**Experiment 8: Diffraction Patterns and Gratings**

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**Abstract**

Interference patterns are observed when coherent light is split and a portion is forced to travel a different distance such that it re-converges at a relative phase difference. Using this fact, and a set of optical flats, which are separated by a strand of hair, we determine that the width of a hair is 14.84 micrometers. The radius of a glass surface is also calculated to be 1962.4km from measurements taken to characterize interference observed as newton rings.

**Introduction**

Diffraction patterns were studied by shining a laser light source through varying masks and onto a screen. This particular laser emitted light of wavelength 651nm. As the light travels through the mask, the resulting pattern depends on the shape of the holes in that mask. Our masks were all on one disk, along its perimeter, such that all that was needed to select a different one was to rotate the disk so that the mask with the desired geometry was hit by the laser.

A metal rail support system was used which we could secure bra

**Analysis & Discussion**

Initially observed the resulting interference pattern from two optical plates stacked one on top of the other. The pattern that results tells us something about the flatness of these plates, as if they were perfectly flat, we’d not expect to see such an easily observed pattern.

The image below was taken at approximately 36.85cm+- 1cm from the top of the flat. Windows from ImageJ are included here as extra description, and to give a more easily understandable profile plot.

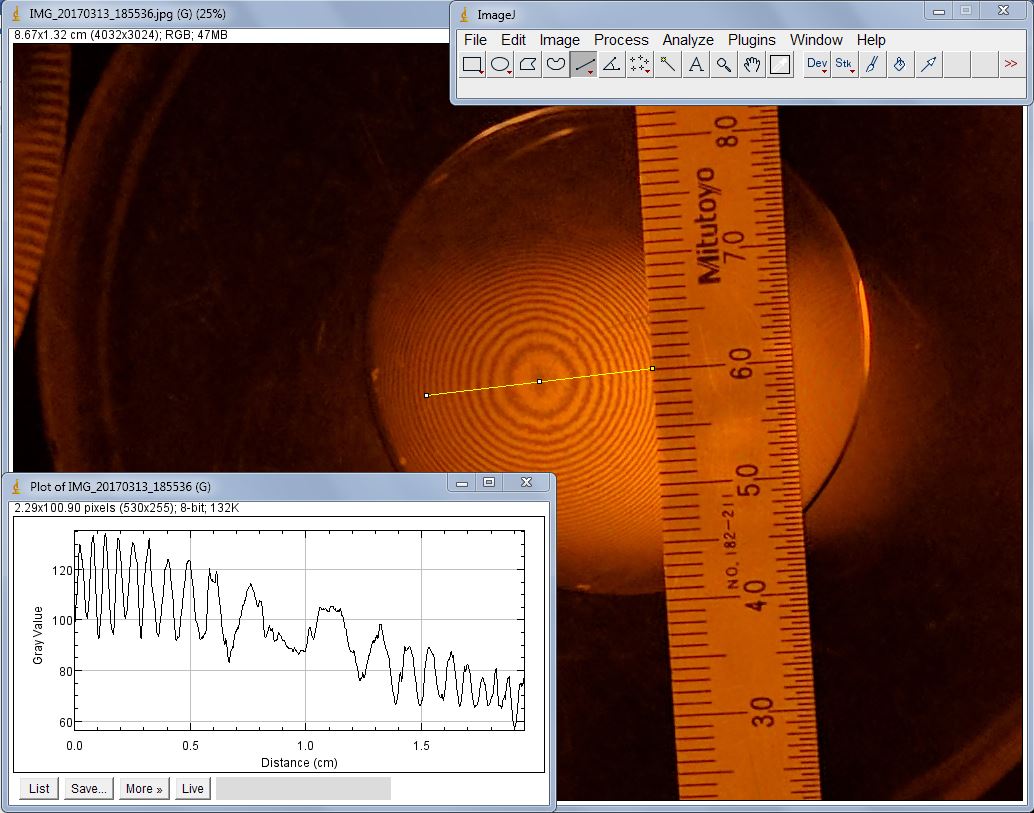


Figure 1:Interference from imperfect Flats

When playing with the angle of this line of analysis, the interference pattern was no longer distinguishable when going a distance 1.07cm from the 0th order fringe [the center]. Therefore, the angle that spans an area of clarity in this case equals: . Regardless of this resolution, these plates are not flat. Plugging the fact that our highest differentiable fringe is of order 24, and our wavelength of 589.2nm into our equation for d, the spacing between the two plates comes out to be about 24\*(589.2nm)/2 = 12=7070nm. This is decidedly worse than expected, and leads to the conclusion that this was not actually a flat, but a curved piece of glass meant for the observation of a newton ring.

When replacing the sodium lamp with white light, it is still possible to see very low order fringes but the interference then becomes very hard to discern. This is because white light is comprised of light of various wavelengths such that the point of constructive interference for one light fills in the gaps that would have been destructive interference for a different light.

The thickness of a strand of hair was found by measuring the interference pattern introduced by placing a hair in-between two glass flats. First we determined a portion of the pattern that has similarly spaced oscillations and measured the distance from peak to peak to be 0.08cm. For the distance from the plates’ point of contact to the hair we measured 4.03cm. These values were entered into a combination of equations from the introduction to give us 14.84 micrometers.

This conclusion does not tell me anything about the roughness of the flats as the hair is about 28 times as thick as a single wavelength. If the previous image for optical flats were in fact flats, this would mean they are rough to about the scale of hair thickness.

