LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Measurement of the Ground Drift at the 40-m Lab

Title

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1. Introduction

This experiment was designed to measure slow motion of the ground at the 40m lab. The measurement was done using a He-Ne laser and a quad photodiode to sense small changes in the beam propagation direction. The beam spot at the photodiode would drift both due to shear motion of the ground and changes in pitch and yaw of the laser source. Similar measurements have been done previously, see [1]. In our measurement the laser is launched through the vacuum system and is not deflected by mirrors attached to vibration isolation stack as in ref. [1].

2. Description of the experiment

The He-Ne laser is placed on the optical table with a beam expander to minimize the divergence of the laser beam, see Fig.1. The periscope raises the beam so that it enters the port in the BS chamber and goes above all the optical components in the BS and EV chambers. Then the beam propagates all the way down to the east end. At the EE chamber the beam has to go through the test mass. After exiting the viewport the beam lands on the photodiode. The signal from the photodiode is recorded by the Concurrent. The fact that the beam should go through the test mass in order to come out of the viewport does not limit the accuracy of the measurement. This is because the wedge of the test mass produces only dc-displacement of the beam and does not affect the measurement. On the other hand the angular motion of the test mass can steer the beam by as much as 0.08 mm in X-direction. However, the time scale of this motion is of the order of 1 sec. Then the effect of such a motion averages to zero over longer periods of time.

The data was collected by the computer starting from midnight, April 8. This time corresponds to zero on our plots. The actual measurement began a few hours earlier to allow for the laser to warm up. The duration of the data run was approximately 33h 20m. The rate was set to one sample every 5 sec.

3. Calibration

To calibrate the photodiode we used a microscope slide mounted on a dial. The thickness of the slide is h=1.3 mm and the index of refraction is n=1.5. The slide was inserted into the beam at normal incidence right after the beam expander. The signal from the photodiode was zeroed at that time. Then the slide was rotated by 10^{o}, 20^{o}, 30^{o} and 40^{o} causing the beam to shift in vertical direction. These are the “steps” on the calibration curve. The formula for the beam displacement

$$d = h \sin a \left(1 - \frac{\cos a}{\sqrt{n^2 - \sin^2 a}}\right)$$

gives 0.37 mm for the angle $a=40^{o}$. Only this angle was used for the calibration.

4. Results

The data shows that the ground motion produces 1 mm drift in X-direction and 0.2 mm in Y-direction during a daily cycle. This is equivalent to 2×10^{-5} rad in yaw and 4×10^{-6} rad in pitch correspondingly. Similar results were obtained in [1].

