

In this lab, you will observe the spectrum from an excited sample of hydrogen gas. The spectrum lines arise from electron transitions between energy levels in the hydrogen atoms given by

$$E_n = -\frac{13.61\text{eV}}{n^2}$$

where n is a positive integer. If the electron is in an excited state ($n_i > 1$), it can fall to a state of lower energy ($n_f < n_i$), emitting a photon of frequency ν . From conservation of energy, the energy $h\nu$ of the photon must be equal to the energy lost by the electron: $h\nu = E_i - E_f$. From $\lambda = c/\nu$, we obtain the wavelength of the emitted photon.

In this lab, you will observe two of these transitions using a diffraction grating mounted on a spectroscope. You will view a source of excited hydrogen atoms through the diffraction grating which will separate the light into “spectral lines”. The relationship between the wavelength λ of each spectral line and the angle θ between the directions of the incident and diffracted light is given by

$$d \sin(\theta) = m\lambda$$

where $d=1657\text{nm}$, the distance between lines on the grating, and m is an integer. Looking into the spectroscope, you ought to be able to find a red line and blue line on each side of the central maximum $m = \pm 1$. (If you look carefully, you may be able to see one or more violet lines too.) For each line, record the angles, θ_1 and θ_2 for $m = 1$ and $m = -1$, respectively. (Note that the direction $\theta = 0$ is marked 180° on the spectroscope. The value of θ which you should record below is the *difference* between 180° and the angle indicated on the spectroscope.) If you performed the measurements correctly, you should have $\theta_{-1} \approx -\theta_1$. Because of errors inherent to the spectroscope, the two angles may not have exactly the same magnitude. In order to remove this source of error, calculate the average $\bar{\theta}$ of the magnitudes of the two angles: $\bar{\theta} = \frac{1}{2}(|\theta_1| + |\theta_{-1}|)$. Then calculate the measured value of λ for each line, using $\bar{\theta}$. Also, calculate the theoretical value of λ for each line.

| Color | n_i | n_f | θ_1 | θ_{-1} | $\bar{\theta}$ | λ (measured) | λ (theoretical) |
|-------|-------|-------|------------|---------------|----------------|----------------------|-------------------------|
| blue | 4 | 2 | _____ | _____ | _____ | _____ | _____ |
| red | 3 | 2 | _____ | _____ | _____ | _____ | _____ |