LSC Six-Month Progress Report

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

Report Date 08/15/1999

Attachment B - Isolation/Suspension/Thermal Noise

Item - Task 8 - GEO System

The double pendulum suspensions for the first mode-cleaner for GEO 600 have been installed on site in Ruthe and initial indications are that isolation and control performance are as was planned.

The design of the main mirror suspensions is essentially complete and drawings have been passed from Glasgow to Hannover to allow fabrication to commence. Full computer models of the suspension system have been developed. One is being used to understand the sensitivity of the suspension to mechanical tolerances. This program can also be used to calculate the level of thermal noise in different mechanical arrangements. Another allows development of control algorithms for the system.

In collaboration with colleagues at Stanford, silica ears were bonded to flats on the side of a test beamsplitter (24cm diameter by 10 cm thick) for GEO 600. This splitter had undergone preliminary fabrication by General Optics. Then after the bonds had cured the faces were superpolished to the required
specification by General Optics. It was felt dangerous to attach the bond after the superpolishing was carried out but it has been accepted now that so long as the faces are well protected bonding can probably be carried out after superpolishing and dielectric coating.

As promised last year two fused quartz masses, each of 16 kg and each with four ears silicate bonded to flats on the sides, were transferred from Glasgow to MIT. The intention was to hang one mass from the other using silica fibres and to study the charging effects on the masses as the vacuum container was pumped down. Unfortunately one of the masses was
seriously damaged while it was on show in the MIT lab and so the hanging experiment was not successfully completed. One mass has been left at MIT for charging experiments while the other has been brought back to Glasgow for further experiments and repair.

Loss factor measurements on silica (and quartz), silica (quartz) fibres, and monolithic silica and quartz pendulums have been continuing. It is clear from our measurements that the lowest loss factors for silica are achieved for synthetic material and our best measurements have been obtained for small cylinders of Corning 7980 (loss factor of ~ 8 x 10^-8 at 40 kHz). This is not as good as has been obtained - in collaboration with Stanford - for a similarly dimensioned specimen of YAG (loss factor of ~ 4.5 x 10^-8 or less).
On the fibre front we have now measured losses of less than 10^-8 for the violin modes of a small pendulum. This is still a factor of 2.5 larger than expected and the reasons for

this are being investigated.
In the pendulum area, last year we took to Moscow a 500g mass with two silicate bonded attachment points. Valery Mitrofanov and colleagues have hung this as a pendulum and are measuring a Loss factor of 4.3 x 10^-9 for the rotational mode, this having improved a factor of 1.5 following baking of the pendulum system.

The breaking stress of fused quartz and silica fibres is under study at present and we have preliminary evidence that pretreatment of the rods from which fibres are drawn can significantly improve their strength. This will be discussed at a later stage.

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Attachment C - Lasers/Optics

Item - Task 8 - Laser

Over the past six month we stabilized the monolithic nonplanar ring oscillator to an ULE reference cavity and achieve an error-point noise of less than 1mHz/sqrt(Hz) in the fourier frequency range between 10Hz and 2kHz. To measure the frequency noise with respect to a second rigid-spacer cavity, we shifted the laser frequency with a double passed acousto-optical modulator by 160kHz and measured a larger fluctuations betweeen the laser frequency and the resonance frequency of the second cavity of aprox. 1Hz/sqrt(Hz). Detailed investigations showed that this noise is mainly introduced by the voltage controlled oscillator which drives the AO.

The prototype of the 12W injection locked laser diode pumped Nd:YAG laser system was transferred from the Laser Zentrum Hannover to the University Lab and integrated into the frequency stabilization setup.
The 12W slave laser was injection locked to the stabilized master laser. A measurement of the 12W laser frequency fluctuations with respect to the second cavity as well as a beat measurement between the stabilized master laser and the 12W laser showed that almost no additional frequency noise is added by the injection locking process.

An aluminium spacer was designed at the Laser Zentrum to connect the slave laser components (mirrors, Nd:YAG crystals, brewster plates) in a more rigid way. This spacer will reduce the lenght noise of the slave laser cavity and hence the size of the injection locking feedback signal needed. Due to this spacer we expect a much more reliable and stable lock of the slave laser to the master laser.

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Attachment D - Advanced Detector Configurations

Item - Task 8 - b. 1

Work on the automatic alignment of the 30m instrument is still underway. The last two degrees of freedom, associated with the signal recycling mirror, remain to be stabilised.

Item - Task 8 - b. 2

The power recycling factor has been doubled (to about 100). Further improvements are expected.

Item - Task 8 - b. 3

The limiting noise in the dual recycling 30 m interferometer(known to be mainly due to insufficient performance of the pre-stabilised laser) has been reduced considerably. The residual noise is due to electronic noise in the main photodetector/mixer circuit, a factor of ~2 above shot noise. This will be improved either through better electronics or increased power in the power recycling system.

Item - Task 8 - b. 4

We have generated a complete design for the control signal sensing in GEO 600. This has been checked against all available models and experimental results and seems satisfactory in all respects. Control laws and feedback methods remain to be investigated in full detail.

Item - Task 8 - b. 5

Some progress has been made in establishing general design methods for output modecleaners (GEO and LSC AIC). A specific design remains to be developed for GEO 600.

Item - Task 8 - b. 6

Work (in collaboration with several LSC AIC members) is underway to prepare the 10 m interferometer for a test of RSE. (The interferometer is being converted to operate at 1064 nm.) Modification of the existing instrument, and design of the RSE test are proceeding in parallel.