Fotometri spektroskopi

Tuesday, April 2, 2019 8:25 AM

1) Fotometri ⟹ Intensitas cahaya

(Foto = cahaya, metri = mengukur)

2) Spektroskopi ⟹ kuat garis, posisi garis, dst.

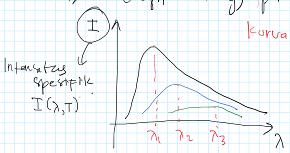
(Spektro = spektrum, skopi = melihat)

Energi terkuantisasi ⟶ $\boxed{\varepsilon = h\frac{c}{\lambda}}$ ⟶ $\boxed{\varepsilon = h\nu}$ (h: Planck)

Benda langit (bintang) perilaku mirip benda hitam

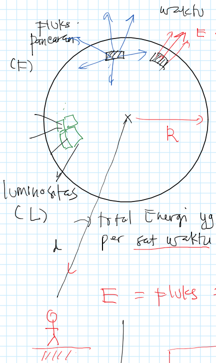
Kurva Planck

↳ benda hipotetik yg pny sifat efisiensi 100% pemancar/penyerap sempurna



Wien : $\boxed{T = \frac{0.2898}{\lambda}}$ (T: perm, λ: peak)

• I : Energi yg dipancarkan satu satuan luas per sat. waktu ⊥ perm



$F = \int_0^{\pi} I = \sigma T^4$ (Fluks pancaran)

(σ: Stefan – Boltzmann)

↳ Energi yg dipancarkan per sat luas per sat waktu ke segala arah

→ total Energi yg dipancarkan seluruh luas permukaan per sat waktu

E = fluks = energi yg diterima pengamat pada jarak d per sat. luas per sat waktu

$\boxed{E = \frac{L}{4\pi d^2}}$ $\boxed{L = \int_0^{4\pi R^2} F = 4\pi R^2 \sigma T^4}$

Pogson ⟶ skala magnitudo

$\boxed{m = -2.5 \log E}$ + konstanta

Jika ada dua bintang dengan m = 0 dan m = 2, tentukan skala terang gabungan jika kedua bintang bersatu

① m = 0 ② m = 2 ⟶ m_{TOT} = ?

$\boxed{E_{TOT} = E_1 + E_2}$

$m_1 - m_2 = -2.5 \log \frac{E_1}{E_2}$

$\frac{E_1}{E_2} = 2.512^{-(m_1 - m_2)}$

$= 2.512^{-(0-2)}$

$\boxed{\frac{E_1}{E_2} = 6.31}$ ⟶ $E_1 = 6.31 E_2$

$E_{TOT} = 6.31 E_2 + E_2$ ⟹ $E_{TOT} = 7.31 E_2$

$\frac{E_{TOT}}{E_2} = 7.31$

$m_{TOT} - m_2 = -2.5 \log \frac{E_{TOT}}{E_2}$

$m_{TOT} - 2 = -2.5 \log \frac{E_2 (7.31)}{E_2}$ ⟶ $\boxed{m_{TOT} = -0.16}$

Misal : d = 10 pc

$m = -2.5 \log E$

utk d = 10 ⟶ $M = -2.5 \log \frac{L}{4\pi (10)^2}$

$M_1 - M_2 = -2.5 \log \frac{\frac{L_1}{\cancel{4\pi 10^2}}}{\frac{L_2}{\cancel{4\pi 10^2}}}$ $\boxed{M_1 - M_2 = -2.5 \log \frac{L_1}{L_2}}$

$m = -2.5 \log E$ + konstanta ⟹ $m = -2.5 \log \frac{\cancel{L}}{\cancel{4\pi} d^2} + C$

$M = -2.5 \log L$ + konstanta ⟹ $M = -2.5 \log \frac{\cancel{L}}{\cancel{4\pi} (10)^2} + C$

$m - M = -2.5 \left(\log \frac{1}{d^2} - \log \frac{1}{10^2} \right)$

$= -2.5 \left(\log \frac{10^2}{d^2} \right)$

$= -2.5 \left(2 \log 10 - 2 \log d \right)$

modulus jarak $\boxed{m - M = -5 + 5 \log d}$

$= -2.5\left(2\log 10 - 2\log d\right)$

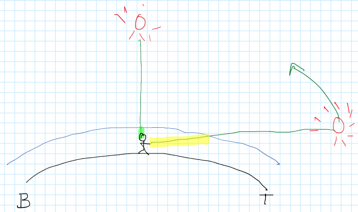
modulus jarak $\boxed{m - M = -5 + 5\log d}$

- Koreksi Bolometrik (BC) → koreksi thd m_V spy memperlihatkan skala m utk seluruh λ

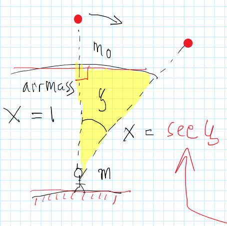
$\boxed{BC = m_V - m_{bol}} \longrightarrow m_{bol} = m_V - BC$

(+)

- Koreksi → atmosper, MAB



- ATMOSFER



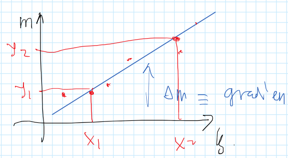
$\boxed{m = m_0 + \Delta m \cdot \sec\gamma}$

$\cos\gamma = \frac{1}{X} \longrightarrow X = \frac{1}{\cos\gamma}$

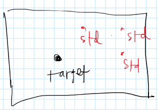
$X = \sec\gamma$

Bintang standar

γ	m
0°	....
10°	...
15°	--
20	--



$\text{gradien} = \frac{y_2 - y_1}{x_2 - x_1}$



- MAB → $R = 3.2$ ← normal

$A_V = R\,E_{BV}$

eksess warna $E_{BV} = (B-V) - (B-V)_0$

$A_V = 3.2\,E_{BV} \longrightarrow m - M = -5 + 5\log d + A_V$

Dari pengamatan diperoleh terang visualnya adalah 10, terang pada panjang gelombang biru adalah 11. Diketahui warna intrinsiknya adalah 0. dan terang mutlaknya adalah 0.8.

a. Terang intrinsik untuk masing-masing warna
b. jarak

$m_V = 10 = V$
$m_B = 11 = B$
$M_V = 0.8$
$(B-V)_0 = 0$

$E_{BV} = (B-V) - (B-V)_0$
$E_{BV} = (11-10) - 0 = 1$
karena MAB normal maka
$A_V = 3.2\,E_{BV}$
$A_V = 3.2 \cdot 1 = 3.2$

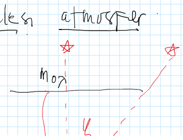
a) terang intrinsik:

$V - V_0 = A_V$
$V_0 = V - A_V$
$= 10 - 3.2$
$\boxed{V_0 = 6.8}$

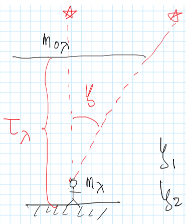
$B - B_0 = A_V$
$B_0 = B - A_V$
$= 11 - 3.2$
$\boxed{B_0 = 7.8}$

$10 - 0.8 = -5 + 5\log d + 3.2$
$\boxed{d = 158.49 \text{ pc}}$

- Koreksi atmosfer



$\boxed{m_\lambda = m_{0\lambda} + 1.086\,\tau_\lambda \cdot \sec\gamma}$



$$\boxed{m_\lambda = m_{0\lambda} + \underbrace{1.086\,\tau_\lambda}_{\Delta m} \cdot \sec \zeta}$$

pakai btg standar u/ berbagai posisi

$\zeta_1 \rightarrow m_1$
$\zeta_2 \rightarrow m_2$

$$m_1 = \cancel{m_{0\lambda}} + 1.086\,\tau_\lambda \cdot \sec \zeta_1$$
$$m_2 = \cancel{m_{0\lambda}} + 1.086\,\tau_\lambda \cdot \sec \zeta_2$$
$$m_1 - m_2 = 1.086\,\tau_\lambda\,(\sec \zeta_1 - \sec \zeta_2)$$

target

Untuk mengamati magnitudo sebuah bintang program digunakan sebuah bintang standar sebagai pembanding. Dari pengamatan terhadap bintang standar ini diperoleh hasil sebagai berikut : pada waktu diamati pada jarak zenith 35^0, magnitudo semunya adalah 9,2, sedangkan pada waktu diamati pada jarak zenith 15^0, magnitudo semunya adalah 9,0. Apabila pada jarak zenith 25^0 magnitudo bintang program adalah 8,9. Tentukan magnitudo bintang program ini sebelum mengalami penyerapan oleh atmosfer Bumi.

$\zeta_1 = 35^\circ \rightarrow m_1 = 9.2$

$\zeta_2 = 15^\circ \rightarrow m_2 = 9.0$

$$m_1 - m_2 = 1.086\,\tau_\lambda\,(\sec \zeta_1 - \sec \zeta_2)$$
$$9.2 - 9.0 = 1.086\,\tau_\lambda\,(\sec 35^\circ - \sec 15^\circ)$$
$$\tau_\lambda = 0.99$$

$\zeta = 25^\circ \rightarrow m = 8.9$, $m_0 = ?$

$$m = m_0 + 1.086\,\tau_\lambda \cdot \sec \zeta$$
$$m_0 = m - 1.086\,\tau_\lambda \cdot \sec \zeta$$
$$= 8.9 - 1.086 \sec(25)$$
$$\boxed{m_0 = 7.71}$$

17. Dua bintang memiliki magnitudo +4,1 mag dan +5,6 mag. Bintang yang lebih terang memberikan 5 x 10^{-4} Watt yang dikumpulkan oleh sebuah teleskop. Berapa banyak energi yang dikumpulkan oleh sebuah teleskop dari bintang yang lebih redup?

