

PHAS1102 – Physics of the Universe 2011

Practice Problem Sheet 2 - solutions

1.

Stefan-Boltzmann law: $F(T) = \sigma T^4$

$$F = 5.67 \times 10^{-8} \times (5800)^4 = 6.42 \times 10^7 \text{ Wm}^{-2} \quad 2$$

$$\begin{aligned} \text{Total power output} = \text{Luminosity} &= 4\pi R^2 \sigma T^4 \\ &= 4\pi (6.96 \times 10^8)^2 (6.42 \times 10^7) = 3.91 \times 10^{26} \text{ W} \end{aligned} \quad 2$$

[4 marks total]

2. Human eyes have evolved to be most sensitive to the Sun's radiation, which has a (~blackbody) peak in the visible region of the EM spectrum. 1

A exoplanet hosting star has a surface temperature 5 times the Sun will have a blackbody spectrum that peaks at a much shorter wavelength than the Sun does:

$$\text{Wien's law: } \lambda_{\max} = 3 \times 10^{-3} / T = 3 \times 10^{-3} / (5 \times 5800) \sim 1 \times 10^{-7} \text{ m}$$

The vision of alien life on the exoplanet would therefore be most sensitive to ultraviolet. 3

[4 marks total]

3. The star distance is $d = 1/0.3'' = 3.33 \text{ pc}$. 1

$$\text{The distance modulus will be } m - M = 5 \log_{10} d - 5 = 2.6 - 5 = -2.4 \quad 1$$

$$\text{The absolute magnitude is } M = m + 2.4 = 2.0 \quad 1$$

[3 marks total]

$$4. V_1 = V_2 = 7.5$$

$$B_1 = 7.2, B_2 = 8.7$$

$$\text{Thus } (B-V)_1 = -0.3 \text{ and } (B-V)_2 = 1.2 \quad 1$$

Star 1 is bluer, because its blue magnitude is smaller than for star 2. 1

Their difference in B magnitude is $\Delta B = B_2 - B_1 = 1.5$, thus

$$\Delta B = 1.5 = 2.5 \log_{10}(f_1/f_2)$$

and star 1 is brighter by a factor of

$$f_1/f_2 = 10^{0.6} = 3.98$$

1

1

[4 marks total]