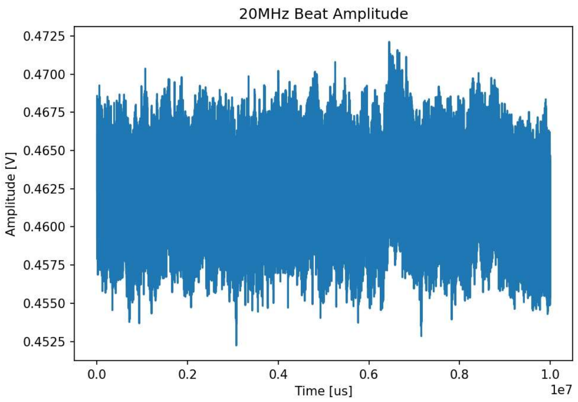
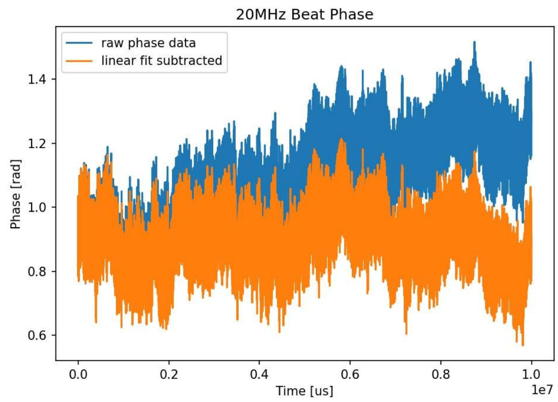
220103 20MHz Beat Signal

5 January, 2022 09:16

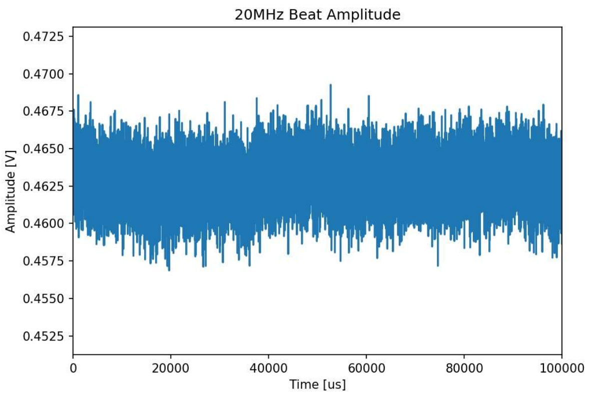
Preliminary data captured by the USRP of the 20MHz optical beat signal shows that the while the amplitude seems mostly stable, there seems to be significant phase modulation of about 0.4rad p-p.

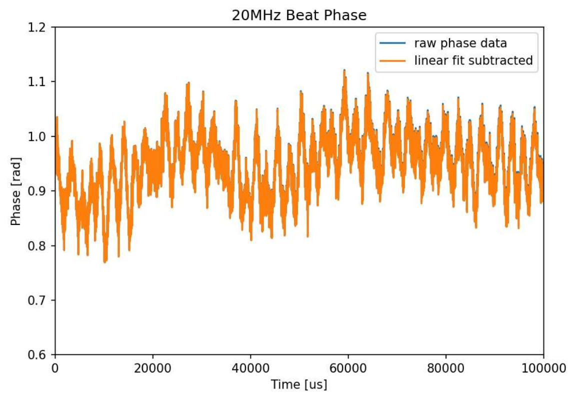




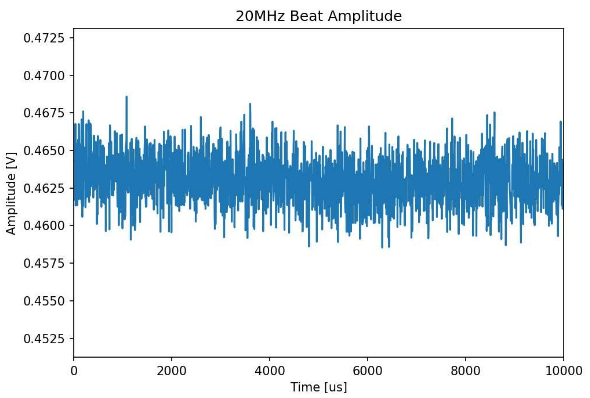
A closer look at the phase signal at smaller time scales reveals that the noise is not generally white in nature but some coherent osscillation:

