LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Technical Note **LIGO-T040120-00-D** 06/02/04

Measurement of the Laser Intensity Noise Coupling to the Interferometer Output

V. Frolov, R. Adhikari, F. Nocera, R. Savage

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project – MS 51-33
Pasadena CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – MS 20B-145
Cambridge, MA 01239
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

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

ABSTRACT

This note is compilation of the measurements of the laser relative intensity noise at Livingston and Hanford 4km interferometers as well as coupling of the laser intensity noise to the interferometer output.

LASER RELATIVE AMPLITUDE NOISE

The laser relative amplitude noise was measured using photodiode that monitors the light transmitted by the Mode Cleaner (MC). The RIN power spectra for H1 and L1 interferometers are shown in Figure 1. The intensity stabilization servo pick-off photo-diode was located after the MC for the L1 and before the MC for the H1.

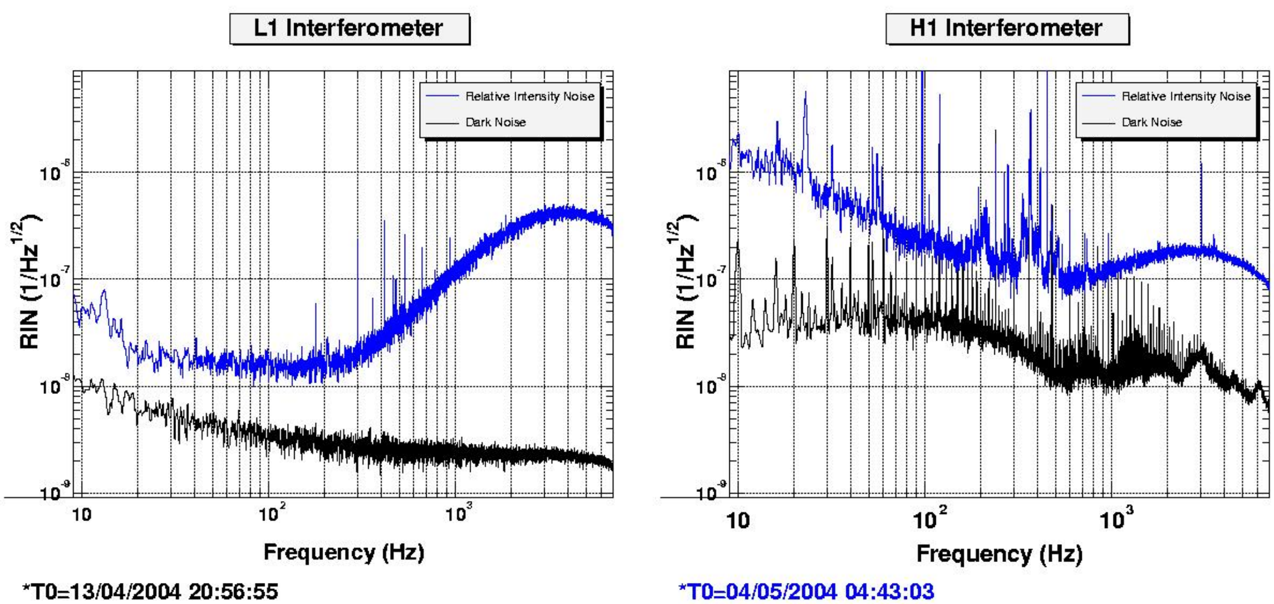

Figure 1. The blue curves are RIN power spectra for L1 (left) and H1 (right). The black curves correspond to the electronics noise.

LASER INTENSITY NOISE COUPLING

The coupling of the laser intensity noise to the interferometer output was measured by injecting the band limited noise (L1) or sine wave (H1) into the excitation point of the intensity stabilization servo and measuring the transfer function from the intensity noise monitoring point – pick-off after the MC - to the interferometer output. The coupling of the interferometer output to the intensity noise appeared to be linear in both H1 and L1. Figure 2 shows the results of the measurements and the estimates of the coupling from two possible sources.

