Interferometry Session 3

Wednesday, November 2, 2022 11:57 AM

Welcome to Martin's Lab Book.
The work in the following section was completed on:

Tuesday, January 17th, 2023
9am – 12pm
in a synchronous manner becoming of a lab workbook.

Aims

- Re-calibration of our set-up after someone messed with our stuff.
- Finding the exact position of the null point (around 6.11mm).
- Take data for a variety of filters of the location of the null point, as well as the distribution for a range of positions, yielding graphs.
- Repeat this for white light, green light, orange and yellow filters.

Unfortunately, someone has touched our set-up, and as a result, we have had to recalibrate our set-up.

Task 8 – Finding the Null Point (continued)
First make sure that the null point is within the range of the movement of your stage by measuring both arms of the interferometer. There are a number of different ways that you can try to find the null point and you will find 3 described below. Ultimately, you will use Method 1, however we suggest that you use either Method 2 or 3 to get you close to the null point first as otherwise this is a slow and long process. Method 2 and 3 can be more quickly achieved by disengaging the the stepper motor from the micrometer head. The methods are:

1. Scanning through the entire range of the stage with the white LED as a source. You will only see interference very close to the null point. So that this doesn't take too long you might want to move the stage at a faster rate. The coherence length of the white LED is about 10µm and so you can calculate the maximum speed that the stage can travel and still see any interference. Once you have spotted the rough position of the null point. Go back and scan through it slowly. Make sure that you look (with your eyes rather than the detector) at the interference pattern that you see.

2. Method 1. works but can be very slow and pains taking. You can get very close indeed using the Haidinger fringes and the laser. If you consider equation 1 for these fringes you will see that changing t changes the angle at which the fringes appear. This means that the number of fringes in your field of view will change depending on how close you are to the null point. So one approach is to start at one end of the stage's travel range; count the number of fringes; move the stage a mm; count again; repeat until you have definitely gone through the null point. Then scan through the reduced length with the white light LED. Make sure that you look (with your eyes rather than the detector) at the interference pattern that you see.

3. This is a refinement on technique 2. If you move the stage by a mm, then scan a small distance looking at your interference pattern. You will either see fringes disappearing into the centre or new fringes appearing out of the centre depending on whether you are scanning towards or away from the null point (can you work out which is which?). So you can repeat method 2 but rather than just counting fringes, scan a little and see when the fringes change directions (i.e. when you have gone past the null point). Then scan through the reduced length with the white light LED. Make sure that you look (with your eyes rather than the detector) at the interference pattern that you see.

IMPORTANT SIDENOTE: When you have found the null point make sure that you record its position as you will need it for what you do next.

Location of the Null Point

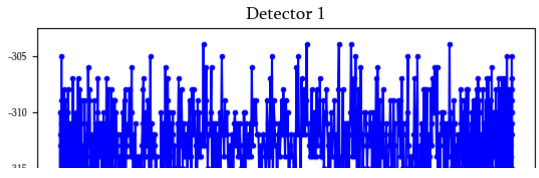
The difference between this position and the null point is 1196080 µsteps.
0.00355mm per µstep.

6.27mm = - 3000000µsteps position.
Null point: 6.15mm = 1803920µsteps position.
5.96mm = 200000µsteps position.

To begin with, we needed to determine the location of the null point. We took several preliminary scans, which encompassed the entire necessary region. Having determined the rough location of the null point manually by hand, we then determine what the location of the suitable range of data collection was.

Having accomplished this, we proceeded to take data beginning roughly at the position –3,000,000 to 200,000 which took about 5 minutes. After this was achieved, the following data found in **Figures 1-10** was obtained, and analysed:

Preliminary Data



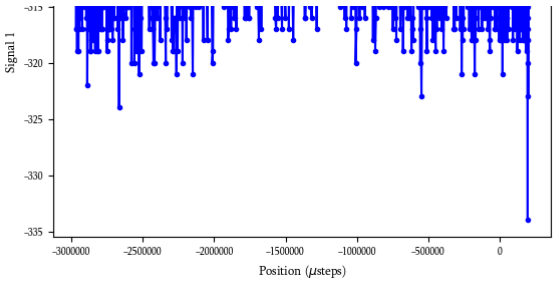


Figure 1: Preliminary data, merely to scout positions. We realised we hadn't turned our apparatus on during this run, but this graph is included for the sake of completion. Consequently, this data is redundant.