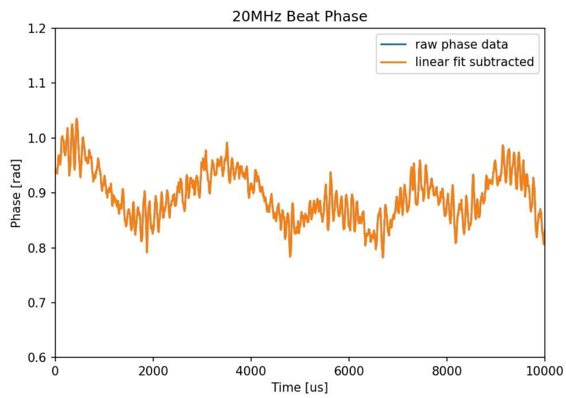
100ms time scale:





10ms time scale:

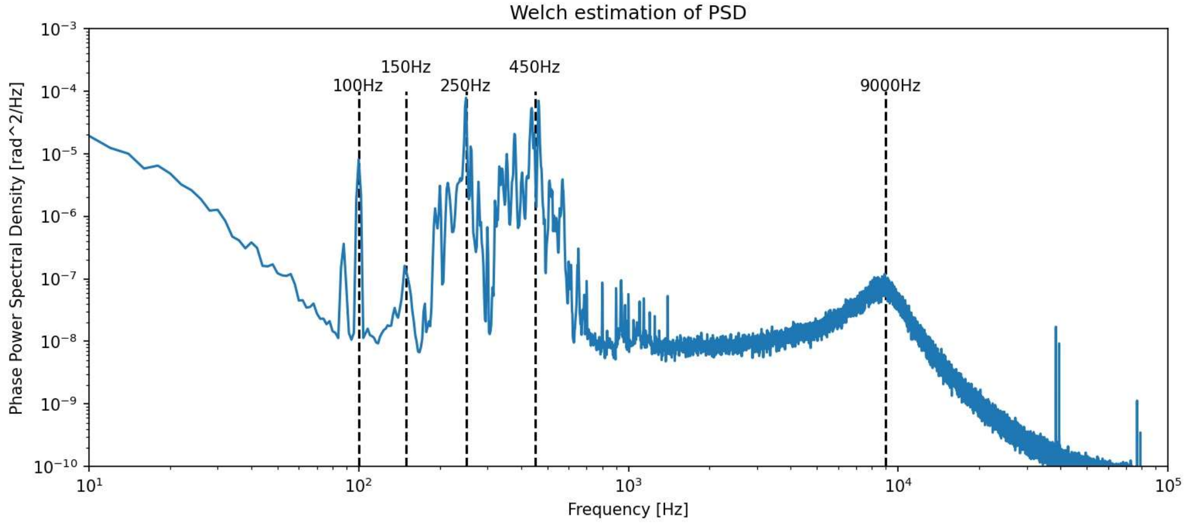




For instance, on the 10ms time scale, the dominant frequency of the phase modulation seems to be ~500Hz (2ms period).