18. Dua buah benda buatan manusia ditempatkan di angkasa luar. Yang satu, sebuah satelit yang mengorbit matahari dalam lintasan elips dengan eksentrisitas 0,5 dan jarak perihelium 80 juta km. Satelit itu dilindungi dari cahaya matahari oleh sebuah cermin besar yang memantulkan 100% cahaya yang diterimanya. Selama mengorbit, cermin tersebut selalu menghadap matahari. Benda yang lain, sebuah pengukur kuat cahaya (fotometer) tahan panas, ditempatkan di fotosfir matahari.
   a. Hitung jarak aphelium orbit satelit tersebut
   b. Berapa magnitudo perbedaan terang maksimum dan minimum satelit tersebut pengukuran fotometer ?

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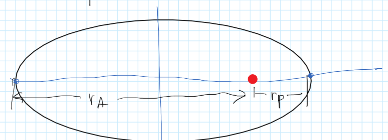
$\boxed{17}$ Dua bintang $\rightarrow m_1 = 4.1 \rightarrow E_1 = 5 \times 10^{-4}$ W
$m_2 = 5.6 \rightarrow E_2 = ?$

$$\frac{E_2}{E_1} = +2.512^{-(m_2 - m_1)} = 2.512^{-(5.6-4.1)}$$
$$\frac{E_2}{E_1} = 0.25$$
$$E_2 = 0.25\,E_1 = 0.25 \cdot 5 \times 10^{-4}$$
$$E_2 = 1.26 \times 10^{-4}\ \text{W}$$

$\boxed{18}$ sat $\rightarrow e = 0.5$, $r_p = 80 \times 10^6$ km } benda hitam



a) krn $R_\odot \lll r_p, r_A$ maka bisa dianggap sensor ada di pusat matahari

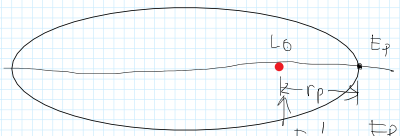
$$r_p = a(1-e) \rightarrow a = \frac{r_p}{1-e} = \frac{80 \times 10^6}{1-0.5} \Rightarrow 160 \times 10^6\ \text{km}$$
$$r_A = a(1+e) \rightarrow r_A = 160 \times 10^6\,(1+0.5)\ \text{km}$$
$$\boxed{r_A = 240 \times 10^6\ \text{km}}$$

$r_A = a(1+e) \longrightarrow r_A = 160\times 10^6\,(1+0.5)$ km

$$\boxed{r_A = 240\times 10^6 \text{ km}}$$

b) $\Delta m = m_{max} - m_{min}$

$$\Delta m = m_{max} - m_{min} = -2.5\log\left(\frac{E_{max}}{E_{min}}\right)$$



$E_p = \dfrac{L_\odot}{4\pi r_p^2} \rightarrow L$

$E_p' = \dfrac{E_p}{4\pi r_p^2} = \dfrac{\dfrac{L_\odot}{4\pi r_p^2}}{4\pi r_p^2}$

$E_{min} = E_A' = \dfrac{L_\odot}{(4\pi r_A^2)^2}$

$E_{max} = E_p' = \dfrac{L_\odot}{(4\pi r_p^2)^2}$

$$\Delta m = m_{max} - m_{min} = -2.5\log\frac{E_{max}}{E_{min}}$$

$$= -2.5\log\frac{\cancel{L_\odot}/(4\pi r_p^2)^2}{\cancel{L_\odot}/(4\pi r_A^2)^2}$$

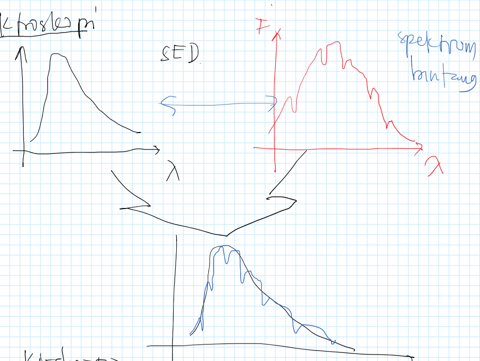
$$\Delta m = -2.5\log\left(\frac{(\cancel{4\pi} r_A^2)^2}{(\cancel{4\pi} r_p^2)^2}\right)$$

$$\Delta m = -2.5\log\left(\frac{r_A}{r_p}\right)^4$$

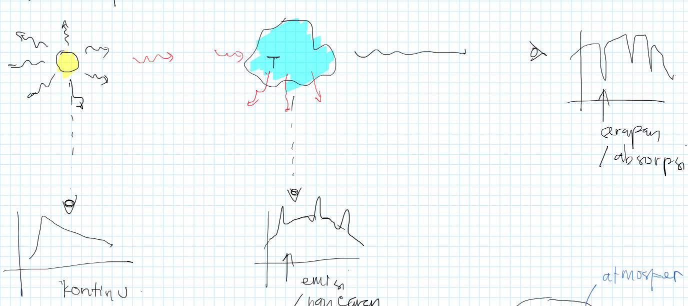
$$= -2.5\log\left(\frac{24\cancel{0}\cancel{\times 10^6}}{8\cancel{0}\cancel{\times 10^6}}\right)^4$$

$$\boxed{\Delta m = -4.77}$$

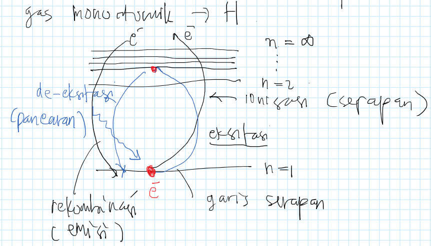
spektroskopi

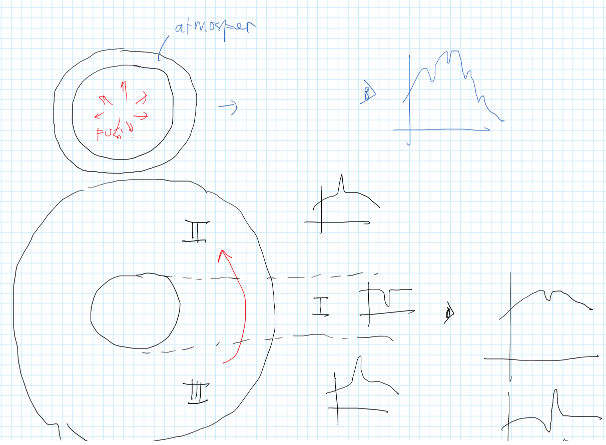


H. Kirchoff



gas monoatomik → H

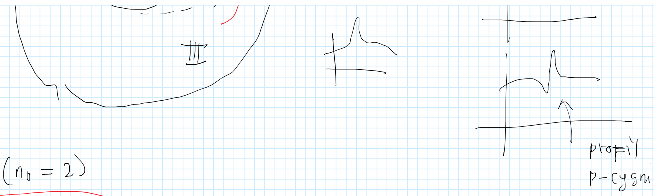




$$\boxed{E = -\frac{13.6}{n^2}\ \text{eV}}$$

$$\boxed{E = -\frac{13.6}{n^2}\ \text{eV}}$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_0^2} - \frac{1}{n^2}\right)$$



$n_0 = 1, 2, \ldots$

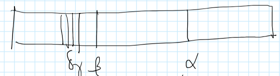
$n = 2, 3, \ldots$

Hidrogen Balmer ($n_0 = 2$)

$$\boxed{\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)}$$

balmer $-\alpha$ = $\lambda_\alpha = 6563$ Å

β = $\lambda_\beta = 4831$ Å



Ketika obyek bergerak → garis bergeser (Doppler)

$$\boxed{\frac{\Delta\lambda}{\lambda_0} = \frac{v_R}{c}} \rightarrow \text{klasik} \quad v \ll c$$

$$z = \boxed{\frac{\Delta\lambda}{\lambda_0} = \sqrt{\frac{1+\frac{v_R}{c}}{1-\frac{v_R}{c}}} - 1} \rightarrow \text{relativistik} \quad v \rightarrow c$$

redshift

3. Jumlah foton minimum per detik pada panjang gelombang 555 nm yang diperlukan untuk rangsangan visual adalah 100. Maka total energi dalam kW adalah ...

(a) 3.58×10^{-16}
(b) 3.58×10^{-17}
(c) 3.58×10^{-18}
(d) 3.58×10^{-19}
(e) 3.58×10^{-20}

$\lambda = 555$ nm

$\rightarrow E_{1\,\text{foton}} = h\frac{c}{\lambda} = (6.626 \times 10^{-34}) \cdot \frac{3\times10^8}{555\times10^{-9}}$ Js

$= 3.582 \times 10^{-19}$ Js ⇒ W

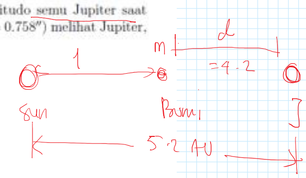
$E_{100\,\text{foton}} \longrightarrow E \cdot 100$

$E = 3.582 \times 10^{-17}$ W

$= 3.582 \times 10^{-20}$ kW

5. Jarak rata-rata Jupiter ke Matahari adalah 5.2 AU dan magnitudo semu Jupiter saat oposisi adalah -2.3. Jika seorang pengamat di α Cen (paralaks = 0.758″) melihat Jupiter, maka terang semu Jupiter sekarang adalah ...

