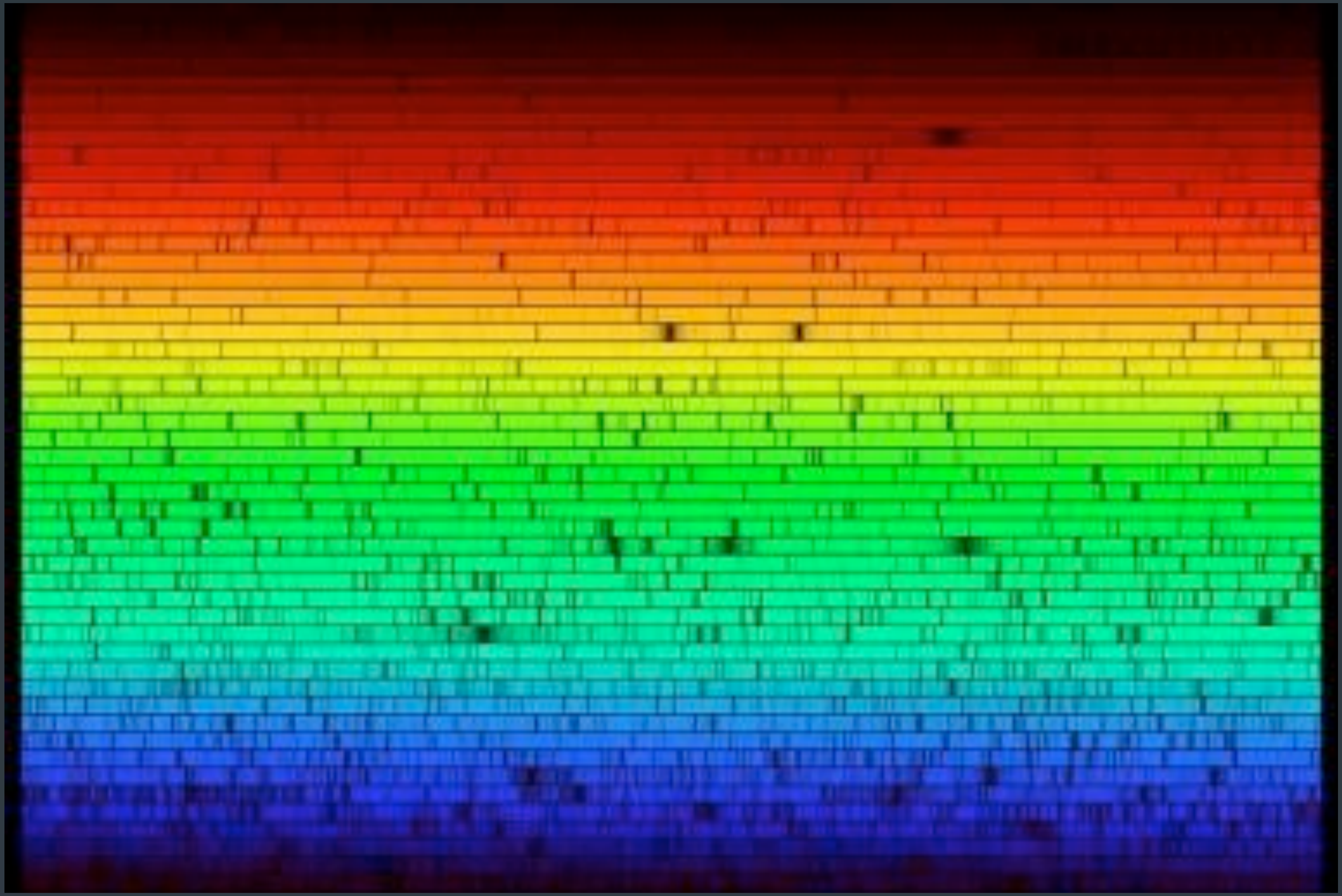
ASTR 1020

Lab 10: Spectroscopy and