ASTR 102

B08

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3: Spectra of Gases and Solids

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Objective/Purpose

The objective of the "Spectra of Gases and Solids" lab is to further understand the absorption, emission, and continuous spectrums. The lab will be completed by observing different light sources through transparent gases and examining with the aid of a small diffraction grating.

Introduction/Theory

Why is the sky blue? Why does the sky change colour when there is a sunset/sunrise, and why does it differ depending on where you are in the world? Well I believe that this lab will be able to shed some light on how light diffraction occurs through different mediums and how it affects the perceived wavelengths. I'm going to assume that depending on which gas tube is analyzed, the visible spectrum will change significantly. To complete this lab, initially different light sources will be observed through a diffraction grating, then the gas discharge tubes will be analyzed to determine their emission spectrums. For the last step, hydrogen and helium will be analyzed to determine the wavelengths of the colours on their spectrums.

Equipment

The following is the equipment required to complete this lab:

- Diffraction grating
    - Ruled with 600 lines/mm
- Tungsten filament light bulbs
- Gas discharge tubes:
    - Helium
    - Hydrogen
    - Neon
    - Mercury
    - Argon
- Camera, Computer, and Camera software

Procedure

The following steps will outline the required procedure to complete this lab.

Initial Observation

1. To begin the observations in this lab, head to the classroom on the 5th floor of the Bob Wright building.
2. Collect the necessary coloured pencils for each colour of the spectrum. With the lights turned off, turn on the incandescent tungsten dimmer light.
3. Using the diffraction grating, examine the colours emitted by the light. The grating will have to be turned in such a way that the spectrum is in a long strip. Record using the coloured pencils.
4. Turn down the heat on the tungsten lamp and re-examine the spectrum using the diffraction grating. Record the changes.
5. Turn off the incandescent light and turn on the fluorescent light. Examine the new light using the diffraction grating and record the emitted light bands.
6. (Optional) If the sun is still up, the last step is to observe what the sun looks like through the diffraction grating. Make a slit in the blinds of the window so only a sliver of light is coming through. Record the colours on the spectrum.

Multiple Discharge Tubes

1. After returning to the lab room, ensure that you still have the diffraction grating and turn on the gas discharge tube lamp.
2. Cycle through each of the gasses in the lamp. Using the diffraction grating, examine the 5 different gasses and the one “Unknown” gas. Colour the different spectrums observed for each gas.
3. After each gas is recorded, using the hydrogen and helium gas bulbs and the computer with the camera, take a picture of the spectrums from each and measure in pixels the distance from the bulb to each of the bright bars on their spectrums.
4. To get the degree of uncertainty, re-measure one of the distances and subtract from the original measurement of the distance.

Hydrogen and Helium comparison graph

1. Plot the points from the helium table in a Wavelength vs X table , where X represents the distance in pixels measured. Draw the best fit line for all the points plotted for Helium.
2. With the distances measured in pixels on the Hydrogen Table, use the best-fit line for the Helium graph to approximate the wavelengths for the hydrogen emission spectrum lines.
3. Using the data interpolated from the Helium’s best-fit line, complete the Hydrogen table.

Observations

The initial lab observations and measurements made for the colours of the spectrum can be found at the end of this lab report.

Initial Observation

The beginnings of this lab consisted of observing the colour spectrum of different tungsten tubes using a diffraction grating. A continuous spectrum with no bright lines was observed initially from the tungsten dimmer light. As the light became dimmer, the red part of the spectrum became more pronounced and brighter. As the light became brighter, the violet and blue part of the spectrum became more pronounced. It seems that this can also be applied to the visible light from stars and correlating it to their perceived temperature. The original drawings can be found at the end of this report.

Discharge Tube Observation

This section of the lab was very interesting as depending on which gas was used to discharge light, different bands of colours in the spectrum were emitted. All of the tubes had their own unique “signature” and set of colours that were specific to the gas. The “Unknown” gas was found to match Mercury exactly and therefore could only conclude that it was in fact Mercury.

Graphing Observations

The purpose of the graphing was to obtain a normal line to interpolate further data from. By using all the points received from Helium, other substances could be photographed and measured to determine their band wavelengths. In this case we wanted to get the wavelengths for Hydrogen. The measurements for both Helium and Hydrogen can be found in the following section, and the original values can be found attached at the end of the lab report.

Tables/Measurements

The initial measurements that were made in the lab are found at the end of this report.

Hydrogen

Line #	pixels	pixels/2	Wavelength (Å)	Colour
1	891	446	6679	Bright Red
2	739	370	5875	Bright Yellowish
3	639	320	5016	Bright Greenish
4	624	312	4922	Faint Green
5	596	299	4713	Faint Blue
6	565	283	4471	Bright blue-violet
7	492	246	3889	Deep Violet

Helium

Line #	pixels	pixels/2	Wavelength (Å)	Colour
1	829	415	6425	Bright Red
2	618	309	4915	Bright Blue

Graphs

The graphs for this lab are attached at the end of the report.

Results

The recorded spectrum colours can be found at the end of the report, along with all the original data collected. The data can also be found in the Tables/Measurements section of the report.

Questions

The following questions are found within the lab manual's description:

1. Is the brightness of the bulb the same with the high and low temperature?
   - ➢ No, higher temperatures yield a brighter bulb/light.
2. Is the bulb's colour the same?
   - ➢ Yes, the visible colour of the bulb remains the same to the naked eye.
3. Is the spectrum the same with the high and low temperature?
   - ➢ The spectrum only varies in intensity, as the red becomes more pronounced at lower temperatures, and vice versa with blue at higher temperatures.
4. How does this apply to stars?
   - ➢ It can be assumed that the same colour to temperature gradient can be applied to stars to determine their approximate surface temperature.
5. Do you see bands of colour as well as a continuous background? (fluorescent bulb)
   - ➢ Yes, there are many bands of colour that stand out amongst the coloured spectrum background.
6. What does this tell you about the sun? Can you see other absorption lines?
   - ➢ Unfortunately we never got a chance to examine the spectrum lines for the sun.
7. What is the Unknown?
   - ➢ The unknown is Mercury. This was determined because the spectrum for the unknown matched that of the Mercury gas exactly in both pattern and colour. All group members agreed that this was the case.
8. Is it a pixel or two different? To what wavelength would it correspond? (Uncertainty)
   - ➢ The picture was very clear so it was only approximately 3 pixels different from edge to edge.

Conclusion/Discussion

The objective of this lab was to further understand absorption, emission, and continuous spectrums, and it was very successful in doing so. By viewing the changes in spectrum with the change in temperature of the bulb gave a very good introductory understanding of the effects of temperature on the spectrum of light. By then viewing each of the gasses change the spectrum of light, we were able to understand the actual process of how the absorption or emission happens with each of the elements. From this understanding we were able to relate it to how important this knowledge is to understanding the composition of stars. It can be concluded that this lab provided invaluable and fundamental understandings to the natures of light, spectrums, and the compositions of stars.

References

No external information was required for the completion of this lab.

Evaluation

I think that having groups pre-set for the lab and having each group assigned a set of coloured pencils would speed up the beginnings of the lab and allow for further time in understanding what exactly needs to be done. It might also allow for the students to get more precise coloured drawings of all the spectrums instead of being rushed while recording the colours.