LIGHT EMISSION AND SPECTROSCOPY

EQUIPMENT (See last page of procedure for experimental setup)

Diffraction grating spectrometer on stand	*Sunglasses*
Ceramic receptacle for bulb	*Frosted 7 1/2 watt incandescent bulbs*
Spectral tubes	*High voltage power supply for spectral lamps*
Colored pencils	*Colored filters*
Spectral Chart	

INTRODUCTION

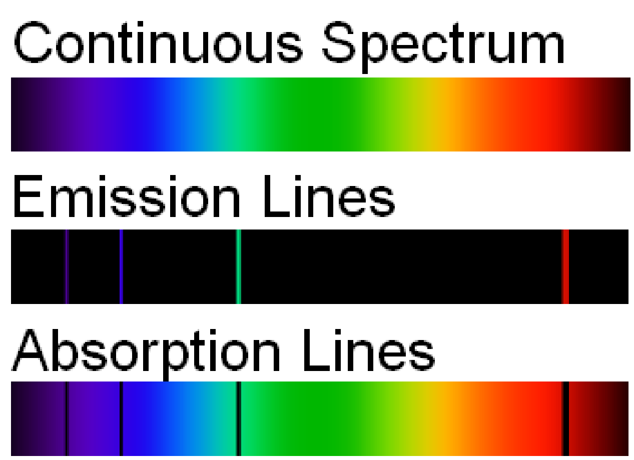
Light is a form of electromagnetic energy emitted in quantized packets called photons. A photon is emitted when an atomic electron that has been excited to a higher energy level de-excites by dropping back down to a lower energy level. The photon carries away an amount of energy equal to the energy difference between the two levels. But the energy of a photon of light (E) is related to the photon's frequency (f) by the equation $E = hf$, where h is Planck's Constant.

Emission Spectra
Electrical discharges passing through a gas cause the gas to glow. This occurs because atoms in the gas are excited by electron collisions, and emit photons of light as they de-excite. If the light emitted by the glowing gas passes through a diffraction grating spectrometer, the spectrum produced is called an emission spectrum of the gas. These spectra appear as a series of individual, discrete frequencies, or colors, which are unique for each element. These spectra are also called line spectra. In the late 1800's scientists found that the emission spectrum, or line spectrum, of each element is unique, a "fingerprint" by which any element can be recognized.

Continuous Spectra
Photon frequencies extend throughout the entire electromagnetic spectrum from radio to gamma rays, but only photons emitted with frequencies from 4×10^{14} to 7×10^{14} Hz are visible to us. The lowest frequencies of visible light appear red, then yellow and green; blue and violet colors appear at higher frequencies. Heated objects emit photons with frequencies directly proportional to the object's temperature. The hotter the object, the higher the frequencies of the photons it emits. However, outer electrons in closely-packed atoms (such as those in a solid or a star) not only have energy level transitions within their own atom, but also between levels in countless neighboring atoms. This leads to an infinite number of transitions and an infinite number of corresponding photon frequencies. This appears as a continuous, unbroken spectrum of frequencies (and therefore colors), and this kind of light emission produced by heating is called incandescent light. At about 500 degrees Celsius, the element on your stove is just hot enough to emit visible (red) light. When an object is hotter than this, a *continuous spectrum* of all visible frequencies (i.e. colors) is emitted and the light appears white. The most common sources of continuous spectra are incandescent bulbs and the surface of the sun. Your text illustrates the spectrum of light emitted by a heated solid in Figure 30.5.

Absorption Spectra
If incandescent light from a star, such as our sun, passes through a cold gas (such as the atmosphere), then the atoms in the cold gas can be excited by absorbing photons that have the same frequencies as the photons that the atoms in the cold gas can emit. When those gas atoms de-excite, photons of the same frequency are emitted, but in different directions. Therefore, the spectra of starlight passing through an atmosphere viewed with a diffraction grating spectrometer *appear as dark bands in an otherwise continuous spectra*. These spectra are called absorption spectra The dark lines in absorption spectra of stars correspond exactly, line for line, with the lines in emission spectra seen in discharge tubes such as the ones you are using in lab today.

