Attachment OPT to the

Memorandum of Understanding (LIGO-M 0970077 -00-M)

between the

German/British Collaboration for the Detection of Gravitational Waves (GEO600)

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

August 15, 2006

This Attachment OPT to the Memorandum of Understanding LIGO-M 0970077 -00-M defines the role of the **German/British Collaboration for the Detection of Gravitational Waves** as a Member of the LIGO Scientific Collaboration (LSC) and a member of the Optics Development Group (ODG). The period of performance for the activities in this Attachment is from August 15, 2006 to August 15, 2007.

1. Optics Development Group - The Optics Development Group (ODG) is the scientific collaboration for defining and developing instruments in optics for use in advanced subsystems for the initial LIGO interferometers or in entirely new advanced interferometers. MOU Attachments define the roles and responsibilities of groups in this development group.

2. During the period August 15, 2006 to August 15, 2007, the members of **GEO600** will participate in ODG in the following areas:

a) Optics Characterization

Coating Losses for Advanced LIGO and beyond

a.1.) Measurements of multi-layer coatings applied to fused silica substrates
(Crooks, Murray, Reid, Rowan, Hough + I. MacLaren)
Reduction of the mechanical loss associated with the addition of coatings to substrates and associated thermal noise remains an important research area for Advanced LIGO and is vital for the success of any future detectors that aim to have sensitivities better than Advanced LIGO.
We thus propose to continue to work with our LSC colleagues- Stanford University, Syracuse University, MIT, and Hobart and William Smith Colleges, on studies of the excess mechanical losses associated with adding dielectric coatings to test mass substrates

a.2.) Measurements of multi-layer coatings applied to sapphire substrates
(Chalkley, Murray, Cumming, Faller, Hough & Rowan)
We aim to revisit our studies of multi-layer coatings applied to sapphire substrates once our work on nodal supports has progressed further.

a.3.) Mechanical loss associated with coatings for diffractive optics
(Cumming, Heptonstall, Rowan and Hough)
Investigation of the mechanical loss associated with the coatings for diffractive optics will continue in collaboration with colleagues in Hanover and Jena.
Once the sources of excess loss in the suspension have been identified and minimised, measurements will be carried out on annealed blank disks, and a disk with a 50nm etched grating and a multilayer optical dielectric coating, to simulate a complete test mass optic.

a.4.) Coating loss measurements using thin cantilever substrates
(Martin, Reid, Heptonstall, Holt, Cunningham, Rowan & Hough)
The loss of <110> oriented single-crystal silicon cantilevers has previously been studied between 290 and 80 K. Currently, our small cryostat is being adapted for cooling to liquid Helium temperature, which will allow measurement of the mechanical loss around 18 K, where the thermal expansion co-efficient (and hence the thermo-elastic dissipation) goes to zero.
We have recently recruited a new group member with expertise in semiconductor nanofabrication and are working towards being able to fabricate in-house silicon cantilevers for further study. In particular, the effects of crystal axis orientation, doping and surface to volume ratio on the mechanical loss will be investigated.
We intend to study further single layer coatings of tantala and silica on both silica and silicon substrates and investigate the effect of doping and coating thickness on the mechanical loss. We plan to be in a position to carry out these measurements from room temperature down to (or close to) 4K.
Over the next six months a third cryostat facility capable of carrying out mechanical measurements down to (or close to) 4K will be commissioned for measuring similar small cantilever-type samples.

b) Other Contributions

Studies of use of non-Gaussian beams

b.1 Numerical simulations of non-Gaussian mode resonators
(Nelson, Strain)
We plan to use numerical methods to explore non-gaussian mode resonators for potential application in GW detectors. A LabVIEW based Fox-Li simulation has been developed and this will be used to explore the design parameters of cavities containing various flat-topped (mesa) beam shapes. Results will be compared to analytical calculations and experiment already carried out within the LSC.

3. Resource Sharing: The LIGO Laboratory will contribute resources including allocation of appropriate scientific and engineering personnel, research facilities and funding in support of the effort in Item No. 2, as indicated below.

a) Research accommodations for **GEO600** group members while on LIGO research assignment at any LIGO Laboratory site,
b) Access to LIGO data through established LSC channels in support of this work.

c) Not Applicable

4. Coordination and Reporting -

GEO600 will perform this research within the structures established by the LIGO Laboratory and the LSC where appropriate. In particular activities described in Item 2 will be carried out within the Optics Development Working Group of the LSC. Coordination will include keeping the Group leaders informed of activities and plans, reporting to the group at meetings and telecons, and through technical documents submitted to the LIGO Document Control Center.

In addition, an annual report will be submitted with the update to this Attachment, giving a summary status on research by topic as indicated in Item No. 2, including progress against the milestones if any, significant accomplishments such as new insights/discoveries or publications, issues of concern if any, and an indication of invested time. This Attachment will be updated at least annually with a plan of activities for the succeeding on-year period. These documents will be due one month before the close of the period of performance under this Attachment.

5. All computer code delivered to the LSC under this Attachment must be developed in consultation with the LSC Data Analysis Software Working Group (DASWG) and archived, documented and reviewed as determined by that group.

Approved:

Jay Marx

LIGO Laboratory Director

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LSC Spokesperson

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GEO Project