Pepito Wavelength Calibration Homework
Observational Techniques for Astronomy (AST 6725)

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1 Mercury Lamp Wavelength Calibration

First, I performed the wavelength calibration with one of the archival mercury lamp images, `hg_lamp_1-sixteenth_s_2.bmp`. This file seemed to be slightly shifted horizontally from the file not ending in 2, `hg_lamp_1-sixteenth_s.bmp`. This was the case for all of the lamp images. *Sarik said this was because the table Pepito was on got bumped when these data were taken, so an additional set of arc lamp images were taken. It is not clear which set of arc lamp images corresponds to the stellar data (pre-bump or post-bump), but I am assuming that the second set of images were taken so that the post-bump conditions could be measured (which would likely be when the stellar spectra were taken). In other words, if the stellar spectra were taken pre-bump, their lamp images would already have been taken, so a second set would not have been necessary.*

I began by converting the bitmap file to a FITS file. I collapsed the spectrum along the slit axis and plotted the intensity against the position on the detector. I found the pixel-position centroid of each of the three lines in the spectrum and input them into a line list file. Then, I used the "Persistent Lines of Neutral Mercury" page from NIST to identify known bright lines of mercury. I determined that the 5460.735 Å, 4358.328 Å, and 4046.563 Å lines (going from red to blue, or 0 to 1600 pixels across the detector) give a linear wavelength solution by plotting known wavelength against detector location. The pixel locations corresponding to the peaks of those lines were 136.85, 1215.22, and 1520.87 respectively. I used a three-degree polynomial fit for this fit. I know the solution is linear because the standard deviation of the residuals (fitted wavelengths versus known wavelengths) is on the order of 10^{-12} Å. I used the polynomial fit to the mercury lamp wavelength solution to more accurately guess to which wavelengths the lines in the krypton lamp spectrum corresponded.

2 Krypton Lamp Wavelength Calibration

Initially, I tried to use the wavelength solution from the mercury lamp to estimate the wavelengths of the lines in the neon spectrum. However, I was unable to match up any estimated wavelengths with lines on the NIST sites for neon (neither the "persistent" or "strong" line lists). So, I decided to try determining wavelength solution using the krypton lamp data, which I would then use to estimate the wavelengths for the neon spectrum in combination with the mercury lines. I used the `kr_lamp_p6_2.bmp` image to keep the filename ending "2" consistent. I followed a nearly identical procedure as I did for the mercury lamp, so I will not reiterate it here (as I have completed this calibration process over eight times in total now, since I kept doing it incorrectly). I managed to get a somewhat linear solution using three bright lines (5570.2894 Å, 4319.5794 Å, and 4273.9694 Å at pixel locations 27.46, 1250.49, and 1295.03 respectively). I tried to identify three more lines, but could not find bright lines that corresponded to them from the NIST list which gave a linear solution. The three-degree polynomial fit to the krypton wavelength solution has residuals on the order of 10^{-12}, so the solution is still very linear.

Next, I combined the mercury and krypton lines I had fit to get another wavelength solution. I fit this with a five-degree polynomial fit and got residuals on the order of 10^{-12}. I used this fit to estimate the wavelengths of the neon lines I identified next using their pixel locations.

3 Neon Lamp Wavelength Calibration

For the neon lamp calibration, I used `ne_lamp_1s_2.bmp`, one of the archival images. Again, I made sure to use the file ending in 2. After converting the bitmap file to a FITS file, I noticed some hot pixels in the image, perhaps because this was a longer exposure than other lamp spectra (1 second for neon, one-sixteenth of a second for mercury, according to their filenames).

I followed the same procedure as I did for the mercury and krypton lamps. This time, I relied heavily on the FITS file as a guide for which lines to focus on, as there were many dim lines in the one-dimensional spectrum that made it a little difficult to find which lines to fit.

Using the wavelength solution from the combined mercury and krypton lines, I estimated the wavelengths of the neon lines I had identified. I was able to find matching known wavelengths from the "Strong Lines of Neon" NIST page for some lines. These were mostly at redder wavelengths (from about 5562 Å to 5330 Å). At bluer wavelengths, my estimates from the mercury and krypton fit were way off, so I adjusted the wavelengths of my lines using the NIST table until my solution was linear. I was eventually able to get a linear solution using the following lines (at the following pixel positions): 5562.7662 Å (33.67), 5400.5618 Å (194.44), 5330.7775 Å (261.70), 5037.7512 Å (547.60), and 4715.344 Å (869.38). Again, my residuals were on the order of 10^{-13}, suggesting a linear wavelength solution. With a valid wavelength solution for neon, I was able to produce the plots requested by the assignment prompt.