Atomic Structure

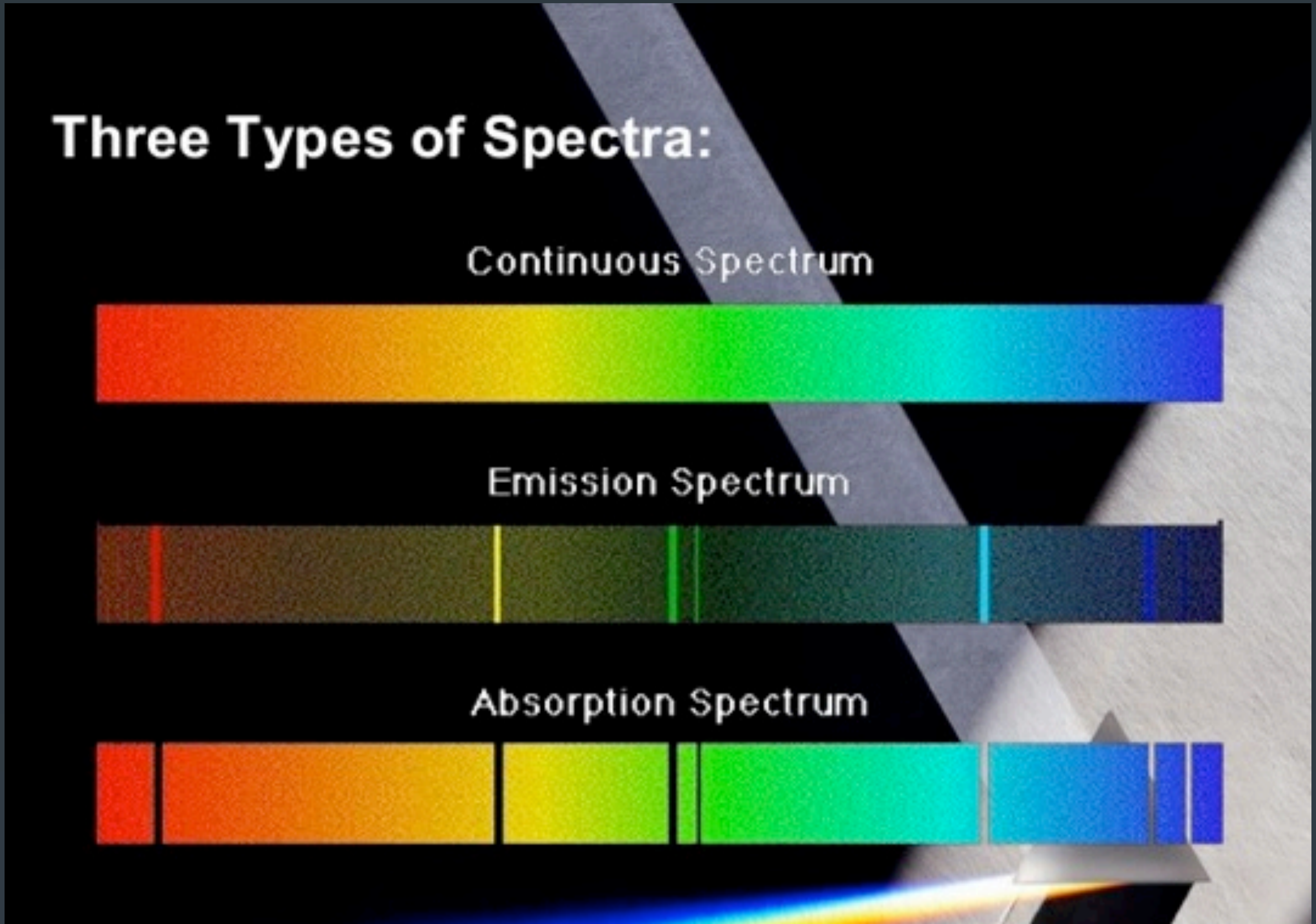
What Is Spectroscopy?

