# The Atomic Spectra: Lab 2

PY 313

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**Introduction:**

Atoms are truly a phenomenon with many different properties that define them. Something interesting that happens to these atoms is that they can emit light when they are excited by some external source. Different wavelengths are emitted which correlate to the colors we see in the dark. No atom is the same; each element gives a specific spectrum and wavelengths. Energy levels in the electrons are quantized, they can have discreet levels of energy. In this lab, we will try and measure the wavelengths of light emitted by different elements and compare the predictions. We will use a spectrometer that can split light into different parts which will also be able to measure the light intensity as well. This experiment will be conducted with four different elements that have been put into a tube where it will be excited by an external source where it can then emit light for us to observe and measure. The four elements are Hydrogen, Deuterium, Sodium, and Helium.

**Procedure:**

Proper equipment set-up in this lab is very important for successful measurements. The very first thing that should be done is the calibration of the collimating slits and lens. These parts must be handled with care since they can scratch and break easily. We adjust the slits and lens so that the light beam has a constant width. This allows the sensor to be as accurate as possible when it tries to pick up the light. After that, we mounted the diffraction grating and calibrated the focusing lens. The lens is put between the diffraction grating and light sensor.

The light should be emitted through the grating and focusing lens. This must be done in a dark room without extra sources of light that may be picked up by the sensor. Scanning the spectrum must be done continuously, not too fast and not too slow. Most data collection is done by computer. The amplification of the light sensor is beneficial when trying to observe low-intensity lines emitted. This can be done by the gain switch or in the computer software. Slit widths can be adjusted in situations when there are too many lines present or too little.

To get a precise measurement of the line spacing, we used a sodium lamp to get that number. Knowing that the wavelength of the sodium lamp is 589.3nm, we can measure the angle between the two first-order lines and divide by two, giving us the diffraction angle. With this, we can use d = nλ/sin(theta) for the line spacing. From here, we can scan the atomic spectra of the different elements given to us.

