HW 6 #2

The XRISM X-ray satellite measured the spectrum of a peculiar star system. One line in the spectrum is marked "SXVI Lyα (b)"

- element is "S" = "sulfur"

- ionization indicator is "XVI", which is Roman numeral for 16, meaning (16-1) electrons have been removed. That leaves just 1 electron

When an atom has only 1 electron, its spectrum is similar to that of hydrogen – but shifted to higher energies.

$$E_n = (-13.6\ eV) * Z^2 * \frac{1}{n^2}$$

(Z ↖ # of protons in ion)

- the term "Ly α", short for "Lyman α", means a transition from $n=2 \rightarrow n=1$.

So we expect an energy of

$$E_1 = (-13.6\ eV)(16^2)\left(\frac{1}{1^2}\right) = -3482\ eV$$
$$E_2 = (-13.6\ eV)(16^2)\left(\frac{1}{2^2}\right) = -870\ eV$$
$$\Delta E = 2611\ eV$$

#2, continued

The observed energy of the line is higher, about $E_{obs} = 2700$ eV. The energy is higher because a Doppler shift increases its frequency. How fast must the gas move toward us?

$$\frac{\Delta\nu}{\nu_0} = \frac{\Delta E}{E_0} = \frac{v}{c}$$

So $$\frac{2700\text{ eV} - 2611\text{ eV}}{2611\text{ eV}} = \frac{v}{c}$$

$$\rightarrow \quad v = 0.034\,c = 1.02 \times 10^{7}\ \text{m/s}$$