Spectroscopy is a way to study light. A diffraction grating breaks up light into its constituent colors, or wavelengths, some of which are bright and others of which are dim.



Types of Spectra

There are three types of spectra. A continuum is a full rainbow and radiates from a hot object. An emission spectrum consists of bright lines emitted from a hot gas. An absorption spectrum consists of dark lines from a cool gas absorbing certain wavelengths of light from a light source behind it.



Color, Wavelength, and Energy

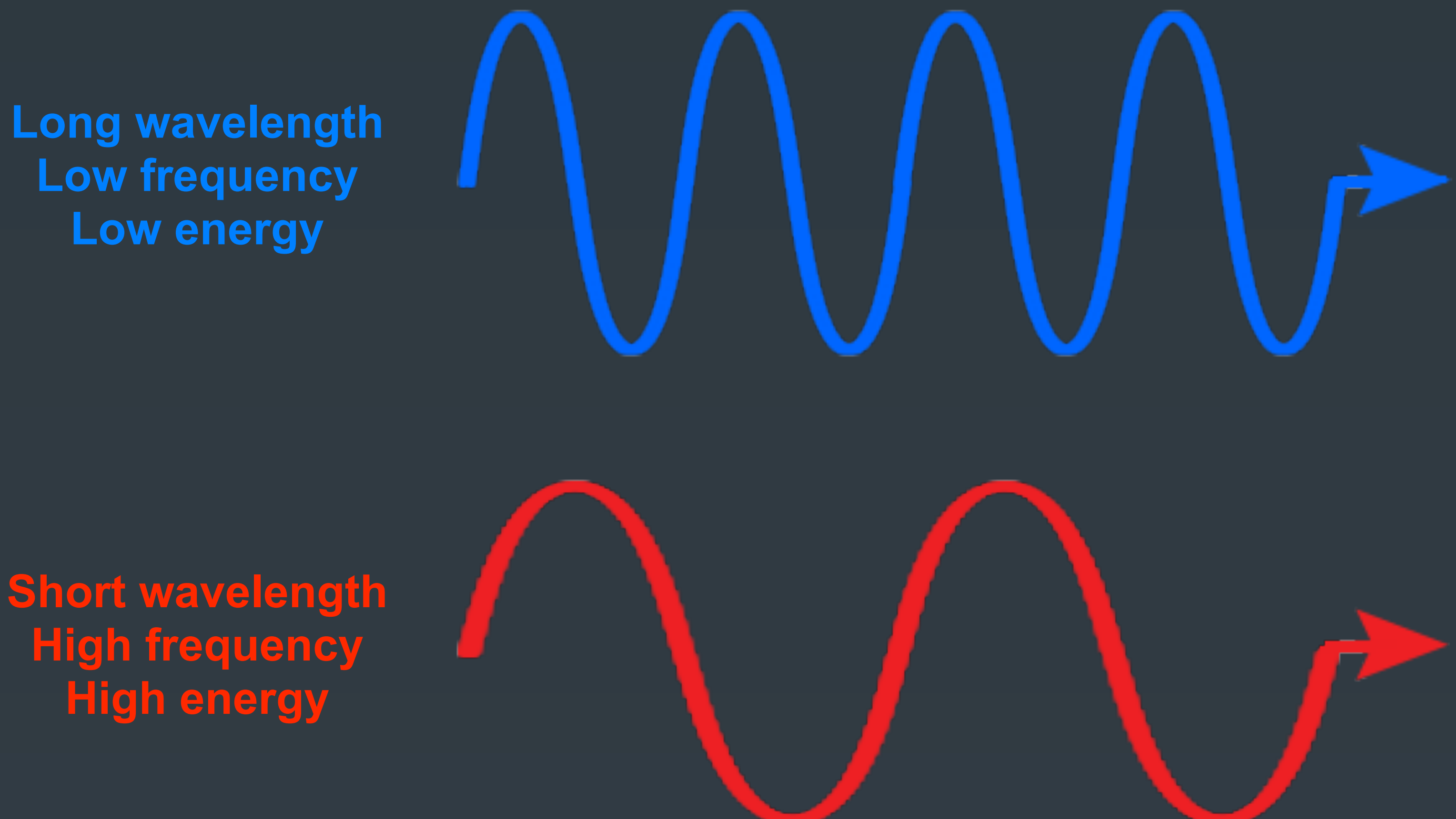
Each color has a wavelength, given in angstroms in today's lab (1 Å = 0.1 nm = 10^{-10} m). Each wavelength has an energy. Blue (short wavelength, high frequency) has higher energy than red (long wavelength, low frequency). Think of a candle flame, which is red, versus a gas stove flame, which is blue and much hotter than a candle flame.