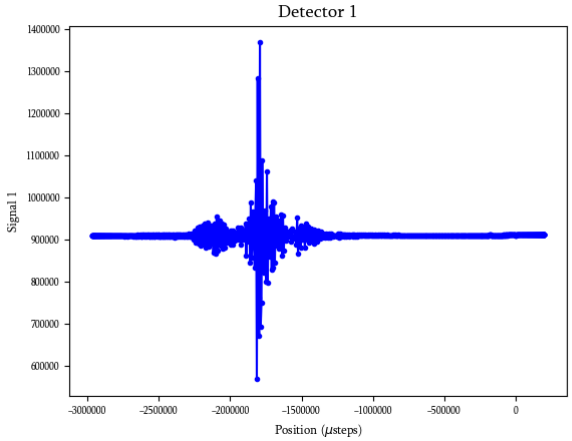


Figure 2: Preliminary data to roughly ascertain the position of the null point. This, ironically, ended up being used as our final graph which we used. This was taking the largest range, of about 3,200,000.

Final Data

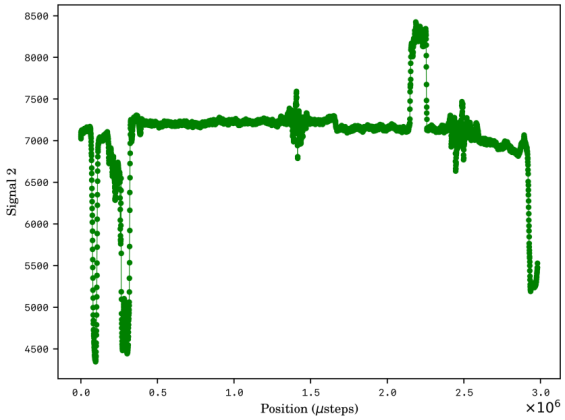


Figure 3: Data collected, from which we realised the null point in a positive value of micro-steps position. This is the data collected from Detector 1. As can be seen, all the data collected in the positive range is useless.

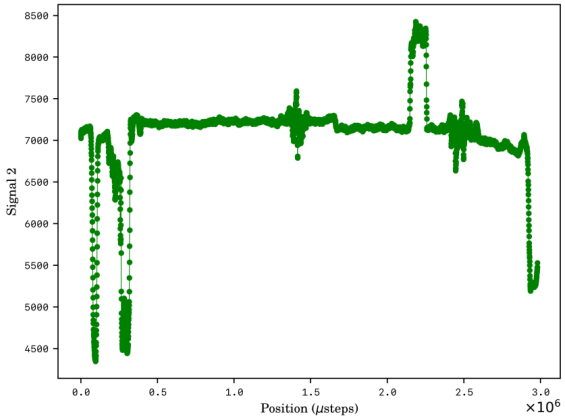


Figure 4: Data collected, from which we realised the null point was at the negative range, in a positive value of micro-steps. This is the data collected from Detector 1. Therefore, this data is pretty much redundant.

