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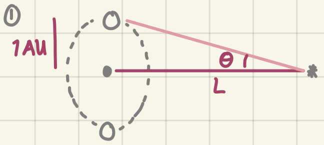
Homework 1

Q1 $\theta = 0.742$ arcsec. $\rightarrow$ find L in pc

$D = 1.4\times10^{11}$ cm, $\varphi = ?$ in rad & arcsec

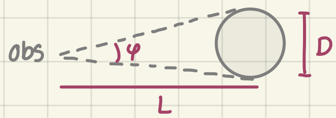
①



$$L = \frac{1\,AU}{\theta} = \frac{1\,AU}{0.742''} = 1.348\,pc$$

↳ convert to rad

②



$$\tan\left(\frac{\varphi}{2}\right) = \frac{D/2}{L} \longrightarrow \varphi = 2\arctan\left(\frac{1.4\times10^{11}\,cm/2}{1.348\,pc}\right) = 3.366\times10^{-8}\,rad$$
$$= 0.00694''$$

Q2

What is the definition of *Absolute Magnitude*? Derive the distance modulus formula, *m-M = 5 log d -5* from the inverse square law *f = L /4 π d*² and the definition of a magnitude Δ*m* = 2.5 log (flux ratio).

- Use the notation: luminosity *L*, apparent flux *f*, distance *d* (in parsec), apparent magnitude *m*, and absolute magnitude *M*.✓
- What is the distance modulus to the center of the Milky Way galaxy?✓
- What will be the apparent magnitude of a star like the Sun at the distance of the galactic center?✓

① Absolute magnitude: apparent magnitude a star would have if it were located at a distance of 10 pc

② At observer: $f_1 = \frac{L}{4\pi d^2}$, $m_1 = m$

At 10 pc: $f_2 = \frac{L}{4\pi\cdot 100\,pc^2}$, $m_2 = M$

Using the flux ratio, we have
$$m_1 - m_2 = -2.5\log\left(\frac{f_1}{f_2}\right)$$
$$m - M = -2.5\log\left(\frac{\cancel{L}}{\cancel{4\pi} d^2}\cdot\frac{\cancel{4\pi}\cdot 100\,pc^2}{\cancel{L}}\right)$$
$$= -2.5\log\left(\frac{10^2}{d^2}\right)$$
$$= -5\log\left(\frac{10}{d}\right)$$
$$= -5\log 10 + 5\log(d)$$
$$m - M = 5\log(d) - 5$$

③ $d_{MW} = 8000$ pc (found online)

so $m - M = 5\log(8000) - 5 = 14.52$

④ $M_{sun} = 4.83$

so $m - M_{sun} = m - 4.83 = 14.52$

$m = 19.35$

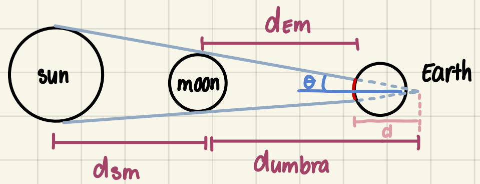
Q3 Many of us enjoyed the solar eclipse over North America this spring. Here are a few questions to get you thinking about eclipses more deeply:

- During which phases of the moon can a Solar eclipse occur? ✓
- Why isn't there a Solar eclipse every Moon cycle? ✓
- Using trigonometry, estimate the "size of totality" of a Solar eclipse on Earth, i.e., the stretch of Earth in kilometers that experiences a total Solar eclipse. Start by making a drawing. ✓

① Solar eclipse → moon passing between Earth & Sun so it has to be in the 'New moon' phase

② the moon isn't orbiting the Earth in the same plane as the Earth's orbit around the Sun. This means that even if we have the moon in it's 'New moon' phase (sun – moon – Earth), they might not actually be aligned to cause an eclipse on Earth (ie. the shadow isn't cast on Earth's surface)

③



$$\tan\theta = \frac{R_s}{d_{sm}+d_u} = \frac{R_m}{d_u}$$

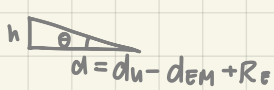
$$\frac{R_s}{R_m} = \frac{d_{sm}}{d_u} + 1$$

$$\frac{R_s}{R_m} - 1 = \frac{d_{sm}}{d_u}$$

$$d_u = \frac{d_{sm}}{(R_s/R_m - 1)}$$

$= d_{sun\text{-}earth} - d_{EM}$ at aphelion ↳ at perigee

$d_u = 3.798 \times 10^8 m$ $\Rightarrow \tan\theta = \frac{R_m}{d_u} = 0.004655$



