5.2: Activities

Equipment

- laser & optical bench
- microscope comparator
- compact disk
- tape measure
- masking tape & paper

The General Idea

There are two parts to this lab, both of them seeking to answer a question. The first question is, "What is the approximate width of a human hair?", and we will do it in two ways. The first is to look at it directly through a special microscope called a comparator. The second way, which we hope to confirm the first measurement, is to use laser light and the diffraction pattern the hair produces thanks to Babinet's principle. In the second part of the lab, the question we seek to answer is, "What is the approximate spacing of the grooves on a compact disk?" For this we'll again use laser light, and observe the reflective interference pattern.

Some Things to Think About

Here is a repeat of the safety warning given in the previous lab regarding the use of the laser:

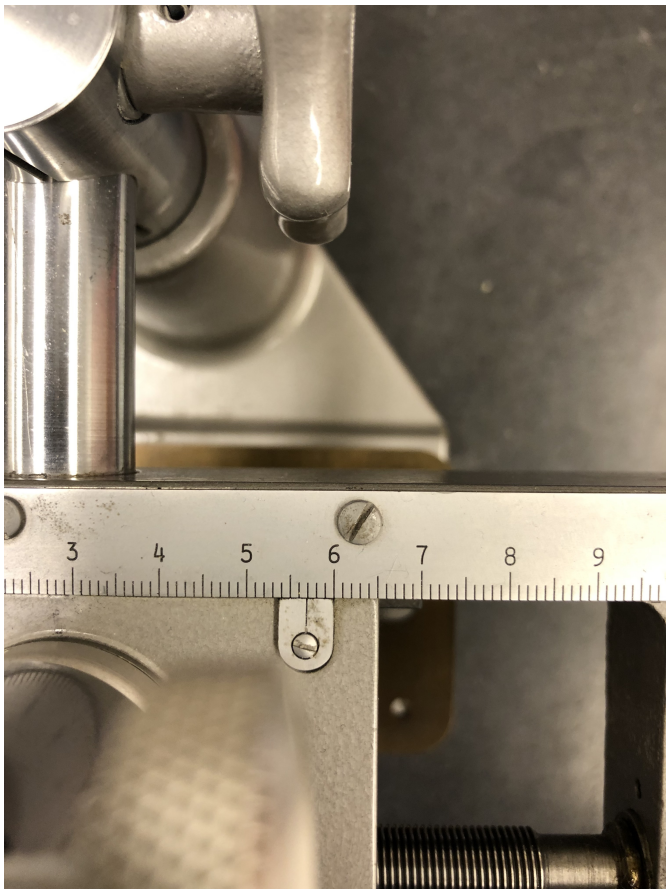
Do not look directly into the laser beam, as it can damage your retina. All viewing of the laser should involve seeing it reflected from a dull, diffuse surface, like a piece of paper. It therefore goes without saying that it should not be pointed at anyone, either.

As with the previous lab, if you need to make any marks to indicate positions in your interference patterns, please use paper & masking tape – please don't write on the walls or blackboard.

We are using the same $633nm$ wavelength laser that we used in the previous lab.