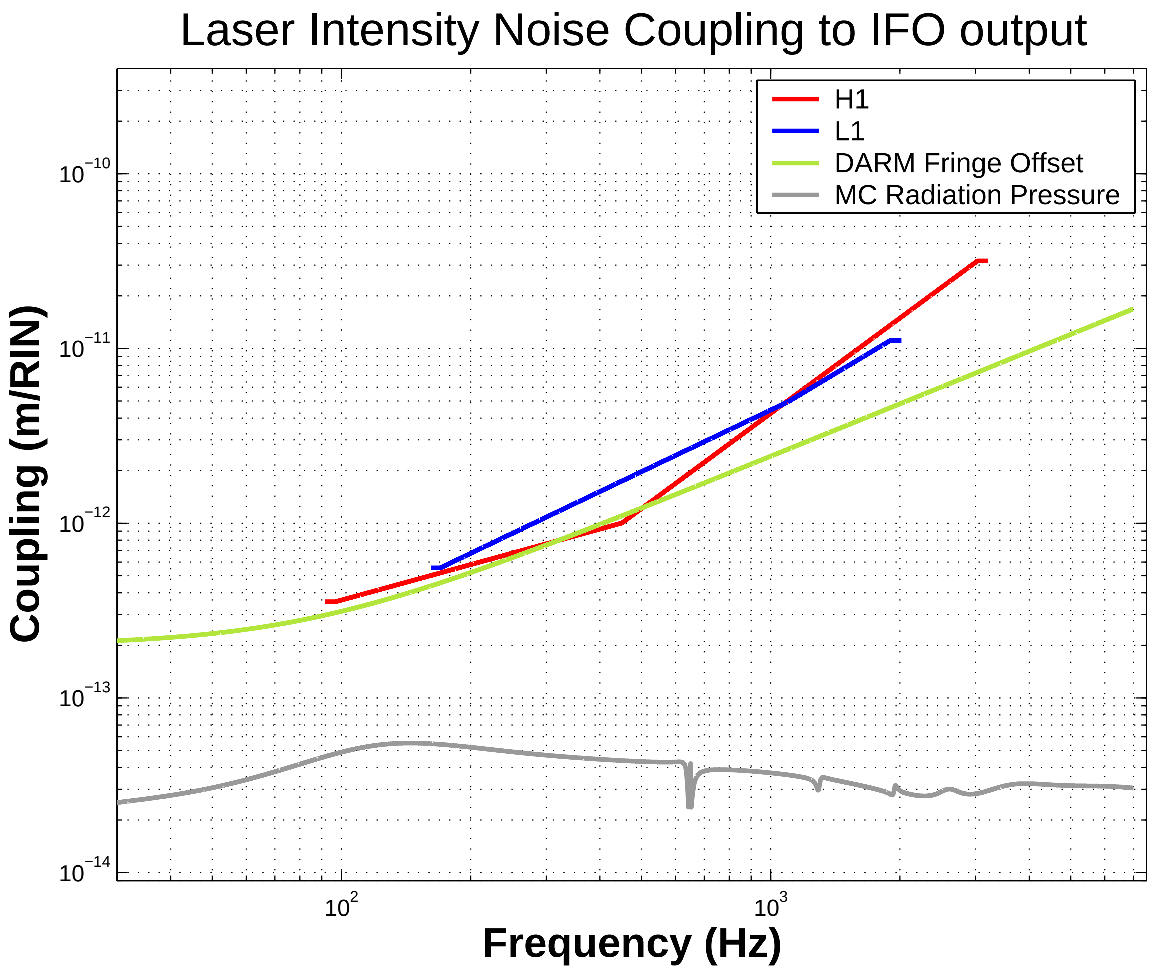

Figure 2. The red and blue curves are the coupling coefficient between the laser relative intensity noise to the interferometer output – displacement – for H1 and L1 respectively. The coupling was measured at 97, 450, and 3030 Hz in the H1 and at 170 and 1900 Hz in L1. The green curve shows the estimate for the coupling induced by the differential arm fringe offset. The DARM loop offset of 10^{-13} m was used to calculate the coupling. Note that this offset does not correspond to the actual offset but serves as a reference only. The grey curve shows the estimate for the coupling mechanism from the radiation pressure induced frequency noise. This noise originates in the MC then gets suppressed by the common mode servo and by frequency noise rejection of the dark port. The L1 Matlab based common mode loop model was used to calculate the open loop gain. The MC input power of 2W was used in this calculation. The frequency noise suppression at the dark port of 400 was assumed.

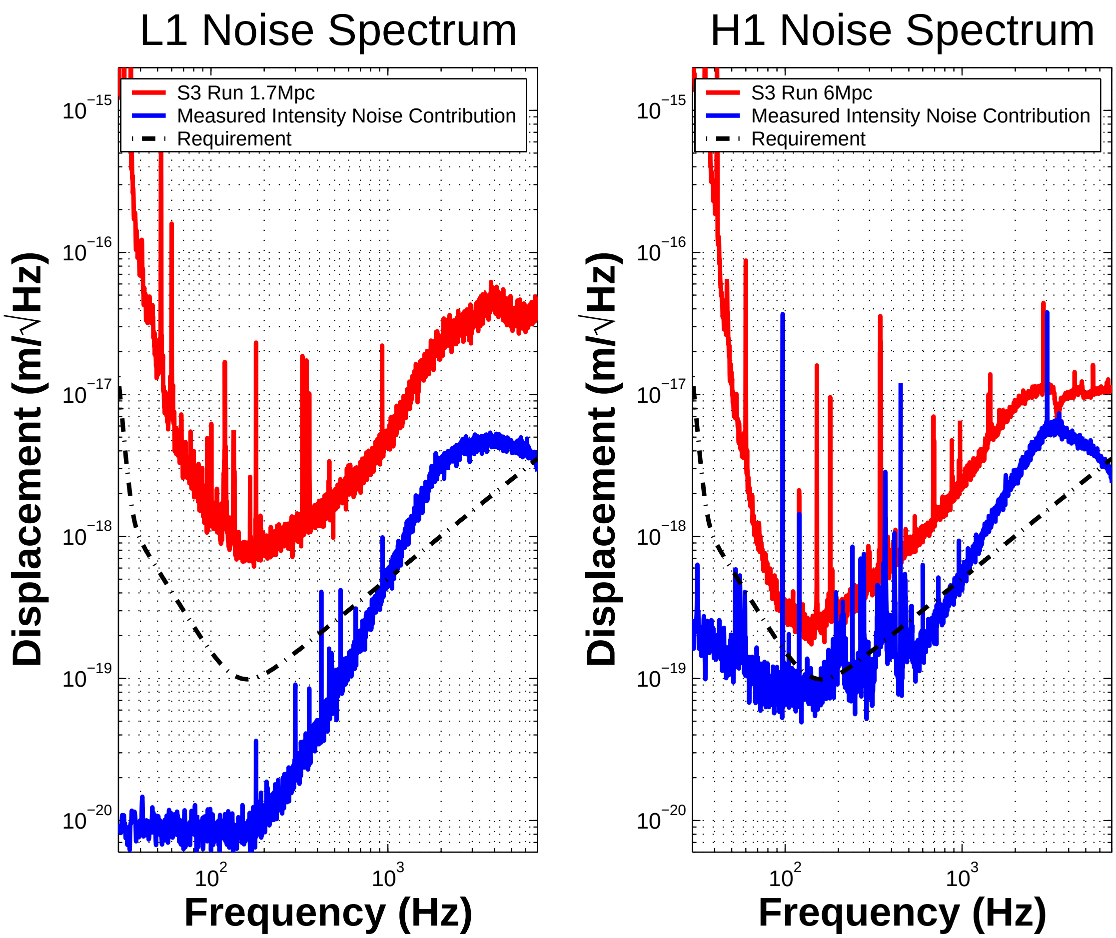

Figure 3. The red curves are the displacement power spectra for H1 (left) and L1 (right) during the S3 run. The blue curves are the measured contributions from the laser intensity noise. Note that the L1 intensity noise contribution was measured after the modification was done to the intensity stabilization servo and therefore this contribution was not the actual contribution to the L1 interferometer noise during the S3 run. The lines at 97, 450, and 3030 Hz in the H1 intensity noise spectrum are the excitation lines.