Spectroscopy is also used to identify compounds from many sources ranging from identifying the age of "old masters" painting forgeries to searching for ozone in the atmosphere. The 3 types of spectra are shown in Figure 21-1. Please note that sometimes the colors are reversed in some spectrometers.



In this laboratory exercise you will view photographs of the continuous spectrum of a hot incandescent light bulb and the emission, or line, spectra of several elements contained in discharge tubes. These were photographed using the lab equipment used in the lab. You will then use the recorded information to identify unknown elements.

PROCEDURE

Please open the PHYS108 webpage: **https://relativity.phy.olemiss.edu/~thomas/weblab/108_web_items_spr_2010/108_items_spr_2010_index.html**

and you will see the following links:

Exp_21_Spectroscopy

continuous spectrum element 1 spectrum element 2 spectrum element 3 spectrum
element 4 spectrum element 5 spectrum element 6 spectrum Spectral chart

A. Continuous Spectra

1. A spectroscope is placed about 20 cm from the incandescent light bulb such that the vertical slit of the scope is aligned with the bulb. When this is done, you will see the spectrum on a numbered horizontal scale. The numbers refer to the wavelength of that portion of the spectrum and are read in hundreds of nanometers (10^{-9} m). For instance, red light is visible in the region of the scale between 600 and 700 (starting at about 670 nanometers).

   See webpage and click on **continuous spectrum** for a photo of the spectrum which was obtained while using the lab setup. This photo is not a true representation of the color distribution.

2. On Part A of the data sheet, label where the colors are in the rectangular box. Red has been done for you. It should be noted that red extends farther to the left than the photo indicates.

3. If a red transmission filter (See section 27-3 of text) is placed in front of the slit some of the light is filtered out (in this case red) and the remaining colors will be visible.

   Indicate what the spectrum would look like on the 2nd rectangular box which is labeled “Red filter”. Since a red (transmission) filter filters out red the other colors will remain.

4. Repeat for the blue, green, and yellow filters and record on the data sheet.

5. Besides making you look cool, sunglasses are useful for blocking out ultraviolet radiation (light). What do you think the spectrum would look like if you put a pair of sunglasses in front of the slit. Record the remaining visible spectrum on the data sheet.

B. Emission Spectra from Gas Discharge Tubes (You will be told which two element spectra to use based upon which lab section you are in).

1. Using the spectra provided on the lab webpage, draw the principal spectral lines in the emission spectra for each gas discharge tube in the spaces provided on the data page. **You may either color in the spectral lines on the data charts, or simply write in the color of each line (e.g., red, blue etc) if you do not have a good set of crayons/colored pencils.** The scale is marked in “nm,” which stands for nanometers; one nanometer is one billionth of a meter. The scale denotes the wavelength of the various colors; e.g., red lines have a wavelength ranging from 600 to 700 nm.

2. Using the “Spectral Chart” link on the lab web page, identify which element is in each spectral tube. **Be sure to label each drawing with the name of the element you identified in each tube.**

Experiment 21

DATA SHEET

Name: ___________________________

Section: ________

A. Continuous Spectra Key

No Filter

Red	Yellow Green light blue	Dark blue violet

700 nm 600 500 400

Red Filter

700 nm 600 500 400

Blue Filter

700 nm 600 500 400

Green Filter

700 nm 600 500 400

Yellow Filter

700 nm 600 500 400

Sunglasses

700 nm 600 500 400

DATA SHEET

B. Line Spectra of Gases

First Element

Element Name: ________________

700 nm | 600 | 500 | 400

Second Element

Element Name: ________________

700 nm | 600 | 500 | 400

QUESTIONS

1) Describe the difference between the sources of the continuous and line spectra of light.

2) What is the difference between an emission spectrum and an absorption spectrum? Which did you see in this 'lab'?

3) What is a spectroscope (or spectrometer) and what does it do?

4) Which has a higher frequency, red or blue light? Which has a longer wavelength?

5) What experimental method would you suggest to support the claim that iron exists in the gases in the sun's atmosphere?

6) Why don't the gases in your tubes finally "run out" of excited atoms and produce dimmer and dimmer light?

Experimental setup is below