(a) 19.76
(b) 20.76
(c) 21.76
(d) 22.76
(e) 23.76



$$\frac{E_J}{E_\odot} = 2.512^{-(m_J - m_\odot)}$$

$$\frac{E_J}{E_\odot} = 2.512^{-(-2.3-(-26.7))}$$

$$\frac{E_J}{E_\odot} = 1.736 \times 10^{-10}$$

α-Cen $= 0.758''$

$d_{\alpha\,cen} = \frac{1}{0.758}$ pc

$= 1.32$ pc

$m_{\alpha\,cen} - m_J = -2.5\log\frac{E_{\alpha\,cen}}{E_{bumi}}$

$m_{\alpha\,cen} + 2.3 = -2.5\log\left(\frac{\frac{E_J}{4\pi d_{\alpha cen}^2}}{\frac{E_J}{4\pi d_J^2}}\right)$

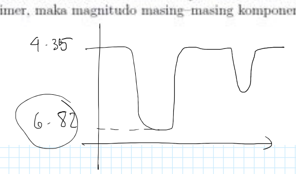
$m_{\alpha\,cen} + 2.3 = -2.5\log\left(\frac{d_J}{d_{\alpha cen}}\right)^2$

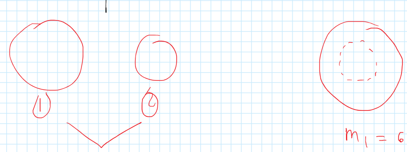
$= -2.5\log\left(\frac{4.2}{1.32 \times 206265}\right)^2$

$\boxed{m_{\alpha\,cen} = 21.76}$

6. Sebuah bintang ganda gerhana memiliki magnitudo semu yang konstan sebesar 4.35 di antara minima dan magnitudo semu 6.82 saat minimum primer. Asumsikan gerhana total terjadi saat minimum primer, maka magnitudo masing-masing komponen adalah ...

(a) 7.39 dan 3.22
(b) 5.11 dan 2.87
(c) 9.03 dan 1.44
(d) 4.24 dan 0.18
(e) 6.82 dan 4.47





$m_{TOT} = 4.35$

$m_1 = 6.82$

$m_2 = ?$

$E_{TOT} = E_1 + E_2$

$m_{TOT} - m_1 = -2.5\log\frac{E_{TOT}}{E_1}$

$\frac{E_{TOT}}{E_1} = 2.512^{-(m_{TOT} - m_1)}$

$= 2.512^{-(4.35 - 6.82)}$

$\frac{E_{TOT}}{E_1} = 9.728$

$E_{TOT} = E_1 + E_2$

$9.728\,E_1 = E_1 + E_2$

$8.728\,E_1 = E_2$

$\frac{E_2}{E_1} = 8.728$

$m_2 - m_1 = -2.5\log\frac{E_2}{E_1}$

$m_2 - 6.82 = -2.5\log(8.728)$

$\boxed{m_2 = 4.47}$

7. With a distance modulus of 12.3 and visual brightness of 4.53, calculate bolometric magnitude of this particular object when it is placed on 10 pc from us with a bolometric correction of +0.8.

7. With a distance modulus of 12.3 and visual brightness of 4.53, calculate bolometric magnitude of this particular object when it is placed on 10 pc from us with a bolometric correction of $+0.8$.

   (a) -8.57
   (b) -8.50
   (c) -8.48
   (d) -8.29
   (e) -8.13

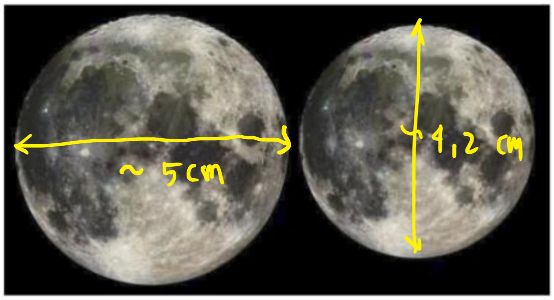
8. Sebuah bintang dengan terang semu 1.0 diamati melewati 5 cermin dengan koefisien refleksi masing-masing adalah 0.7. Jika sebuah kamera dengan ukuran sensor 10×10 cm digunakan untuk mengambil gambarnya, maka total energi yang diterima sensor kamera adalah ...

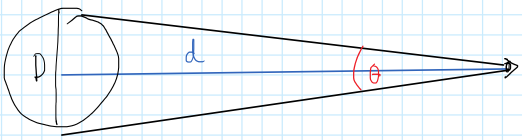
   (a) 1.876×10^{-11}
   (b) 1.876×10^{-13}
   (c) 1.876×10^{-15}
   (d) 1.876×10^{-17}
   (e) 1.876×10^{-19}

Tes 1

Tuesday, April 2, 2019 4:06 PM

1. There are two photos of the Moon taken by the same camera mounted on the same telescope (telescope is placed on the Earth). The first photo has been made while the Moon was near its perigee and the second one near the apogee. Find the value of the Moon's orbit eccentricity.





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

jika $\theta \ll \longrightarrow \tan\theta \approx \theta$

$$\theta = \frac{D}{d}$$

$\uparrow$ rad

$$\theta = \boxed{\frac{D}{d}} \times 206265''$$

$\uparrow$ arcsec

$$\frac{\theta_P}{\theta_A} = \frac{D_{gambar,P}}{D_{gambar,A}} = \frac{5}{4.2}$$

$$\theta \sim \frac{1}{d} \longrightarrow \frac{\theta_P}{\theta_A} = \frac{d_A}{d_P} = \frac{\cancel{a}(1+e)}{\cancel{a}(1-e)} = \frac{5}{4.2}$$

$$4.2 + 4.2e = 5 - 5e$$

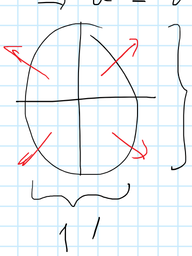
$$9.2e = 0.8$$

$$\boxed{e = 0.087}$$

2. The Ring Nebulae (M57) is located 2700 lightyear from Earth. It has an angular diameter of 1.4 × 1.0 arcmin and is expanding at the rate of $\underline{20 \text{ km/s}}$. How long ago did the central star shed its layers?

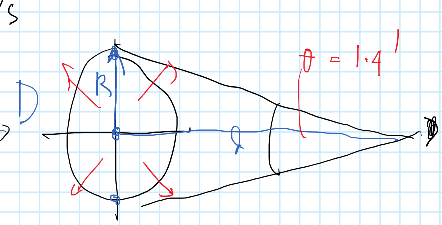
$\uparrow V_R$

M57 $\rightarrow d = 2700$ ly



$v = 20$ km/s

t=0



$\longleftarrow \theta = \frac{D}{d} \times 206265''$

$$D = \frac{\theta \cdot d}{206265} \Rightarrow 2R = \frac{\theta \cdot d}{206265} \quad \Big| \quad t = \frac{\theta \cdot d}{2 \cdot v \cdot 206265} \text{ s}$$

$$R = v \cdot t$$

$R = v \cdot t$

$\Rightarrow 2R = \dfrac{\theta \cdot d}{206265}$

$2v \cdot t = \dfrac{\theta \cdot d}{206265}$

$t = \dfrac{\theta \cdot d}{2 \cdot v \cdot 206265}$ s

$= \dfrac{(1.4 \times 60) \cdot \left(\frac{2700}{3.26} \times \cancel{206265} \times 1.4959 \times 10^8\right)}{2 \cdot (20)\, \cancel{206265}}$ s

$\boxed{t = 2.6 \times 10^{11}\ \text{s} = 8249.5\ \text{tahun}}$

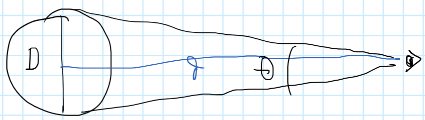
3. Star X has a parallax of 0.2" and angular diameter of 2.67×10^{-3}". This star emit its energy at peak wavelength of 3864 Å. Calculate its absolute magnitude. Hint: look for our Sun's parameters in the constants table to help you.

$X \rightarrow p = 0.2''$

$\theta = 2.67 \times 10^{-3}\ ''$

$\lambda_{max} = 3864\ \text{Å}$

$M = ?$



$\theta = \dfrac{D}{d} \times 206265$ (θ in ″)

$p = \dfrac{1}{d} \leftarrow pc$ (p in ″) $\longrightarrow d = \dfrac{1}{p} = \dfrac{1}{0.2} = 5\ pc$

$\theta = \dfrac{D}{d} \times 206265$

$D = \dfrac{\theta \cdot d}{206265}$ pc

$= \dfrac{2.67 \times 10^{-3} \cdot 5 \times \cancel{206265}}{\cancel{206265}}$ AU

$\boxed{D = 0.013\ \text{AU}}$

Pogson

$M = -2.5 \log L + C$

$\boxed{M - M_\odot = -2.5 \log \dfrac{L}{L_\odot}}$

$L = 4\pi R^2 \sigma T^4$

$T = \dfrac{0.2898}{\lambda} \leftarrow \text{cm}$

$= \dfrac{0.2898}{3864 \times 10^{-8}}$ K

$T = 7500$ K

$\dfrac{L}{L_\odot} = \dfrac{\cancel{4\pi} R^2 \cancel{\sigma} T^4}{\cancel{4\pi} R_\odot^2 \cancel{\sigma} T_\odot^4}$

$\dfrac{L}{L_\odot} = \left(\dfrac{R}{R_\odot}\right)^2 \left(\dfrac{T}{T_\odot}\right)^4 = \left(\dfrac{\frac{1}{2} 0.013 \times 1.4959 \times 10^8}{6.9 \times 10^5}\right)^2 \left(\dfrac{7500}{5785}\right)^4$

$\boxed{\dfrac{L}{L_\odot} = 5.61}$

$M - M_\odot = -2.5 \log \dfrac{L}{L_\odot} \Rightarrow M - 4.79 = -2.5 \log (5.61)$

$\boxed{M = 2.92}$

$\boxed{M = 2.92}$

4. There are 250 million stars in the elliptical galaxy M32. Apparent magnitude of this galaxy is 9. If luminosities of all stars are equal, calculate apparent magnitude of **one star** in this galaxy.

