SOLUTION SET 7
Physics 2022

1. $L_* = 1000\ L_{sun}$ $T_* = 100{,}000$ K $T_{sun} = 5800$ K

$L_* / L_{sun} = (R_* / R_{sun})^2 (T_* / T_{sun})^4$

$1000 = (R_* / R_{sun})^2 \ (100{,}000 / 5800)^4$

$(R_* / R_{sun})^2 = 1.13 \times 10^{-2}$

$R_* = 0.11\ R_{sun}$

2. v = 20 km/s   d = 2,700 LY θ = 1.2 arcmin = 72 arcsec

d = 2,700 LY (1pc / 3.26 LY) = 828 pc

$R = d \tan\theta = (828 \text{ pc}) (206{,}265 \text{ AU/pc})(1.5 \times 10^8 \text{ km/AU}) \ \tan [(72 / 2) / 3600]$

$= 4.5 \times 10^{12}$ km   Radius because half of the angle was used.

$t = D / v = (4.5 \times 10^{12} \text{ km}) / (20 \text{ km/s}) = 2.2 \times 10^{11}$ sec = 6970 yr

3a. $\lambda_{max} = 0.0029 / T = 0.0029 / 30{,}000 = 9.67 \times 10^{-8}$ m = 96.7 nm

3b. Because of Wien's Law, much more light is being emitted in the X-ray because the temperature of the White Dwarf is 30,000 K but temperature of its companion is about 10,000 K.

4. $\mathcal{M} = 1.0\ \mathcal{M}_{sun} = 2 \times 10^{30}$ kg $R_* = R_{earth} = 6378$ km

$\rho = \mathcal{M} / V = (2 \times 10^{33} \text{ g}) / (4\pi / 3) (6378 \times 10^5 \text{ cm})^3 = 1.84 \times 10^6 \text{ g/cm}^3$

5. Radius = 0.1 m   Density = 10^6 g/cm^3

Volume = $4/3\, \pi R^3 = 4/3\, \pi (10 \text{ cm})^3 = 4.2 \times 10^3 \text{ cm}^3$

Mass = Volume x Density = $(4.2 \times 10^3 \text{ cm}^3) \times (10^6 \text{ g/cm}^3)$

$= 4.2 \times 10^9 \text{ g} = 4.2 \times 10^6 \text{ kg}$ = 4,200 metric tons

6. $\Delta m = 20^m = 2.5 \log (l_1 / l_2)$ $l_1 / l_2 = 10^8$

7. $d = 425$ LY $(/ 3.26$ LY/pc$) = 120$ pc

$$m - M = 5 \log (d / 10)$$

$$m = 5 \log (120 / 10) + (-17) = -11.6 \text{ mag}$$

8. **Because the spectrum showed Si lines, it is a Type Ia supernova. Therefore, the peak absolute magnitude is $M = -19$ mag.**

$$m - M = 5 \log (d / 10)$$

$$16.5 - (-19) = 35.5 = 5 \log (d / 10)$$

$$7.1 = \log(d / 10)$$

$$d = 1.3 \times 10^8 \text{ pc} = 130 \text{ Mpc}$$