ASTR 205: Stellar Astronomy
Questions about Black Body Radiation
Class Assignment 3: Jan 25 2019

1. A star has a parallax of 0.0038 arcsec. Its apparent magnitudes are m_v = V = 5.66 and m_B = B = 5.92. It has an effective temperature T_{eff} of 12,600 K. The star is reddened with a colour excess E_{B-V} of 0.3.
(a) How far is this star from Earth in parsecs?
(b) What is its absolute visual magnitude M_V and its visual luminosity in solar units?
(c) Estimate its radius in solar radii?

2. An average person has $1.4m^2$ of skin at a temperature roughly 33 C. People radiate much like blackbody sources.
(a) Calculated the energy radiated by the person in watts.
(b) How does this emission of radiation compare to the amount of radiation a body of the same surface area receives from the Sun?
(c) Determine the peak wavelength λ_{max} of the radiation emitted by your body. In what region of the electro-magnetic spectrum is this wavelength found?

3. The star δ Sco has a surface temperature of 28,000 K and a radius of 5.16×10^9 m. It is located 123 pc from Earth. Determine

(a) The star's luminosity

(b) Its distance modulus

(c) Flux at the Earth's surface and compare this with that received from the Sun.

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1. (a) $\pi = .0038'' \Rightarrow D(pc) = \frac{1}{\pi} = 263\ pc$

(b) M_V? $(m - M) = 5 \log \frac{r}{10} + A_V$

$m = V = 5.66$, $r = 263$, $A_V = 3 \times 0.3 = 0.9$

$\therefore (V - M_V) = 5 \log \frac{263}{10} + 0.9$

$\therefore -M_V = -5.66 + 7.10 + 0.9$

$\therefore -M_V = 2.34$

$\Rightarrow M_V = -2.34$

Visual luminosity in solar Units

M_V sun $= 4.75$, this star is

$M_{sun} - M_{star} = 2.5 \log \frac{L_{star}}{L_{sun}}$

$\frac{4.75 + 2.34}{2.5} = \log \frac{L_{star}}{L_{sun}}$

$2.84 = \log \frac{L_*}{L_{sun}}$

$\boxed{\therefore L_* = 685\ L_{sun}}$

(c) $\frac{L_*}{L_{sun}} = \frac{4\pi R_*^2 \sigma T_*^4}{4\pi R_\odot^2 \sigma T_\odot^4}$

$\left(\frac{R_*}{R_\odot}\right)^2 = \frac{L_*}{L_{sun}} \times \frac{T_\odot^4}{T_*^4} = 685 \times \left(\frac{5778}{12,600}\right)^4$

$\boxed{\therefore \left(\frac{R_*}{R_\odot}\right) = 5.50}$

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2. (a) $L = A \sigma T^4$ (A = surface area) L in Watts.

33C = 306°K (273 = 0C)

$\therefore L = 1.4\,m^2 \times 5.6 \times 10^{-8} \frac{W}{m^2 K^4} \times (306)^4$

$L = $ 687 watts.

(b) Flux from Sun = 1.366 $\frac{K\,Watts}{m^2}$

$= 1366 \frac{watts}{m^2}$

$\simeq$ 975 watts over entire surface so numbers are comparable.

(c) $\lambda_{max} T = 2.898 \times 10^{-3}\ m\,°K$

$\therefore \lambda_{max} = \frac{2.898 \times 10^{-3}}{306}\ m$

$= 9.5 \times 10^{-6}\ m$

$= 9.5\ \mu m.$ (in IR)

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3. (a) $L = 4\pi R^2 \sigma T^4$

$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}$

$R = 5.16 \times 10^9 m$

$T = 28{,}000 K$

$\therefore L = 1.17 \times 10^{31} W$

(compare with Sun $\simeq 3.8 \times 10^{26} W$
$\simeq 30{,}686 L_\odot$)

(b) $(m - M) = 5 \log \frac{r}{10}$

$r = 123 pc$

$\therefore (m - M) = 5.45$

(c) Flux = W/m^2
Sun = 1366 W/m^2

This star 123 pc = ~~1.3~~ 3.1 $\times 10^{16} \times 123$
= ~~1.6~~ 3.8 $\times 10^{18}$ m.

$\therefore$ Flux at Earth

$F = \frac{L}{4\pi R^2} = \frac{~~30,686 \times 3.8~~ \; 1.17 \times 10^{31} W}{4\pi (~~1.6~~ \; 3.8 \times 10^{18})^2 m^2}$

$= ~~3.64~~ \; 6.43 \times 10^{-8} W/m^2$

~~a factor of 3.76×10^9 less than Sun's Flux~~