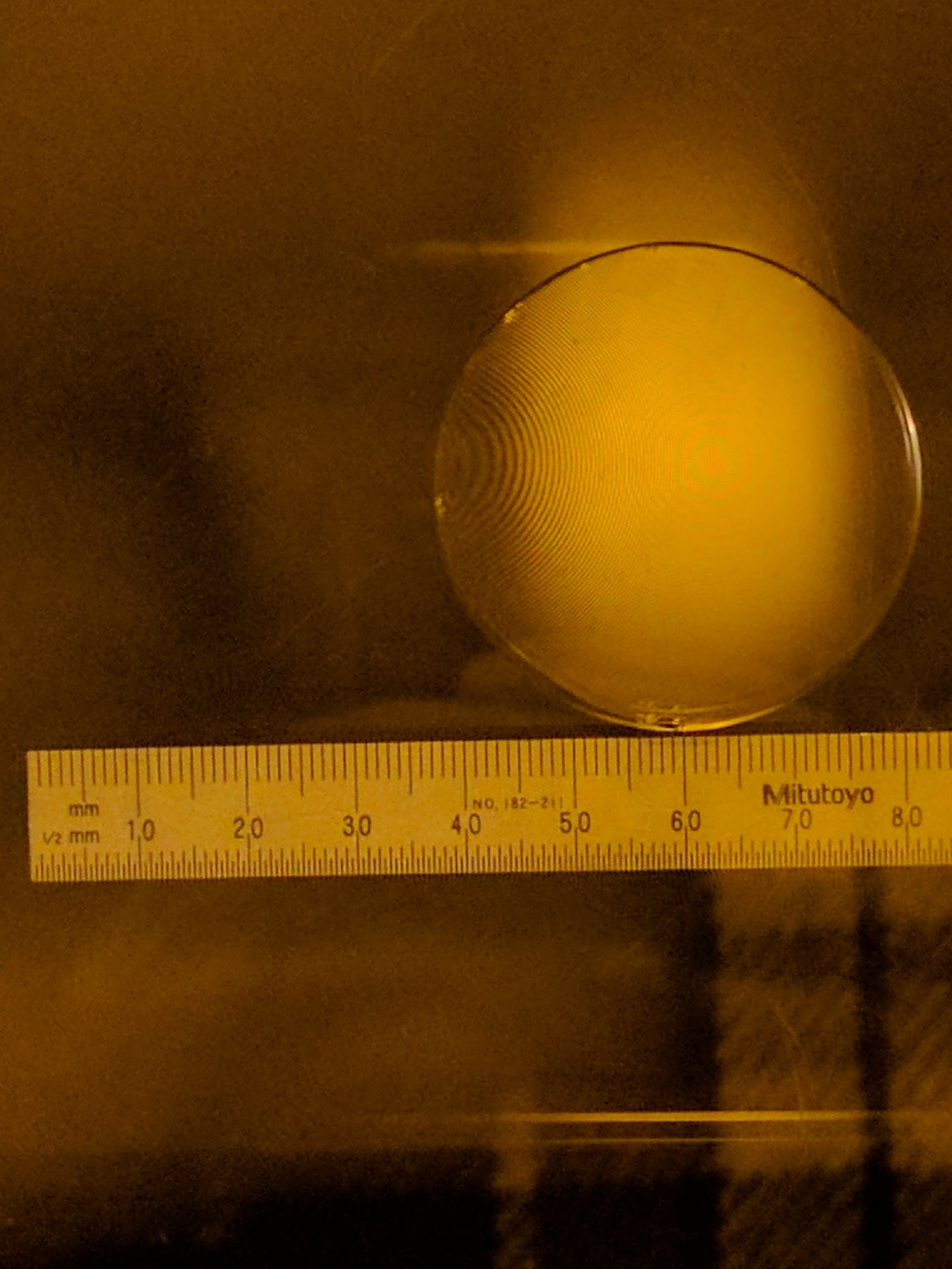


Figure 2:Thickness of Hair

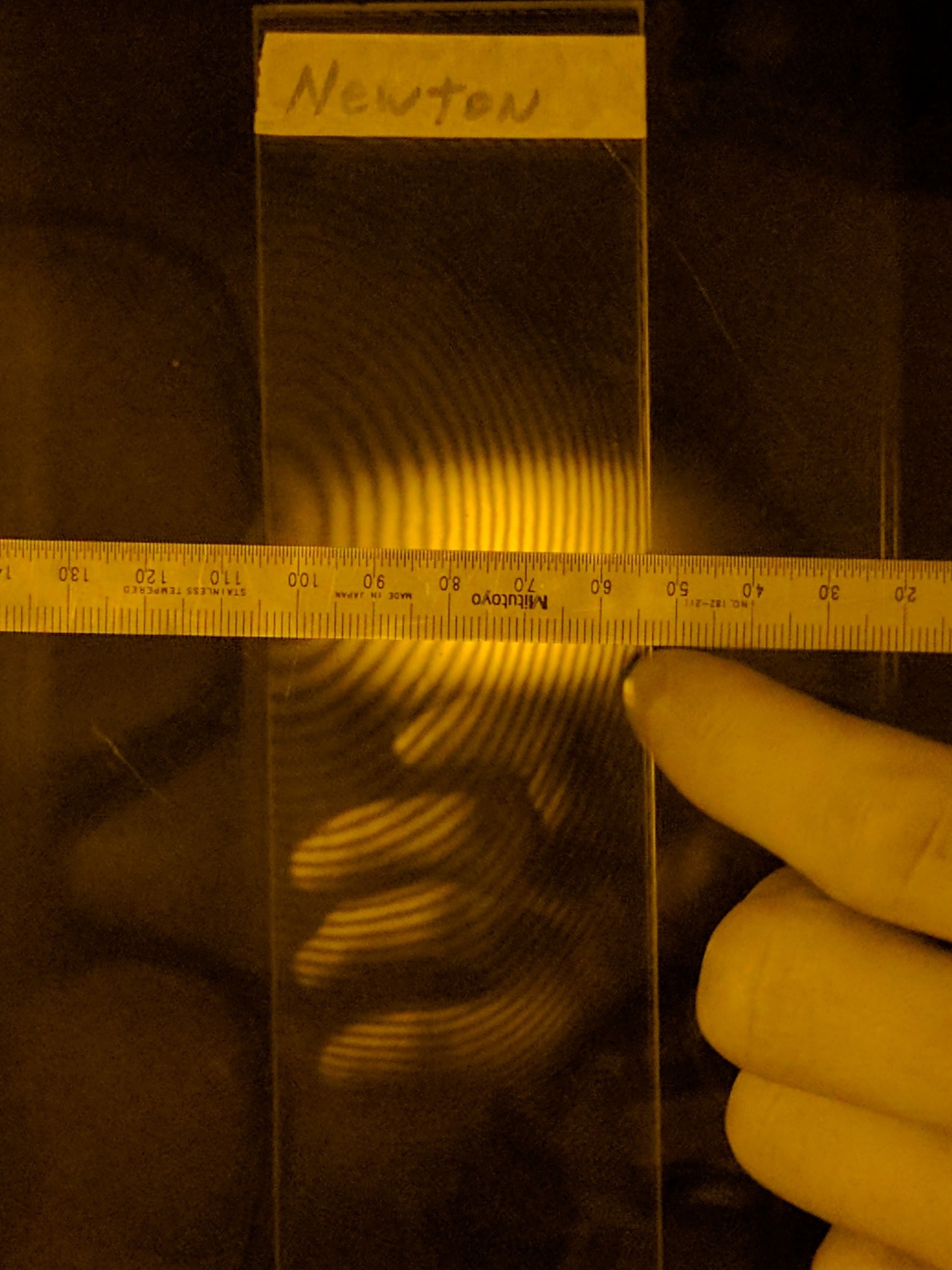


Figure 3: Newton Rings

Circular fringes [Newton’s Rings] were then observed with the curved side of a piece of glass face down on top of another flat. The diameter of each ring should grow as the square root of its order as can be seen in the image and the equation from the introduction.

Figure 4: The radius of concentric circles in a newton ring interference pattern grow with sqrt(n)

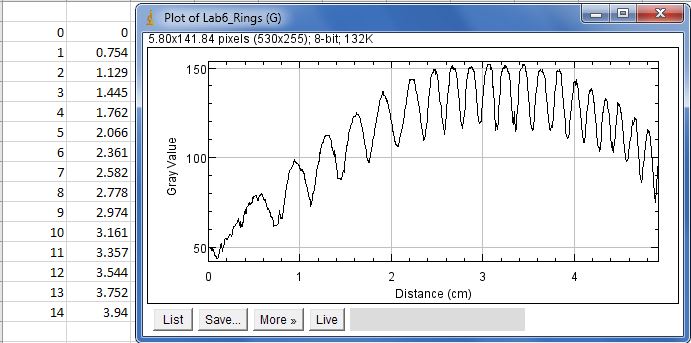


Figure 5: The profile of the image in figure 3 is plotted using ImageJ

Note that the raw data in figure 5 is not squared, yet the square of this data is what was used in the plot from Figure 4.

You can see that a linear plot fits very well to the data giving an R-Squared value of 0.9953. Associating the slope to , and knowing that the wavelength is 589.2nm it can be concluded that we’ve measured the radius of curvature for the curved glass to be 1.1563/589.2nm = 1962.5 km. This radius seems difficult to believe.

**Conclusion**

We measured the angle of clarity that could be seen when looking at interference observed from two optical flats to be 1.66 degrees. This is the angle made from our eye and spanning the zeroth order to the last discernable fringe.

The smoothness of the initial two flats was measured to be in the order of 12 times the wavelength: 7.07 micrometers. This is far higher than the expected factor of 1-4. It is very likely that these plates were not normal flats and an opportunity to verify this is needed.

Measuring the thickness of something in the order of a strand of hair is quite effective from observations of resulting interference patterns. The thickness of thin blonde hair was calculated to be 14.84 micrometers and very nicely agrees with the known values thicknesses of hair referred to as ‘Flaxen’.

Measuring the differences in trough to trough distances in newton ring interference patterns gives us a radius of curvature for the curved glass plate. However, a calculated radius of 1962.5km seems curiously high. It is very likely that this could be improved by taking more care to image the plate such that more data could be taken.