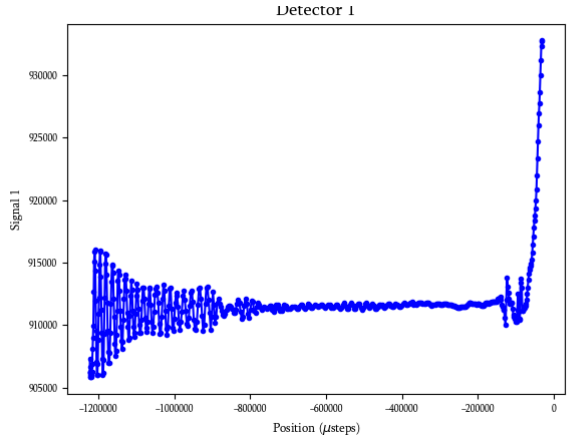


Figure 5: Data collected when scouting the null point. From this, we can see that we are beginning to approach the null point as we go further to the left, hence we require that our range is less than –120000 micro-steps.

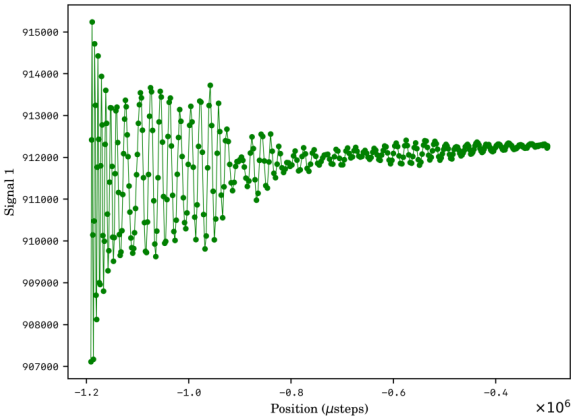


Figure 6: More data, similar to **Figure 5**. As can be seen, we haven't yet reached the null point, which is beyond the –2,000,000 micro-step range, so we need to go further back. Consequently, we took our interferometer back to a position of approximately –3,000,000.

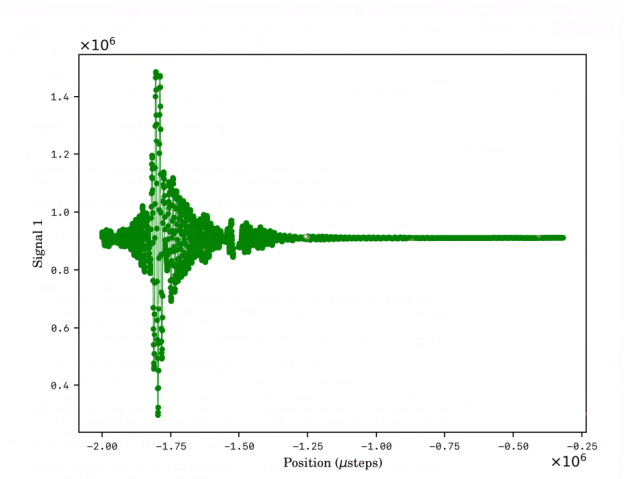


Figure 7: More data to **Figure 6**. Again, we need to go further back before we can identify the position of the null point, which can be found approximately at –180,000.

Figure 8: The completed graph showing the null point at approximately –180,000 micro-steps, as outlined above in **Figure 7**. This is characterised by an abrupt increase in the amplitude of the signal.

Figure 9: Garbage data. This is included for the sake of completion within the lab book.

Figure 10: More garbage data, included for the sake of completion. This was bad data as we hadn't even turned on some of our apparatus, evidently resulting in this monstrosity.

Task 9

You have been given a white LED and a blue LED.

1. *Take interferograms of the white LED, the blue LED and the white LED with one of the filters.*
2. *Find the mean wavelength of each of these sources (assuming constant distance between samples)*

3. *Find the coherence length of each source*
4. *Use this to find the spectral width of each source. You can use the formula:* $\Delta\nu \times L = \frac{c}{2\pi}$ (4). *To turn this into wavelength you can use:* $\Delta\nu = \left(\frac{c}{\lambda^2}\right)\Delta\lambda$ (5).
5. *Try taking an FFT of these interferograms. Does what you see make sense?*

In order to take this data, we simply swapped out the green laser for the white LED, as well as the blue LED. This is taking into account the new position of the null point. Having done this, we started with the blue LED and took two interferograms, without any filters. This was done over a broad range in order to result in better data collection. From this, we used quick_plot.py in order to plot our data, and resulting in the following **Figures 11 – 15** which can be seen below.