$M32 \longrightarrow N = 250 \times 10^6$

$m_{TOT} = m_{galaxy} = 9$

L sama u/ semua btg $\Rightarrow L_{TOT} = 250 \times 10^6 L_1$

$$m_1 - m_{TOT} = -2.5 \log \frac{E_1}{E_{TOT}}$$

$$= -2.5 \log \frac{\frac{L_1}{\cancel{4\pi d^2}}}{\frac{L_{TOT}}{\cancel{4\pi d^2}}}$$

$$m_1 - m_{TOT} = -2.5 \log \frac{L_1}{L_{TOT}}$$

$$m_1 - 9 = -2.5 \log \left(\frac{\cancel{L_1}}{250 \times 10^6 \cancel{L_1}}\right)$$

$$\boxed{m_1 = 29.99 \approx 30}$$

5. We observe two stars, A and B. Star A is dimmed because it is behind a dust cloud whereas we have a clear view of star B. Star A is observed to have 8 times the flux of star B does.

   (a) We observe a parallax of 0.1" for star A and 0.05" for star B. What is the ratio of $\frac{d_A}{d_B}$ of the distances to the two stars?

   (b) Suppose we are able to determine that both stars have the same exact diameter, but that star A has a surface temperature twice that star B. What is the ratio of $\frac{L_A}{L_B}$.

   (c) By what factor is the dust blocking star A dimming its brightness? (i.e. what is the ratio of the brightness we would observe for the star A were the dust not there to the brightness we actually observe?)

A & B $\rightarrow E_A = 8 E_B$

A: ada debu

B: clear

a) $\left.\begin{array}{l} p_A = 0.1'' \\ p_B = 0.05'' \end{array}\right\} \frac{d_A}{d_B} = ?$

$p = \frac{1}{d}$

$$\boxed{\frac{d_A}{d_B} = \frac{p_B}{p_A} = \frac{0.05}{0.1} = 0.5}$$

b) $\left.\begin{array}{l} D_A = D_B \\ T_A = 2T_B \end{array}\right\} \frac{L_A}{L_B} = \frac{\cancel{4\pi R_A^2 \sigma} T_A^4}{\cancel{4\pi R_B^2 \sigma} T_B^4} = \left(\frac{T_A}{T_B}\right)^4$

$= \left(\frac{2\cancel{T_B}}{\cancel{T_B}}\right)^4$

$$= \left(\frac{2 T_B}{T_B}\right)^4$$

$$\boxed{\frac{L_A}{L_B} = 16}$$

c) $\frac{E_A}{E_A'} = ?$ $E_A = 8 E_B$

$\frac{E_A}{E_B} = 8$ ← ada debu

$$\frac{E_A'}{E_B} = \frac{\frac{L_A}{\cancel{4\pi} d_A^2}}{\frac{L_B}{\cancel{4\pi} d_B^2}} = \frac{L_A}{L_B} \cdot \left(\frac{d_B}{d_A}\right)^2$$

pengukuran jarak dgn paralaks tdk terpengaruh debu

$$= 16 \cdot (2)^2$$

$$\frac{E_A'}{E_B} = 64$$

$$\therefore \frac{E_A}{E_A'} = \frac{8}{64} = \frac{1}{8}$$

6.

6. Let's assume you discover a new star and you measure an apparent magnitude of 7.66, a parallax of 0.26" and a recessional velocity of 50 km/s.

(a) What is its redshift?

(b) Assuming that there is interstellar extinction of 1 mag, what is its absolute magnitude?

(c) Calculate the luminosity of that star is solar units

$m = 7.66$

$p = 0.26''$

$V_R = 50$ km/s

$d = \frac{1}{p} = \frac{1}{0.26}$

a) $z = \frac{\Delta\lambda}{\lambda} = \frac{V_R}{c} = \frac{50}{3 \times 10^5} = 1.67 \times 10^{-4}$

b) $A_V = 1$

$m - M = -5 + 5 \log d + A_V$

$7.66 - M = -5 + 5 \log\left(\frac{1}{0.26}\right) + 1$

$$\boxed{M = 8.73}$$

c) $\frac{L}{L_\odot} = 2.512^{-(M - M_\odot)}$

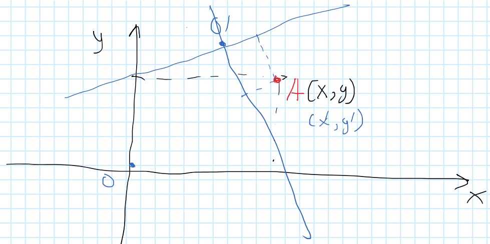
$= 2.512^{-(8.73 - 4.79)}$

$$\boxed{\frac{L}{L_0} = 0.026 \approx 0.03}$$

Astronomi posisi lanjut

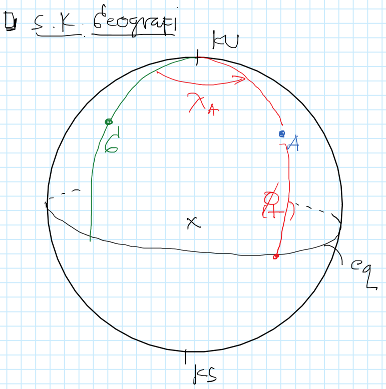
Wednesday, April 3, 2019 7:54 AM

Posisi: Acuan; pasangan koord.

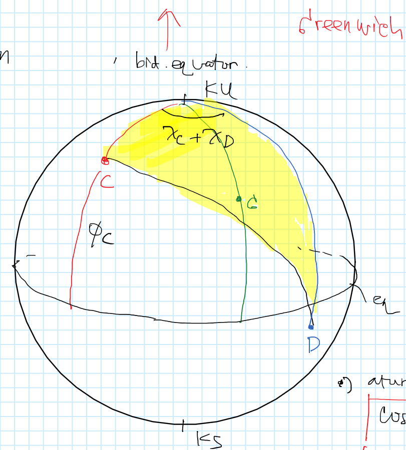


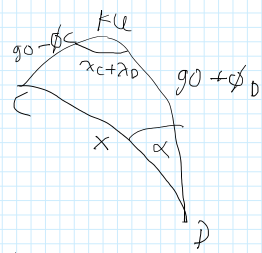
sistem koord
- posisi pengamat → s.k. geografi
- Posisi benda langit: Horizon; Equatorial I, II; ekliptika; galaktik

1) S.K. Geografi



Acuan





Δ bola :

•) aturan cos

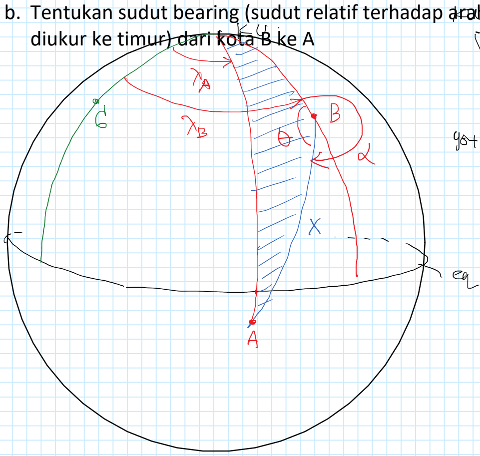
$$\boxed{\cos x = \cos(90-\phi_C)\cos(90+\phi_D) + \sin(90-\phi_C)\sin(90+\phi_D)\cos(\lambda_C+\lambda_D)}$$

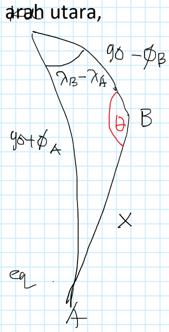
•) aturan sin

$$\boxed{\frac{\sin\alpha}{\sin(90-\phi_C)} = \frac{\sin(\lambda_C+\lambda_D)}{\sin(x)}}$$

Ada dua kota A dan B dengan koord A(lintang= -10,bujur=+75); B(lintang=+60, bujur=+100).

a. Tentukan jarak A dan B dalam km (1' = 1 mil laut = 1.852 km)
b. Tentukan sudut bearing (sudut relatif terhadap arah utara, diukur ke timur) dari kota B ke A





$$\cos x = \cos(90+\phi_A)\cos(90-\phi_B) + \sin(90+\phi_A)\sin(90-\phi_B)\cos(\lambda_B-\lambda_A)$$

$$= \cos(100)\cos(30) + \sin(100)\sin(30)\cos(25)$$

$$x = 72^\circ 47' 21.63''$$

a) $\boxed{x = 7948.6 \text{ km}}$

b) sudut bearing dr B ke A.

$$\frac{\sin\theta}{\sin(90+\phi_A)} = \frac{\sin(\lambda_B-\lambda_A)}{\sin(x)}$$

$$\sin\theta = \frac{\sin(\lambda_B-\lambda_A)}{\sin(x)} \cdot \sin(90+\phi_A)$$

$$= \frac{\sin(25)}{\sin(72^\circ 47' 21.63'')} \cdot \sin(100)$$

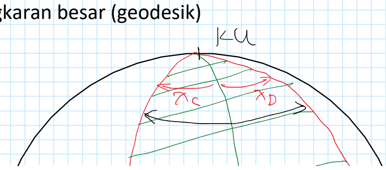
$$\theta = 25^\circ 49' 49.1''$$

$$\text{bearing} = \alpha = 360^\circ - \theta$$

$$\boxed{= 334^\circ 10' 10.9''}$$

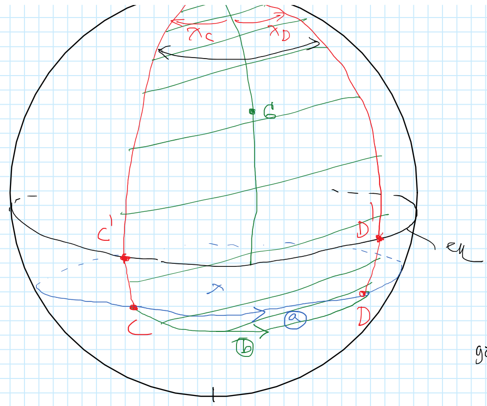
Ada dua kota C dan D memiliki lintang yang sama (lintang = -25). Bujur C adalah -30 dan bujur D adalah +45.

