LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO- T040070-00-R 4/20/2004

Research Plan on Noise Effects of Electric Charge on Advanced LIGO

Gregg Harry

Distribution of this document:
LIGO Science Collaboration

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project - MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project - NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

Phase 1 – Determination of problem

Fundamental Gaussian noise from a charged optic is described in T960137-00-E as a Markov process. To use this theory, the correlation time of charges on silica and sapphire needs to be experimentally measured.

Silica and sapphire samples will be measured using a Kelvin probe at Goddard Space Flight Center and at Moscow State University to determine the charge distribution as a function of position and time. In case the number of Kelvin probe tests needed is greater than can be performed at GSFC and/or MSU, preliminary work has started on constructing one at LIGO-MIT.

The surface preparation of the samples may play a role in their conductivity and charge build up. Samples will be prepared according to LIGO Large Optics and COC's Cleaning Procedures in E990035-B-D. The effects of various earthquake stop materials (silica, viton, teflon) on charge buildup will also be measured. See the discussion in E021000-05 for the effect of stop design on charging.

Non-Gaussian noise caused by sudden increases in surface charge is being investigated at Moscow State University on a silica sample. This is described in G040090-00.

Preliminary work on lithium ion deposition in silica and sapphire to increase surface conductivity has begun at the University of Glasgow.

Phase 2 – Research into reduction of noise from charging

If phase 1 identifies a problem with Gaussian noise, research into reducing the noise will begin. The experiments at Glasgow to increase surface conductivity will be carried forward, in collaboration with the University of Surrey. The group at Surrey has experience with and equipment for ion implantation in insulators. A detailed plan will be developed with Surrey and the LSC on ion species, penetration depth, amount, and other relevant parameters to develop a technique to increase surface conductivity. This must be done without causing degradation of other important material parameters, i.e. mechanical loss, optical absorption and scatter, and bonding to suspensions. Measurements of these quantities will be undertaken at Glasgow (modal Q, bonding), Stanford (optical absorption), MIT (modal Q), and Caltech (scatter). The MIT Kelvin probe will be developed should it prove necessary.

Further work at Moscow State University on both Gaussian and non-Gaussian noise is planned after a modernization of the experiment, expected to be complete by fall 2004. This will allow examination of sapphire and coated samples, beyond the silica sample which has been done up until now. Theoretical work modeling charging, losses, and fluctuating forces is also planned.

Choice of earthquake stop material will be made based on initial tests with the Kelvin probe and further work at Caltech.

Timeline

June 2004 – Preliminary discussions with the University of Surrey for ion implantation work.

July 2004 – Measurement at GSFC of silica and sapphire samples. Measurement at MSU of silica samples. First ion implantation at Surrey on small silica and sapphire samples.

September 2004 – Further measurements at GSFC on ion implanted samples and earthquake stop materials. Measurements of optical loss and scatter at Glasgow.

October 2004 – Ion implantation of larger samples, measurement of modal Q and bonding. If needed, Kelvin probe development at MIT.

November 2004 – Development of new, long term charge observation experiment at MSU.

December 2004 – Assessment of ion implantation technique.

2005 – Long term charging experiment and theoretical work at MSU

2006 – Correlation of charging events with cosmic ray detectors at MSU