Figure 1 shows intensity (in ADU) versus wavelength (in Å) which I produced by applying my neon wavelength calibration to the neon spectrum (originally in intensity versus detector position in pixels). Figure 2 is a plot of wavelength versus position, the "wavelength solution" for neon that I got. Figure 3 shows the wavelength residuals as a function of position for my neon solution. The standard deviation of the residuals for my neon wavelength solution was 4×10^{-13}.

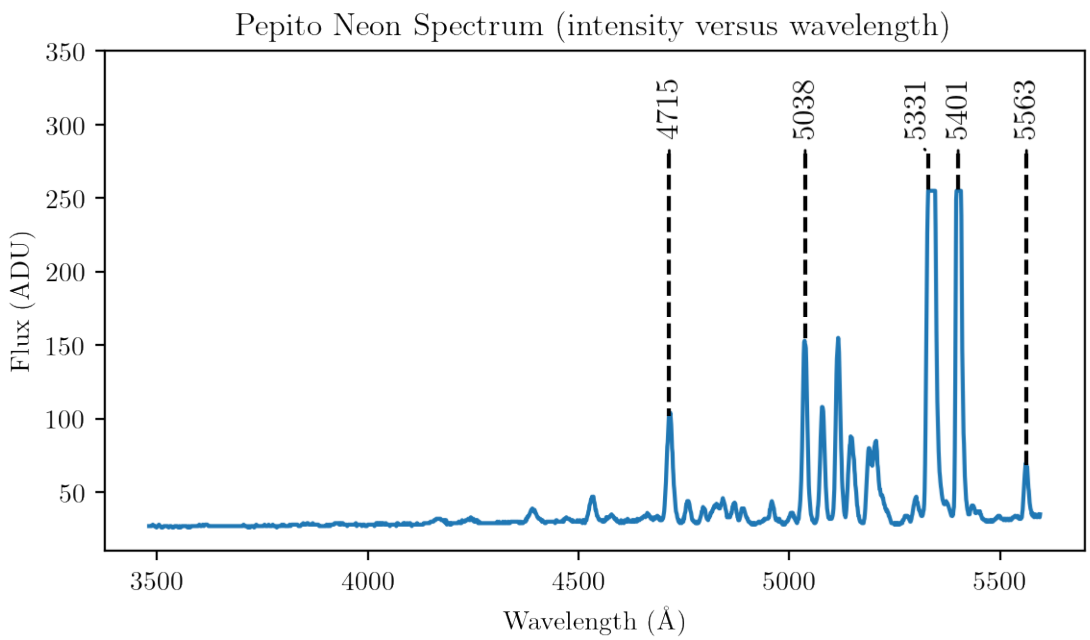

Figure 1: Intensity (in ADU) versus wavelength (in Å) for neon from our Pepito data. The known lines I was able to identify are labeled with dotted lines. The wavelengths are in units of Å and are rounded to 1 Åto fit more easily on the plot.