The data shown includes: the blue LED (zoomed in), blue LED (zoomed out), white LED with orange filter, white LED, and white LED with yellow filter, in the order shown.

Preliminary Data

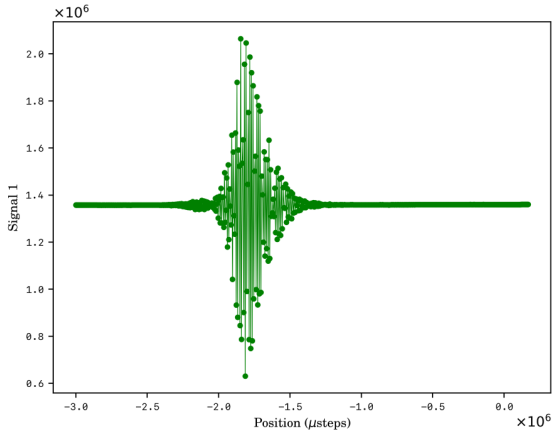


Figure 11: The preliminary signal intensity distribution for blue light, showing the position of the null point at approximately –180000 micro steps. Only Detector 1 was used for this experiment. Even in this data, we can see that there is an asymmetric distribution.

Final Data

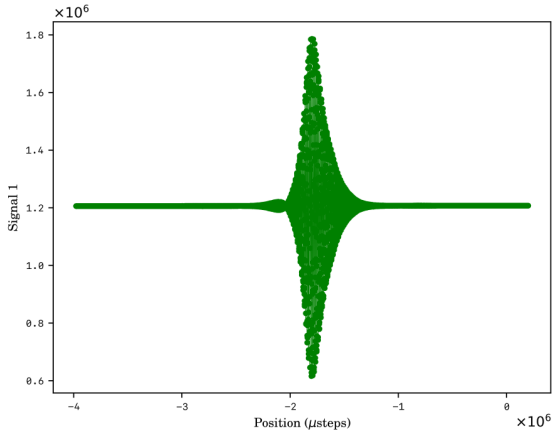
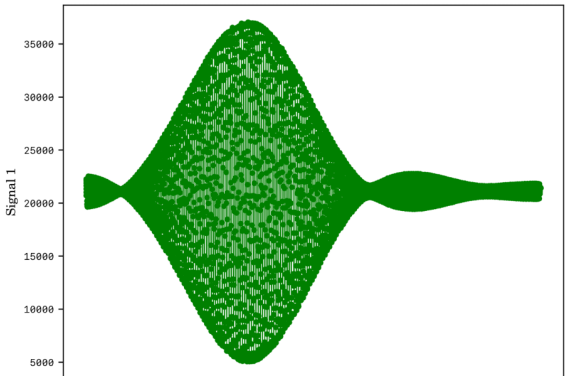


Figure 12: The final signal intensity distribution for blue light when moving the mirror (a repeated trial), showing the position of the null point at approximately -180000 micro steps. Only Detector 1 was used for this experiment. There is clearly an asymmetric distribution, with the data being skewed towards the right.



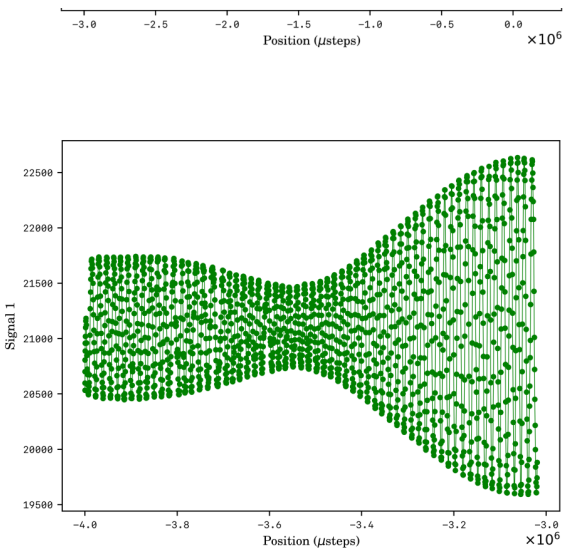


Figure 13: The final signal intensity distribution for orange light, showing the position of the null point at approximately –180000 micro steps. Only Detector 1 was used for this experiment. This asymmetry exists.