$\tan\theta = \frac{h}{d}$

$h = d\tan\theta$

$h = (d_u - d_{EM} + R_E)\tan\theta$ at perigee

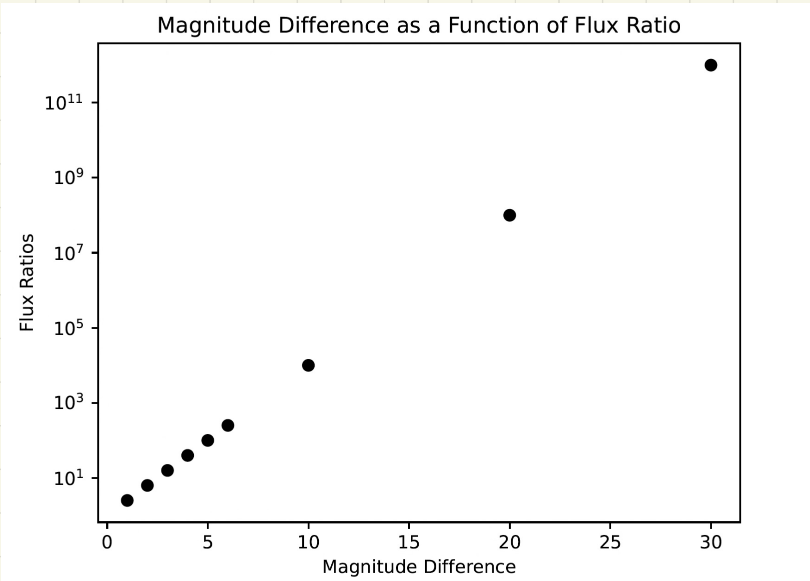
$h = 107$ Km

so diameter is 214 km

Q4 a. Write a python script, *magnitude.py*, that calculates the *flux ratios* for stars with a *magnitude difference* Δm of 1, 2, 3, 4, 5, 6, 10, 20, 30 mags. Present the results graphically. (Check out section 3.3 of *Python for Astronomers* if you aren't sure where to start!) ✓

b. The faintest stars we can observe with our 16-inch telescope are about V=16, while for the recorded with the Hubble Space Telescope its about V= 30. What is the brightness ratio? ✓

a)



b) from python script, the brightness ratio is 3.981×10^5

Q5 The star Vega is the prime photometric standard in many astronomical filter systems. In the ***Johnson*** system, U B V R I J H K L M, Vega is (almost) zero magnitude at all wavelengths. The conversion from apparent magnitude in each filter to monochromatic flux density can be found at: https://irsa.ipac.caltech.edu/data/SPITZER/docs/dataanalysistools/tools/pet/magtojy/

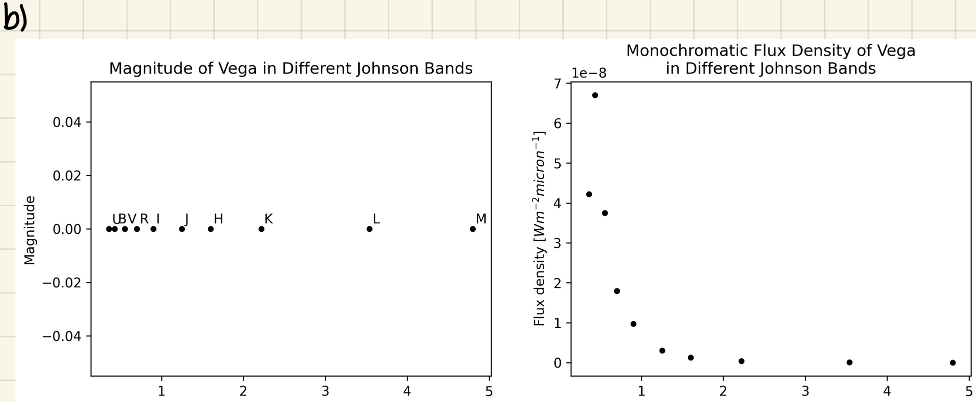
a. Run the conversion routine for each of the 10 Johnson filters at magnitude = 0, and record
   - **F_λ** in in Wm^{-2} $micron^{-1}$ ✓
   - **λ_c** central (effective) wavelength in micron. ✓

b. Write a plotting script in python with an array for magnitude, **F_λ** and **λ_c**. Make two plots on one page. (You can stay in these units or convert to nm with 1000 nm = 1 micron).
   - The magnitude of each filter UBVRIJHK versus wavelength ✓
   - Monochromatic Flux density at each filter versus wavelength ✓

a)

