Lab 6: Spectra (I)

Name:

Partners:

NetID:

Lab section number:

1 Introduction

Objectives

In this lab you'll use a spectrometer to examine the spectra of a variety of light sources to understand how spectra can tell us the composition of objects.

Materials

A Project STAR spectrometer, a digital spectrometer, a computer with Logger Pro 3.8.xx, and various light sources.

Using the Spectrometer

Hold the spectrometer so that you can look through the grating in the narrow end. You should be able to see two rows of calibration marks and numbers. Pay attention to the lower row, which gives the wavelength (in nanometers, or nm) of the light in the spectra above it. The upper row tells you the corresponding photon energies in eV.

To observe a spectrum, keep holding the spectrometer up to your eye, and turn your whole body until the slit at the right-hand side of the front is pointed at the source of light you want to examine. (This is the most counter-intuitive part of the whole procedure. Most people are tempted to just aim the middle of the spectrometer at the light source. Aim the right side instead.) When you have the spectrometer aimed properly, a spectrum of the light source should appear above the wavelength scale. This procedure takes a little practice. If you need help, ask your TA.

Your TA will set up a variety of light sources for you to study in the lab.

In this lab, you will be asked to make observations of the spectra of these different sources and answer questions about them. You can make the observations of the spectra in any order you like (it will help to prevent crowding if people do these in different orders). You can answer the questions at any time during the lab, but you should make sure you have observed all the spectra before you leave the lab. Observe each source with your eyes and through the STAR spectrometer and answer the questions below.

Using Logger Pro

- Ensure that your spectrometer (The small metal box) is connected to your computer's USB port, and that it is also connected to the brown fiber optic cable.
- From your computer desktop, launch LoggerPro 3.8.xx.
- In the experiment drop down menu along the top of the screen, scroll down to "Change Units" and choose "Spectrometer 1", and then select "Intensity".
- Click on the green arrow button near the top of the screen to begin collecting data.

Data will now appear on the screen as long as light is able to enter the spectrometer. If no data appears, make sure the black cap has been removed from the end of the brown fiber optic cable. At any time during or after data collection, you can click the autoscale button to resize your graph.

If you find that part of your graph "flattens out" at the top, you should move the probe farther away from the source and retake your data.

- Once you have taken a set of data, you can collect another spectrum and choose to either store or erase your previous spectrum. If you choose to store your latest data set, you will notice that the bold line will change to a fine stroke.
- Clicking "Analyze" and then selecting "Examine" will allow you to move a cursor around your graph and read the wavelength and relative intensity from the dialog box.

2 Observing Spectra

You will now observe the color of light emitted by excited gases of elements in sealed glass tubes called "spectrum" tubes. Direct current, DC, high voltage electrons are used to excite the atoms in the spectrum tube. High voltage means 1000 to 2000 volts. This is more than 10 times normal household voltage which is 120 volts AC.

The excited atoms release the energy they gained. Some of this energy is in the form of heat and some is in the form of light. The billions of excited atoms release energy. The excited atoms do not all emit the same energy light because the amount of energy that excited them may differ, but there are limitations on the colors they do emit. The kind of light energy that can be emitted by excited atoms is unique for an element. The pattern of "lines' or colors emitted can be used to identify an element. An powerful extension of this is the ability to measure amounts of an element by measuring the brightness of the emitted light. The emission lines can be seen when you look through the spectroscope at the light source. You will be able to observe the "line" spectrum for the elements and record the spectral lines.

2.1 Observing a Source

Question 1. Use the plastic STAR spectrometer to observe the light coming from your table's light source (If your table does not have a source, or you have the continuous light source, observe the light reflected off the ceiling instead). Describe what you see below.

Question 2. Now use the Logger Pro spectrometer to observe the same source. Make sure that Logger Pro is set to record in units of "Intensity", and that the black cap is not currently on the fiber optic cable. Describe what you see below.

Question 3. Compare your observations made with the STAR spectrometer to those made with LoggerPro. Do the spectral lines that you see, if any, agree? Which was easier to use? Can you think of different situations where one tool or the other would be more useful in giving you information?

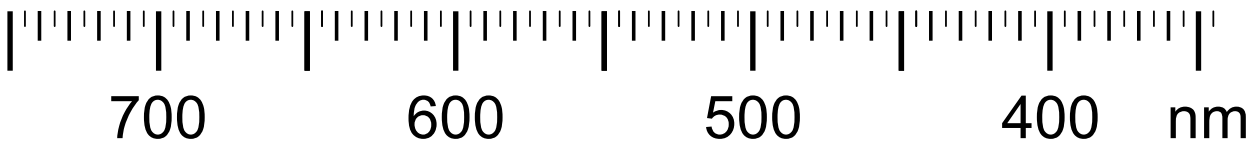
2.2 Neon, Hydrogen, and Sodium

Sources A, B, and C are, respectively, neon, hydrogen, and sodium lamps. Using your spectrometer, look at each of these sources. For each source:

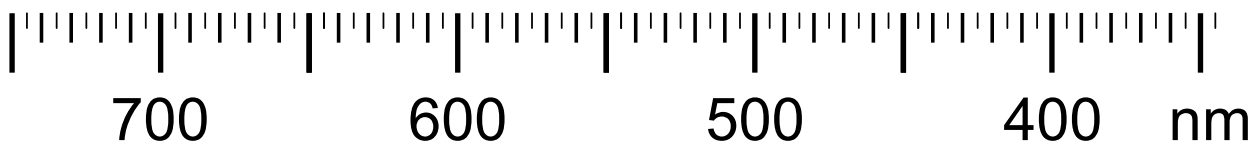
- a.) Draw the spectra you observe, taking care to note any emission lines, absorption lines, and relative intensity of the colors.
- b.) Classify the spectrum as continuous, emission, absorption, or some combination thereof. As a reminder: a continuous spectrum is one made up of a continuous range of wavelengths. An emission spectrum is a spectrum made up of bright lines, corresponding to wavelengths emitted from gas that has been excited in some way. An absorption spectrum is a spectrum that looks like a continuous spectrum with dark lines overlaid; these dark lines represent wavelengths that have been absorbed by an intervening material.