a. Tentukan jarak C ke D dalam km jika jalurnya sejajar equator
b. Tentukan jarak C ke D dalam km jika jalurnya mengikuti lingkaran besar (geodesik)



a) $CD = C'D' \cos\phi$

$= (\lambda_C+\lambda_D)\cos\phi$



a) $CD = C'D' \cos\phi$

$= (\lambda_C + \lambda_D)\cos\phi$

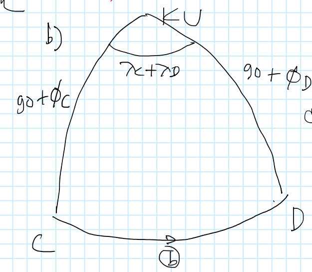
$= (30+45)\cos(25)$

$= 75 \cdot \cos 25$

$CD = 67.973\ldots^\circ$

$\boxed{CD = 7422.66 \text{ km}}$

b)



$\phi_C = \phi_D$

$\cos CD = \cos(90+\phi_C)^2 + \sin(90+\phi_C)^2 \cos(\lambda_C+\lambda_D)$

$= \cos(115)^2 + \sin(115)^2 \cos(75)$

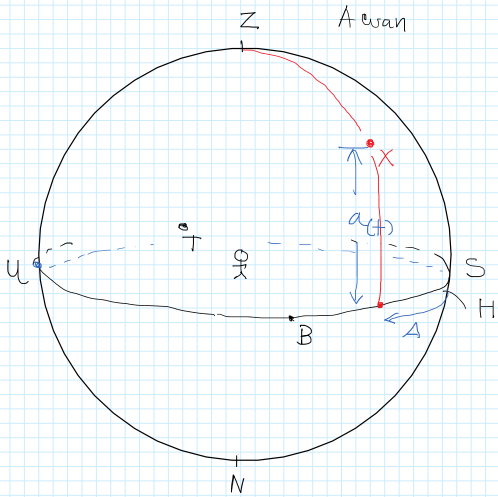
$CD = 66.97\ldots^\circ$

$\boxed{CD = 7313.22 \text{ km}}$

☐ Horizon

psgn koord : A , a

Acuan : ↑ Utara ; ↑ bid Horizon



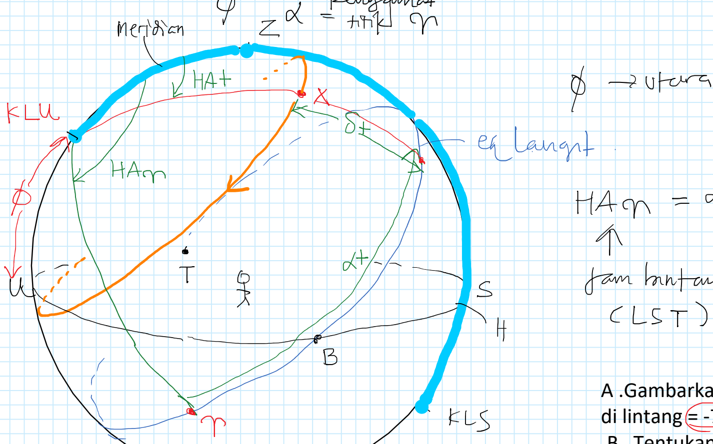
☐ Equatorial

	I	II
psgn	HA , $\boxed{\delta}$	RA , $\boxed{\delta}$ / α , $\boxed{\delta}$

acuan $\delta \rightarrow$ bid ekuator

HA = meridian pengamat

ϕ α = titik Υ



$\phi \rightarrow$ utara

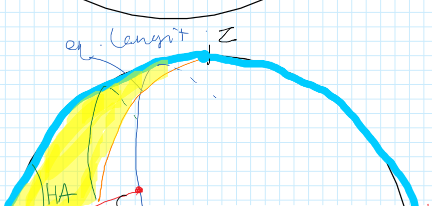
$HA_\Upsilon = \alpha_X + HA_X$

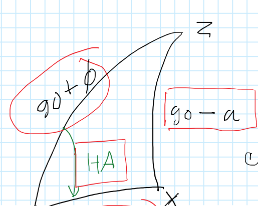
↑ Jam bintang lokal (LST)

$\boxed{LST = \alpha_X + HA_X}$ ✓

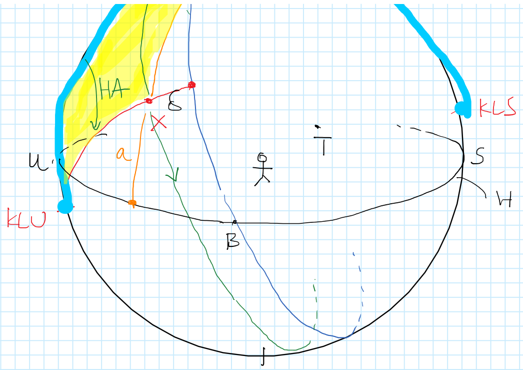
A .Gambarkan bintang X (HA = +3h, DEC = +10) untuk pengamat di lintang = -7.

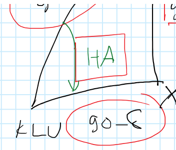
B. Tentukan altitude dari bintang X untuk pengamat di soal A.





$\cos(90-a) = \cos(90+\phi)\cos(90-\delta) + \sin(90+\phi)\sin(90-\delta)\cos HA$

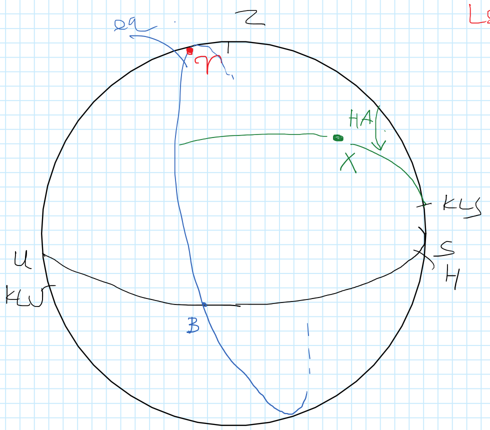




$$\cos(90-a) = \cos(90+\phi)\cos(90-\delta) + \sin(90+\phi)\sin(90-\delta)\cos HA$$
$$= \cos(97)\cos(80) + \sin(97)\sin(80)\cos(45)$$
$$90 - a = 47^\circ 50' 55.44''$$
$$a = 90 - 47^\circ 50' 55.44''$$
$$\boxed{a = 42^\circ 9' 4.56''}$$

posisi titik Aries (Υ) → $\boxed{HA_\Upsilon = LST}$

$LST = HA_X + \alpha_X$



1) lihat software

RA = 2h 20m 26s
HA = −2h 1m 4s

$LST = 2^h 20^m 26^s + -2^h 1^m 4^s$

LST tgl 3 April jam 11:26 LT ← $\boxed{LST = 0^h 19^m 22^s}$

2) pendekatan:

$$\boxed{LST \simeq t + \Delta N \times \frac{24^h}{365.25}}$$

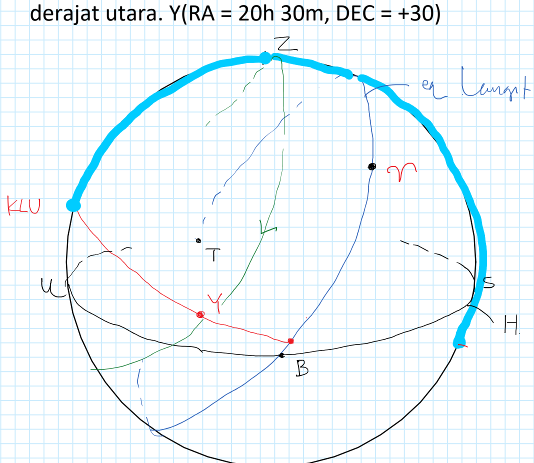
selisih hari dr tanggal 23/9

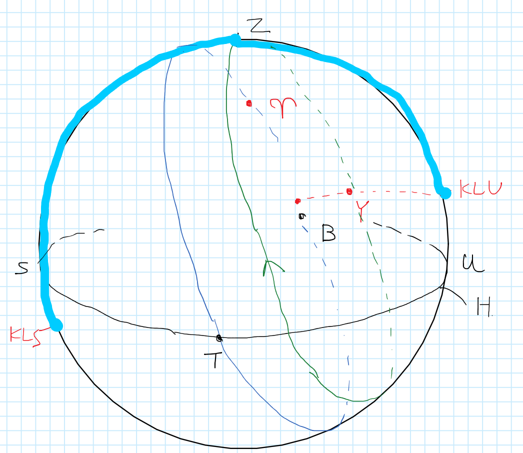
u/ 3 April jam 11:26

$$LST \simeq 11^h 26^m + 192 \times \frac{24^h}{365.25} = 24^h 2^m 57.66^s$$

HA_Υ ← $\boxed{LST = 0^h 2^m 57.66^s}$

Gambarkan posisi bintang Y pada tanggal 25 Maret 2019 jam 14:00 waktu lokal untuk pengamat di lintang 20 derajat utara. Y(RA = 20h 30m, DEC = +30)



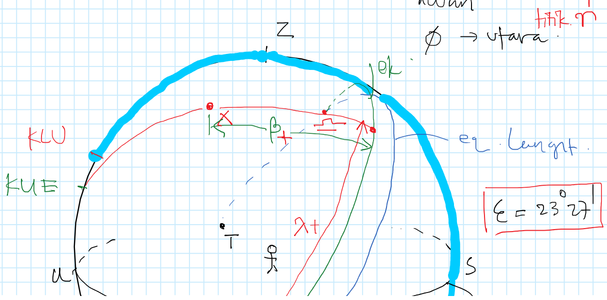


$$LST = t + \Delta N \times \frac{24^h}{365.25}$$
$$= 14^h + 183 \times \frac{24}{365.25} = \boxed{2^h 1^m 28.71^s = HA_\Upsilon}$$

