

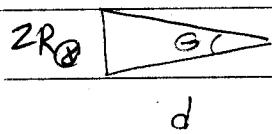
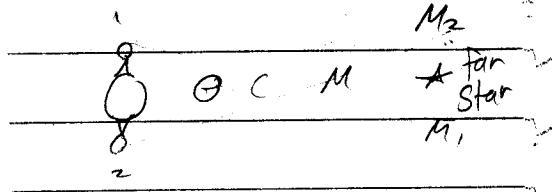
# Astrophysics Ch 3: Light & Spectra

# 1, 6, 8, 13

EJZ  
See ~~notes~~ of  
12 Feb

- 3.1 In 1672, an international effort was made to measure the parallax angle of Mars at the time of opposition, when it was closest to Earth; see Fig. 1.6.

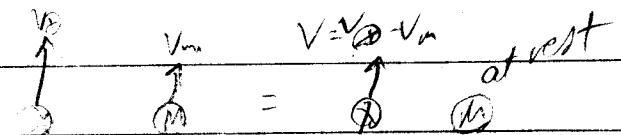
- (a) Consider two observers who are separated by a baseline equal to Earth's diameter. If the difference in their measurements of Mars' angular position is  $33.6''$ , what is the distance between Earth and Mars at the time of opposition? Express your answer both in units of cm and AU.
- (b) If the distance to Mars is to be measured to within 10%, how closely must the clocks used by the two observers be synchronized? Hint: Ignore the rotation of Earth. The average orbital velocities of Earth and Mars are  $29.79 \text{ km s}^{-1}$  and  $24.13 \text{ km s}^{-1}$ , respectively.



$$2R_{\odot} = d \theta \text{ where } \theta = 33.6'' / 1' / 1^\circ / 2\pi \text{ rad} / = \frac{1}{60''/60'/360^\circ} \text{ rad}$$

$$d = \frac{2R_{\odot}}{\theta} = \frac{R_{\odot}}{\theta_2} =$$

- (c) The motion of the Earth will add an error to the uncertainty:



$$\frac{\Delta d}{d} = \frac{1}{10} = \frac{|d' - d|}{d} \text{ where the } d \text{ is wrong; actually, } d' = R_{\odot} + v_{\text{rel}} t$$

3.6

 $M =$ 

A  $1.2 \times 10^4$  kg spacecraft is launched from Earth and is to be accelerated radially away from the Sun using a circular solar sail. The initial acceleration of the spacecraft is to be  $1g$ . Assuming a flat sail, determine the radius of the sail if it is

- (a) black, so it absorbs the Sun's light.
- (b) shiny, so it reflects the Sun's light.

*Hint:* The spacecraft, like Earth, is orbiting the Sun. Should you include the Sun's gravity in your calculation?

SUN

SAIL



$$\leftarrow J = 1AU \rightarrow$$

[NOT TO  
SCALE]

p. 71  $F = m \cdot a$

$$F_{\text{rad}} = K \langle S \rangle A$$

$$a = g = 9.8 \frac{m}{s^2}$$

$$K = \begin{cases} 1 : \text{absorption} & : \text{BLACK} \\ 2 : \text{reflection} & : \text{SHINY} \end{cases}$$

$$\langle S \rangle = \frac{E_0 B_0}{2\pi d} = \frac{\text{power}}{\text{area}} = \frac{\text{intensity of solar radiation}}{\text{at distance } d}$$

$$\text{Intensity} = \frac{\text{power}}{\text{area}} = \frac{L_0}{4\pi d^2} = \langle S_0 \rangle = 1360 \text{ Watts}$$

$$mg = K \langle S \rangle A \rightarrow A = \frac{mg}{K \langle S \rangle}$$

$$A = 3.8 \times 10^8 \frac{m}{s} (1.2 \times 10^4 \text{ kg}) 9.8 \frac{m}{s^2}$$

$$K \cdot 1360 \text{ (Watts)} = \frac{\text{Joules}}{\text{m}^2 \text{ sec}} = \frac{\text{kg m}^2}{\text{s}^3}$$

$$A = \frac{1}{K} \text{ m}^2$$

$$A_{\text{black}} =$$

$$A_{\text{shiny}} =$$

Need not include Sun's gravity, since sail is always orbiting the Sun, with Earth

- 3.8 Consider a model of a star consisting of a spherical blackbody with a surface temperature of 28,000 K and a radius of  $5.16 \times 10^{11}$  cm. Let this model star be located at a distance of 180 pc from Earth. Determine the following for the star: *Dschubba - center of Scorpion's head*

- (a) Luminosity.
- (b) Absolute bolometric magnitude.
- (c) Apparent bolometric magnitude.
- (d) Distance modulus.
- (e) Radian flux at the star's surface.
- (f) Radian flux at Earth's surface (compare this with the solar con-
- (g) Peak wavelength  $\lambda_{\text{max}}$

$$R = 5.16 \times 10^9 \text{ m}$$

$$L_0 = 3.826 \times 10^{\frac{33 \text{ erg}}{\text{s}}} \left| \frac{\text{J}}{10^7 \text{ erg}} \right|$$

$$= 3.826 \times 10^{26} \left( \frac{\text{J}}{\text{s}} = \text{Watts} \right)$$

(3.16) (a)  $L = 4\pi R^2 \sigma T^4 = 4\pi (5.16 \times 10^9 \text{ m})^2 5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \text{K}^4} (2.8 \times 10^4 \text{ K})^4$   
 $L = \underline{\hspace{10cm}} \text{ Watts}$

