John

Problem 3: B.O.B - 7.4

Consider an eclipsing spectroscopic binary with the following properties:

- Orbital period is 6.31 yr.
- Maximum radial velocities of Star A and Star B are 5.4 kms^{-1} and 22.4 km s^{-1}.
- Time period between first contact and minimum light is 0.58 d, and the length of the primary minimum is 0.64 d.
- The apparent bolometric magnitudes of the maximum, primary minimum, and secondary minimum are 5.40 magnitudes, 9.20 magnitudes, and 5.44 magnitudes, respectively.

Assuming circular orbits and that the plane of the system lies in our line of sight, find the following:

a) [2 pts] Ratio of the stellar masses.

b) [2 pts] Sum of the masses.

c) [2 pts] Individual masses.

d) [2 pts] Individual radii.

e) [2 pts] Ratio of the effective temperatures of the two stars.

Aug 2011

#3

$P = 6.31$ yr

$v_{r,A} = 5.4 \frac{km}{s}$

$v_{r,B} = 22.4 \frac{km}{s}$

a) $\frac{m_A}{m_B} = \frac{v_B}{v_A}$

$= \frac{22.4}{5.4}$

$= 4.15$

b) $P^2 = \frac{4\pi^2}{G(m_1+m_2)} a^3$

$(m_1+m_2) = \frac{4\pi^2}{G P^2} a^3$

* but $a = a_1 + a_2$

$= \frac{P}{2\pi} v_1 + v_2$

$= \frac{4\pi^2}{G P^2} \left(\frac{P}{2\pi} [v_1 + v_2] \right)^3$

$= \frac{4\pi^2 P}{G 8 \pi^3} (v_1+v_2)^3$

$= \frac{P}{2\pi G} (v_1+v_2)^3$

$= \frac{P}{2\pi G} \frac{(v_{1,R}+v_{2,R})^3}{\sin^3 i}$

$= 1.02 \cdot 10^{31}$ kg

c) $m_A = 4.15\, m_B$

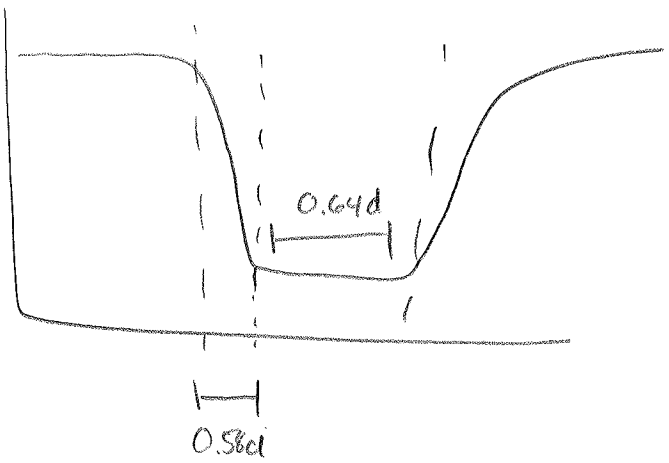
$\Rightarrow 5.15\, m_B = 1.02 \cdot 10^{31}$ kg

$m_B = 1.98 \cdot 10^{30}$ kg

$m_A = 8.23 \cdot 10^{30}$ kg

#3 (cont.)

d)



$$r_B = \frac{v}{2}(0.58 \text{ days})$$

$$= \frac{\left(5.4 \frac{km}{s} + 22.4 \frac{km}{s}\right)}{2}\left(0.58 \cdot 365.25 \frac{\text{day}}{\text{yr}} \cdot 24 \frac{hr}{\text{day}} \cdot 3600 \frac{s}{hr}\right)$$

$$= 6.965 \cdot 10^{8} \text{ km}$$

$$= 6.97 \cdot 10^{8} \text{ m}$$

$$r_A = \frac{5.4 \frac{km}{s} + 22.4 \frac{km}{s}}{2}\left([0.58 + 0.64] \cdot 24 \cdot 3600\right)$$

$$= 1.47 \cdot 10^{6} \text{ km}$$

$$= 1.47 \cdot 10^{9} \text{ m}$$

c)