1400 °C (2600 °F)

1950 °C (3542 °F)

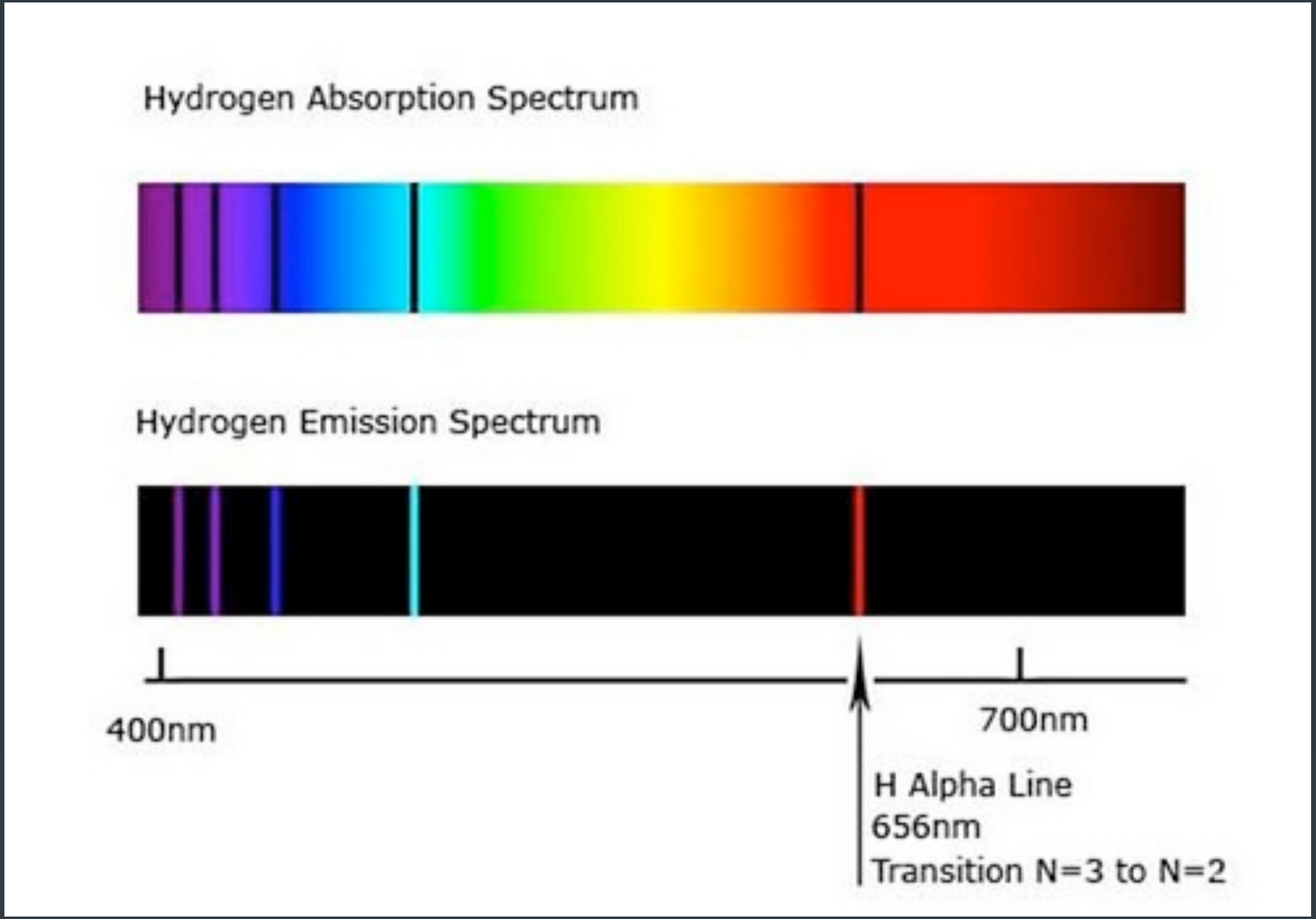
What Is a Photon?