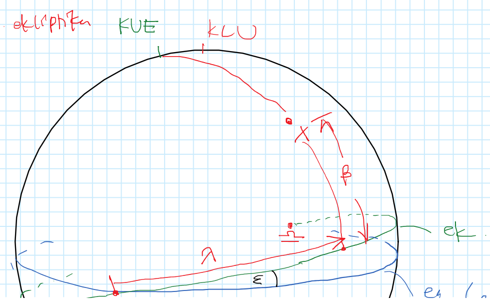
I Ekliptika

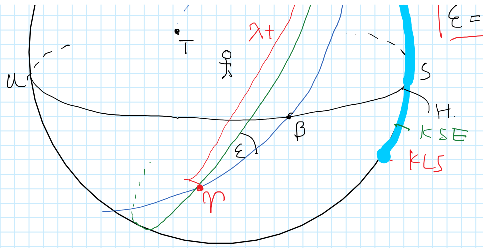
pasangan : λ°, β°
sewan
ϕ → utara

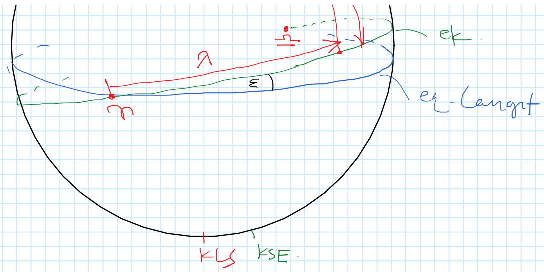
titik Υ bid ekliptika



$\boxed{\varepsilon = 23^\circ 27'}$





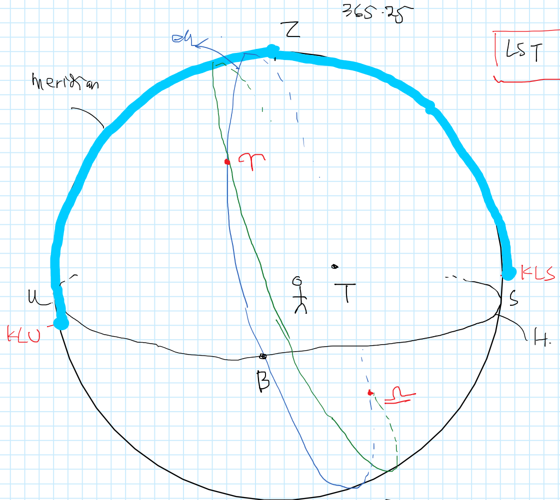


Gambarkan orientasi bidang ekliptika terhadap ekuator untuk hari ini (3 April 2019) pukul 13:30 WIB untuk lokasi Parung (7 deg S)

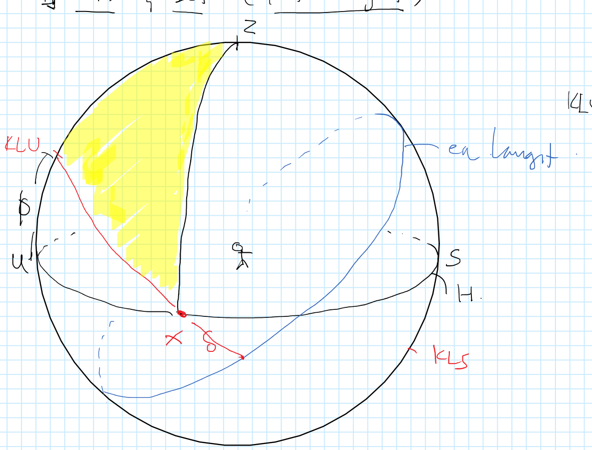
Posisi ♈ (3 April 2019 jam 13:30)

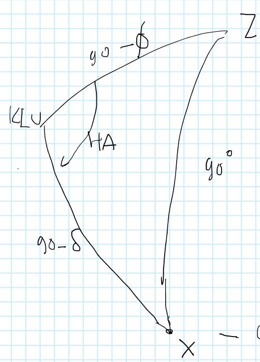
$$LST = t + \Delta N \cdot \frac{24^h}{365.25} \rightarrow LST = 13^h 30^m + 192 \times \frac{24^h}{365.25}$$

$$\boxed{LST = 2^h 6^m 58^s = HA_{♈}}$$



rise & set (+ twilight)





$$\cos 90 = \cos(90-\phi)\cos(90-\delta) + \sin(90-\phi)\sin(90-\delta)\cos HA$$

$$0 = \sin\phi \cdot \sin\delta + \cos\phi \cos\delta \cos HA$$

$$-\cos\phi \cos\delta \cos HA = \sin\phi \sin\delta$$

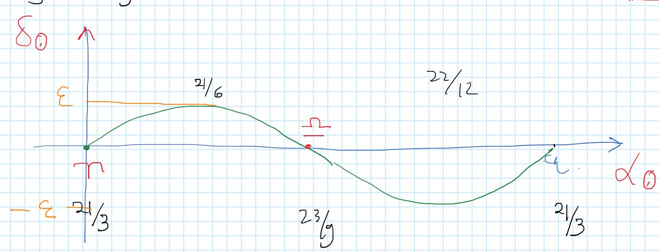
$$\cos HA = -\frac{\sin\phi \sin\delta}{\cos\phi \cos\delta}$$

$$\boxed{\cos HA = -\tan\phi \tan\delta}$$

Hitung panjang siang hari ini di Parung (7 deg S)

berhub. dgn Matahari

$$\text{panjang siang} = 2\,HA \quad ; \quad \cos HA = -\tan\phi \tan \boxed{\delta_\odot} \; ?$$



selisih hari dari 21/3

$$\boxed{\begin{aligned} \alpha_\odot &\simeq \Delta D \times \frac{24^h}{365.25} \\ \delta_\odot &\simeq \varepsilon \cdot \sin\left(\frac{\Delta D}{365.25} \times 360°\right) \end{aligned}}$$

$23°27'$

$$\delta_\odot \simeq 23°27' \cdot \sin\left(\frac{13}{365.25} \times 360°\right)$$

$\delta_\odot \cong 23°27' - \sin\left(\frac{13}{365.25} \times 360°\right)$ 23°27'

$= +5° \ 12' \ 2.01''$

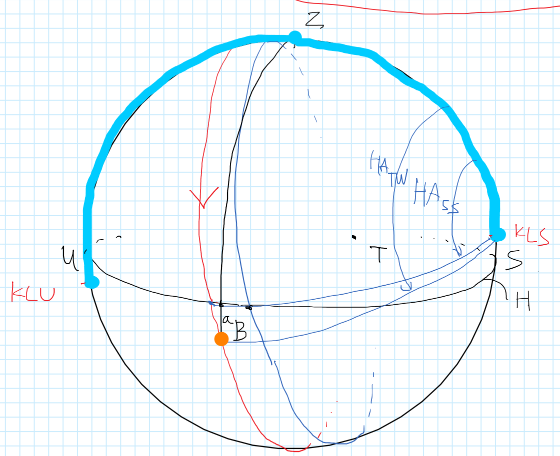
$\phi = -7°$

$\cos HA = -\tan(-7°)\tan(5°12'2.01'')$

$HA = 5^h 57^m 26.32^s$

Panjang hari sekarang : $2HA = \boxed{11^h 54^m 53^s}$

twilight :
- civil $\longrightarrow$ $a_\odot = -6°$
- nautical $a_\odot = -12°$
- $\boxed{\text{astronomical} \quad a_\odot = -18°}$ senja



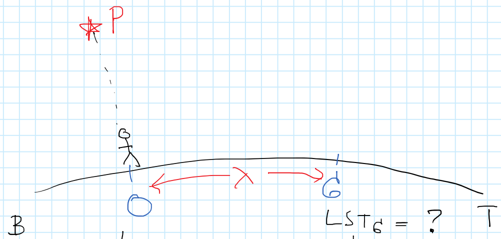
Lamanya senja astronomis

$\Delta t = HA_{TW} - H_{SS}$

1. Find the Zone Time on February 3rd when Procyon ($\alpha = 7^h36^m10^s$) crosses the meridian of Ottawa ($\lambda = 75°43'$ W), given that at UT 0^h February 3rd, the Greenwich Sidereal Time is $8^h48^m8^s$. The zone is –5.

jam 0 Greenwich

jam bintang di greenwich



$LST_G = ?$

$t_G = ?$

$t_O = \ldots$

$LST_O = \alpha_P + HA_P$

$LST_O = \alpha_P$ (saat P melintas meridian)

$LST_O = 7^h36^m10^s$

$LST_G = LST_O + \lambda$

$GST = 7^h36^m10^s + \dfrac{75°43'}{15°}$

$GST = 12^h39^m2^s$ (ini adalah LST_G saat P lewat meridian Ottawa)

$t_G = 0^h \rightarrow GST = 8^h48^m8^s$

$t_G = \ldots \rightarrow GST = 12^h39^m2^s$

$$t_{G,\text{saat kejadian}} = t_{G,0^h} + \frac{\Delta GST}{23^h56^m} \times 24^h$$

$$= 0^h + \frac{3^h50^m54^s}{23^h56^m} \times 24^h$$

$$t_{G,\text{kejadian}} = 3^h51^m33^s$$

$$t_{O,\text{kejadian}} = t_{G,\text{kejadian}} - 5^h$$

$$= 3^h51^m33^s - 5^h = \boxed{22^h51^m33^s}$$

2. Pada tengah hari lokal suatu tanggal, waktu sideris lokal adalah 14^h. Tentukan waktu sideris lokal pada tengah hari lokal di tempat itu 50 hari kemudian. Ambil panjang tahun tropis sebesar 365.25 hari.

