LSC Six-Month Progress Report

Organization German/British Collaboration for the Detection of Gravitational Waves (GEO 600)

Report Date August 15, 2000

Attachment B - Isolation/Suspension/Thermal Noise

Participation

a) Suspension developments relevant to LIGO II and LIGO III

Over the last 6 months there have been significant developments in a number of areas relevant to the design of LIGO II suspensions.

Installation of triple pendulum suspensions in GEO 600 has continued, including the first installation of a triple pendulum plus adjacent triple reaction pendulum. The dummy aluminium masses are currently being replaced by test optics to allow the 1200 m single arm test interferometer experiments to begin during the next period.

Janeen Hazel from LIGO-lab has visited Stanford to see the GEO-style triple pendulum plus reaction pendulum hanging from the single layer active isolation platform constructed there. Diagrams of the triple pendulum system have been provided to her. The Stanford group have examined the characteristics of the local control loops for the triple pendulum when the active system is off and on, and find as expected that the impact on the pendulum dynamics is negligible.

Modelling work on suitable design of BSC and HAM suspensions has continued since the reference design document was produced at the end of January 2000, taking into consideration developments in the theory of thermoelastic damping (see below) and possible changes in the target sensitivities and lower cut-off frequency. Work on the design requirements document and the conceptual design document have begun.

A 10kg mass continues to hang on 4 silica fibres of diameter 200 micron. This was constructed in November 1999 and had been exposed to standard damp atmosphere.

Experiments were carried out to test for excess mechanical losses associated with welding the ends of fibres; no measurable losses were found.

Thermoelastic damping theory has been extended to include the effects of change in Young's modulus with temperature (collaboration between Cagnoli and Willems).

New fibre pulling machines are being built and implemented in preparation for the installation of two full scale monolithic silica suspensions in GEO during the next period. (Installation has been rescheduled to minimize delay caused by mirror coating problems.)

b) Materials research relevant to LIGO II and LIGO III

Measurement of the mechanical losses in bulk materials is continuing, a Q factor of 2.6 x 10(7) at 69kHz having been measured for a sample of GGG (5cm by 2.5 cm).

Further measurements of losses associated with silicate bonding of silica to silica and now silica to sapphire are underway (in collaboration with Stanford) and results will be available in the next period.

A sapphire flat with a silica ear bonded to it has been heated to 100 degrees C without any noticeable

efffect on the bond or the components and further experiments will be carried out in this area.

Preliminary measurements of the loss factors of coated and uncoated samples of Corning 7940 silica suggest that there is a measureable mechanical loss associated with the ion beam coatings applied on a super-smooth substrate by General Optics. New samples have been ordered for further experiments. Experiments are also being carried out on a sapphire sample supplied by LIGO which is to be coated by REO. Modelling of mode shapes with the finite element program ALGOR is being carried out to help us with the interpretation of these results.

Some problem has been identified with the silicate bonding of two super-polished silica surfaces. It appears that the potassium hydroxide does not always react with the surface material. However, experiment indicates that this problem can be overcome by light etching of the surfaces before bonding.

c) Other relevant research

Development of an experiment to allow direct measurement of the thermal noise from a small silica substrate continues at Hannover.

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Attachment C - Lasers/Optics

Participation

Over the last six months there have been a number of significant developments in the Laser work relevant for LIGO II.

A suspension system for the reference cavity at the GEO site was installed and tested. The reference cavity is suspended in two wire slings which are clamped at the tips of four soft cantilever blades. This system provides vertical and horizontal isolation of the cavity against seismic motion. Furthermore, coupling of acoustics via the vacuum vessel are reduced. The pendulum modes are damped by colocated damping of 5 degress of freedom. Shadow sensor / coil units attached to the vacuum tank serve together with flags /magnets glued to the reference cavity as sensors / actuators for these feedback control loops.

After the installation and testing of the suspension system we re-measured the frequency noise of the NPRO relative to reference cavity. For this measurement the NPRO was frequency stabilized to the 8m suspended modecleaner and the length of the modecleaner was changed to bring the laser into resonance with the reference cavity. A low bandwidth control loop was then used to keep the laser on resonance with the cavity. The Pound-Drever method was used to measure the frequency noise of the laser relative to the reference cavity. Compared with earlier results when the reference cavity was not suspended show a significant reduction of the noise in the acoustic Fourier frequency region. However, the noise spectral density level at 1kHz is still around 100mHz/sqrt(Hz) which is much higher than the fundamental shot noise limit for this measurement. Further investigations are needed to understand the excess noise and to reduce it

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