Physics 231 – Lab 8
Atomic Spectra

Equipment: Force Plate, Motion Sensor mounted on high rod, hydrogen emission tubes, hand-held spectrometers.

Objectives

In this quick lab, you'll take a look at the Hydrogen spectrum and use the mathematical model of its energy-level structure to predict the levels visible to the un-aided eye.

Hydrogen Spectrum

1. Background

To quote problem 8.22, "The eye is sensitive to photons with energies in the range from about 1.8eV, corresponding to red light, to about 3.1 eV, corresponding to violet light. White light is a mixture of all the energies in the visible region. If you shine white light through a slit onto a glass prism [or through a diffraction grating], you can produce a rainbow spectrum on a screen, because the prism bends different colors of light by different amounts. If you replace the source of white light with an electric-discharge lamp containing excited atomic hydrogen, you will see only a few lines in the spectrum, rather than a continuous rainbow." These lines are produced when atoms transition down from excited states (defined by different K+U values). The energy of the photon emitted equals the energy lost by the atom when it transitions between states: $E_{light} = -\Delta E_{atom} = -\left(E_{atom.f} - E_{atom.i}\right)$.

For the Hydrogen atom, the energy (K+U) of the n^{th} state is $E_{H\,n} = \dfrac{-13.6eV}{n^2}$ where n can be any positive integer.

2. Theory

Predict the energies of *visible* lines in Hydrogen's emission spectrum. For these, give both the energy and the "n" values of the states between which the Hydrogen transitioned in order to produce that light.

For the sake of comparison later, calculate the corresponding wavelengths of light seen for each visible transition. The conversion between light's wavelength and its energy is $\lambda_{light} = \dfrac{hc}{E_{light}}$ where λ stands for 'wavelength' and $hc = 1239.8eV \cdot nm$.

3. Experiment

We've got hand-held spectrometers and the equivalent of neon lights for hydrogen; turn on the hydrogen light and view it through the spectrometer. To do this, you look through the small end of the spectrometer and align the slit (at the other end) with the hydrogen tube. Within the spectrometer, you should see the hydrogen's spectrum against a scale off to the right. Now, the scale is in terms of not the light's *energy* but its *wavelength* measured in 100 nano-meters (nm=$10^{-9}m$); for example, when it reads "4" it means 400nm.

You should see one less line in the spectrum than you predicted (more about that later.) If that is not correct, you may want to look more carefully.

4. Comparison

Qualitatively, how do these compare with the energies you predicted? (Note: these hand-held spectrometers aren't calibrated well enough to make really accurate measurements, so we're just looking for the measurements to agree moderately well with the theory.)

Notice which predicted line you did *not* see. Apparently, this is produced by a transition down from initial state that the electron beam flowing through the gas discharge tube isn't energetic enough to knock many atoms up to that initial state.