

The Hydrogen Spectrum and Energy Levels Spring 2009

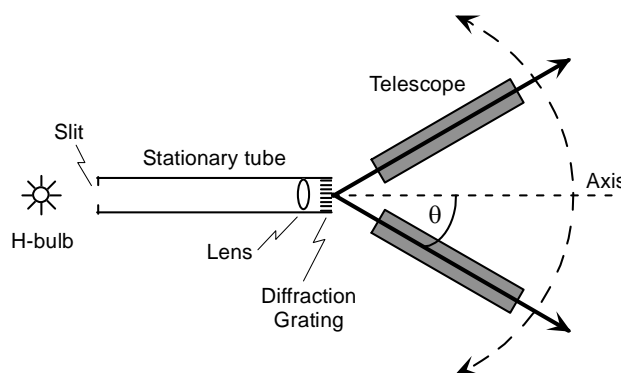
Introduction

In this experiment you will use a diffraction grating to measure the wavelengths of the four visible lines emitted by hydrogen, and from those results determine the allowed energy levels of the hydrogen electron. You should be able to measure the wavelength of each line to within 1 or 2%!

Experiment

1. Measuring the diffraction angle for Hydrogen and Sodium lines:

- a. Your instructor will explain the operation and initial setup of the spectrometer, as shown below.



- b. Create a data table in your report as follows:

Line Color	Angle (left), θ_{left}	Angle (right), θ_{right}	Average Angle, θ	Wavelength, λ (nm)
Faint-Violet				
Violet				
Blue-Green				
Red				
Yellow Sodium				589.3

sample:
create your own table!

- c. Swing the telescope *left* of center until the crosshair is lined up with the first hydrogen line you see. When the hydrogen line is centered, write down the angle θ indicated by the pointer (you should estimate to 0.1°). Have your partner check the angle as well. Repeat for the other hydrogen lines that are visible.
- d. Swing the telescope *right* of center, and repeat the measurements of θ for the four hydrogen lines. Average θ for each hydrogen line observed.
- e. The spectrometer must now be calibrated; set it up in front of the sodium lamp in the lab and measure the angle θ for the yellow line.

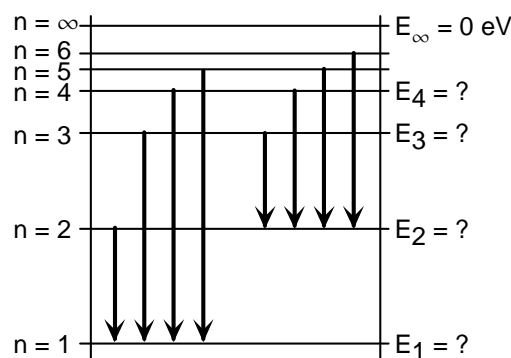
2. Calculating wavelengths:

- a. The wavelength of the yellow line of sodium, λ_{Na} , is 589.3 nm. Find the wavelengths of the four hydrogen lines using the expression below, and record those wavelengths in your table. **Be sure to use 4 significant figures!**

$$\frac{\lambda_H}{\theta_H} = \frac{\lambda_{Na}}{\theta_{Na}}$$

3. Calculating theoretical energy levels and wavelengths:

- a. Construct a *large* (at least half the page) energy level diagram (as shown below) and calculate the theoretical energy levels for $n = 1$ to $n = 6$ using $E_n = -13.61/n^2$. The units are *electron volts* ($1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$). Write these energy levels on the diagram.



- b. Calculate the wavelengths for *all eight* transitions shown, using:

$$\lambda = \frac{1240}{E_{\text{Upper Level}} - E_{\text{Lower Level}}} = \frac{1240}{\Delta E}$$

(if ΔE is in *eV*, then λ has units of *nm*). Write these wavelengths next to each transition on the diagram.

4. Calculating the energy levels from your measured colors:

- a. Identify the series and the individual transitions for each line observed by comparing your measured wavelengths with those found in step 3b above. Write the colors on the energy level diagram.
- b. Calculate the percent difference between your measured and calculated values of the wavelength of each line.

Discussion

- Restate your results: the measured and actual wavelengths, and their % difference.
- Discuss your results. What were some sources of error?