14 March 2024

Winter 2024

experiment 10

Spectra

University of Wollongong in Dubai

SUBMITTED BY:

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Physics for Engineers

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Purpose

To determine the wavelengths of the colors in the spectrum of a mercury vapor light.

Hypothesis Statement

The mercury vapor light should emit light at distinct wavelengths, resulting in spectral lines appearing at specific angles when passed through the diffraction grating. By measuring the angle of each spectral line using the rotary motion sensor and graphing the intensity of each line detected by the high sensitivity light sensor, one can determine the wavelength associated with each color component in the spectrum.

Materials

- Spectrophotometer System (OS-8539) or Spectrophotometer Kit (OS-8537)
- Rotary Motion Sensor (CI-6538)
- Aperture Bracket (OS-8534)
- Mercury Spectral Tube and Power Supply
- PASCO Interface
- High Sensitivity Light Sensor (CI-6604)
- Basic Optics Bench (part of OS-8515)
- Rod, 45 cm (ME-8736) (2)
- Large Rod Stand (ME-8735) (2)
- Data acquisition software

Procedure – Equipment Set up

1. Position the spectrophotometer near to the mercury vapor light source, as indicated in Figure 1. If necessary, use the Rod Stand Mounting Clamps, two rods and two bases to raise the Spectrophotometer to the same height as the light source aperture.
2. If the light source has a large opening, mask the opening so it transmits a narrow (0.5 to 1.0 cm) beam to the Collimating Slits.
3. Switch on the mercury vapor light source and let it warm up for at least 10 mins.
4. Once the light source is all warmed up, adjust the light source, collimating slits, collimating lens, and focusing lens so that the Aperture Disc and Aperture Screen in front of the High Sensitivity Light Sensor display clear images of the core ray and the first-order spectral lines. Adjust the Aperture Disc so that the central ray is aligned with the smallest slit on the disc.
5. Connect the PASCO interface to the computer and turn on the interface. Start the data acquisition software.
6. Connect the High Sensitivity Light Sensor cable to Analog Channel A. Connect the Rotary Motion Sensor cable to Digital Channels 1 and 2.

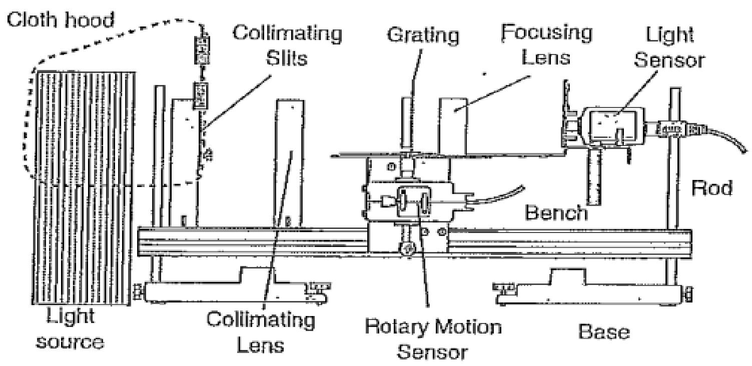

Figure 1: Equipment set-up

Procedure – Gathering Data

1. Select graph display on the Pasco interface.
2. Set two vertical axes on the graph, one being the actual angular position (rad) and the other as Light intensity, the horizontal axis should display time taken.
3. Darken the room by switching the lights off and cover the set-up with cardboard sheets in order to examine the emission spectrum closely to determine the different bands of color.
4. Begin recording the data on the PASCO data acquisition software.
5. Rotate the rotary motion sensor from the first line of the spectrum gradually until all different bands of spectral lines have been picked up by the light sensor and recorded on the graph.
6. Stop the recording.

Data, Graphs & Calculations

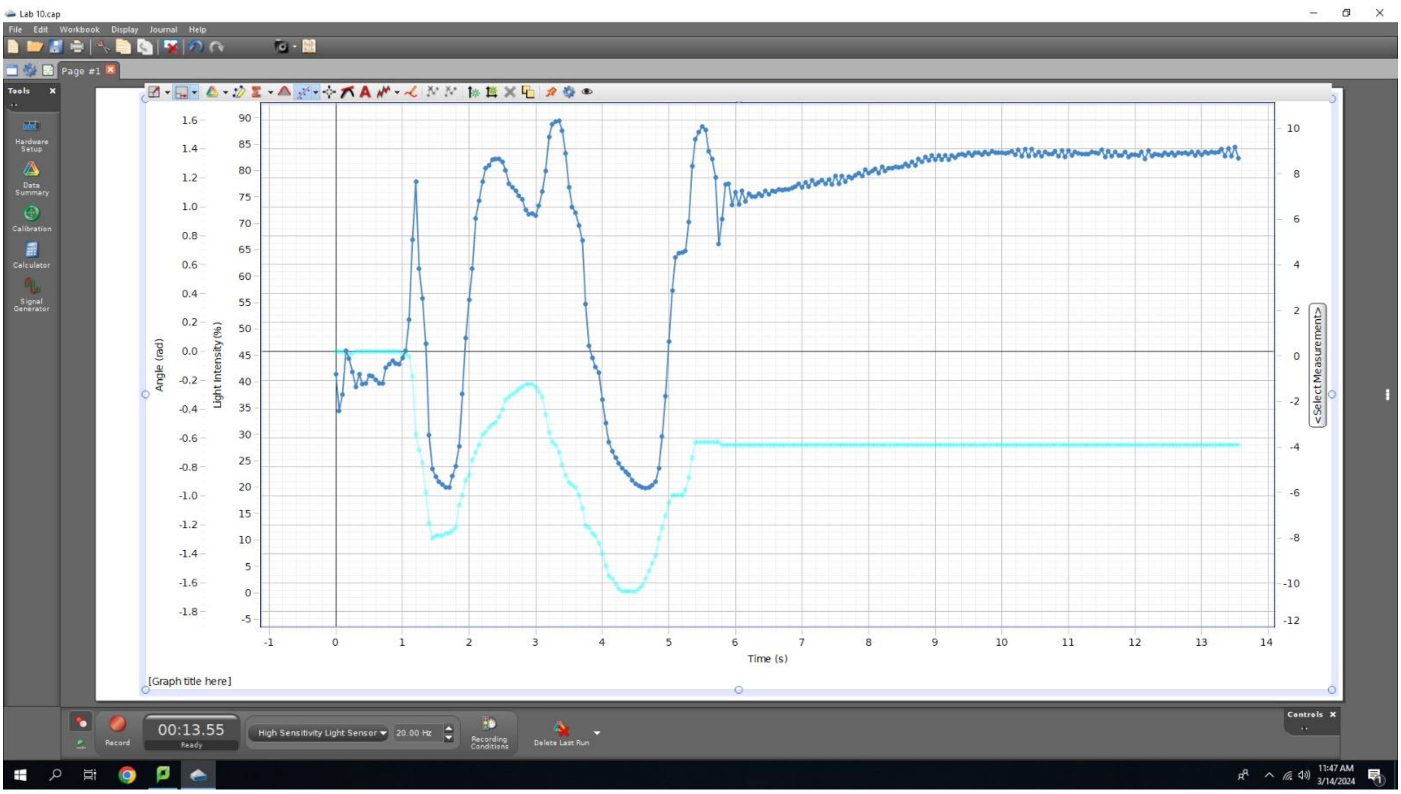

Figure 2: Angular Position & Light Intensity vs Time(s) for emission spectrum

Observations

The emission spectrum graph for mercury vapor light exhibits notable features. Sharp intensity spikes at certain wavelengths signify the existence of spectral lines resulting from atomic transitions within the mercury atoms. The locations and magnitudes of these peaks offer insights into the energy levels and transitions taking place inside the mercury atoms. Moreover, the general pattern and arrangement of the emission spectrum illustrate the dispersion and comparative strengths of the various spectral lines. As evident from the graphs, the yellow light has the longest wavelength, while the green light exhibits the highest intensity.

Conclusion

1. What was the purpose of this lab?

This experiment's purpose was to find the wavelengths of the colors in the spectrum of mercury vapor light.

2. How does the lab we performed relate to what we are studying in class?

The concepts of emission spectroscopy and distinct spectra are being taught in classes. The lab directly corresponds to this, as it determines the wavelengths of colors in a spectrum and provides students with practical and hands-on learning experiences.

3. Give a brief recap of the procedure used.

Position the spectrophotometer near a mercury vapor light source, mask its opening, warm it for 10 minutes, adjust the applications settings, and connect the PASCO interface to the computer for data acquisition software. Gather the data by rotating the sensor to record all spectral line bands.

4. What problems did you have during the lab? Did you have to modify your procedure?

There were a few issues with starting the experiment using the PASCO interface and the data acquisition software. However, the team was quick to solve them and proceed further. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

Yes, the results make sense as it matched the theory taught in class. Some sources of error include the improper alignment of the light source, collimating slits, and lens, and focusing lens for clear images. Additionally, improper masking of the light source to obtain a narrow beam of light, or improper alignment of the aperture disk and the central ray, can also contribute to errors.

