Progress Report 2

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August 3, 2015

1 Description of Work Done in Past Month

1.1 Coupling Functions' Effect on Differential Arm Movement

A significant amount of work has been done on the program that calculates the effect of coupling functions on the differential arm movement(DARM). At the time of the first progress report, a Python program that received inputs of an output signal containing a coupling function from a PEM sensor, the DARM output signal, the frequency of the first harmonic, and which harmonics to analyze had been created. This program would output a table with the factor of effect on DARM for a single unit of the signal being measured by the sensor.

In the past four weeks, this program has been adapted and improved upon quite a bit. The first step taken was to change the output of the program to a text file that contained a table of the factors for each frequency. The next steps with this program were testing it on Physical Environment Monitoring injection data. These datasets had a magnetic field with a fundamental harmonic frequency of 11 Hz injected into the area of the interferometer. Three different sets of injected magnetic fields at these harmonics were tested with the program. After the initial testing, the output of the program was modified to be two separate text files, one with the factors for each frequency, and one with an estimate of a the effect on DARM for a certain value of signal. Currently the program allows for that value to be input.

1.2 Ambient Background Noise's Effect on Differential Arm Movement

At the time of the first progress report, there was no part of the Python program that received inputs of a sensor's signal with injected noise, a reference signal for the sensor, the DARM output with the injected noise, and a DARM reference signal. Since the first progress report, this program has been created. The program calculates the effect of

ambient background noise on the differential arm movement by using the change in both the sensor signal and the DARM signal compared to the references. The output of this program was originally a table of factors for each frequency.

After writing this program, the next step was to test it on different sets of data. The data sets that this program was tested on were those in which either speakers were set up and played in the LVEA, or shakers were placed on HAMs. Both of these techniques will be discussed in the acoustic coupling section. After initial testing, the output of this program also evolved into two separate text files: one with factors for each frequency and one with estimates.

1.3 Acoustic Coupling Studies

In the past four weeks, the study of acoustic coupling has moved away from HAM 6 and towards each different horizontal access module, or HAM, and beam splitting chamber, or BSC. In order to test if a chamber is effected by acoustic coupling, a shaker is placed on the chamber's blue support beam and is run through a sweep of frequencies. This is done when the interferometer is in lock, and the difference in DARM before and during these injections is analyzed. This would be a situation where the use of the ambient background noise program is likely. As was done with HAM 6 before the first progress report, the goal of these injections is to identify any acoustic coupling within the chambers and find the source of it. So far, there are setups ready in the corner station LVEA and once the interferometer is in lock, testing a couple other HAMs and BSCs will be possible.

1.4 Magnetometer Calibration and Documentation

At the time of the previous progress report, only the magnetometer in the corner station's vertex had been calibrated and leveled. Since then, almost every magnetometer has been calibrated and leveled. The calibration process is done by analyzing the signal of the magnetometer before and during a solenoid is placed over the magnetometer. The solenoid is provided with a voltage from a function generator, and the output of the the system is analyzed on a oscilloscope. The magnetometer signal, which is originally in counts, is then converted to a voltage and the known magnetic field from the solenoid. The ratio of the magnetic field signal to the output voltage is then calculated and compared to the previously calculated ratio on the PEM website.

The magnetometers that are on tripods, such as the one on either end station's floors and the corner station's vertex, were all leveled, and new placement areas were drawn on the floor so that if they are moved, they can be replaced at the same configuration. The magnetometers not on tripods are all supposed to be in the correct vertical position, which

the one at Input Optics is, but not the Output Optics magnetometer. Therefore, it was also necessary to reorientate that magnetometer.

With all of this work being done on the magnetometers, it was noticed that the photographs and sample spectrums of the magnetometers on the PEM website are few and far between, with many of them outdated. Therefore, another aspect added to this project was retaking and updating that data.

2 Progress of Work

The program that will eventually contain many options to analyze injected PEM noise is currently split into two working programs: one that calculates ambient background noise and one that does its calculations using harmonic peaks. These two programs do their calculations by magnitude and have been tested using real PEM injection data, Based on the results of those tests, they seem to be working well, as the points are around where they are expected.

The acoustic coupling studies have not come too far since the previous progress report, but there are set-ups ready to start testing on both a HAM and a BSC in the corner station LVEA. These set-ups will allow for quick and easy testing once the interferometer is in lock.

Almost every magnetometer, except for Input Optics, which is waiting on a power box, have been calibrated. All magnetometers on tripods have been leveled and their new leg positions have been labeled on the floor. Output optics was also reoriented so that it will correspond to the correct directions. Photographs and sample spectrums have been taken of each magnetometer, and those should be posted on the website very soon.

3 Problems Encountered

The largest problem that I have encountered has been unfamiliarity with data analysis in Python. Luckily, I have done a lot of reading up on Python programming and used different internet programming databases to help me hurdle any barrier that has come up. One problem that I found with the harmonic magnitude program was finding a way to find the points with the harmonic frequency because as the bandwidth varies between datasets, the spacing between frequency points varies. I fixed this problem by having the program calculate the spacing between points and using that to find the points where the peaks are.

4 Research Goals for Remainder of the Project

4.1 Program that Calculates Environmental Signals' Effect of Differential Arm Length

For the remainder of my project, my goal is to complete the implementation of the program that calculates the effect of environmental signals on DARM. In order to complete this program, I will be creating two more separate portions that calculate the effect ambient background noise and the effect of coupling functions, but by using Root Mean Squared, or RMS, calculations. Then, once all different programs are completely functioning, a complete program that allows the user to choose which calculations they would like run and input their data will be compiled from all of the programs.

4.2 Acoustic Coupling Studies

For the acoustic coupling studies, my goal for the remainder of the summer is to run shaker tests on as many HAMs and BSCs in the corner station LVEA as possible. Running these tests will help us find any environmental effects of acoustic coupling within these chambers before the science run begins. I also hope to be able to play the loud speakers in both end stations so that any acoustic coupling in the end stations can be found.

4.3 Magnetometer Calibration and Documentation

As for the calibration and set up as magnetometers, my goal is to have every magnetometer working and calibrated by the end of this project. I also plan on having updated all magnetometer pictures and sample spectrums on the PEM website, so that the information can be updated in time for the Science Run.