

LSC Six-Month Progress Report

Organization Department of Physics, California State University Dominguez Hills,
Elementary Particles and Relativity Group (EPRG-CSUDH)

Report Date February 15, 2005

For period from August 15, 2004 to February 15, 2005

Attachment A / LIGO I

Task-1: (Ganezer and Wiley)

The CSUDH group will undertake computation and documentation of active thermal compensation for Advanced LIGO (A-LIGO) and LIGO I using the LIGO-FFT program and other software including the FEMLAB /MATLAB model of Phil Willems with thermal lensing. The A-LIGO simulations will be used to address design issues for A-LIGO. The LIGO-I computations will involve comparison of simulations based on as-built configurations and phase maps of H1, H2, and L2, when available, with the actual performance of the LIGO-I IFOs.

We performed A-LIGO simulations using phase maps generated by Willems to simulate thermal lensing for 30 mW of heating in the ITMs for fused silica at first and then for Sapphire. We also adjusted the physical radius of curvature of the SRM in order to simulate in an indirect and inexact manner the curvature mismatch that results from thermal lensing on GW sidebands and on the carrier without using thermal phasemaps and with the physical (cold) optical specifications.

It was assumed that optical substrates would be composed of Sapphire, the leading choice for A-LIGO optics for several years. These were similar to simulations described in the progress report for the last MOU period (from February 15, 2004 through August 15, 2004) for modulation sidebands in the SRC and LIGO-I, except in this MOU period we obtained our first thermal phasemaps for both fused-silica and Sapphire ITMs and we concentrated on both the GW-sbs in the SRC and the carrier in all cavities of A-LIGO. For the fused-silica and Sapphire optics ITM phasemaps a heating power of 30 mW and 50 mW, if my memory is correct, respectively was assumed in the FEMLAB model, and included only thermal lensing since thermal expansion has not yet been included in the FEMLAB model.

We were not surprised to see that that the thermal phasemaps had very little effect on the carrier power and on its modal structure (there was very little excitation of higher order modes) for both fused silica and Sapphire. We found that there were significant curvature mismatches at the SRM and excitation of higher order modes in the SRC for the GW-sbs when phase maps for both fused silica and Sapphire were used to simulate thermal lensing. Unfortunately most of our efforts were on the Sapphire optical configuration for A-LIGO, since we incorrectly assumed that Sapphire would be chosen for the substrates. One interesting difference between Sapphire and fused silica came up upon examination of the phasemaps from the FEMLAB model. When we plotted the input thermal phases (from the phasemap) we found a constant shift (of phase) for all points (in the transverse

plane) that were within the spot size that was about four times larger than the maximum phase shift (at the center) due to thermal lensing. This amounts to an effective translation along the optical axis of all points on the optical cross section that is likely due to the high thickness of the Sapphire substrate. We suggested, on the basis of experience with FFT calculations, that there would be significant thermal lensing in the beamsplitter, although beamsplitter maps from the FEMLAB model only became available recently and only to our knowledge for the fused silica optics of LIGO-I. Studies of A-LIGO thermal effects in the beamsplitter and various schemes for thermal heating (for example central heating or a ring map) are topics for us to examine in the new MOU period.

In this paragraph we qualitatively outline our results on thermal effects on GW sidebands in the SRC. Quantitative results have been given to members of the LIGO laboratory optics group and have been written up in our NSF grant proposal of November 2004. We plan to disseminate these results at upcoming optics working group meetings. It was found that thermal maps for the ITMs yielded significant shifts to lower frequencies of the peak of the GW-sb Amplitude-GW frequency spectrum, increasing the width of the spectrum and gradually washing out the peak. We found that curvature mismatches (with changes in the cold SRM ROC) has similar effects on the GW-sb spectrum, as thermal phase-maps. A simple modal analysis and intensity maps and profiles revealed that large proportions of higher order modes were present in cases with thermal phase maps or significant curvature mismatches. There seemed to be a good analogy between our LIGO-I and Advanced LIGO studies of modulation and GW sidebands, both types of sidebands undergoing similar degradations due to either thermal phasemaps or curvature mismatches at the PRM or SRM respectively.

Our modal decomposition was made using a simple FORTRAN program originally used in Bochner's thesis that is presently coded to examine up to 256 modes. We found that in order to properly perform this kind of detailed modal decomposition of the GW-sbs the ROC of the sideband rather than that of the carrier had to be used as an input parameter. We also obtained new more recent versions of the A-LIGO FFT code from Brett Bochner, that have not been used since Bochner finished his thesis, that we are told do a better job of keeping track of losses and other functions of A-LIGO simulation. We are currently looking at the new versions of the code to see if they will be useful for thermal simulations.

In conjunction with Phil Willems, we worked out a brief plan for our project, Optical Simulations for Active Thermal compensation in Advanced LIGO, involving collaboration with Phil and other members of LIGO laboratory. This plan was contained in our NSF proposal submitted in late 2004.

Ganezer and Wiley participated in the January 31- February -1 spatial mode workshop at Caltech, Ganezer having attended nearly the entire meeting.

Task-2 (From MOU): (Ganezer) Efforts on burst source analysis. The CSUDH group will work with the burst source analysis group on burst source S2 and S3 data. CSUDH will help to improve methods for correlating cosmological neutrino measurements with LIGO I gravity wave data for a galactic supernova and other burst sources. The CSUDH group will work along with members of the burst source group on establishing upper limits on gravity waves from the S2 and S3 data runs and on formulating manuscripts on these analyses.

Ganezer contributed to the S2 and S3 burst source analysis by participating in weekly burst group teleconferences including one meeting in which he took notes. Ganezer attended most of the burst face-to-face meeting at Caltech February 14-15 and gave a brief talk at that meeting on possible new supernova neutrino detectors and what that might mean for correlations of GW searches with neutrinos from supernovas, entitled "GdCl3 and the promise of improved supernova neutrino detectors and a better SNEWS".

Task-3 (from MOU): (Ganezer) The CSUDH group will undertake the required number of scientific monitoring shifts for the S4 data run if it occurs during the MOU period and will maintain and upgrade when needed the seismic-BLRMS anthropogenic noise monitor software.

S4 did not take place during this MOU period but one shift (the requisite number for our two authors) was assigned to CSUDH for S4. Tests of the blrms software were setup at LHO and LLO. A new version of the seismic monitors for the anthropogenic and other seismic FOMs at LHO and LLO that marks data loss episodes (with -1s in FOM plots), was written, tested and has been running at LHO and LLO since early November, called revised version-1 of the seismic software. A second revision of the seismic software that marks filter ring-downs with 0's and suppresses display of the ring-down so that it would not be confused with a genuine seismic peak, was written during the MOU period, and was tested at both sites shortly after the this MOU period ended. Ganezer was a regular participant in Detector Characterization teleconferences.

Task-4: (from MOU): (Ganezer). The CSUDH group will participate in the final preparations of the 40m for data taking and in initial tuning of the 40m for data taking. Ganezer visited the 40m on occasion to obtain updates on the 40m upgrade.

Grant Writing Activities (Ganezer and Wiley):

In early November 2004 Ganezer submitted a grant application to the NSF, on behalf of the CSUDH LIGO subgroup that focused on Optical Simulations for active thermal compensation in Advanced LIGO and included some work on the seismic (BLRMS) software. Ganezer presented this proposal at the LIGO PAC meeting at MIT in December 2004.