A photon is a little packet of light, essentially, moving as a wave at the speed of light. Again, each wavelength has an energy. Blue (short wavelength, high frequency) has to finish its wavelength in a short space. Red has to finish its wiggle in a longer space. Thus blue has higher energy than red.



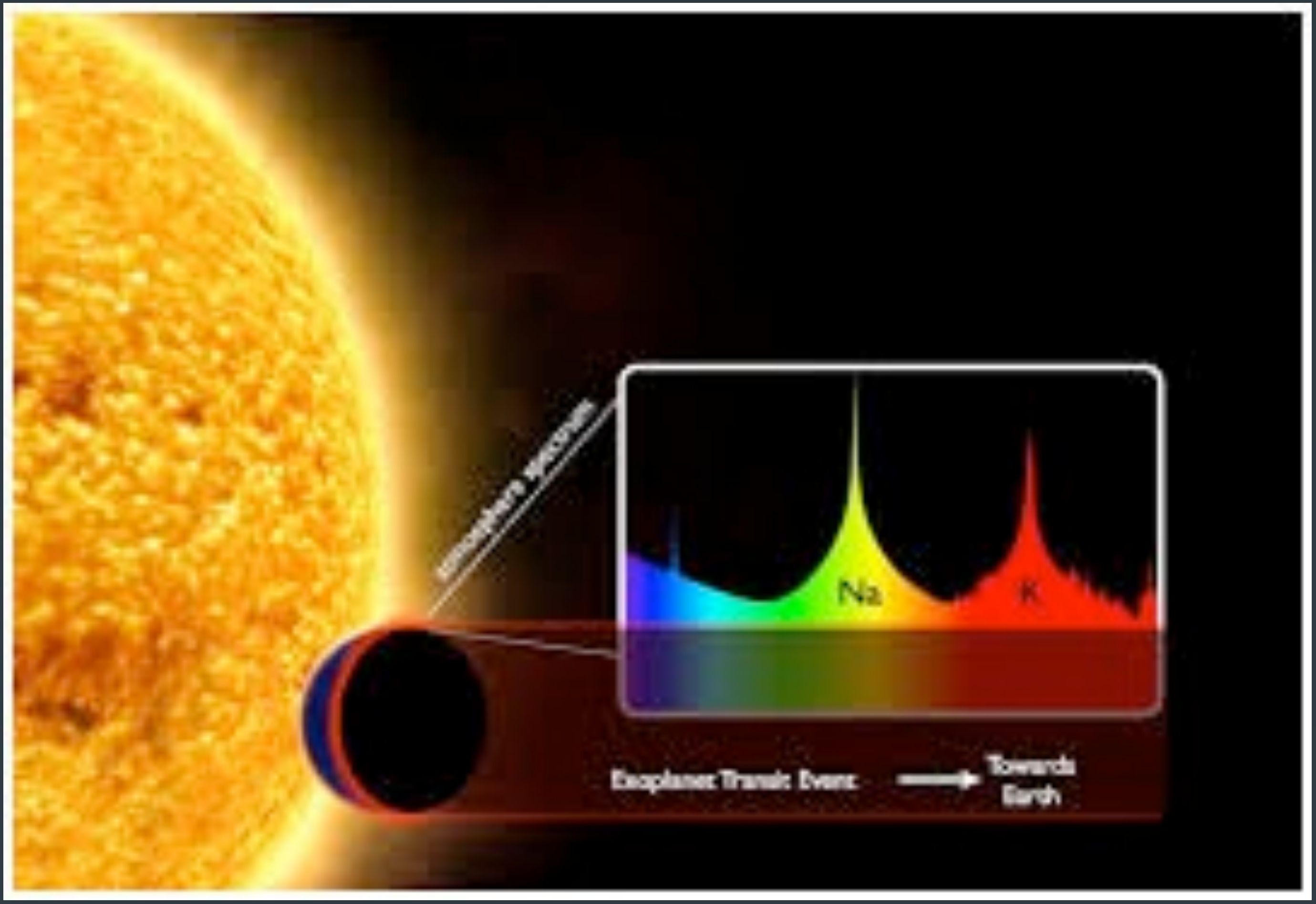
