Lab 5 – Spectroscopy of Simple Quantum Systems

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Part I: Hydrogen Gas Discharge Tube

Figure 1 shows the plot of the measured hydrogen spectrum. The plot depicts four hydrogen peaks between 400 nm and 700 nm. The center wavelength of each peak was found using a Gaussian fit to each peak. The center wavelengths in order of each peak 1-4 were 434.8 nm, 486.81 nm, 657.09 nm, and 778.1 nm respectively.

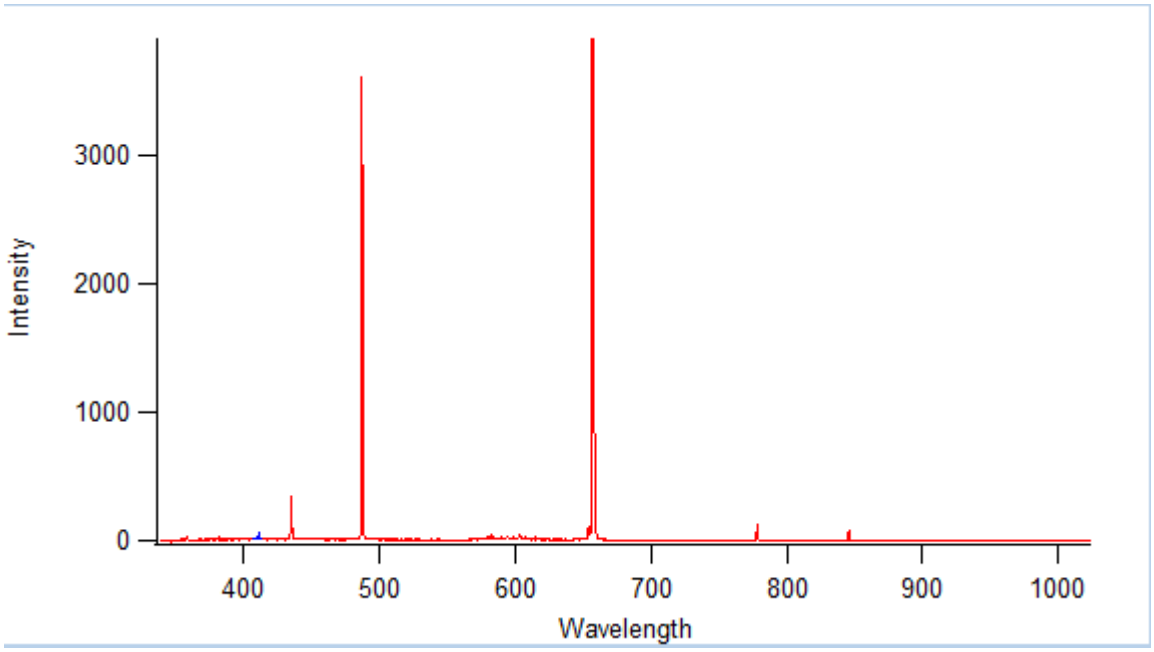

Figure 1: Measured Hydrogen Spectrum

A plot of the inverse peak wavelengths vs. (1/2^2 – 1/ni^2) is shown in figure 2. For this plot, we took the central wavelengths for each peak multiplied by 10^9, then used the formula 1/wavelength to calculate the inverse of the wavelength. Next, we assigned n values in order of 6,5,4,3 to each inverse wavelength value. Lastly, using the n value, we calculated (1/2^2 – 1/ni^2) and plotted the inverse wavelength vs. our calculated values of (1/2^2 – 1/ni^2).

