Pepito Lab Characterization: Wavelength Calibration

AST 4930 Obs Tech 2

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Intro

The purpose of this lab is to determine the grating angle of the instrument Pepito and find the wavelengths of spectra of various gases captured during the lab. These spectra will help us further characterize Pepito and calibrate the instrument.

Procedure and Data & Results

To begin, the angle of Pepito was roughly measured using paper, a ruler, and a protractor to get an idea of the grating angle. This angle was approximately 17 ± 1 degrees by my measurement of the inner angle.

After, we pointed the light collecting fiber towards the ceiling and captured a 1 second exposure. The goal of this exposure was to capture a mercury spectrum.

Next, we took exposures of the sunlight for three seconds, ten seconds, and thirty seconds. The following class lab assistant Jared recaptured sun spectra for us to use in this lab.

Then, we excited vials of helium, hydrogen, and neon and took ten second exposure of each.

Once the data was acquired, all files were uploaded to a dropbox and distributed. This data was then uploaded into a jupyter notebook. Once uploaded, I printed the images to estimate where I needed to crop the file. This turned out to be 350 to 450 on the y axis and 0 to 900 on the x axis for each image. Once cropped, I took the mean along axis = 0 to form a usable spectrum for each image.

I then plotted all the spectra on one graph to see their values relative to each other, shown in figure 1. After this I printed the NIST wavelength table for each element to help me identify any obvious wavelengths. I used the observable wavelength column to plot behind the spectra to see if any of the lines matched. These plots are shown in figures 2 through 5.

Chart

Description automatically generatedChart, histogram

Description automatically generated

Figure All Spectra Figure Mercury

Chart, histogram

Description automatically generatedChart, histogram

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Figure Helium Figure Hydrogen

Chart

Description automatically generated

Figure Neon

Once the spectrum was plotted began with the neon spectrum making estimates of where I believed the spectral spikes to be. Then, following the wavelength calibration notebook I improved upon these guesses which produced eight x values listed below. These guessed points are plotted in figure 6.

[84.04518316319938,

114.78478093524011,

183.78829039174053,

206.40975505276685,

220.63915380859257,

239.6429633695977,

260.1708826893014]

Chart, histogram

Description automatically generated

Figure Guessed Neon points

Then, I further improved upon these guesses using the NIST data table to provide known neon lines. The improved guesses are listed blow, we can see that some of our original guesses have been improved, some removed, and some added. The 400 and 300 values were x guesses we entirely left out in our first estimations.

[525.9785306943977,

418.1729633027523,

418.12914795699726,

417.7485068438266,

417.5125463331328,

417.0405190404364,

374.0953070683661,

358.58622830067657,

332.5209137373527,

290.4229791661179,

115.9923643827471,

115.12967868360643,

114.97258363509087,

84.6300646285281]

The first fit for neon is shown in figure 7 as well as the points in figure9, and for comparison the second fit is directly beside it in figures 8 and 10. Here for the line plot we can see that our points are now better spread out and follow the line a little more closely and that the noisy points for the point plot have been filtered out as well.

Chart, line chart

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Figure First Neon fit - line Figure Second Neon fit - line

Chart

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Description automatically generated

Figure First Neon fit - points Figure Second Neon fit - points

This same process was repeted for hydrogen and helium, resulting in the plots below.

Chart, histogram

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Figure Helium points fit Figure Helium final line fit

Chart

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Description automatically generated

Figure Hydrogen first fit - points Figure Hydrogen second fit - points

A picture containing chart

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Figure Hydrogen fit line

Chart, line chart

Description automatically generated

Figure Best Wavelength Fit, all

Plot 16 gives us our final fit, showing that the linear fit is in good agreement with the hydrogen, helium, and neon spectra. Finally, by taking the median of our hydrogen, helium, and neon final wavelength fits, we get a wavelength that we can plug into the grating equation to solve for the angle of pepito. These values are shown in table 1. The grating equation, , solved for theta = where n = 1 and D = 830 mm.

|  |  |  |
| --- | --- | --- |
| Element | Wavelength (mm) | Angle (degrees) |
| Neon | 475.34639000000004 | 34.939174 |
| Hydrogen | 460.2201 | 33.675047 |
| Helium | 395.143845 | 28.429491 |

Error

The first measurement of the grating angle varied greatly from person to person. Error was introduced in positioning the protractor and reading the measurements. It is possible that the exposures have some error from the fiber alignment, however the nearly straight alignment of the lines in the exposures tell us that the cables fit well enough.

When taking the exposures of Mercury, we used the overhead lights as our source. These lights are contaminated and not purely mercury, therefore introducing error into our spectra. It is possible our other sources were contaminated from age as well. For these reasons the Mercury spectra was not included in this lab because It might throw off the wavelength solutions too severely.

The group I was in changed the focus on Pepito leading to data skewed from the other two groups. This introduced additional error into our data.

I had to complete the wavelength solutions in another notebook due to unknown difficulties in the first notebook. The same code ran in a clean, new notebook so two .ipynbs will be submitted for this report.

Conclusions

The angle found at the beginning of the lab, 22 degrees, is not in good agreement with the angles found by the captured spectra. This could be a result of the discussed errors in the error section of the report. There were multiple points where inaccuracies could have been introduced to the experiment. I would have expected the angle to be off by plus or minus five degrees, however we see that the closest angle calculated is still six points away.

* Sun spectra - fiber is titled slightly
* Seeing some images of slit – more blurring than idea (unsure)
* Never perfectly aligned with x axis. Spectra has some natural curve t it. To counteract this we use tracing. We see slope to spectra and hint of curvature when looking up close. Need out b/c we’re averaging. If we took it straight across we would be averaging two diff sources b/c not aligned correctly.