Spectral Lines

Each chemical element has its own set of lines. Notice that the lines are dark on a rainbow background for an absorption spectrum and bright on a dark background for an emission spectrum, but the location of the lines is the same for a given element.

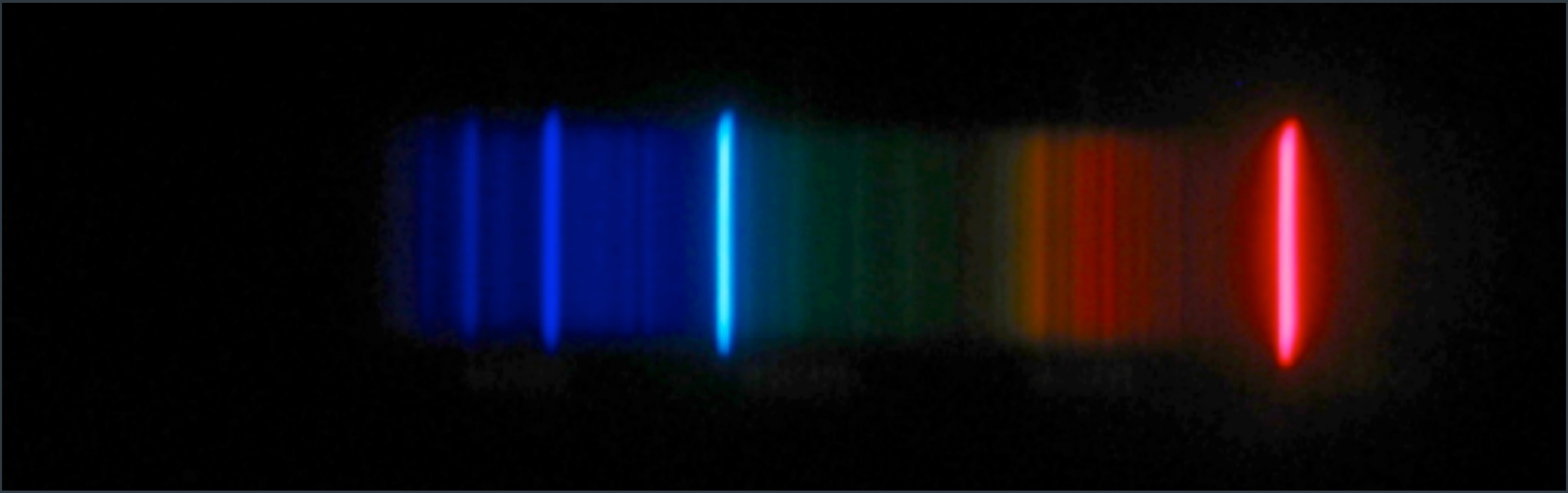


What Can Spectroscopy Tell Us?