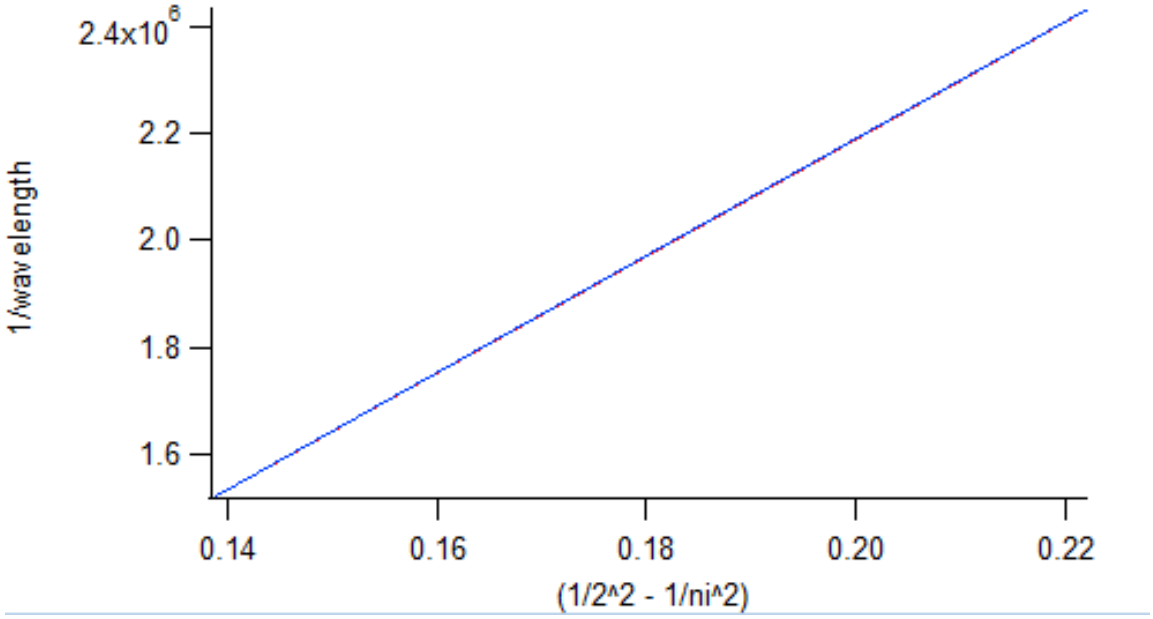

Figure 2: Inverse peak wavelengths vs. (1/2^2 - 1/ni^2)

By using the slope of the linear fit applied to this graph, we were able to get an experimental value for the Rydberg constant. The known value for the Rydberg constant is 1.09737e+07, and the experimental value from this data was 1.0939e+07. The calculation of the standard error is as follows:

$$\frac{|1.0939 \times 10^7 - 1.09737 \times 10^7|}{5.78 \times 10^{-}3} = 6 \times 10^6$$

This calculation shows that the experimental value is in close agreement with the known value for the Rydberg constant as it falls within 3 standard errors from the known value.

Part II: Quantum Dots

For this part of the lab, we used vials containing quantum dots of different sizes that were illuminated by a 390 nm almost UV light and a spectrometer. The spectrometer was placed in front of each vial and the vial was illuminated by the 390 nm light. The detector integration time was increased to 500 ms as the signal was weak at first. Figures 3-6 show the plots of intensity vs. wavelength for each quantum dot color.

Red Orange

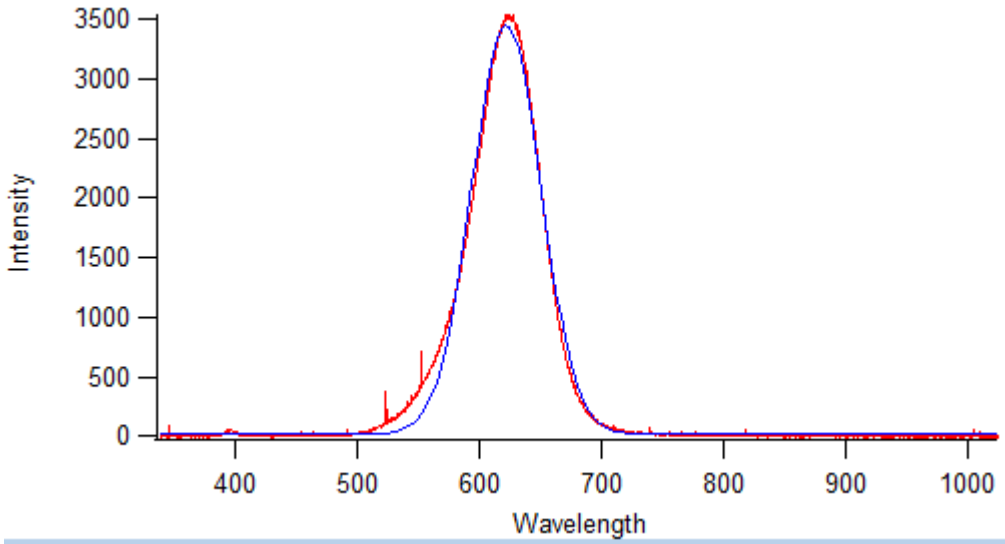

Figure 3: Intensity vs. wavelength for the red-orange quantum dot

Orange

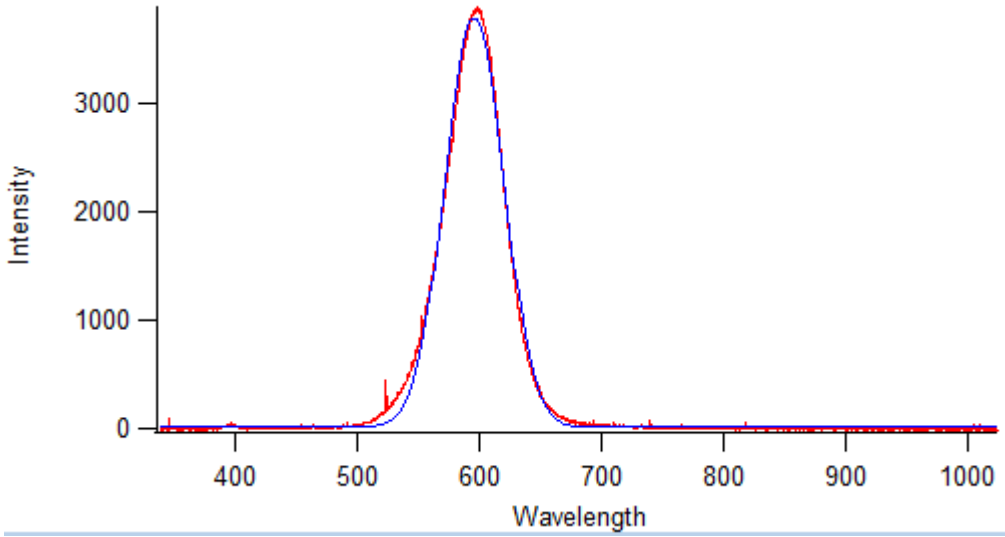

Figure 4: Intensity vs. wavelength for the orange quantum dot

Yellow

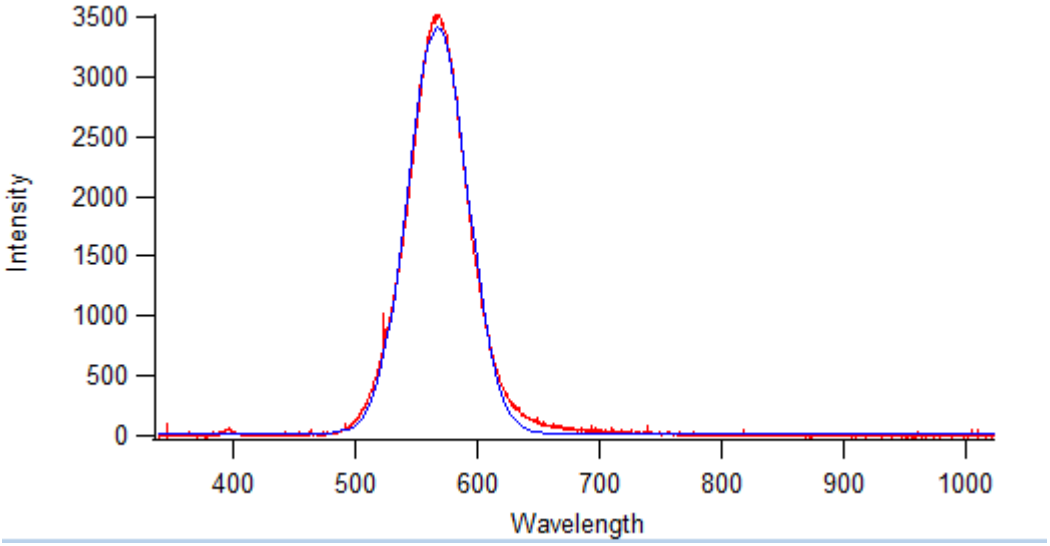

Figure 5: Intensity vs. wavelength for the yellow quantum dot

Green

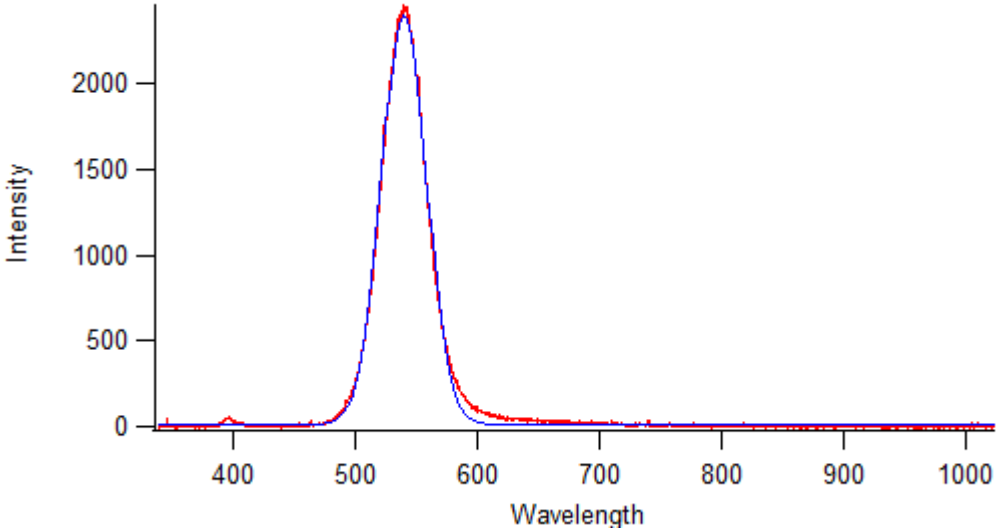

Figure 6: Intensity vs. wavelength for the green quantum dot

Quantum dot color	Fitted Center Wavelength	Wavelength Standard Deviation	Average dot radius	Radius standard deviation
Red orange	621.98	0.066	2.1387815e+16	5.4652139e-34
Orange	595.76	0.0438	2.0932152e+16	5.7057435e-34
Yellow	567.37	0.0359	2.042732e+16	5.9912469e-34
Green	539.61	0.0285	1.9921324e+16	6.2994639e-34