(3.16) (b)  $M = M_\odot - \frac{5}{2} \log \left( \frac{L}{L_\odot} \right) = 4.76 - \frac{5}{2} \log \left( \frac{3.826 \times 10^{26} \text{ W}}{3.826 \times 10^{26} \text{ W}} \right)$

$$M = \underline{\hspace{10cm}}$$

(3.16) (c)  $m = M + 5 \log_{10} \left( \frac{d}{10 \text{ pc}} \right) = \underline{\hspace{10cm}} + 5 \log_{10} \left( \frac{180}{10} \right)$

$$m = \underline{\hspace{10cm}}$$

(3.16) (d)  $m - M =$

(e) Flux = Intensity =  $\frac{\text{Power}}{\text{Area}} = \frac{L}{4\pi R^2} = \sigma T^4 =$

$$\text{Flux}/F_0 = \frac{\sigma T^4}{\sigma T_0^4} = \frac{(28000)^4}{(5770)^4} =$$

This is at each star's surface.

⑦ 3.8: Dschubba's radiant flux at the Earth's surface

$$F = \frac{L}{4\pi d^2} \quad \text{where } d = 100 \text{ pc} \left| \frac{3.1 \times 10^{16} \text{ m}}{\text{pc}} \right| =$$

$$F = \frac{1.2 \times 10^{31} \text{ W}}{4\pi (10^3 \text{ m}^2)} = \frac{\text{W}}{\text{m}^2}$$

(3.15) ⑨ Peak wavelength from Wien's law:  $\lambda_{\max} = 2.9 \times 10^{-3} \text{ m}$

$$\lambda_{\max} = \frac{2.9 \cdot 10^{-3} \text{ m} \cdot 10^9 \text{ nm}}{2.8 \times 10^4 \text{ m}} = 100 \text{ nm} \quad \text{ultraviolet}$$

3.13 Use the data in Appendix E to answer the following questions.

- Calculate the absolute and apparent visual magnitudes,  $M_V$  and  $V$ , for the Sun.
- Determine the magnitudes  $M_B$ ,  $B$ ,  $M_U$ , and  $U$  for the Sun.
- Locate the Sun and Sirius on the color-color diagram in Fig. 3.10. Refer to Example 3.6 for the data on Sirius.

$$M_V = 4.83 \text{ absolute}$$

$$\text{Ex 3: } m - M = -31.57$$

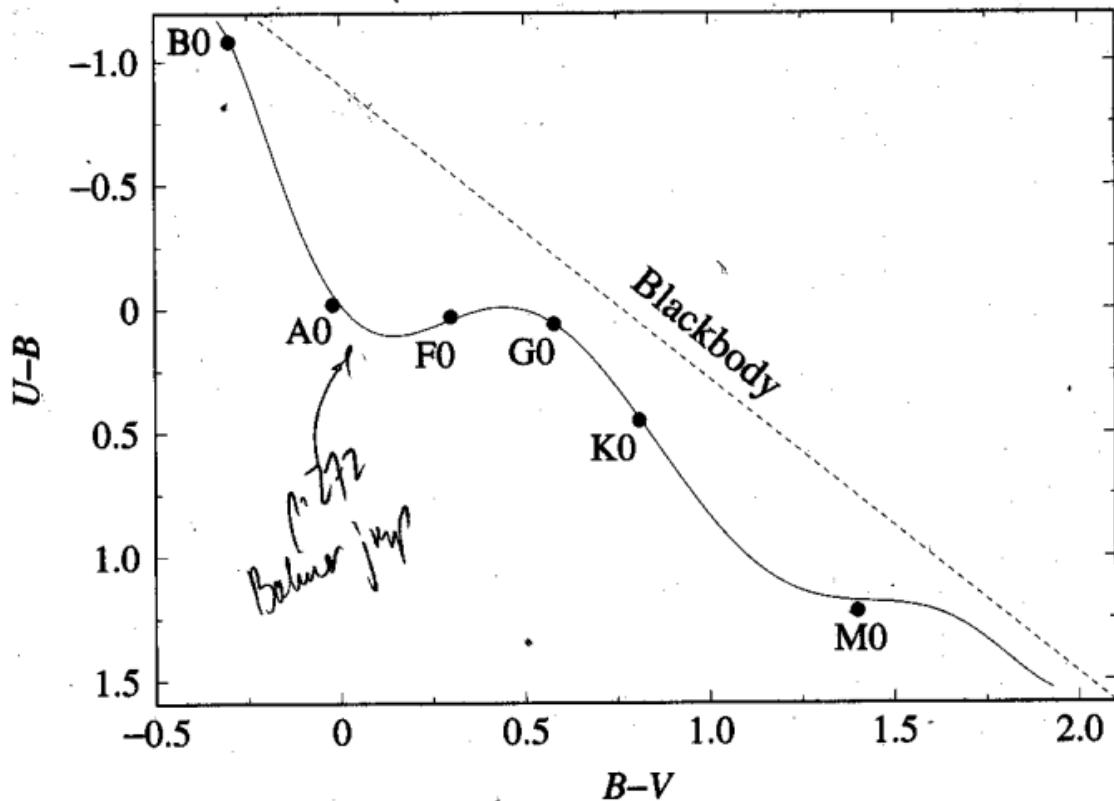
= distance modulus

② Apparent visual magnitude  $V = M_V + (\text{distance modulus})$   
 $= 4.83 - 31.57 = 26.74$

③ App. E:  $B - V = 0.64$ ,  $U - B = 0.16$

So  $B - V + 0.64 = \rightarrow U = B + 0.16 =$

$M_B = B - \text{distance modulus}$   $M_U = U - \text{distance mod}$



3.10 Color-color diagram for main-sequence stars. The dashed line represents a blackbody.