Because each chemical element has a unique set of lines, a spectrum can tell us what elements are present in a gas, such as the atmosphere of a star. Line shapes and shifts can tell us how hot the gas is, how fast it is moving, and in which direction.

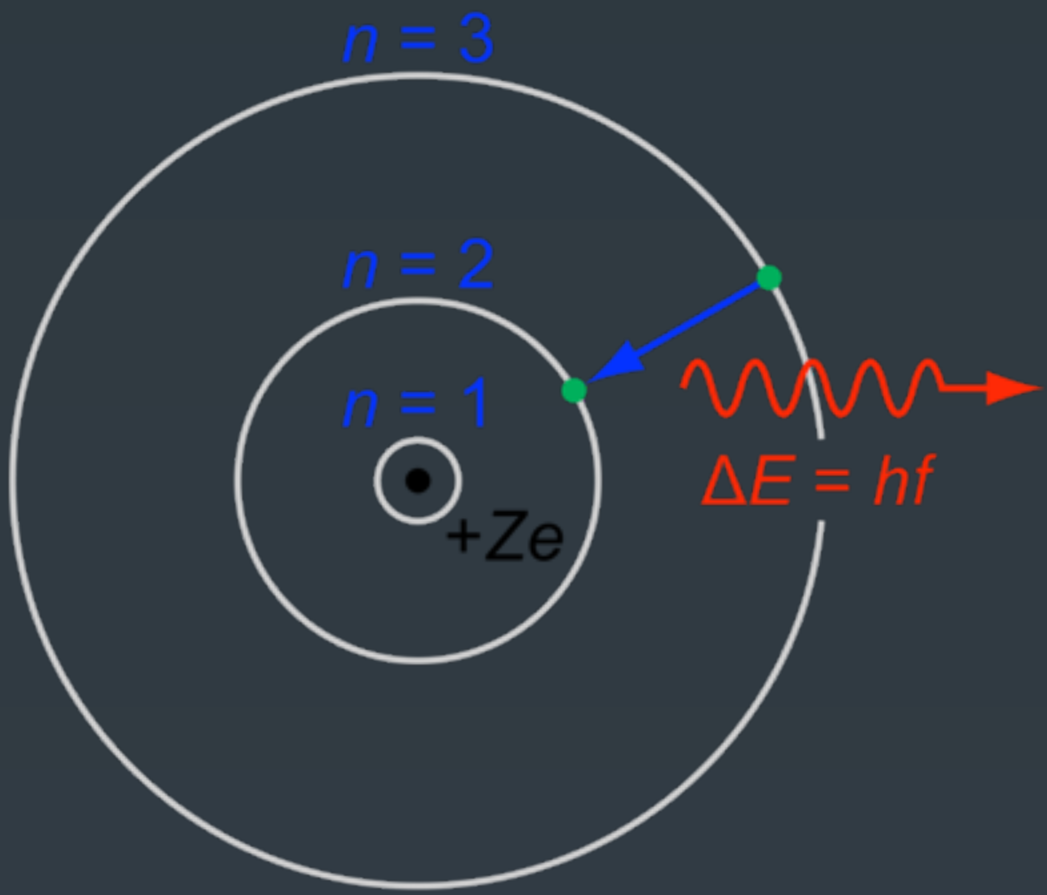


This is the spectrum of hydrogen.



Atomic Energy Levels

Each element has a unique set of lines because each atom has a unique set of energy levels. Photons are emitted or absorbed when electrons jump from one energy level to another. Bigger jumps involve more energy. If we know what element our atom is, and if we know the wavelengths of several transitions, we can deduce the radii of the energy levels and draw a scale model of the atom.



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