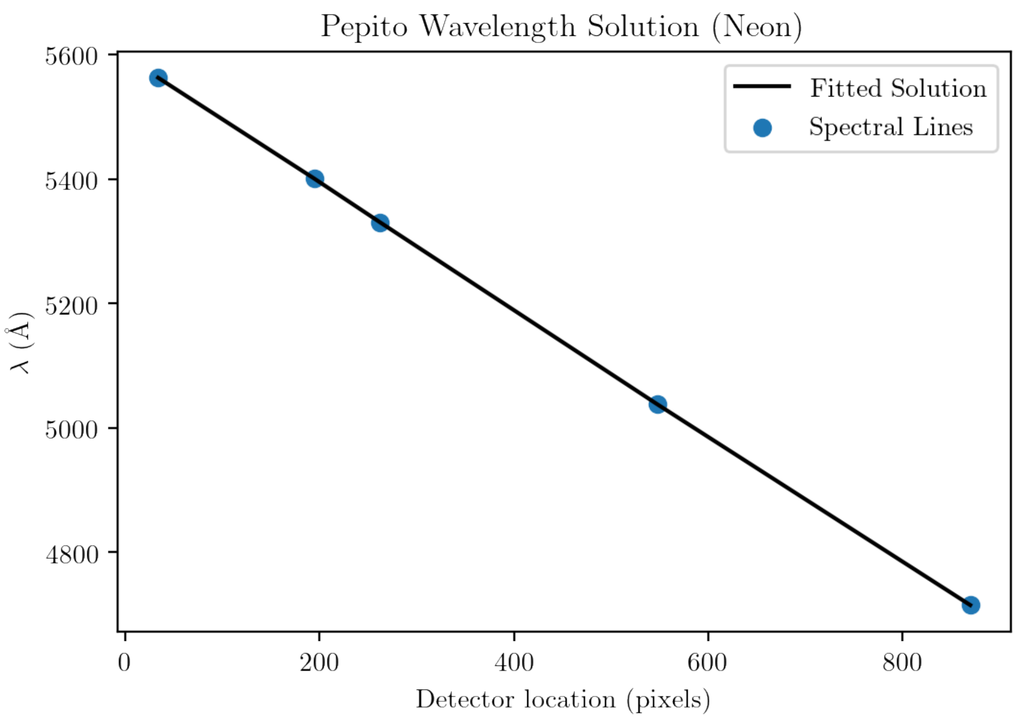

Figure 2: Wavelength (in Å) versus position on the detector (in pixels) for our neon wavelength solution from Pepito. The location of each of the spectral lines I identified in both wavelength and detector x-position are the points. The five-degree polynomial fit to these points is shown as a solid line. The solution is linear to the eye.

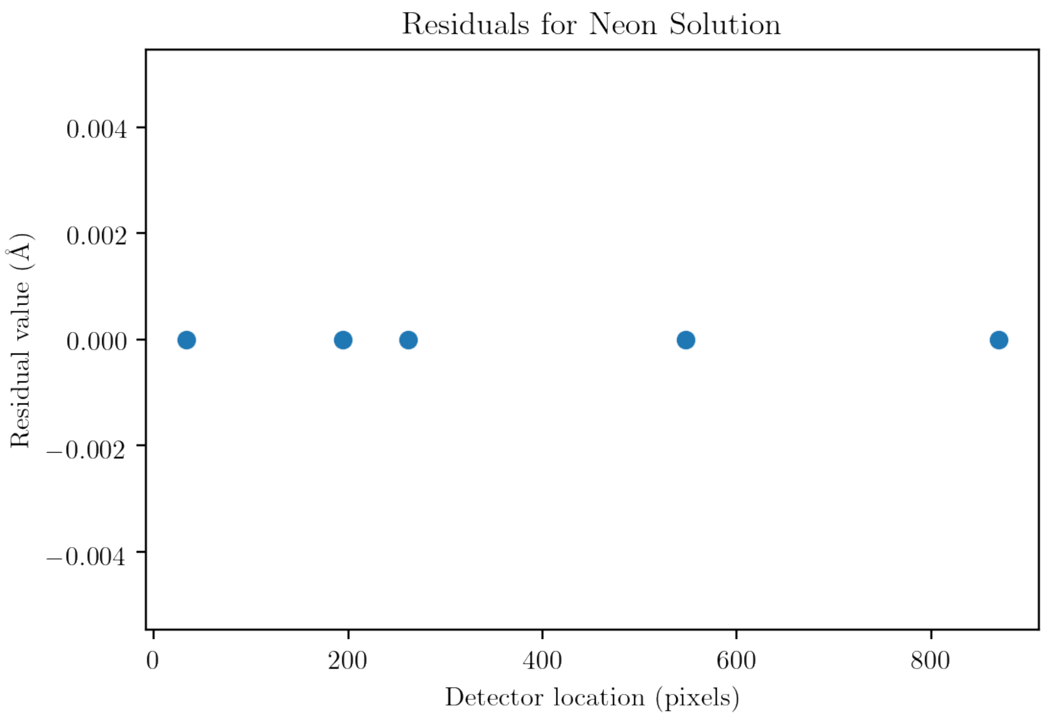

Figure 3: Residual values for my linear fit to the neon wavelength solution, which was shown in Figure 2. The residual values are very close to zero (the standard deviation of the values is on the order of 10^{-12}).