LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Advanced LIGO Mode Cleaner Wire Suspension Preliminary Design Review Report

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LIGO Science Collaboration

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Participants

Presenters:

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Review Committee:

- Garilynn Billingsley, Doug Cook, Riccardo DeSalvo, Gregory Harry, Roger Route, Phil Willems

Documents Presented and Discussed

Reviewed Documents:

- ETM/ITM Monolithic Stage Conceptual Design for Advanced LIGO ETM/ITM (T050215-00-K)
- ETM/ITM Monolithic Stage Fabrication and Assembly (T050213-00-K)
- Silica Bonding, Ears, Ribbon/Fibre Status/Research and Development Plan (T040170-01-D)
- The Use of Steel Wires for the Advanced LIGO Modecleaner (T060008-00-R)

Charge: *Review the plan to use steel wires on the MC and RM substrates instead of fibers with respect to the performance requirements, design change impacts, and the properties/capabilities of steel wires.*

Note on Charge: The committee only reviewed the use of steel wires on the input mode cleaner mirrors. This is in line with the material presented to review and reflects that no change is being proposed for the suspension design for the two recycling mirrors, the 2001 Conceptual Design (T010103-05-D) included steel wires for Recycling Mirror suspensions.

The committee reviewed plans to use steel wires rather than fused silica fibers in the suspensions of the three input mode cleaner mirrors. We feel that it is likely that with steel wire suspensions the noise requirements in these optics can still be met and that this change can be implemented with a reasonable amount of additional effort.

There was some concern that the thermal noise caused solely by internal friction in the steel wires may not be able to be realized because of rubbing friction, with most concern about the standoffs. However, there is a factor of 2.5 safety margin between the requirement and the level at which suspension thermal noise in these mirrors will cause problematic frequency noise. Based on experience in initial and enhanced LIGO suspensions, it is unlikely that friction will contribute enough excess loss to cause the thermal noise to exceed this safety margin. For the input mode cleaner mirrors, there is an additional margin from the common mode servo; if the frequency noise from the input mode cleaner is high it can be compensated for with this servo. The committee

recommends continuing work on rubbing friction between steel wires and mirror standoffs to better understand and reduce excess loss. The alternatives to wire loops mentioned for the penultimate mass in the quad suspensions should also be explored for the mode cleaner and recycling mirrors if it is found to reduce mechanical loss.

The committee asked about jitter in the input mode cleaner. This will be dominated by jitter coming into the input optics from the laser, so any additional noise from the steel wire suspension will not be problematic.

The committee also asked about frequency equalization of violin mode frequencies. It will be valuable to have all violin mode frequencies be within 2% of each other to reduce phase margin from notch filters in feedback loops. This should be fairly simple to achieve with the steel wires, corresponding to equalizing lengths to within 4.4 mm. The reduction in violin mode Q's from using steel over silica will also ease the notching requirements.

Preliminary Design Review Checklist from M050220-02

System Design Requirements, especially any changes from the DRR – OK

Subsystem and hardware requirements, and design approach – OK other than possible improvement in standoffs and/or alternatives to wire loops.

Justification that the design can satisfy the functional and performance requirements – OK

Resolution of action items from DRR – OK

Interface control documents – OK

Instrumentation, control, diagnostics design approach – OK

Fabrication and manufacturing considerations – OK

Preliminary reliability/availability issues – OK

Installation and integration plans – OK

Environment, safety, and health issues – OK

Human resource needs, cost, and schedule – OK

Any long-lead procurements – OK

Technical, cost, and schedule risks and planned mitigation – OK

Test plan overview – OK

Planned tests or identification of data to be analyzed to verify performance – OK

Identification of testing resources – OK

Test and evaluation schedule, prototype, and production – OK

Lessons learned documented, circulated – OK

Problems and concerns – OK other than above