**Data:**

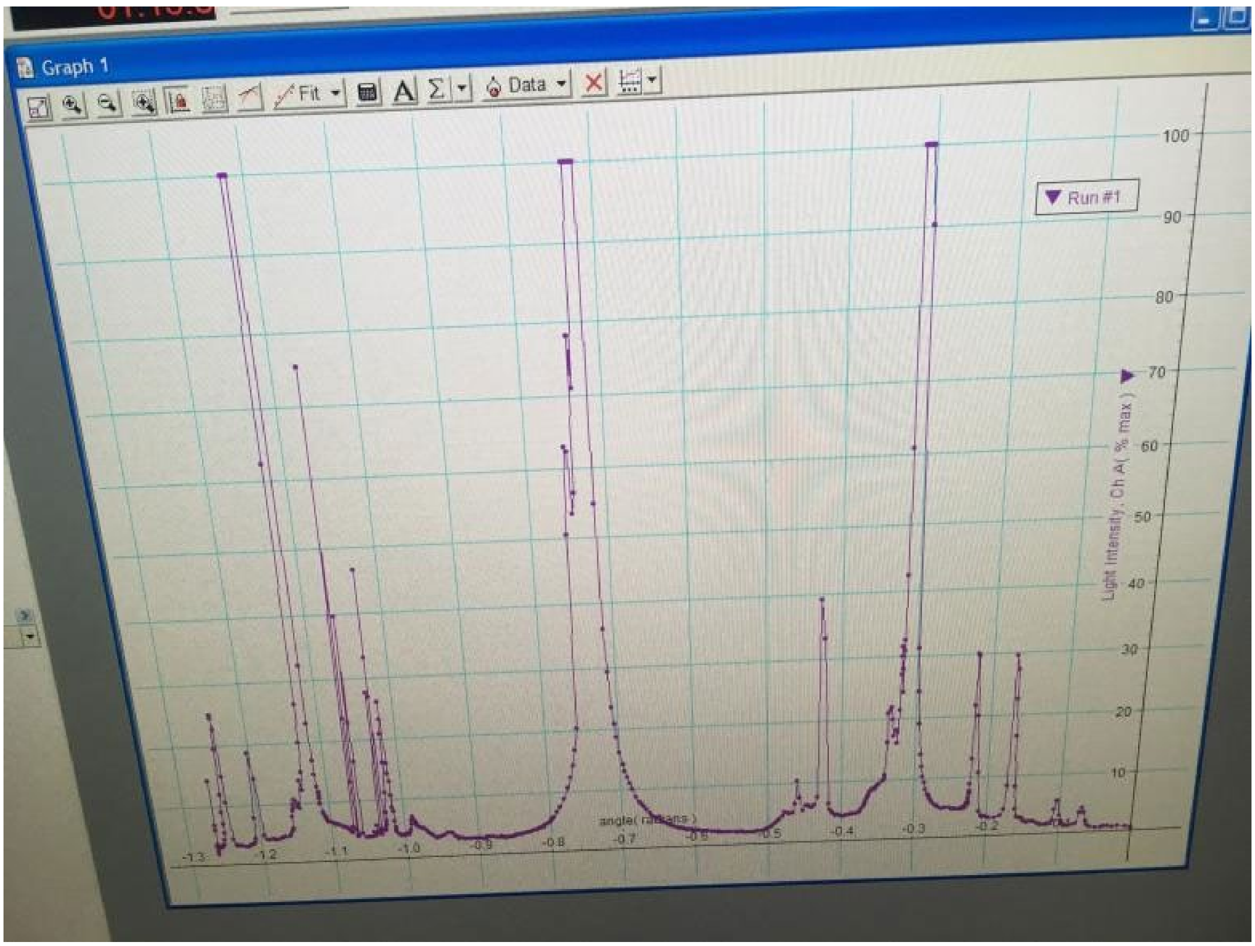



*Figure 1: A graph of hydrogen's atomic spectra.*

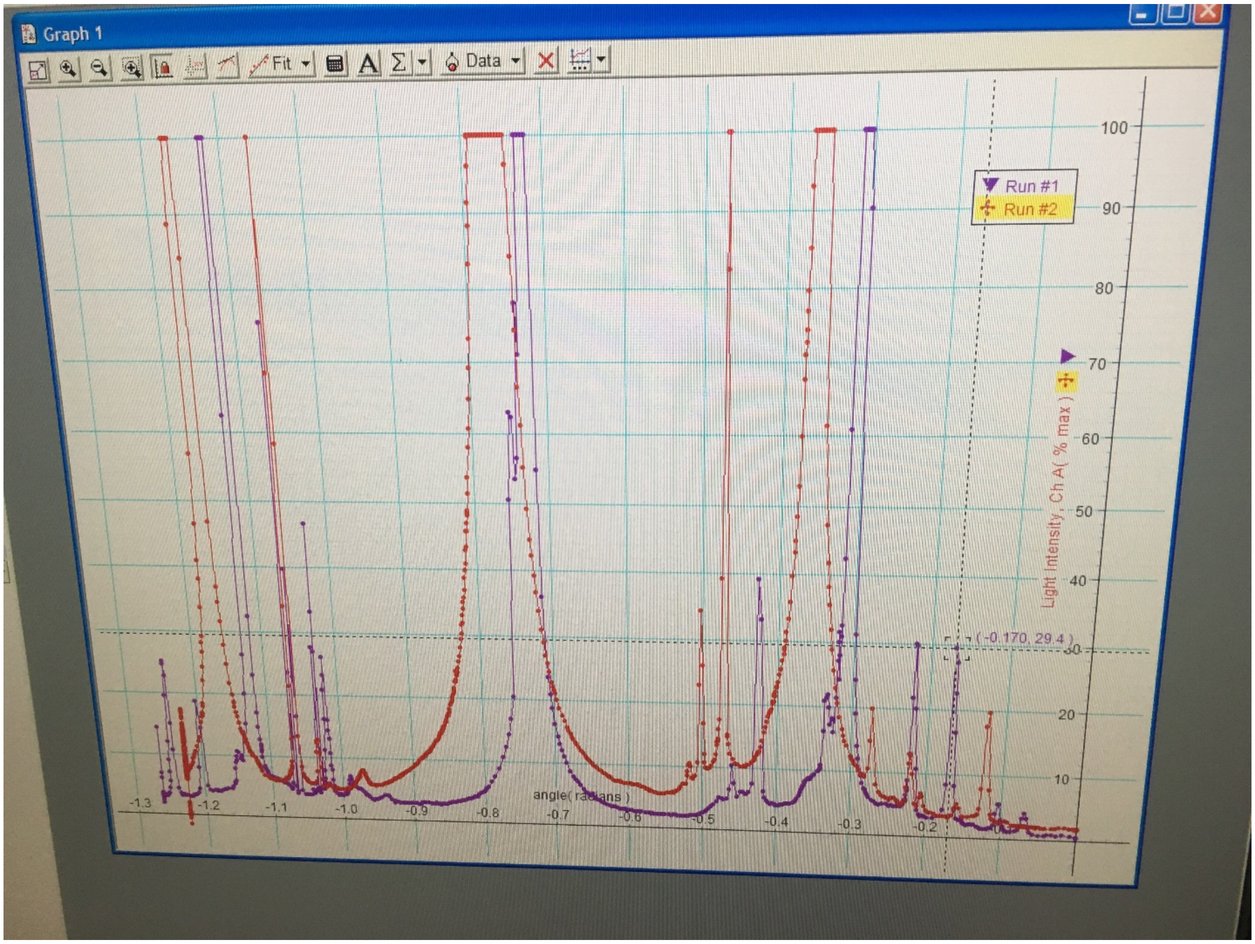



*Figure 2: A graph of Deuterium (orange) and hydrogen's (purple) spectra for comparison.*