- c.) Identify all spectral lines by listing their wavelengths.
- d.) If you didn't already know what gases were in these three lamps, could you identify which ones they were? Why or why not? If you could, explain what features of the spectrum would allow you to positively identify the gas involved.

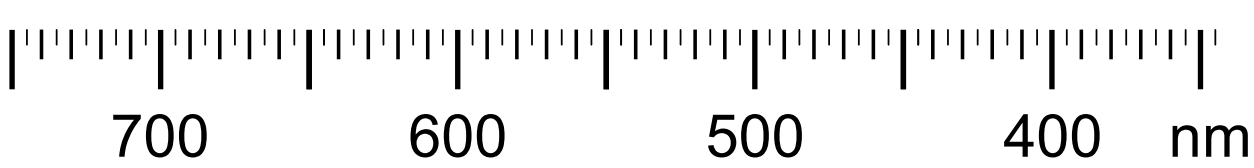
Source A:



Source B:



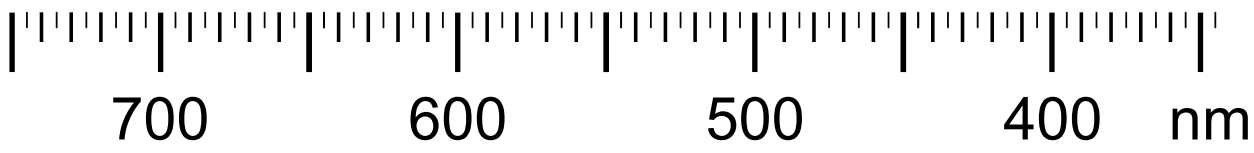
Source C:



2.3 Identifying Composition

Observes sources D and E with your spectrometer and draw what you observe.

Source D:



Source E:

Unlike with the neon, hydrogen, and sodium lamps, it's up to you to discover what gases are in sources D and E. One of them is mercury, and the other is helium, but you do not know which is which!

The table below shows a list of some of the visible spectral lines emitted by helium and mercury.

Wavelength (nm)	Element	Wavelength (nm)	Element
447	Helium	436	Mercury
502	Helium	546	Mercury
588	Helium	579	Mercury
668	Helium		
706	Helium		

Using your drawings of the spectra and the table above, determine which element is in each emission tube D and E. Circle the correct answers below.

Source D: Mercury Helium

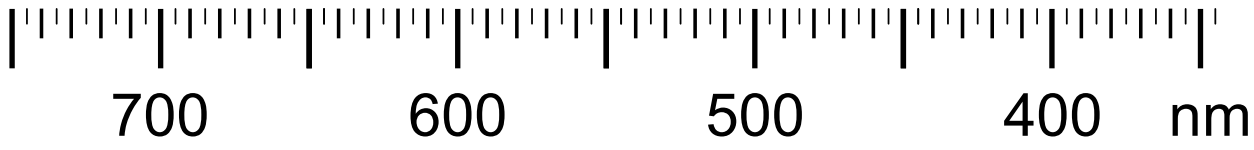
Source E: Mercury Helium

2.4 Absorption

The final apparatus, labeled source F, consists of a light bulb behind a pane of colored glass. Use your spectrometer and look at the light emitted by the source WITHOUT looking through the pane of glass. What type of spectrum is this source emitting?

Now, look at the spectrum again with your spectrometer, this time looking through the pane of glass. Draw the spectrum you see below.

Source F:

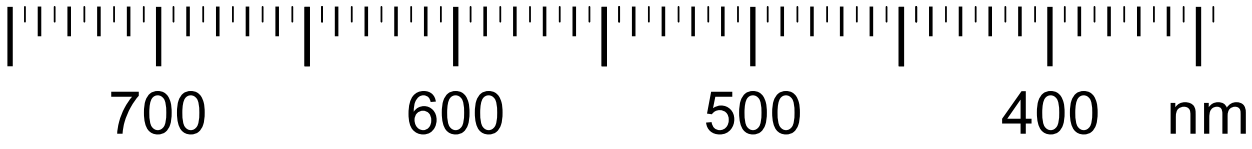


How did the pane of glass change the spectrum observed by the spectrometer? What type of spectrum is the spectrometer observing? Explain what is happening in the atoms in the glass that causes the features you observe.

Fluorescent Lamp

Observe one of the white fluorescent ceiling lights in the lab through your spectrometer. Notice that although the spectrum appears somewhat continuous, like the white light bulb, there are bright lines in the spectrum. A fluorescent tube is a gas-discharge lamp that uses electricity to excite a gas inside the lamp. The gas produces multiple wavelengths of light by its atomic transitions. Some of them are visible to us. However, it also produces ultraviolet light which causes a phosphor coating on the inside of the lamp to fluoresce, producing additional visible light. In this lab, we want to determine which gas is inside the lamp making the phosphor coating fluoresce.

Question 11. Carefully make a sketch of the spectrum that you see through the spectrometer on the scale below. Draw a vertical pencil line at each wavelength where you observe the brighter lines in the spectrum of the fluorescent lamp.



Question 12. Once you have observed all the spectra in the lab, use your drawing and the spectra from the previous exercises to determine what gas is inside the fluorescent lamp. Circle your answer below. Do you observe other spectral lines besides the ones coming from the gas you've circled? To what do you attribute those?

Hydrogen Mercury Helium Neon Sodium