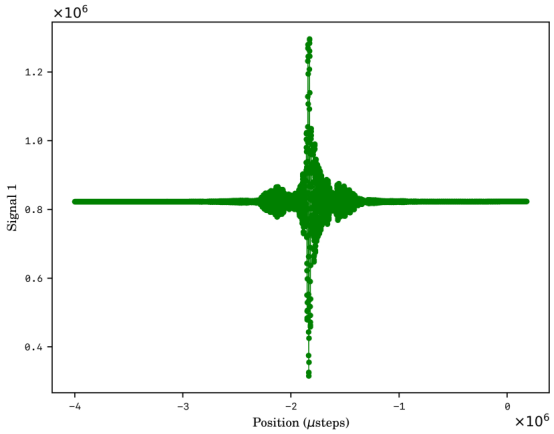


Figure 14: The final signal intensity distribution for white light, showing the position of the null point at approximately –180000 micro steps. Only Detector 1 was used for this experiment. For white light, as can be seen, there is continuum of wavelengths exhibited resulting in this less sharp distribution, more $sinc$ in its behaviour. There is also less of a skew in this data, albeit with a slight asymmetry.

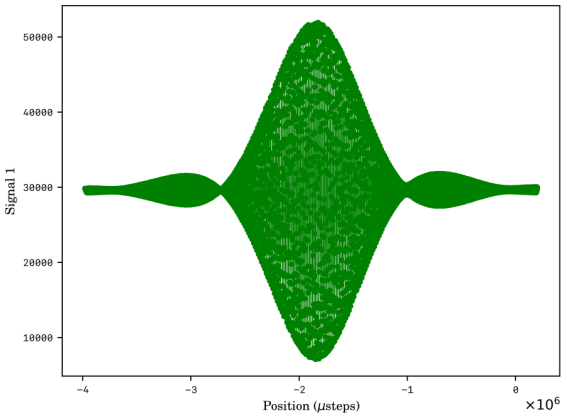
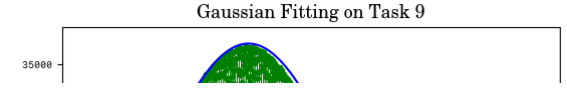


Figure 15: The final signal intensity distribution for yellow light, showing the position of the null point at approximately –180000 micro steps. Only Detector 1 was used for this experiment. There is quite a significant asymmetry, with the equivalent data being cut off on the left hand side of the null point peak.

Gaussian Fitting



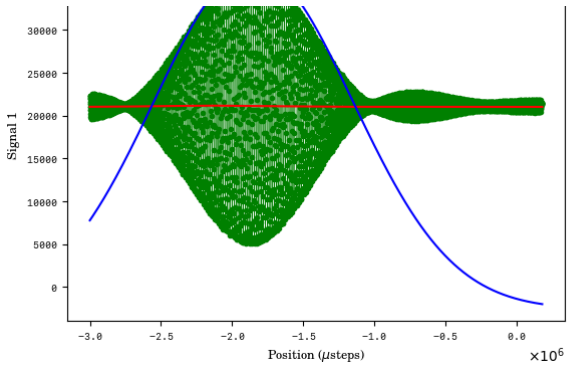


Figure 15: The final signal intensity distribution for yellow light, showing the position of the null point at approximately –180000 micro steps. Only Detector 1 was used for this experiment. There is quite a significant asymmetry, with the equivalent data being cut off on the left hand side of the null point peak.