

Investigation 2: Atomic Spectroscopy

Focus Questions: Why are only certain colors of light emitted from excited state atoms? Can the frequencies of light emitted from an atom be related to the differences between the energies of the atom's energy levels? How can the value of the Rydberg constant (R_H) be determined experimentally?

Pre-lab required reading

[Chemistry: an Atom-Focused Approach](#): Sections 3.2 – 3.4

[Technical Primers](#):

[Safety Rules](#)

[Keeping a Laboratory Notebook](#)

Safety and Waste Disposal

- Do not touch the discharge tubes. They are very fragile.
- The discharge tubes operate at very high voltages. Do not touch any wires or connections.
- Avoid looking directly at the lamps; ultraviolet light from the discharge tubes can damage your eyes.

Background

Early scientists observed that metal salts give off colored light in a flame. In addition to being colorful, the colors emitted are useful for identification purposes. Each salt has colors characteristic of the metal in the salt. The color and intensity can be used in both qualitative and quantitative analysis. It was also noticed that when the light was passed through a prism, the light was separated into several lines that together provide the overall color for the salt. It is now known that the light is being emitted from discrete gaseous atoms as opposed to molecules, hence the term atomic spectroscopy.

The development of atomic spectroscopy was crucial to the development of one of the most important theories of the 20th century: the quantum theory. You will use simple atomic spectroscopy to discover experimental evidence for the quantum theory and then develop a modern although simplistic picture of the atom. In addition you will learn some pertinent points about spectroscopy.

A spectroscope contains a grating that separates the light into its component colors and a scale that allows for the determination of the wavelength of light corresponding to each color observed. Using the spectroscope you will observe the emission line spectra of gaseous elements. Then, you will use the spectroscope to accurately determine the wavelengths of visible light that are emitted by the hydrogen atom. The “meter stick” spectroscope that you will use is pictured below in Figure 1.

The wavelength of each emission line as observed at position 1 and position 2 can be calculated by knowing the angle, θ , and the spacing between lines on the diffraction grating used. The Huygens-Fresnel principle gives the relationship between the angle (θ), the diffraction line spacing (d), and the wavelength of light (λ) as:

$$n\lambda = d \sin \theta \quad (1)$$

where n is the “order” of the diffraction lines and equals one for first order diffraction, two for second order diffraction and so on. You will observe several sets of line spectra. The first order diffraction is seen closest to the slit between the meter sticks. The diffraction line spacing (d) can be calculated from the number of lines per mm printed clearly on each grating.

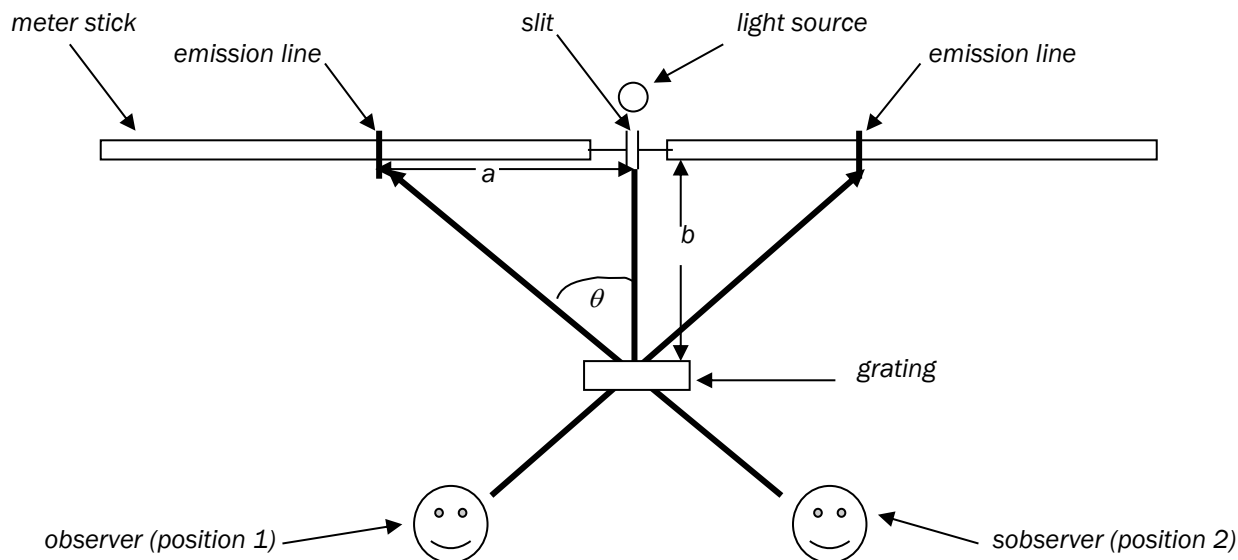


Figure 1. Schematic of the “meter stick spectroscope”

Procedure

Observe the spectrum of hydrogen using a discharge tube and the “meter stick spectroscope”. Describe what you see in your notebook. Record the slit position and the number of lines per millimeter of the grating. Record the distance between the slit and the grating (not simply to the plastic frame holding the grating, but to the grating itself). Record the color and position on the meter stick for each line that you observe. Record measurements at each observer position for each line in the first-order emission line spectrum on both sides of the slit.

Use the “meter stick spectroscope” to observe the emission spectrum of other elements as directed by your instructor. Record your observations.

References

Atkins, P.; Jones, L. “Chemical Principles: The Quest for Insight”, 5th ed.; Freeman: New York. 2010.