LSC Six-Month Progress Report

Organization Syracuse University Experimental Relativity Group (SUERG)

Report Date 08/15/1999

Attachment A - LIGO I

Item - Task 8 - a)

a) During the week of May 24 -28, PRS visited the LIGO Hanford Observatory. The time was spent in a mix of activities: getting acquainted with the overall installation process, observing and helping with some specific installation tasks (mainly test mass hanging/balancing and stack installation), and discussing commissioning issues with Stan Whitcomb and others. This first working visit is to be followed by others this summer and fall; the location will shift to LIGO Livingston Observatory for the later visits. PRS will also start participating in the weekly installation telecons. These activities represent the startup of real activity by Syracuse as an active member of the LIGO I Development Group, and also serve as preparation for the role PRS will play helping to guide installation and commissioning activities at LLO in calendar year 2000.

Item - Task 8 - b)

b) Steven Penn has begun participation in LIGO I software development. This work includes testing the code for the Data Monitoring Tool on Linux and two flavors of Unix. In addition he has begun writing some of the basic analysis functions to be part of LIGO's software library.

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Attachment B - Isolation/Suspension/Thermal Noise

Item - Task 8 - a) Carry out research into the loss mechanisms in fused silica.

1. Andri Gretarsson was joined by Gregg Harry in extending and analyzing his measurements of Q versus diameter for fused silica fibers and rods. For fused silica samples with diameter above 1 mm, bulk losses dominate, while below 1 mm the Q is inversely proportional to diameter. They were able to show that these data are well fit by a model of bulk loss plus surface loss. A paper describing this work was submitted to the Review of Scientific Instruments, and has received a favorable referee's report.

2. Subsequent analysis of pendulum designs shows how surface losses in fibers or ribbons of a pendulum enters into the thermal noise budget. This kind of analysis will help to guide pendulum designs for LIGO II. A preliminary version of this calculation was presented at the LIGO II Suspension Design Summit at MIT.

3. Surface treatments have continued to be explored by Gretarsson, Harry, and graduate student John Schiller. Although many surface treatments only serve to degrade the Q, one fiber with a strongly damaged surface had that damage repaired by a deep (100 micrometer removal) etch in HF. The post-etch Q of that fiber slightly exceeded the Q expected for a "normal" surface.

4. The inverted pendulum apparatus developed by Steven Penn with undergraduate Joe Kummer has been brought to the point where it is ready to take data. It now has an in-vacuum excitation mechanism and is in the final process of calibration. By the addition and careful placement of weights on the inertia arm, we expect to learn about the loss in fused silica flexures at its base, especially about any possible stress dependence. Enhanced loss at high stress has been proposed by the Moscow group as a possible explanation for the failure of violin modes to so far reach the high Q values predicted by dissipation dilution theory. Columbia University undergraduate Sol Swords is woking with us this summer to take data with this apparatus.

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Item - Task 8 - b) Carry out research into loss mechanisms in sapphire.

Research on sapphire took a back seat to work with fused silica in the anelastic aftereffect apparatus. However, we did make one preliminary test of whether that apparatus can be made to work with sapphire. Bill Startin and Steven Penn placed a sapphire sample (loaned to us by the Stanford group) in the apparatus, recorded some anelastic aftereffect data. As expected, they noticed that the fixed birefringence of sapphire made the measurements more susceptible to the influence of bulk vibrations of the sample; however, the level of this sensitivity is not so great that it ought to prevent measurements, as long as careful alignment of the squeezing mechanism is carried out. They also noticed an undiagnosed memory effect, a DC shift in measured birefringence from shot to shot. Most likely, this was due to a steady shift of the position of the sample in the V-block mount. We hope that use of a different mount will solve this problem.

We intend to return to measurements of sapphire when some of the remaining systematic issues in the anelastic aftereffect apparatus have been resolved. (See below.)

Item - Task 8 - c) Carry out research into levels of mechanical loss in mirror coatings.

Gregg Harry's experiment has been moving forward. The scheme is to measure the Q values of uncoated fused silica "microscope slides", then have them coated. Possible degradation of Q after coating would be a signature of mechanical dissipation in the coating; the thin samples make these measurements more sensitive than the thick-mirror geometry of LIGO itself.

Harry has measured the Q of several fused silica slides, and has found Q values up to 4 x 10^6. This is somewhat lower than expected based on the surface loss values from our fiber measurements; however, it is still good enough to make the coating measurements very sensitive. Some slides have been included in the latest LIGO coating run, so expect to have the first results on coating loss soon.

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Item - Task 8 - d) Continue improvement of the anelastic aftereffect measurement system, both in support of the other research objectives listed above and as a diagnostic tool for LIGO suspensions.

The present status of our measurement capability is as follows: random errors in phi (1 Hz) are less than or of order 1 x 10^-8, and measurements of fused silica samples typically show significant anelastic aftereffect, of order 3 x 10^-7 or greater. However, there are systematic variations from run to run, also of order 3 x 10^-7. This may be evidence of corruption of the measurement from effects in the sample support, or perhaps it is some other undiagnosed systematic error. In any case, we can only treat our fused silica measurements as upper limits, not yet reliable determinations of the loss level in the samples.
Work has continued on ensuring that our data analysis technique is not responsible, including improvements of separating logarithmic signals from linear offset drifts, and in removing sinusoidal signals.

Bill Startin is now writing up his thesis. Steve Penn will continue work on improving the apparatus, working with new Ph.D. candidate Scott Kittelberger, who starts work on his thesis in September.

Item - Task 8 - e) Work to develop a violin monitor suitable for use with suspended pendulums, and with sufficient sensitivity to measure Brownian motion with 1 sec integration times.

Gretarsson has done some design work. He made a breadboard model of a sensor that can work with a ribbon geometry, based on sensing the angle of the ribbon with an optical lever. He has begun detailed comparison of the features of this design with shadow sensor and interferometer designs. This work will be coordinated with the Glasgow group.

Item - Task 8 - f) Participate in Development Group design activities.

We added surface losses into pendulum design models, as described above. PRS coordinated thermal noise presentations at the Suspension Design Summit in May. We have hosted several conference calls with the Glasgow group, and one with Glasgow, Stanford, and Caltech (Willems) to coordinate research projects.