LSC Six-Month Progress Report

Organization Moscow State University Relativity Group (MSURG)

Report Date 08/15/1999

Attachment B - Isolation/Suspension/Thermal Noise

Item - Task 8 - a

The goal of the MSU research group is to find and to develop a new technique in order to suppress thermal noise in the suspension by increasing the Q's of the pendulum and the violin modes.

V.Mitrofanov and K.Tokmakov have carried out the experimental investigation of the damping of the torsional-pendulum mode for the 2-kg fused silica cylinder suspended from two fused silica fibers. The fibers were welded to the bumps which were carved in the cylinder. Q = 1.86 10^8 (+/- 10%) was obtained for this pendulum (eigen frequency 0.34 Hz).
Also they have tested the suspension of the fused silica cylinder (mass is about 500g) with two small quartz pieces joined to the cylinder using the hydroxide-catalysis bonding technique. Jim Hough and his collegues from Glasgow provided this sample for testing. Two fused silica fibers were welded to the attached pieces. The measured Q for the torsional-pendulum mode (f=1.17Hz) was 2.3 10^8 (+/-10%). The investigation of the weak dissipation mechanisms at this level of losses is continuing.

Organization Moscow State University Relativity Group (MSURG)

Report Date 08/15/1999

Item - Task 8 - b

The development and realization of methods of measurements which permit to register the excess noise in all fused silica fibers.

I.A.Bilenko and M.L.Gorodetsky proposed and analysed a new method of optical measurement of small oscillations of transparent objects, which may be used for the tracking the excess noise in fused silica suspension fibers of LIGO mirrors without attaching any additional mirrors to the fibers. The analysis have shown that this method allows to register oscillations with sensitivity better then 10^{-15}{cm}/\sqrt{Hz}. Preliminary experiments prooved the validity of the method. The new setup for the research of excess noise in fused silica fibers using this method is now in preparation. The article describing the method was accepted for publication in 'Soviet Physics Doklady'.

Item - Task 8 - c

The investigation the sources of noises produced by the electrostatic actuators.

The study of the dissipation mechanisms caused by electric field applied to the surface of the suspended test mass was continued. Various materials for the electrodes and methods of applying electric field were considered and tested. This work is in progress (V.Mitrofanov and graduated student N.Styazhkina).

Organization Moscow State University Relativity Group (MSURG)

Report Date 08/15/1999

Attachment D - Advanced Detector Configurations

Item - Task 8 - d

The analysis of alternative designs of the readout system aiming to reduce the pump power and to beat the Standard Quantum Limit (SQL).

V.B.Braginsky, F.Ya.Khalili and M.L.Gorodetsky in collaboration with Kip Thorne have finished the detailed analysis of quantum speedmeter for gravitational wave antenna. This speed meter is based on two microwave resonators, one of which couples evanescently to the position of the test mass. The sloshing of the resulting signal between the resonators, produce a signal in the waveguide that (for sufficiently low frequencies) is proportional to the test-mass velocity rather than its position. This permits the speed meter to achieve force-measurement sensitivities
better than the standard quantum limit (SQL), both when operating in a narrow-band mode and a wide-band mode. A scrutiny of experimental issues shows that it is feasible, with current technology, to construct a demonstration speed meter that beats the wide-band SQL by a factor 2. A concept is sketched for an adaptation of this speed meter to optical frequencies; this adaptation forms the basis for a possible LIGO-III interferometer that could beat the gravitational-wave standard quantum limit, but perhaps only by a factor $\xi^{-1}= 3$ (constrained by losses in the optics) and at the price of a very high circulating optical power -- larger by ξ^{-2} than that required to reach the SQL. The article about quantum speedmeter will be soon presented for publication in 'Phys. Rev.'

S.P.Vyatchanin in collaboration with Kip Thorne, Jeff Kimble and Yury Levin began analysis of a new wideband variational quantum technique which may be applied to the gravitational wave antenna.

S.P.Vyatchanin and M.L.Gorodetsky spent two weeks in April in Caltech as guests of Kip Thorne working on these problems.