3.12 Doppler Effect

PRE-LECTURE READING 3.12

- *Astronomy Today*, 8th Edition (Chaisson & McMillan)
- *Astronomy Today*, 7th Edition (Chaisson & McMillan)
- *Astronomy Today*, 6th Edition (Chaisson & McMillan)

VIDEO LECTURE

- Doppler Effect[1] (12:40)

SUPPLEMENTARY NOTES

Doppler Effect

- See Doppler Effect[2].
- Consider an emitter of waves. These waves get compressed in the direction of motion and decompressed opposite the direction of motion.

The amount of compression is given by:

$$\frac{\Delta\lambda}{\lambda_{\text{em}}} = \frac{v}{v_{\text{wave}}} \tag{15}$$

- $\Delta\lambda$ = change in wavelength
- λ_{em} = emitted wavelength
- v = speed of emitter toward or away from observer
- v_{wave} = speed of wave

- For light, $v_{\text{wave}} = c$. Solving for $\Delta\lambda$ yields:

$$\Delta\lambda = \left(\frac{v}{c}\right) \times \lambda_{\text{em}} \tag{16}$$

[1] http://youtu.be/vFNtV37m2a4
[2] http://en.wikipedia.org/wiki/Doppler_effect

- If the source is moving toward you (or you are moving toward it), the observed wavelength is shorter than the emitted wavelength, and hence the light is *blueshifted*:

$$\lambda_{\rm obs} = \lambda_{\rm em} - \Delta\lambda \tag{17}$$

- If the source is moving away from you (or you are moving away from it), the observed wavelength is longer than the emitted wavelength, and hence the light is *redshifted*:

$$\lambda_{\rm obs} = \lambda_{\rm em} + \Delta\lambda \tag{18}$$

EXAMPLE:

A star is moving toward us at $1/1000^{\rm th}$ of the speed of light. You take a spectrum of this star and identify a Balmer absorption line series. Balmer alpha (Hα) is always emitted at 656.5 nm. You observe it to be shifted by

$$\begin{aligned} \Delta\lambda &= \left(\frac{v}{c}\right) \times \lambda_{\rm em} \\ &= 0.001 \times 656.5 \text{ nm} = 0.06565 \text{ nm}. \end{aligned}$$

Since the star is moving toward us, you observe it at

$$\begin{aligned} \lambda_{\rm obs} &= \lambda_{\rm em} - \Delta\lambda \\ &= 656.5 \text{ nm} - 0.06565 \text{ nm} = 655.8 \text{ nm}. \end{aligned}$$

EXERCISE

Experiment with UNL's Doppler Shift Demonstrator[3].

ASSIGNMENT 3

- Do Question 9.

[3] http://astro.unl.edu/classaction/animations/light/dopplershift.html