6. What did you learn from this lab?

We learnt from this lab how the diffraction pattern depends on the wavelength of light, the grating line spacing, and the diffraction angle. It also shows the principles behind emission spectra and diffraction through gratings, essential for understanding spectroscopy and related fields.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this experiment again in the future, we will be more prompt with setting up all the materials in the beginning of the experiment and carefully aligning them together.

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Purpose

To determine the wavelengths of the colors absorbed by a liquid sample.

Hypothesis Statement

When white light travels through a liquid sample, the sample is anticipated to absorb specific wavelengths of light. This absorption will be indicated by dark lines or gaps in the resulting absorption spectrum, corresponding to the wavelengths that were absorbed by the liquid.

Materials

- Spectrophotometer System (OS-8539) or Spectrophotometer Kit (OS-8537)
- Rotary Motion Sensor (CI-6538)
- Aperture Bracket (OS-8534)
- High Sensitivity Light Sensor (CI-6604)
- Basic Optics Bench (part of OS-8515)
- Incandescent Light Source, DC, regulated
- Large Rod Stand (ME-8735) (2)
- Rod, 45 cm (ME-8736) (2)
- PASCO Interface
- Colored Liquid Sample (about 5 mL)
- Data acquisition software

Procedure – Equipment Set up

1. Set up the spectrophotometer next to a DC light source as shown. Move the High Sensitivity Light Sensor to the second position on the Light Sensor Arm so there is room for a cuvette between the back of the Aperture Disk and the opening to the sensor.
2. Put an empty cuvette in front of the High Sensitivity Light Sensor between the sensor and the back of the Aperture Disk. Make sure that the smooth sides of the cuvette are in line with the opening to the sensor (Fig. 3).
3. If the light source has a large opening, mask the opening so it transmits a narrow (0.5 to 1.0 cm) beam to the Collimating Slits. Adjust the Collimating Slits slide so the number 2 slit is in line with the light source. Put a cloth hood over the light source and attach the edge of the hood to the plate on the Collimating Slits.
4. Turn on the light source. Once it is warmed up, adjust the light source, Collimating Slits, Collimating Lens, and Focusing Lens so clear images of the central ray and the first order spectral pattern appear on the Aperture Disk and Aperture Screen. Turn the Aperture Disk so the second smallest slit on the disk is in line with the central ray.
5. Connect the PASCO interface to the computer, turn on the interface. Start the data acquisition software.
6. Connect the High Sensitivity Light Sensor cable to Analog Channel A. Connect the Rotary Motion Sensor cable to Digital Channels 1 and 2.

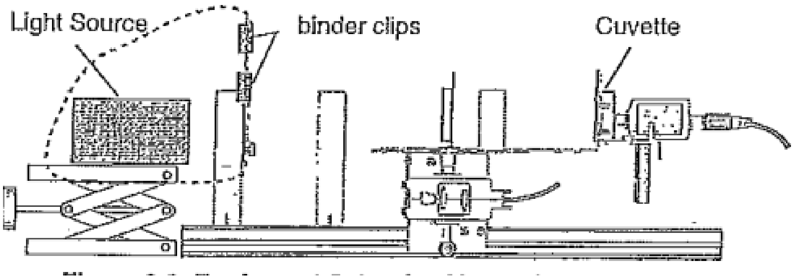

Figure 3: Experimental set-up

Procedure - Gathering Data

1. Select graph display on the Pasco interface.
2. Set two vertical axes on the graph, one being the actual angular position (rad) and the other as Light intensity, the horizontal axis should display time taken.
3. Darken the room by switching the lights off and cover the set-up with cardboard sheets in order to examine the spectrum closely to determine the dark bands.
4. Begin recording the data on the PASCO data acquisition software.
5. Rotate the rotary motion sensor from the first dark line of the absorption spectrum gradually until all dark line/bands have been picked up by the light sensor and recorded on the graph.
6. Stop the recording.

