Hw 3, #3

Finding the distance to an eclipsing binary – using the radial velocity graph,

velocity $v = 37\ km/s$

The duration of each eclipse is

$$\Delta t = 0.09 \cdot P = 0.09\,(189.995\ d) = 17.1\ d$$
$$= 1.48 \times 10^6 \text{ seconds}$$

Assuming the two stars were the same size, we would infer that size to be

$$R = \tfrac{1}{2}\,\Delta t \cdot v = 2.73 \times 10^{10}\ m$$

However, additional data has revealed the actual sizes to be

$$R_A = 1.963 \times 10^{10}\ m$$
$$R_B = 3.268 \times 10^{10}\ m$$

and temperatures

$$T_A = 5327\ K$$
$$T_B = 4541\ K$$

We can compute their luminosities:

$$L_A = 4\pi R_A^2 \sigma T_A^4 = 2.21 \times 10^{29}\ W = 577\ L_\odot$$
$$L_B = 4\pi R_B^2 \sigma T_B^4 = 3.24 \times 10^{29}\ W = 845\ L_\odot$$

Together, the two stars have luminosity

$$L_{tot} = 1422\ L_\odot$$

Since Sun's absolute mag is +4.83, and the bolometric correction is BC = −0.40 mag, we can compute

$$\text{abs mag}\quad M_V = M_\odot - 2.5 \log_{10}\left(\frac{L_{tot}}{L_\odot}\right) - BC$$

$$= 4.83 - 2.5 \log\left(\frac{1422}{1}\right) - (-0.40)$$

$$= -2.65$$

The apparent mag of the binary is — from light curve

$$m_V = 16.13 - \underbrace{3.1 * (0.115)}_{\text{extinction}} = 15.77$$

Thus

$$(m_V - M_V) = 15.77 - (-2.65) = \underline{18.42}$$

The distance is therefore

$$d = 10^{0.2\,((m-M)+5)} = 48.4 \text{ kpc}$$