PHYS 3021

Sean Eva

September 2021

1. Stefan-Boltzmann Law: $E = 4\pi R^2 \sigma T^4$

$$\frac{E_{\text{giant}}}{E_{\text{hotter}}} = (4)^2(\frac{7500}{12000})^4$$
$$\frac{E_{\text{giant}}}{E_{\text{hotter}}} = 2.44.$$

The giant star is 2.44 times as luminous as the smaller, but hotter star is.

2. Kepler's Third Law: $(M_1 + M_2)P^2 = a^3$

$$(M_1 + M_2) = \frac{a^3}{P^2}$$
$$(M_1 + M_2) = \frac{(\tan(\frac{2}{3600}) * (6.25 * 206265))^3}{(17)^2}$$
$$(M_1 + M_2) = 6.76 \text{ solar masses}$$

3. (a) Spectroscopic Binaries: $\frac{M_1}{M_2} = \frac{v_2}{v_1}$

$$\frac{M_1}{M_2} = \frac{500}{100}$$
$$\frac{M_1}{M_2} = 5.$$

One star is 5 times more massive than the other.

(b) Kepler's Third Law: $(M_1 + M_2)P^2 = a^3$ where $(M_1 + M_2) = 6M_2$ since $M_1 = 5M_2$

$$(6M_2) = \frac{a^3}{P^2}$$
$$(6M_2) = \frac{(0.21)^3}{(0.04)^2}$$
$$(6M_2) = 5.71 \text{ solar masses}$$
$$M_1 = 4.82 \text{ solar masses}$$
$$M_2 = 0.96 \text{ solar masses}$$

4. (a)

$$\begin{aligned}\log(\frac{L_1}{L_2}) &= 0.4(m_2 - M_1)\\ \frac{L_1}{L_2} &= 10^{0.4(m_2-m_1)}\\ &= 10^{0.4(11.5-1.8)}\\ &= 7.59 * 10^3.\end{aligned}$$

(b) Stefan-Boltzmann Law: $L = e\pi R^2 \sigma T^4$

$$\begin{aligned}\frac{T_1}{T_2} &= (\frac{L_1}{L_2}(\frac{R_1}{R_1})^2)^{1/4}\\ &= (7.59 * 10^3(\frac{0.01}{1.4})^2)^{1/4}\\ &= 0.789\end{aligned}$$

5. Kepler's Third Law: $(M_1 + M_2)P^2 = a^3$

$$\begin{aligned}a &= ((M_1 + M_2)P^2)^{1/3}\\ &= ((8)(0.0018)^2)^{1/3}\\ &= 0.03\text{AU}\end{aligned}$$

6. (a) Mass-Luminosity Relationship: $L \propto M^4$

$$\begin{aligned}L &= (0.085)^4\\ L &= 5.22 * 10^{-5}\\ L &= (100)^4\\ L &= 10^8.\end{aligned}$$

This range is between $5.22 * 10^{-5}$ to $1 * 10^8$ times as luminous as the sun.

(b) Mass-Luminosity Relationship: $L \propto M^4$

$$\begin{aligned}0.1 &= (M)^4\\ M &= 0.56 \text{ times the mass of the sun}\\ 1000 &= (M)^4\\ M &= 10^{3/4} \text{ times the mass of the sun.}\end{aligned}$$

7. Kepler's Third Law: $(M_1 + M_2)P^2 = a^3$

(a)

$$\begin{aligned}(M_1 + M_2)P^2 &= a^3\\ (3.0027 * 10^{-5})(0.575)^2 &= a^3\\ a &= 0.021\text{AU}\end{aligned}$$

(b)

$$\begin{aligned}(M_1 + M_2)P^2 &= a^3 \\ (5.03 * 10^5)(0.00011)^2 &= a^3 \\ a &= 0.183\text{AU}\end{aligned}$$

(c)

$$\begin{aligned}(M_1 + M_2)P^2 &= a^3 \\ (M_1 + M_2)(0.25)^2 &= (0.47)^3 \\ (M_1 + M_2) &= 1.66 \text{ solar masses}\end{aligned}$$

(d)

$$\begin{aligned}(M_1 + M_2)P^2 &= a^3 \\ (M_1 + M_2)(1.82 * 10^{-3})^2 &= (0.02)^3 \\ (M_1 + M_2) &= 2.42 \text{ solar masses}\end{aligned}$$

(e)

$$\begin{aligned}(M_1 + M_2)P^2 &= a^3 \\ (13)P^2 &= (5.2)^3 \\ P &= 3.29 \text{ years}\end{aligned}$$