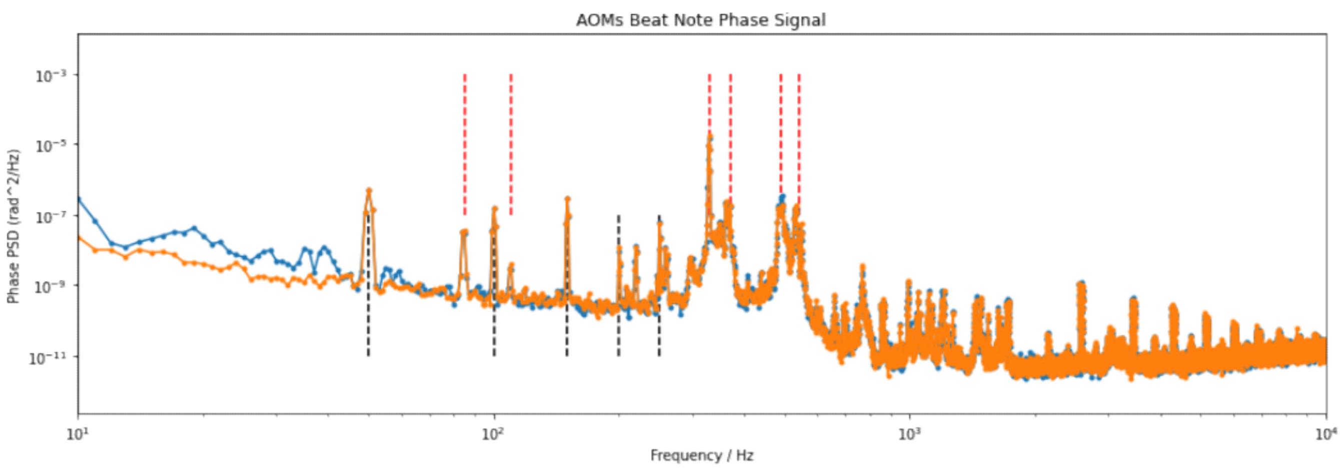
We can conduct a Fourier Transform on the phase time series to examine its frequency components. Equivalently, this is called the power spectral density (PSD) of a time series. In practice, a Welch estimate of the PSD is carried out - it chops up the entire time series into segments, then conducts a Fourier transform of each segment to find an individual PSD, then averages the PSD between segments.

We find that the dominant frequency components of the phase modulation are around 250Hz, 450Hz, followed by 100Hz (note that the y axis is logarithmic).



Looking at previous data collected over 1 min, (in \\bitfreeze.quantum.nus.edu.sg/workspace/Scratch/Michael/phase_chirp/long_free-running/210929_1600221min.csv)

We see that the PSD then wasn't entirely great either, but the peaks are not as high.



<u>Some possible sources of the noisy phase:</u>

1. Path length stabilization is inducing more noise than it is reducing
    a. Path length stabilization only stabilizes the phase of (twice) the optical path from the beam first beam splitter to each retroreflection mirror. However, if there is differential phase noise on each retroreflection mirror, then the resultant phase noise at the 20MHz beat signal is no longer common mode.
2. Air-con is inducing phase noise (by inducing vibrations on mirrors) / air coming from the open door.
3. Mirror mounts are causing the phase noise. (the unstabilized path, i.e. the mirrors at the end used for coupling both beams into the fiber could be responsible for the phase noise)

<u>Some ways to investigate the phase noise:</u>

1. Instead of using path length stabilization, use a DDS to drive the 84MHz AOM to obtain an exact frequency (currently, a VCO is used for it) - then path stabilization can be turned off and the 20MHz beat note can still be seen. One can then see directly whether path length stabilization improves or worsens the phase noise.

2. Turn off the air-con / close all windows / doors & run experiment to see if there is any difference.
3. To determine if the noise is of mechanical or electrical origin, one can use speakers to sweep the acoustic frequency range while directed at the experiment. If the speaker frequency hits a mirror resonance, then that resonance should show up clearly on the beat note phase. Else, if it is some electrical noise, then it would not be amplified by acoustics.
4. A side-experiment can be set up with 1 AOM and detect the beat note between those 2 beams. We can vary the mirrors used & try to use heavier mirrors which won't induce as much phase modulation.