ASTRO 1050
The Electromagnetic Spectrum

ABSTRACT

Astronomers rely on light to convey almost all of the information we know about distant astronomical objects. In addition to measuring the brightness of a given object, we can also determine its brightness as a function of wavelength, that is, its *spectrum*. In particular, it is found that a hotter object will generally emit more of its light at shorter wavelengths and a cooler object will emit more of its light at longer wavelengths. This continuous spectrum has a broad peak that can be used to infer the temperature of the object. Now this “thermal spectrum” or “black-body spectrum” is usually produced by a solid object or dense gases. Spectra that show certain behavior are the result of a specific phenomena and are collectively known as *Kirchhoff's Laws*. They are summarized here:

- A hot solid, liquid or gas, under high pressure (compact object), gives off a continuous spectrum.
- A hot gas under low pressure (diffuse gas) produces a bright-line or emission line spectrum.
- A dark line or absorption line spectrum is seen when a source of a continuous spectrum is viewed behind a cooler gas under low pressure.
- The wavelength of the emission or absorption lines depends on what atoms or molecules are found in the object under study.

Refer to Figure 1.

Materials

Part I: Five different discharge tubes, Spectroscope
Part II: Incandescent light bulb attached to dimming control
Part III: Spectrograph with wavelength scale (dark gray box)

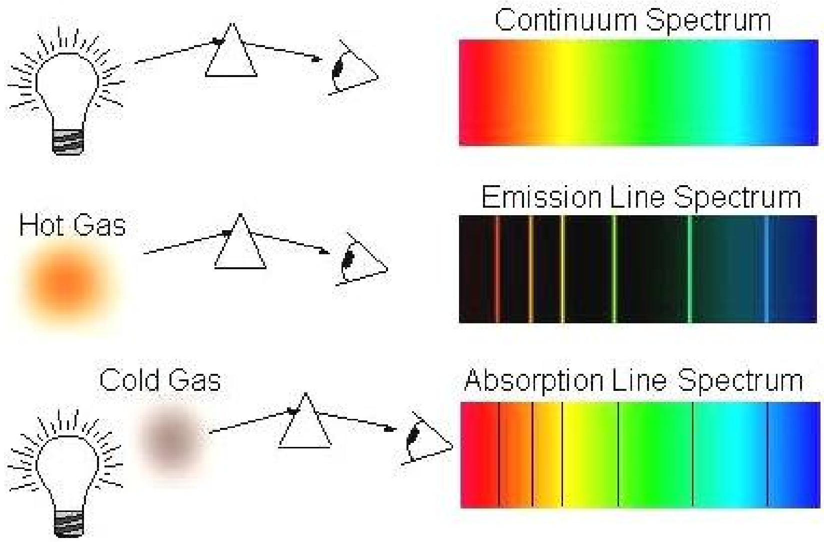

Fig. 1.— Exhibiting Kirchoff's Laws.
(Source: http:casswww.ucsw.edu/archive/public/tutorial/Stars.html

1. Introduction

As stated above, the wavelength of the emission or absorption lines depends on what atoms or molecules are found in the object under study. The atoms or molecules that exist depend on:

- temperature
- chemical composition

Each atom or molecule exhibits a different pattern of lines (rather like a fingerprint or DNA signature).

The Bohr Atom: The origin of discrete wavelengths of emission and/or absorption by gasses of a given composition was a mystery until Niels Bohr developed what later became known as the Bohr model of the atom. In this model, the atom is considered as a kind of planetary system with the nucleus forming the center and the electrons orbiting around it.

However, Bohr proposed that the electrons are only found in very specific orbits. When a given atom is illuminated with a thermal spectrum, it will absorb only those wavelengths that correspond to the differences in energies of these orbits, allowing the electron to "jump" to a higher level. The inverse is also true, meaning electrons in a high energy orbit can emit a particular wavelength of light and lose energy to "jump" to a lower orbit. The spectrum emitted and/or absorbed is then related to energy of the atom's orbits. The result is that each atom will have a unique spectral signature. Thus astronomers can determine the chemical composition of a distant star or galaxy by comparing its spectrum to known gasses measured in the laboratory.

