An analysis of the microseismic peak at LIGO Hanford Observatory

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- Introduction -

Isolation of the LIGO detectors from seismic noise is necessary to achieve a desired level of performance. Analysis of seismic noise is essential to make improvements in seismic isolation, and to validate gravitational-wave candidates with a high degree of certainty. Seismic noise in the 0.1 - 0.3 Hz band is primarily attributed to the microseismic peak caused by pressure exerted on the ocean floor by ocean waves and deep-sea storms.

- Methods -

Hourly trends of seismic noise in the 0.1 - 0.3 Hz frequency band from Guralp CMG-40T three-axis seismometers located at LHO’s Corner Station (CS), End Station-X (EX), and End Station-Y (EY) were analyzed over a three year period, 2013 - 2016. The O1 50% threshold for this band was determined by the percentage of hours that laser lock was maintained when ground velocity exceeded given thresholds ranging from 0.1 – 2 μm/s during the O1 observation run. Analysis was conducted using the R statistical computing and graphics environment.

- Results -

Fig. 1: Average ground motion in the microseismic peak was about four times greater during December than during summer months. This is thought to be due to a greater number of ocean storms that occur during the winter months than during summer months.

Fig. 2: Blue columns indicate ground velocities below the O1 50% threshold, while red columns indicate ground velocities above this threshold. In about 15% of hours over the entire three year period analyzed, average ground motion of all three stations exceeded the O1 50% threshold.

- Results Cont’d -

Fig. 3: Winter months experienced the highest percentage of hours with ground motion above the O1 threshold of 1μm/s. Average ground motion exceeded the O1 50% threshold for over 40% of total hours in December.

Fig. 4: Ground motion in the z direction (vertical) was consistently higher than the horizontal directions (x and y) at all stations. In winter months, ground motion in the z direction was about 1.4 times the motion in the horizontal axes.

- Conclusion -

No significant differences in ground motion were observed between hours of the day or days of the week. However, the increase in ground motion during the winter months suggests that the microseismic peak may contribute to difficulties maintaining laser lock in LHO’s gravitational-wave detector in 40 times as many hours in December as in summer months.

- References -