$LST = 14^h$

$LST_{50\text{ hari kemudian}}$

$$LST_{50\text{ hari kemudian}} = LST + \frac{50}{365.25} \times 24^h$$

$$= 14^h + 3^h17^m$$

$$\boxed{= 17^h17^m}$$

3. Paralaks dua bintang diketahui sebesar 0.074 dan 0.047 detik busur. Jika kedua bintang ini memiliki RA yang sama, dan deklinasi masing–masing adalah 62° N dan 56° N:

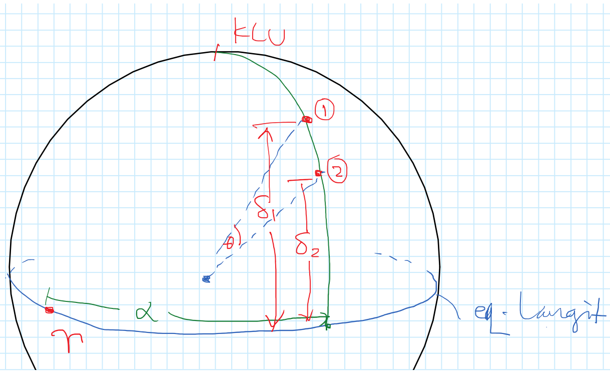
   (a) Sketsakan persoalan di atas dalam bola langit

   (b) Hitung jarak kedua bintang ini dari Matahari, dan jarak antara keduanya, dalam satuan parsek (pc)

$p_1 = 0.074''$

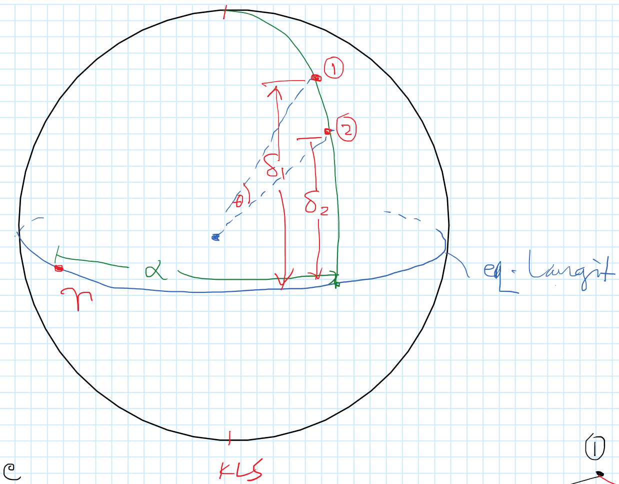
$p_2 = 0.047''$

a)



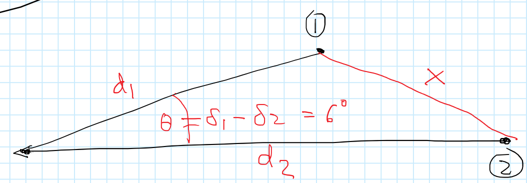
$p_2 = 0.047''$

a)



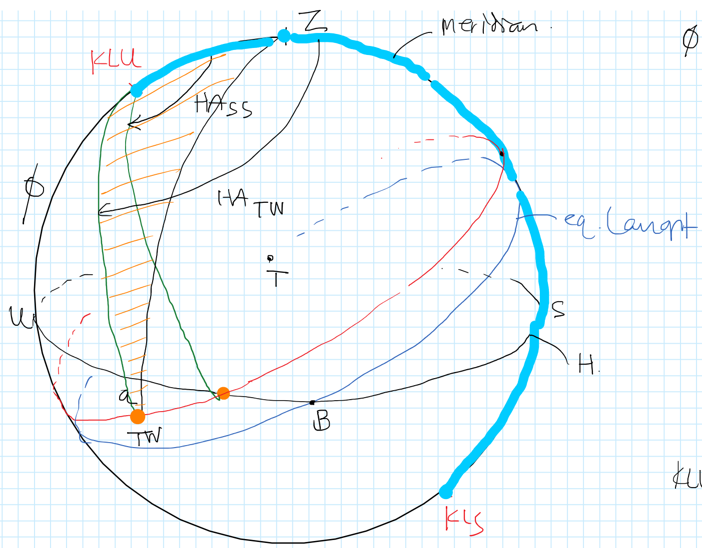
b) $d_1 = \frac{1}{p_1} = \frac{1}{0.074}$ pc $= \boxed{13.51 \text{ pc}}$

$d_2 = \frac{1}{p_2} = \frac{1}{0.047}$ pc $= \boxed{21.28 \text{ pc}}$



$$x^2 = d_1^2 + d_2^2 - 2 d_1 d_2 \cos\theta$$
$$= (13.51)^2 + (21.28)^2 - 2(13.51)(21.28)\cos(6°)$$
$$\boxed{x = 7.97 \text{ pc}}$$

4. Calculate the duration of evening astronomical twilight for a place in latitude 50° N when the Sun's declination is 5°20′ N.



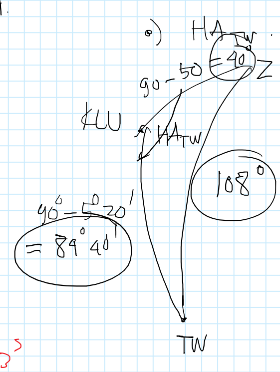
$\phi = 50°$ N

$$\Delta t = HA_{TW} - HA_{SS}$$

• $\cos HA_{SS} = -\tan\phi \tan\delta_\odot$
$= -\tan(50°)\tan(5°20')$

$\boxed{HA_{SS} = 6^h 25^m 33^s}$

• HA_{TW}



$\cos(108°) = \cos(40°)\cos(84°40') + \sin(40°)\sin(84°40')\cos HA_{TW}$

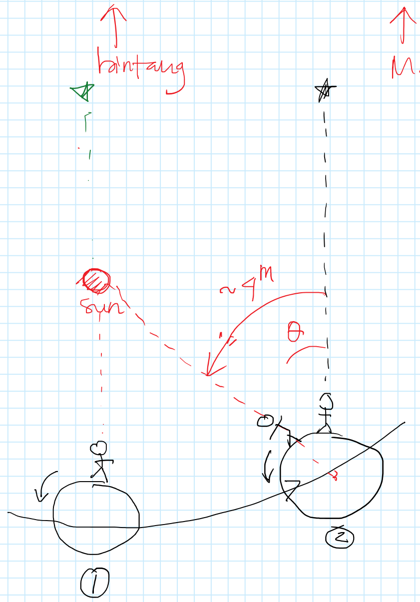
$\cos HA_{TW} = -0.59\ldots$

$\boxed{HA_{TW} = 8^h 25^m 48^s}$

$\therefore \Delta t = HA_{TW} - HA_{SS}$
$= 8^h 25^m 48^s - 6^h 25^m 33^s$

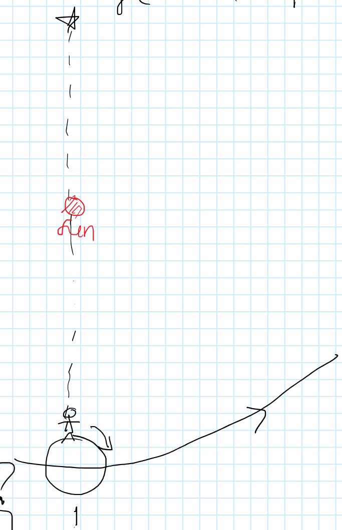
$\boxed{\Delta t = 2^h 0^m 15^s}$

Kok bisa jam bintang beda dengan jam surya?



1 putaran 360° → sideris ⇒ hari bintang $= 23^h\,56^m$

surya ⇒ 24^h

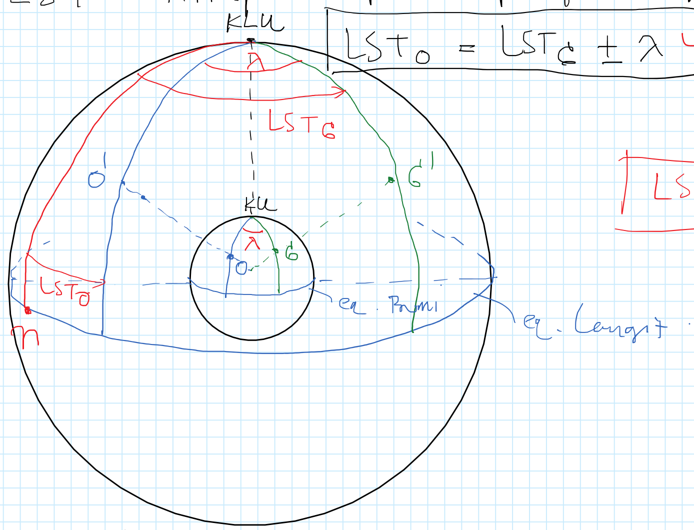


Apa yang terjadi jika bumi berotasi berlawanan arah sekarang?

Jam bintang lokal

$LST = HA_{\Upsilon}$ — posisi pengamat?