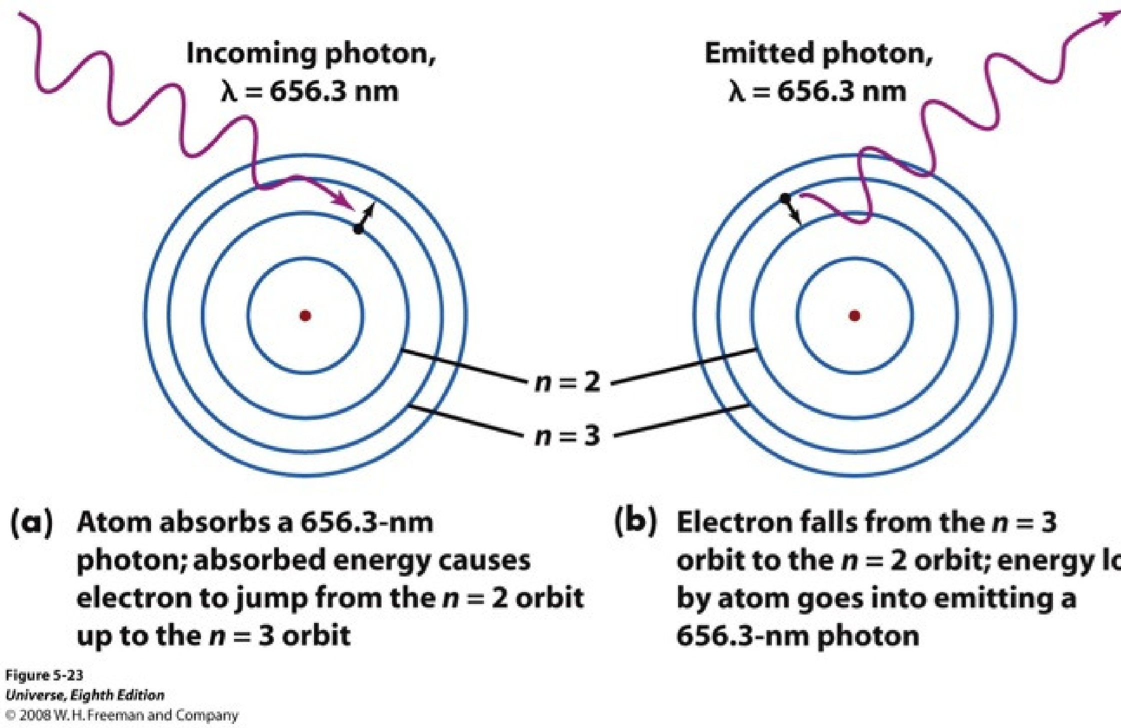

Fig. 2.— (a) Excitation versus, (b) De-excitation. Remember $E = hc/\lambda$.

2. Exercises

Part I: Identifying Gas Composition from the Emitted Spectrum

Around the lab room are five different discharge tubes consisting of five unknown gases. Your goal is to determine which gas is in each discharge tube. First, state the general color of the gas in the tube as seen without a spectroscope. Next, using the spectroscope, examine the spectra of each gas and draw the spectrum as best you can. Put red wavelengths on the right and blue on the left (use the colored pencils or crayons). Also, pay careful attention to the intensities (a.k.a. how bright the lines are) of the lines as well as the relative spacing between the lines in the spectra. Use the spectrum charts located at the back of the lab room to identify your gases according to their signature spectrum lines.

Tube #	General Color	Spectrum	Gas Identification
______	______________		____________________
______	______________		____________________
______	______________		____________________
______	______________		____________________
______	______________		____________________

Part II: Blackbody Continuous Spectrum and Planck Curves

Use the incandescent light bulb attached to the dimming control at the back of the room. The light bulb represents a blackbody continuous spectrum. The goal for this section is to observe the continuous spectrum of this blackbody at "high temperatures"/bright and at "low temperatures"/dim light. Draw the continuous spectrum with the light very beight and then with the light very dim as seen through your spectroscope.

Continuous Spectrum with BRIGHT light: [ ]

Continuous Spectrum with DIM light: [ ]

(a) What colors were apparent when the light was bright?

(b) Which colors were missing in the dim light?

(c) Explain why certain colors were "missing" in the dim light, using your knowledge of the Blackbody Planck curves, temperatures, wavelengths of light and their corresponding colors: