Optical Spectroscopy of Hydrogenic Atoms:

Calibration against Mecury and the Balmer Series

of Hydrogen Isotopes

Jason Gross

MIT - Department of Physics

Goals

- test the Balmer-Bohr formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

- determine the value of the Rydberg constant

$$R_H = \frac{R_\infty}{1 + m_e/M}$$

- determine the hydrogen-deuterium mass-ratio
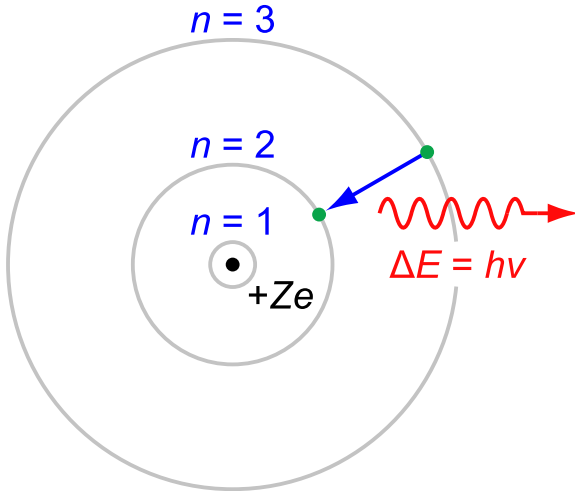
Goals

- test the Balmer-Bohr formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

- determine the value of the Rydberg constant

$$R_H = \frac{R_\infty}{1 + m_e/M}$$

- determine the hydrogen-deuterium mass-ratio

Goals

- test the Balmer-Bohr formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

- determine the value of the Rydberg constant

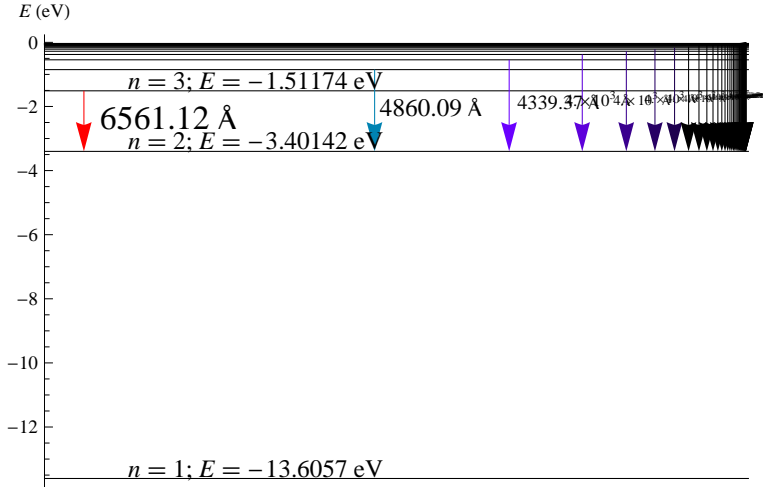$$R_H = \frac{R_\infty}{1 + m_e/M}$$

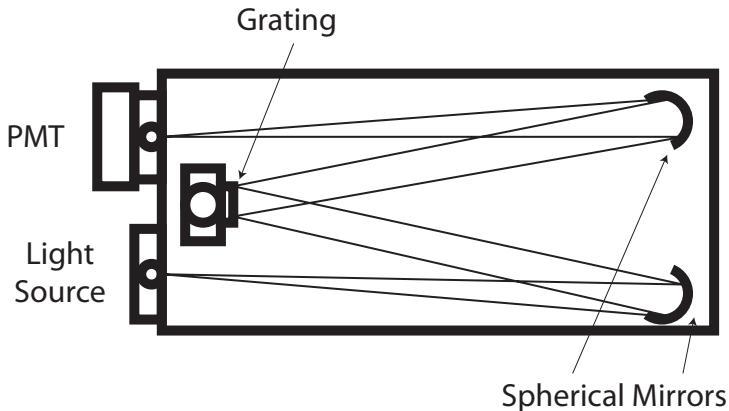- determine the hydrogen-deuterium mass-ratio

Bohr Model

$n = 3$

$n = 2$

$n = 1$

$+Ze$

$\Delta E = h\nu$

Balmer Series

Hydrogen Energy Level Diagram

Experimental Setup

Grating

PMT

Light
Source

Spherical Mirrors

Mercury Spectrum

Hydrogen Peak

Deuterium Balmer Plot (Uncorrected λ)

Residuals

$\chi^2_\nu = 1.9$
$\mu_D = (3883.8244 \pm 0.0003)\,\text{Å}$
$\mu_H = (3885.0185 \pm 0.0004)\,\text{Å}$
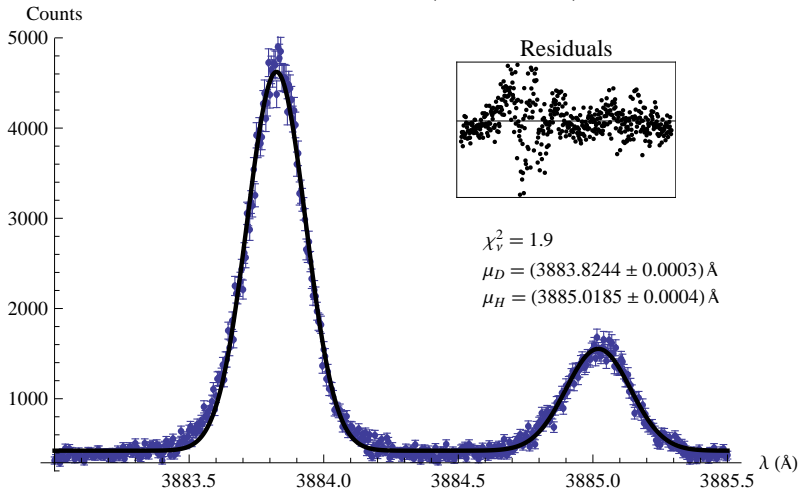
Rydberg Constant

Book Value: 0.00109737 $^{-1}$

Balmer Series for Hydrogen

λ (Å)

Residuals

$\chi^2_\nu = 7.3 \times 10^8$

$R_{\mathrm{H}} = (0.0010997 \pm 8. \times 10^{-7})$ Å

n
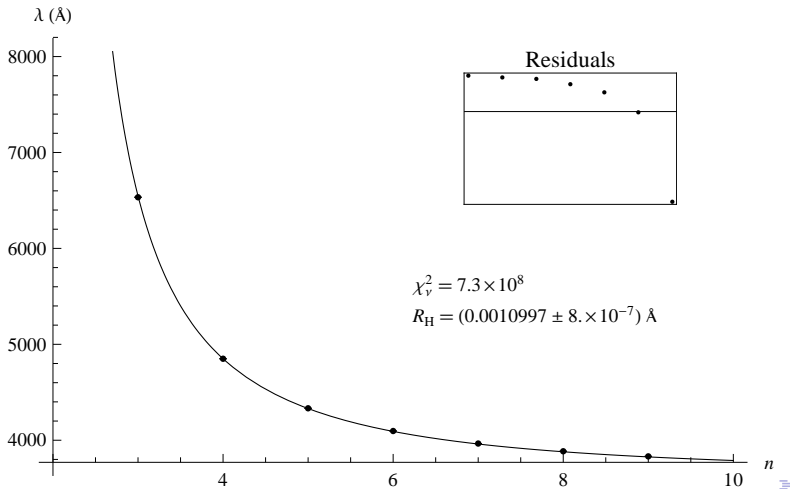
Rydberg Constant

Balmer Series for Deuterium

$\chi_\nu^2 = 7.8 \times 10^8$

$R_D = (0.0011000 \pm 8. \times 10^{-7})$ Å
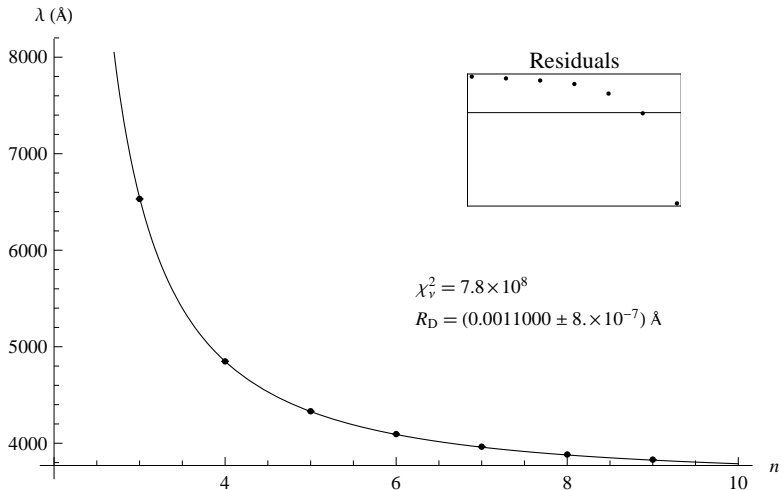
Mass Ratio

Book Value:

$$\frac{1 + m_e / M_D}{1 + m_e / M_H} = 0.999724$$

Our Value:

$$\frac{1 + m_e / M_D}{1 + m_e / M_H} = 0.9997 \pm 0.0010$$

Thank You

Any questions?