Band	F_λ	λ_c
U	4.22e-08	0.36
B	6.70e-08	0.43
V	3.75e-08	0.55
R	1.80e-08	0.7
I	9.76e-09	0.9
J	3.08e-09	1.2
H	1.26e-09	1.6
K	4.06e-10	2.2
L	6.89e-11	3.5
M	2.21e-11	4.8

b)



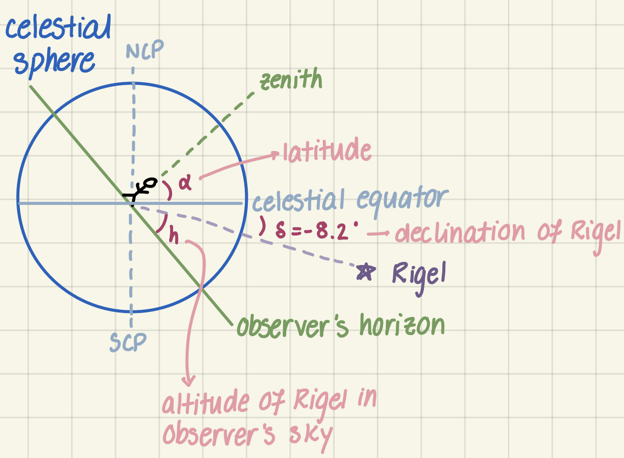
Q6

When planning an observing session you have to think of when the object you want to study will be visible from the site of the observatory you are using.

a. To get you thinking about celestial coordinates: imagine you are the navigator on a ship without modern technology and you happen to know that the declination of Rigel (one of the stars is Orion) is -8.2 degrees. How do you figure out the latitude you are sailing on? ✓

b. Catalogs of astronomical objects typically list their right ascension and declination. Using the astropy library, write a function that takes the right ascension and declination of an object as input and plots the visibility of that object as a function of time (think of what coordinate determines the visibility of an object at any given time), for a given place on Earth (see http://docs.astropy.org/en/stable/coordinates/index.html to learn how you can use astropy to convert coordinates). Use the function to plot the visibility of the Triangulum Galaxy (M33) from Montréal on the night of September 13, 2024. You'll receive full marks for a correct plot of altitude vs. time.

a)



So we have $90° = |\alpha - \delta| + h$

want angles to add up if opposite signs & subtract if same sign

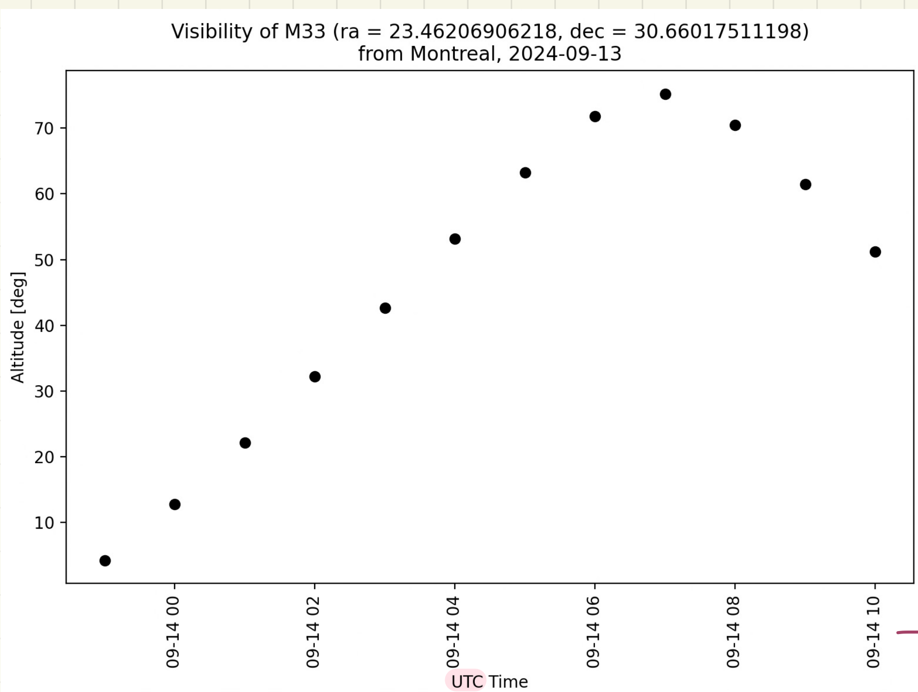
⇒ our latitude is $\alpha = \pm(90° - h) + \delta$

↳ + if obs is in north hemisphere
− if obs is in south hemisphere

eg. if we observe Rigel at $h = 30°$ (Randomly chosen) and we are in the North hemisphere, we have $\alpha = +(90° - 30°) - 8.2°$

$\alpha = 51.8°$

b)



→ sept 13 → sept 14 night