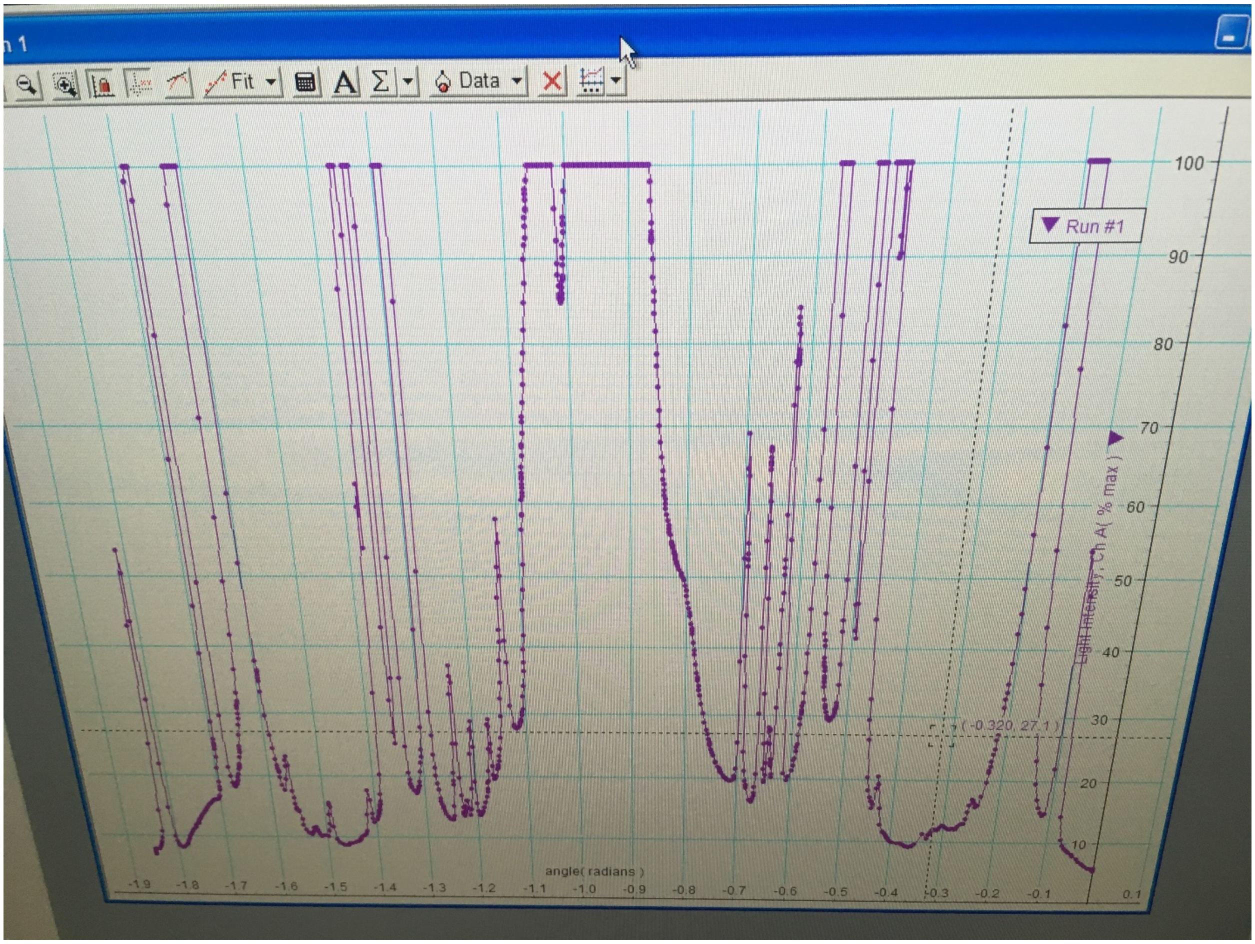



*Figure 3: A graph of helium's atomic spectra*

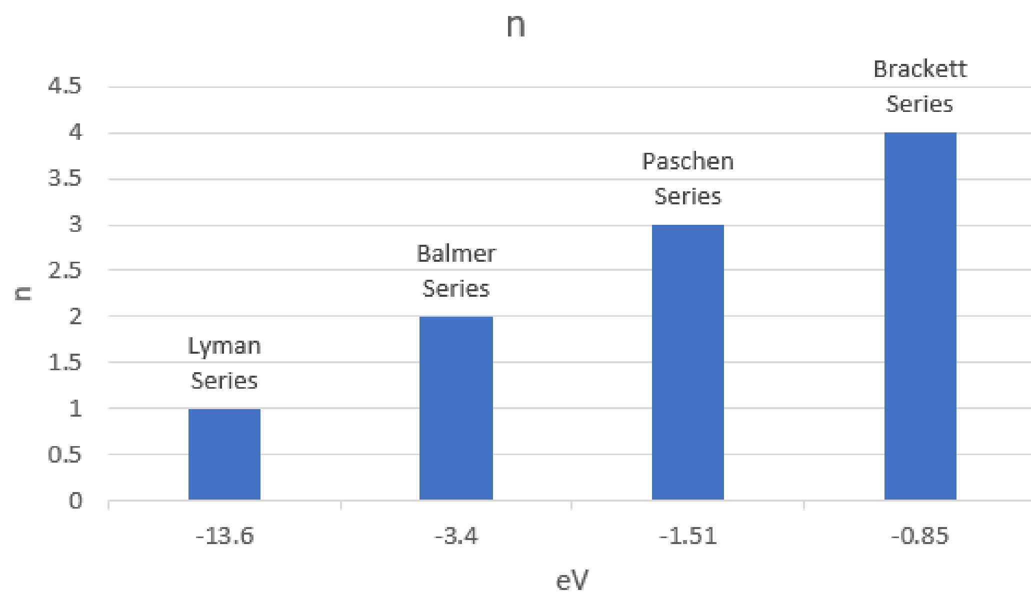
| Element | Angle of Diffraction 1st/2nd Order (degrees) | Wavelength 1st | Wavelength 2nd |
|---|---|---|---|
| Hydrogen | 23.34 | 651.48 | N/A |
| Deuterium | 16.98/23.17 | 480 | 647 |
| Sodium | 21 | 589.29 | N/A |
| Helium | 23.20/42.79 | 648 | 1117.05 |

*Figure 4: A table of each element's diffraction angle at the first and second-order and their respective wavelengths.*

**Questions:**

1. Our value of d was 1644.39nm which was off by roughly 23nm. Using a sodium lamp to calibrate the grating was good because we can see how having a test tube inside

affects us seeing the grating space. Having first-order lines because it would be more accurate. It was hard to see the second-order yellow lines since it wasn't very pronounced, so using them to calibrate the grating wouldn't be as good as the first-order lines.




2.

This is an energy level diagram for the hydrogen elements. The predicted hydrogen wavelength was 656nm at n=2, the first excited state of the atom whereas our measured wavelength was 651nm at the first excited state.

3. To calculate the difference in wavelength for different numbers of visible lines, we use $\Delta\lambda = \lambda/nN$, where N is the number of visible lines. $\Delta\lambda$ for 2 visible lines is 120nm for where n=2, the first excited state. At 3 visible lines $\Delta\lambda$ = 96nm. WE can find the angle between the hydrogen and deuterium lines by finding the difference in wavelengths and using the equation dsin(theta) = n$\lambda$ and solving for theta. For first-order lines, the angle between the two lines is 5.96 degrees.

4. Given the sodium d lines 589nm and 589.6nm, we can find the angle between them in the first-order spectrum. We can take the difference of the wavelengths and divide by

the diffraction grating and solve for theta. With the D lines having such a small difference, the angle between them is also very small at 0.021 degrees.

**Conclusion:**

The atomic spectra show us that each element has different properties which we can see visually when they emit light after being excited. We can also see with Bohr's model that the electrons have different "levels" of energy at each excited stage. This shows us that their energies are quantized. This also has to do with its atomic number. We can calculate the wavelengths where these elements emit their light which allows us to see the different colors. Using the theory of how atoms emit light and putting It together with a practical system, we can see how our derivations translate into the real world.