Part 1

- The use of the comparator is not immediately obvious, though you'll understand it better with a bit of trial-and-error. The idea is this: This device is a microscope with cross-hairs (or perhaps just a vertical line), which can move side-to-side, achieved by turning a crank. The amount it moves can be measured to a very small dimension. Measurements come from two scales on this device that are used in tandem. The first is on the horizontal bar, and this is a typical ruler – the markings show centimeters and are subdivided into millimeters. There are also markings on the dial around the crank, dividing it into 10 numbered sections, with 10 subdivisions each (so a total of 100 measurable positions per crank revolution). You should play with this crank to see how the dial divisions are related to the horizontal bar distances, so that you can use both scales together to get an accurate measurement of the distance that the microscope moves laterally when the crank is turned.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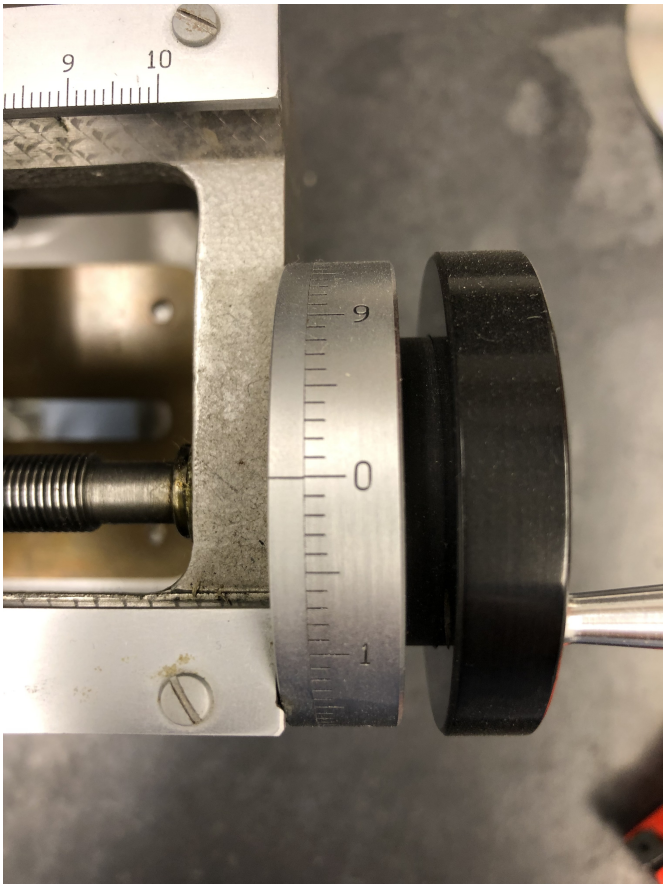
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- You are using this comparator to measure the width of a hair, so once the hair is aligned with the line (which of course can only be done after you bring the hair into focus), then moving the line from one side to the other should give you what you need.
- The interference pattern create when you shine the laser through the hair is not quite the same as the one you saw with the double slit in the previous lab. The equations of the two cases look similar, but they are subtly different, and understanding the difference is important.
- Because of the broad area covered by bright fringes and narrow regions, it is better to use separations of dark fringes rather than separations of bright fringes. [Also, it is mathematically more challenging to determine the formula for the spacing of brightest points.]
- As always, the percentage uncertainty is reduced when you use larger dimensions for a given absolute uncertainty. The dark fringes are equally-spaced, so this should give you an idea about how to determine these separations more accurately.
- How will you compute the $\sin\theta$ (found in the formula) from what you can measure?
- What do you estimate to be the percentage uncertainty in comparator measurements of the hair width, and how does this compare with estimated percentage uncertainty of hair width using the laser, i.e. which is the weakest link?

[*Not part of lab report: Do you recall seeing a pattern similar to this within the double-slit pattern from the previous lab (i.e. shown in the brightness of the many fringes)? Any idea why it would be there? Check with your TA to see if you have the answer.*]

Part 2

- Remember that in this case, the laser light is reflecting off the grooved (shiny) side of the compact disk.
- In order to make the distance between bright fringes as easy as possible to measure, you will want them to deflect from the central bright fringe *horizontally*. Think about how you should position the compact disk in the laser beam to achieve this.
- How will you compute the $\sin\theta$ (found in the formula) from what you can measure?
- How many bright fringes can you see? How many can you use to make measurements?
- Once you have determined the spacing of the grooves, convert this into a groove *density*. Approximately how many grooves are there on the entire CD?
- If the distances to the bright fringe(s) on the right are a different distance from the cental fringe than those to the left, what does this tell you about the alignment of your apparatus?
- We don't really have numbers to compare in this case, but you should still make an estimate of percentage uncertainty in your measurement of the groove spacing.

Lab Report

Craft a lab report for these activities and analysis, making sure to include every contributing group member's name on the front page. You are ***strongly encouraged*** to refer back to the Read Me as you do this, to make sure that you are not leaving out anything important. You should also feel free to get feedback from your lab TA whenever you find that your group is at an impasse.

Every member of the group must upload a separate digital copy of the report to their lab assignment in Canvas *prior to leaving the lab classroom*. These reports are not to be written outside the lab setting.
