Notes for Hermograph's *Classroom Astronomer*
Spectrum Viewer for Indoor and Outdoor Lighting

Usage tips

Sometimes, especially for distant or tiny sources of light, a slight vertical shaking of the Viewer will extend the visible dots into lines, providing a better match up to the comparison spectra.

The measuring scales are only approximations. Do not rely on them for precision measures of visible lines.

You can adjust the distance of the Viewer card from your eye so that the spectra in the window will enlarge or shrink (somewhat!) until it is the same scale of the comparison spectra.

WARNINGS!

1) **Under no circumstances should you use the Spectrum Viewer to see the spectrum of the Sun!** The Viewer does nothing to stop the Sun's harmful rays or reduce intensities, and damage to the eye can be immediate. Hermograph Press, *The Classroom Astronomer*, and its personnel and related companies cannot and will not be held responsible for injuries or damages by the use of this product, accidentally or deliberately, for attempting to view the solar spectrum.

2) The film in the Viewer window is sensitive to the oils in human fingernails. Do NOT touch the film! It can eat away the film and its diffraction grating rulings. Fingerprints can be removed with isopropyl alcohol--dabbed on with an eye-glass cleaning cloth, some film cleaners, or anti-static cleaners but these, too, can ultimately degrade the film. You can add a piece of transparent film, such as for use with overhead transparencies, on each side to protect the film if you wish. Degraded-by-usage/fingerprints Viewers can not be returned.

3) The colors you see with your eye may not completely match up the hues in the comparison spectra for a variety of reasons. Not all eyes see all colors exactly the same, and some can see a bit into the ultraviolet (UV) or infrared (IR). Both film and digital cameras have different responses to each color/wavelength of light than human eyes do. Even the printing process itself, exposure to light (or age of the unit, over time) can cause the colors to differ and to change.

Notes about the spectra of the various lights

1) Just because a spectrum is continuous doesn't mean the lamp is an incandescent light that uses a filament. There are other kinds of *lamps* that produce a continuous spectrum but they all use heat as the source of the light.

2) Some details in the spectra of metal halide lamps may differ because of the type and amounts of different metals that are added to the chemical mix. Even regular mercury vapor lamps do not cause spectra that always look precisely like the spectrum of Mercury, the element.

An example of an energy-efficiency calculation

We have two new values for the on-card table. This changes the example area lighting calculations.

Type of Light	**Energy Efficiency [Average]**	**Typical Lamp Life (Hours)**	**Color Rendering Index**	***TCA* Cost Efficiency**
LED	50-105 [88]	40,000	25-100	3520
Low Pressure Sodium	100-180 [140]	18,000	0	2520

Suppose you are outside at night and see three high pressure sodium, two metal halide and one old incandescent bulb lamps. From the table's column 4, you get 3 x 1860 + 2 x 1225 + 1 x 10 for the total cost efficiency, or 8040 (Lumens/Watt per 1000 hours). That, divided by 6 x 3520 (= 21,120), the ideal for six lamps, calculates your area as 38% cost efficient. The energy efficiency calculation, using the average values in Column 1, is 3 x 78 + 2 x 73 + 1 x 13 = 393; divided by 6 x 140 or 840, your area is 46% energy efficient in its lighting.

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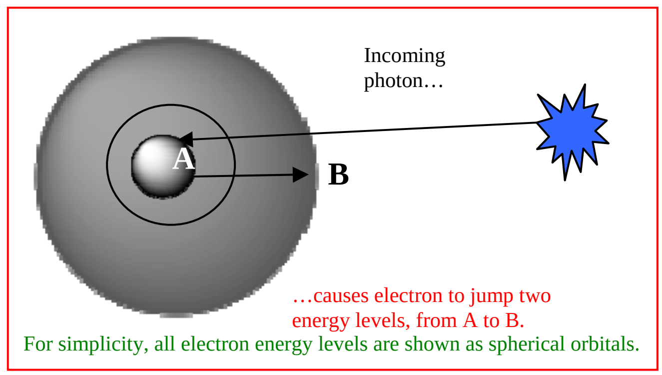
How are spectra made?

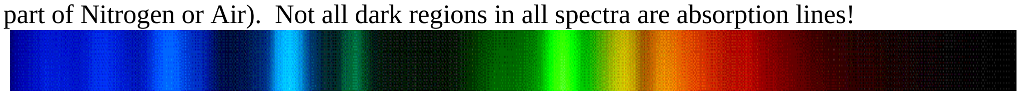
There are three kinds of spectra, though sometimes they can be viewed together.

All spectra require a source of energy (heat). Hot objects produce a **continuous background spectrum,** such as seen in the background of "impure" hydrogen spectra and most of the others here, such as Iodine (I) or Oxygen (O). This is a macroscopic spectrum that has more to do with the atom reacting to heat rather than something atomic, as in the case of the next two types of spectra.

Continuous Spectrum

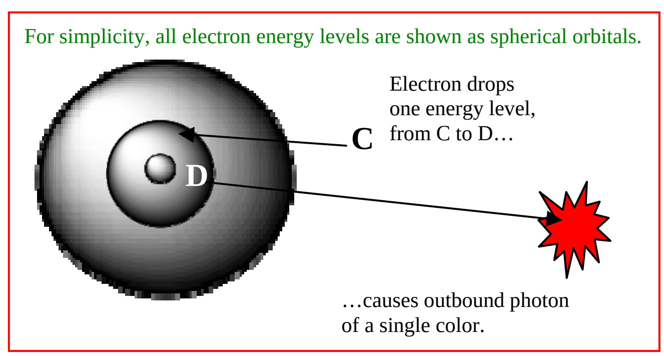
Dark lines or absorption lines: An element (a single atom of a specific substance, like Helium) has a nucleus of protons and neutrons (not involved with spectra), surrounded by "clouds" where electrons will be found. These "clouds" are centered at different distances from the nucleus and correspond to higher levels of electron energy. If an electron in a lower energy-level "cloud" receives the precise amount of energy it needs to jump to a higher level, it will absorb that photon of energy/light and rise to that specific energy-level. It cannot jump just part-way; it is all the way or no jump at all. If that electron is in material, such as a gas, in front of the heat source that produces a continuous spectrum, you will see a dark gap in front of the background spectrum (see the thin absorption line in the red in the Oxygen spectrum, or the large dark bands in the green part of Nitrogen or Air). Not all dark regions in all spectra are absorption lines!

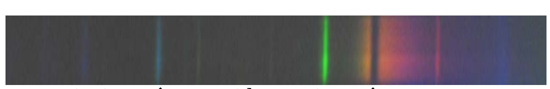




Absorption line in High Pressure Sodium Lamp ↥

Bright lines (emission spectra or emission lines) seen in most of the spectra on the Viewer are also caused by specific photons of energy that match the gaps between different energy-levels in the element's (or elements' or molecules') atomic structure. In this case, though, it is from an electron already in a higher energy-level. Electrons, however, prefer to be as close to the nucleus as possible. As soon as it can, a higher-level electron will release the precise amount of energy (also known as a quantum of energy) to slip down to a lower energy-level in the atomic cloud around the atom's nucleus, not necessarily the energy-level it came from. In doing so it releases the energy as light, a single ray of a particular wavelength of light, which we see as color.





Emission ↥ Absorption ↥

Low Pressure Sodium Lamp with emission and absorption lines

v.1.3