5. References

[1] R. Spero, in ~robert/data/seismo-mon/sep06.ps

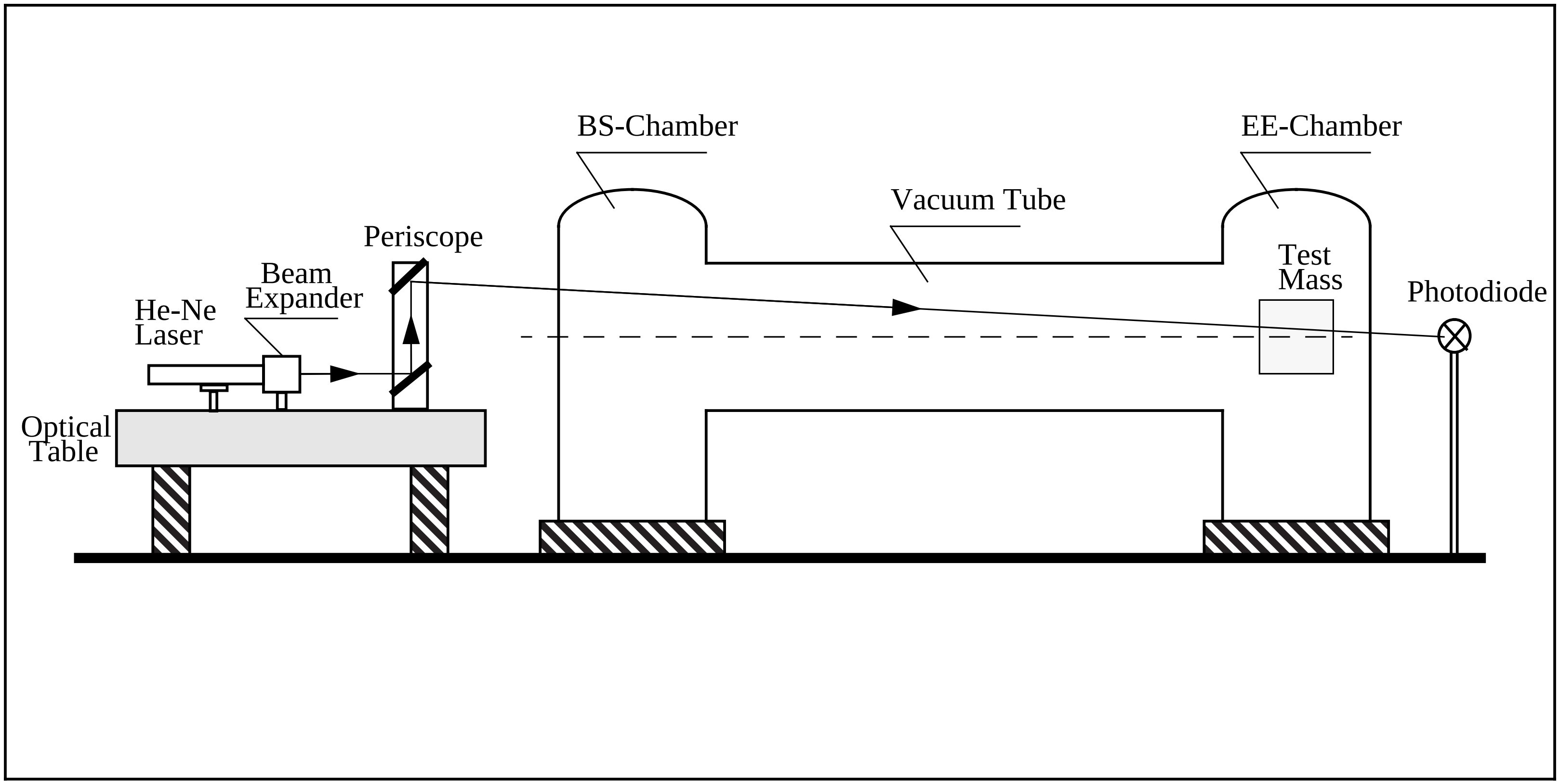
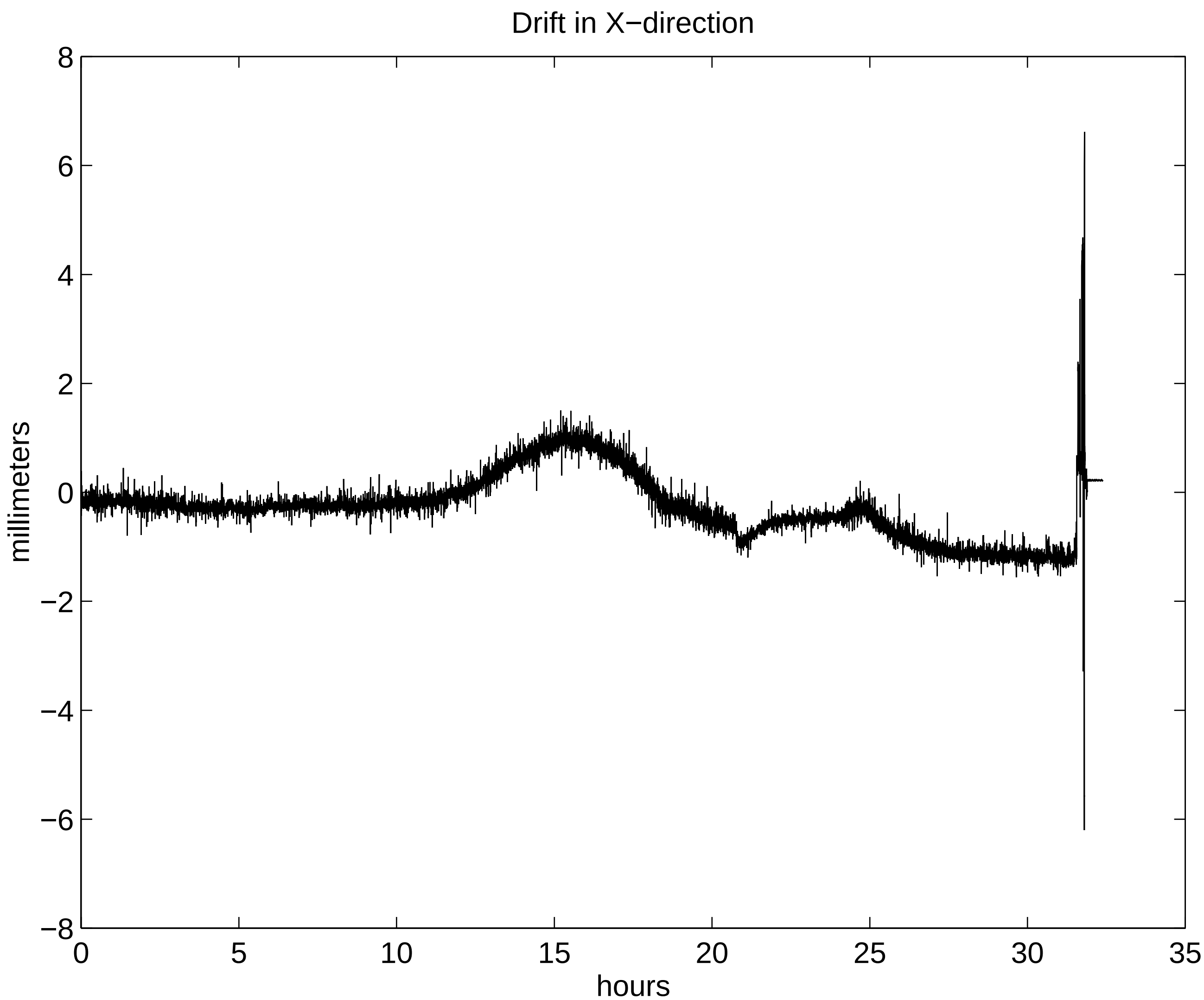
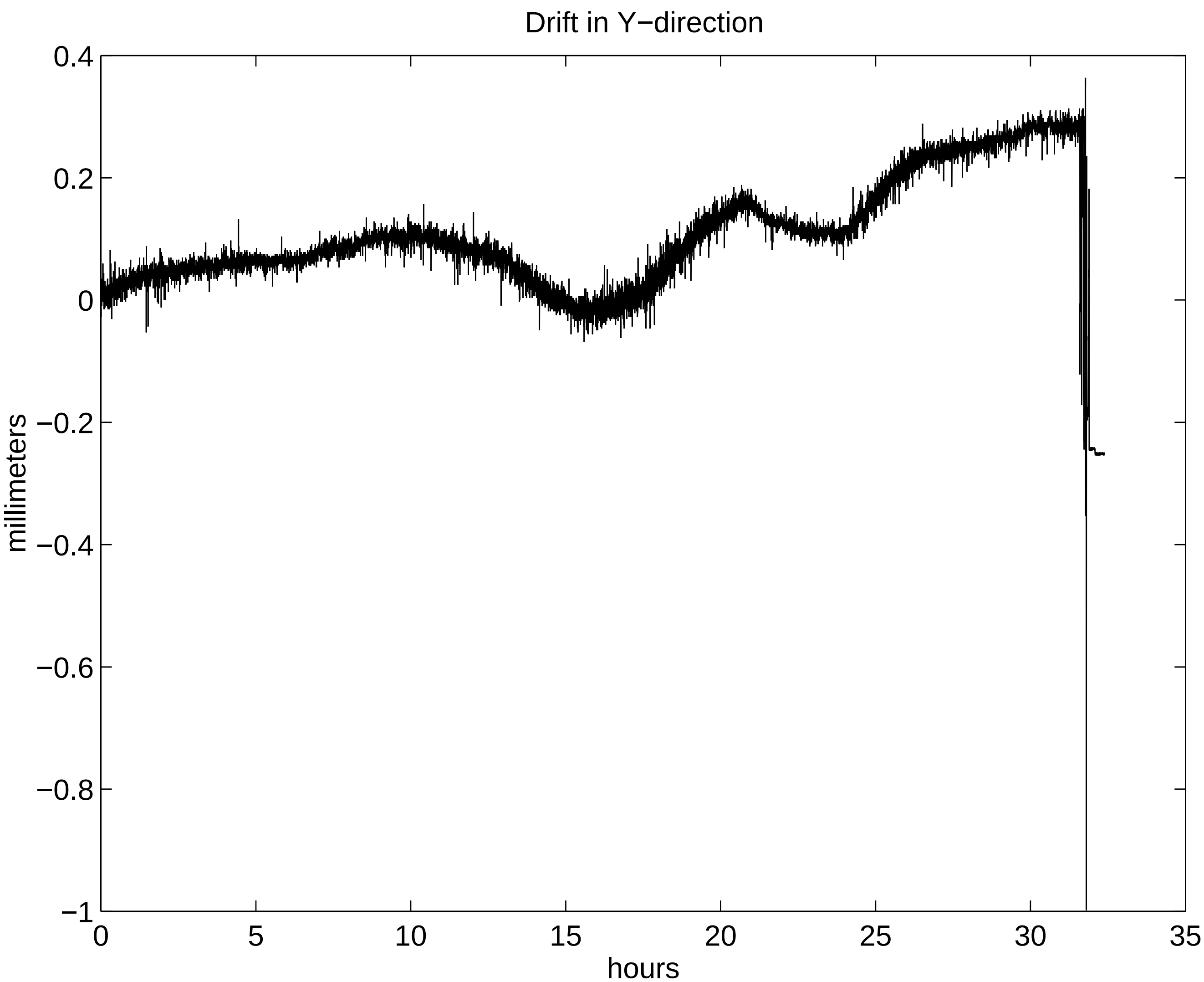
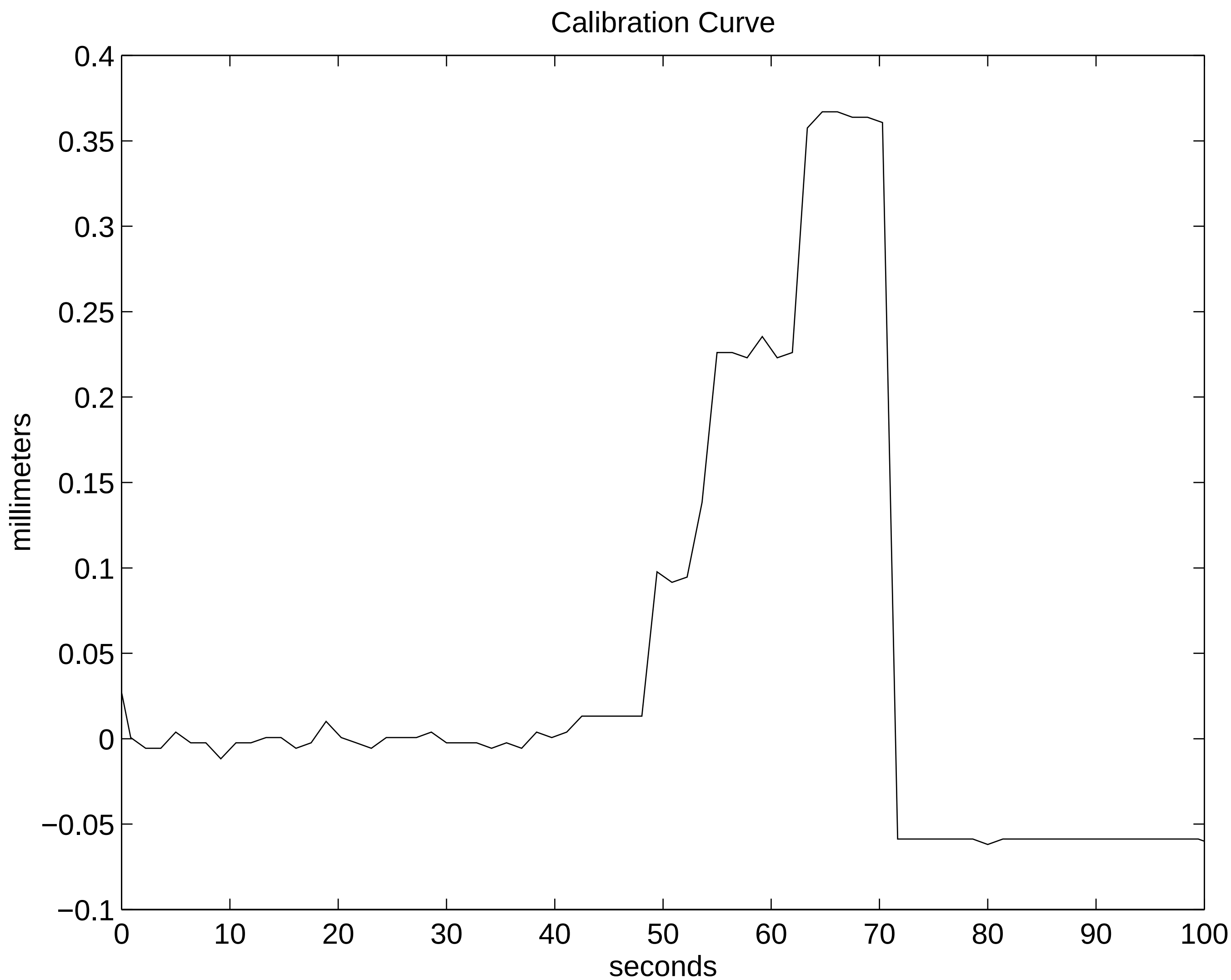


Fig.1. EXPERIMENTAL SET-UP


Drift in X−direction
millimeters
hours
8
6
4
2
0
−2
−4
−6
−8
0
5
10
15
20
25
30
35


Drift in Y−direction
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
millimeters
0
5
10
15
20
25
30
35
hours


Calibration Curve
millimeters
seconds
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
0
10
20
30
40
50
60
70
80
90
100