a) The 2k interferometer simulation program combines the PSL, IO and core optics system with their servo controls. The UF simulation group part is to complete the description of the IO simulation program and integrate it into the entire interferometer simulation program. The integration assumes the development of the IO interfaces to the PSL and core optics and implementation of the simulation modules for the IO control system.
b) We plan to write two LIGO notes which describes the IO optics simulation: 1) Mode Decomposition Formalism, 2) The IO optics simulation modules.

Item - Task 9 - Data Anal.

Broadband characterization in the frequency domain is being carried out. A large number of short data runs provides the best means of obtaining confidence limits for the discussion of rare events. Long runs (up to .5M points so far) provide for increased stability for all persistent features in the frequency domain. Analysis of identifyable features has commenced.

Plan for Aug. 99 - Feb. 00

Data characterization will continue. Requests will be made for all available techniques for removing isolated lines from the frequency spectrum. These are to be implemented and compared before any recommendation for an optimum scheme can be presented. Similarly, any available techniques for analysing resonances, as distinct from other forms of line spikes, will also be called for.

Data characterization is being carried out in conjunction with a new ACIGA group at ANU. It is hoped that first results will be available in time for

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Attachment C - Lasers/Optics

Item - Task 7 - Anc. Optic

We tested the performance of the Faraday isolator and the Electro optic modulators that we actually will use for the 2K system. These tests were made using the actual PSL beam. The Faraday isolator showed single pass isolation ratio of better than 40 dB. All the three EOMs showed required modulation depth, respectively. For the resonant frequency EOM, we measured static RFAM (radio frequency amplitude modulation). It showed a RFAM level of 10^-5 (in intensity), which is better than the required levle of 10^-3. We also tested the resonant frequency EOM for continuous operation (~10 days) by having it exposed to the maximum PSL power (~ 7 W). The modulation performance (carrier height vs side band height measured by an optical spectrum analyzer) was unchanged during the continuous operation test.

Development of alternative Faraday isolation geometries was undertaken in collaboration with research scientists from the Institute of Applied Physics in Nizhny Novgorod, Russia. Thermally induced depolarization due to the laser induced photoelastic strain was determined to be the primary cause for loss of isolation. We were able to show that by using two 22.5 deg. rotators instead of a single 45 deg. rotator, it is possible to compensate for the thermally induced depolarization and increase the isolation by 10 dB at 5 W powers.

Plan for Aug. 99 - Feb. 00

During this period, we intend to continue testing EOMs for dynamic RFAM in the LIGO gravity wave band by demodulating the RFPD output at the modulation frequency to better understand how low frequency noise sources couple to the phase modulation to produce amplitute modulation.

We will begin testing larger aperture LiNBO3 at higher laser powers to determine the effects of damage, second harmonic generation, etc. In order to carry out this research, we will collaborate with Stanford University to utilize their high power (> 50W), single frequency laser capability.

Work will also begin on developing alternative modulation architectures which circumvent the problems associated with high power propagation laser beam propagation through phase modulators. We will extend our earlier measurements on Mach Zender interferometric modulation.

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Attachment D - Advanced Detector Configurations

Item - Task 7 - Dual Rec.

Planning of the prototype experiments has started and we discussed the goals, design constrains, necessary manpower, estimated costs, time frames and so on with the Caltech group, the Glasgow group and Aciga for completing the tabletop experiments and moving to a suspended configuration.

The mode matching for the tabletop experiment is finished and all of the optics are aligned except the 2 recycling mirrors. The plan was to first measure all cavity and dark Michelson related signals without the complication of recycling and the coupling of the signals. The arm cavities were locked independently to measure the PZT-resonance frequencies and to optimise the feedback loops. The signals strengths at various ports were measured and compared with the expected signal strengths. The phase shifter were tested in the feedback loops. The drivers of the Galvos were tested and used to lock a simple Michelson.

The cavities have been locked using the transmitted signals and the Michelson was held on a dark fringe so it was possible to measure the common mode Fabry Perot, the differential mode Fabry Perot and the differential Michelson error signals. The next step is to lock the cavities and the Michelson interferometer using these signals. First experimental tests of lock acquisition will be performed.

A webpage for the STAIC-community was made. This page includes summaries for most of the programs discussed at the workshops, links to ftp-servers and contact names for each program to support the exchange and validation of the programs. It also includes links to the proceedings of the last workshop.

Plan for Aug. 99 - Feb. 00

The Planning of the prototype AIC experiments will proceed. The results will go into a proposal which will be send to the NSF in October.

In the tabletop experiment we will improve the error signals and finish the final feedback loops. We hope to be able to lock the entire dual recycled interferometer during this period and examinate its behaviour.

Preliminary results suggest that the noise floor in the lab is low enough to tune the interferometer to its working point and to measure the linear coupling between the different error signals and degrees of freedom. This should allow the possibility of tuning the signal recycling cavity using several (we expect only 2) dependent offsets added to the appropriate error signals. First, we will attempt to lock the detuned SR-cavity with these offsets. The next step will be to decouple the error signals in a detuned SR-interferometer using the phase shifters.

Again, because of the low noise floor compared with the intrinsic stability of each component in our interferometer, we should be able to lock the system without any advanced lock acquisition system. This opens the possibility to move mirrors, observe the signals, and look experimentally for possibilities for lock acquisition. This can be compared with current models and is expected to be very helpful designing an advanced acquisition system for suspended interferometers.