Data, Graphs & Calculations

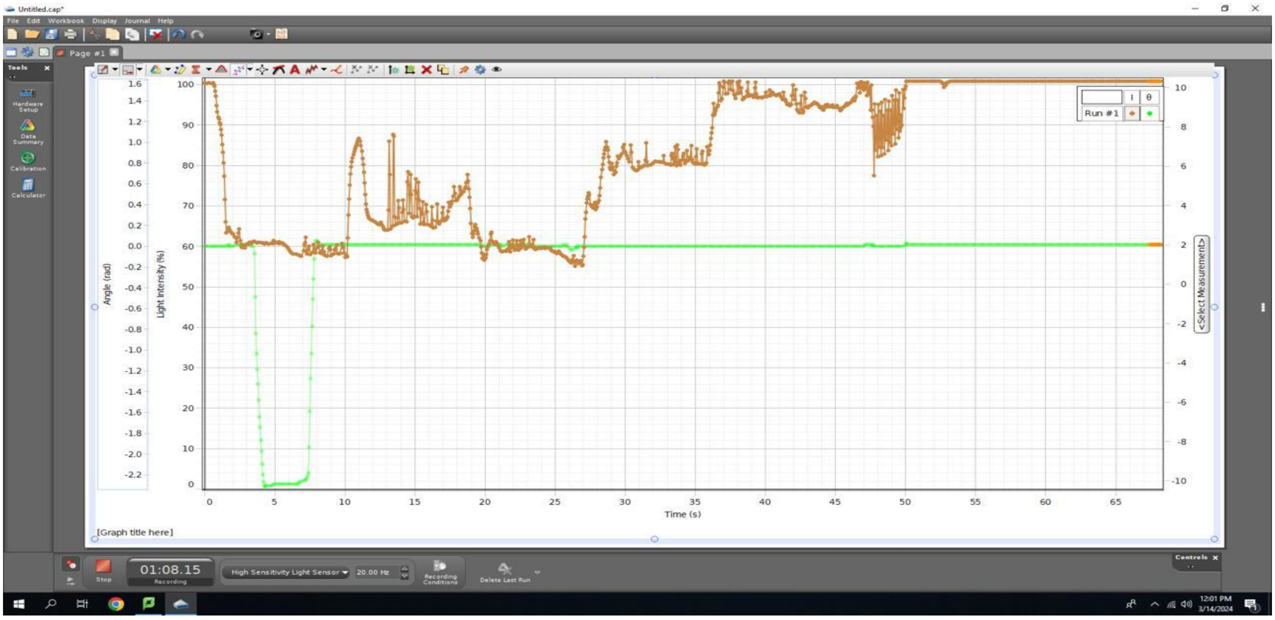

Figure 4: Angular Position & Light Intensity vs Time(s) for absorption spectrum

Observations

The graph illustrates how light intensity fluctuates with varying angles. Peaks indicate angles with highest intensity, while dips correspond to lower intensity levels. There may also be a constant background intensity unaffected by angle changes. Additionally, the observed absorption spectrum does not directly translate to the visible colors in the sample. The spectrum reveals absorbed wavelengths, but perceived colors are influenced by reflection, transmission, and scattering of light. Although some absorbed wavelengths indirectly impact color perception, there is no direct correlation.

Notably, in the liquid sample, only blue and violet light are absorbed, with blue light exhibiting higher intensity than violet.

Conclusion

1. What was the purpose of this lab?

This lab's purpose is to determine the wavelengths of the colors absorbed by a liquid sample.

2. How does the lab we performed relate to what we are studying in class?

The concepts of emission spectroscopy and distinct spectra are being taught in classes. The lab directly corresponds to this, as it determines the wavelengths of the colors absorbed by a liquid sample.

3. Give a brief recap of the procedure used.

Set up a spectrophotometer, position the High Sensitivity Light Sensor, and adjust the Collimating Slits, Collimating Lens, and Focusing Lens for clear images. Connect the PASCO interface to the computer and start data acquisition software.

4. What problems did you have during the lab? Did you have to modify your procedure?

Fortunately, there were no problems during the lab as the experimental results matched the theory taught in the class. Hence, there was no need to modify the procedure.

5. Do your results make sense? What are the sources of error?

Yes, the results make sense as it matched the theory taught in class. Some sources of error include any residue or impurities left in the cuvette, which can alter the absorption spectrum and lead to incorrect results. Misalignment of the materials, such as the Hg light, collimating slits and lens and focusing lenses, can cause variations in the intensity of light. Improper calibration of the spectrophotometer system may also contribute to errors.

6. What did you learn from this lab?

We learnt that when white light travels through a liquid sample, the sample is anticipated to absorb specific wavelengths of light and the intensities of wavelengths differ with the colors.

7. If you were to repeat this lab in the future, how would you modify or improve the procedure?

If we were to repeat this experiment again in the future, we would exercise greater caution with the calibration of the spectrophotometer and alignment of the materials.

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