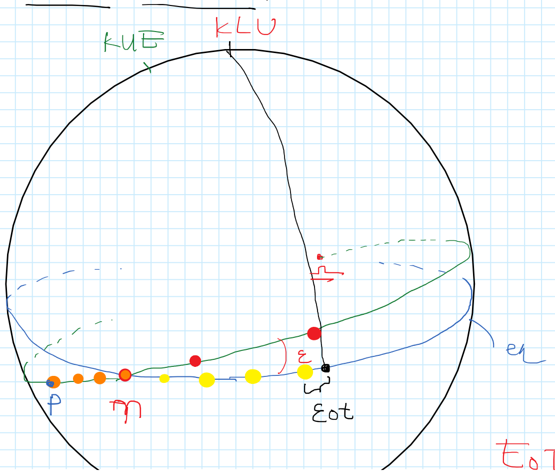
$\boxed{LST_\sigma = LST_G \pm \lambda}$



$\boxed{LST_G = LST_\sigma + \lambda}$

λ barat G

Waktu Matahari



$\varepsilon = 23°27'$

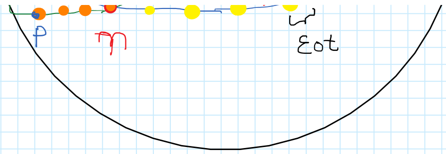
$\boxed{EoT = RA_{MS} - RA_\odot}$

$HA_\odot - HA_{MS}$

Diketahui EoT pada suatu tanggal adalah +7m. Tentukan kapan Matahari terbenam saat diamati dari lintang 10 deg S; 107 deg E. tanggal 4 April 2019.

α_{MS}

$EoT = +7^m$



Matahari terbenam saat diamati dari lintang 10 deg S; 107 deg E. tanggal 4 April 2019.

α_{MS}

$EoT = +7^m$

$t_{set} = ?$

kapan Matahari ada di Meridian $\rightarrow HA_\odot = 0^h$

$LST = \alpha_\odot =$

$\alpha_{MS} = \Delta D \times \frac{24^h}{365.25} = 14 \times \frac{24^h}{365.25}$

21/3

$\alpha_{MS} = 0^h 55^m 12^s$

$EoT = \alpha_{MS} - \alpha_\odot \rightarrow \alpha_\odot = \alpha_{MS} - EoT$

$= 0^h 55^m 12^s - 0^h 7^m$

$\alpha_\odot = 0^h 48^m 12^s$

Saat Matahari di tengah hari

$LST = \alpha_\odot + HA_\odot$

$LST = \alpha_\odot = 0^h 48^m 12^s$

$LST = t + \Delta N \times \frac{24^h}{365.25} \rightarrow t = LST - \Delta N \times \frac{24^h}{365.25}$

23/9

$= 0^h 48^m 12^s - 193 \times \frac{24}{365.25}$

$\boxed{t_{noon} = 12^h 7^m 18^s}$

$\delta_\odot \simeq \varepsilon \sin\left(\frac{\Delta D}{365.25} \times 360^\circ\right)$

$= 23^\circ 27' \sin\left(\frac{14}{365.25} \times 360^\circ\right)$

$= +5^\circ 35' 35''$

$\cos HA = -\tan\phi \tan\delta_\odot$

$\boxed{t_{set} = t_{noon} + HA}$

$\cos HA = -\tan(-10^\circ)\tan(+5^\circ 35' 35'')$

$\boxed{HA = 5^h 56^m 3^s}$

$\therefore t_{set} = t_{NOON} + HA$

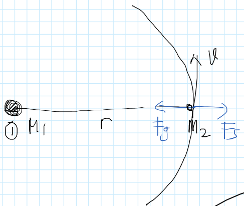
$= 12^h 7^m 18^s + 5^h 56^m 3^s$

$\boxed{t_{set} = 18^h 3^m 21^s}$

Mekanika → gerak benda relatif thd benda lain (orbit)

orbit: terbuka (parabola, hiperbola); tertutup (lingkaran, elips)

lingkaran

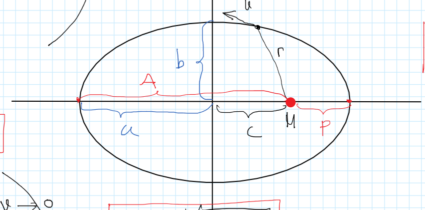


$\boxed{v = \frac{2\pi r}{P}}$

$F_g = F_s \longrightarrow G\frac{M_1 \cdot \cancel{M_2}}{r^{\cancel{2}}} = \frac{\cancel{M_2} v^2}{\cancel{r}}$

$\boxed{v = \sqrt{\frac{GM_1}{r}}}$

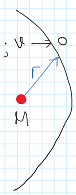
elips → e



$\boxed{e = \frac{c}{a}}$

$\boxed{v_{elips} = \sqrt{GM\left[\frac{2}{r} - \frac{1}{a}\right]}}$

parabola → $r \to \infty$; $v \to 0$



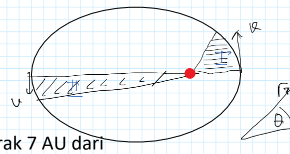
$\boxed{v_{esc} = \sqrt{\frac{2GM}{r}}}$

Hiperbola → $r \to \infty$; $v \neq 0$; $\boxed{v_{excess} = \sqrt{GM\left[\frac{2}{r} + \frac{1}{a}\right]}}$

II H. Kepler

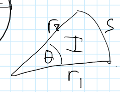
1) orbit planet → elips ; Matahari di salah satu pusatnya.

2) luas yg disapu u/ Δt sama adl sama.



Δt

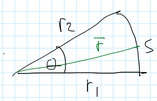
$L_I = L_{II}$



$S = \theta r_1$

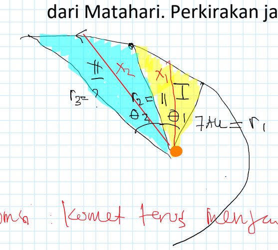
$L_I \approx \frac{1}{2} S \cdot r_1$

$= \frac{1}{2}\theta r_1^2$



$L_I = \frac{1}{2}\theta \bar{r}^2$

Sebuah komet diamati berada pada jarak 7 AU dari Matahari. Setahun kemudian, komet ini berjarak 11 AU dari Matahari. Perkirakan jarak komet ini 2 tahun lagi.



asumsi : komet terus menjauh. 8hg

u/ Δt sama ; Luas sama.

H. II kepler : $L_I = L_{II}$

•) $\frac{1}{\cancel{2}}\theta_1 \cdot r_1 \cdot \cancel{r_2} = \frac{1}{\cancel{2}}\theta_2 \cancel{r_2} \cdot r_3$

$\boxed{\frac{\theta_1}{\theta_2} = \frac{r_3}{r_1}} \longrightarrow \boxed{\frac{\theta_1}{\theta_2} = \frac{r_3}{7}}$

•) $x_1 \approx \frac{r_1 + r_2}{2} = \frac{7 + 11}{2} = 9$ AU

$x_2 \approx \frac{r_2 + r_3}{2} = \frac{11 + r_3}{2}$

$L_I = L_{II}$

$\frac{1}{\cancel{2}}\theta_1 x_1^2 = \frac{1}{\cancel{2}}\theta_2 x_2^2$

$\boxed{\frac{\theta_1}{\theta_2} = \left(\frac{x_2}{x_1}\right)^2}$

$\frac{r_3}{7} = \left(\frac{x_2}{x_1}\right)^2$

$\frac{r_3}{7} = \left(\frac{11 + r_3}{2}\right)^2 \cdot \left(\frac{1}{9}\right)^2$

$\frac{r_3}{7} = \frac{121 + 22r_3 + r_3^2}{4} \cdot \frac{1}{81}$

$\frac{r_3}{7} = \frac{121 + 22r_3 + r_3^2}{324}$

$324\, r_3 = 847 + 154\, r_3 + 7r_3^2$

a b c

$7r_3^2 - 170r_3 + 847 = 0$

$r_3\big|_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$r_3\big|_1 = \frac{+170 + \sqrt{(170)^2 - 4(7)(847)}}{2(7)}$

$\boxed{r_3\big|_1 = 17{,}28 \text{ AU}}$ ✓

$r_3\big|_2 = \frac{170 - \sqrt{(170)^2 - 4(7)(847)}}{2(7)}$

$\boxed{r_3\big|_2 = 7 \text{ AU}}$?

∴ 2 tahun lg jarak komet dr Matahari adl 17,28 AU

•) $a^3 \sim P^2$

m, kg, s

$\boxed{\frac{a^3}{P^2}} = \frac{G}{4\pi^2} M_\odot \Rightarrow \boxed{\frac{a^3}{P^2} = 1 M_\odot}$

AU, tahun, $M_\odot$

m, s, kg

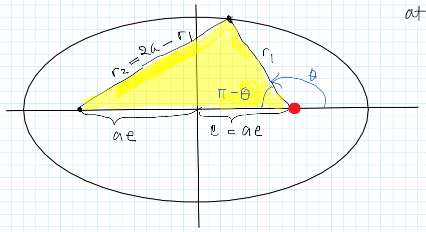
$\frac{G}{4\pi^2} = 1 \longrightarrow G = 4\pi^2$

kg tahun $M_\odot$

$$\frac{G}{4\pi^2} = 1 \longrightarrow G = 4\pi^2$$

Sebuah komet bergerak dalam lintasan pada jarak 20 AU dari Matahari. Jika diketahui e = 0.7, dan jarak terdekatnya adalah 0.6 AU tentukan:

a. Anomali benar orbit
b. Kecepatan orbit saat jarak 15 AU



aturan cos : $r_2^2 = r_1^2 + (2ae)^2 - 2r_1 \cdot 2ae \cos(\pi - \theta)$

$$(2a - r_1)^2 = r_1^2 + 4a^2e^2 - 4r_1 ae \cos(\pi - \theta)$$

$$4a^2 - 4ar_1 + \cancel{r_1^2} = \cancel{r_1^2} + 4a^2e^2 - 4r_1 ae \cos(\pi - \theta)$$

$$\cancel{4a}(a - r_1) = \cancel{4a}(ae^2 - r_1 e \cos(\pi - \theta))$$

$$a - r_1 = ae^2 - r_1 e \cos(\pi - \theta)$$

$$r_1 e \cos(\pi - \theta) - r_1 = ae^2 - a$$

$$r_1 (e \cos(\pi - \theta) - 1) = a(e^2 - 1)$$

$$r_1 = \frac{a(e^2 - 1)}{e \cos(\pi - \theta) - 1}$$

$$r_1 = \frac{a(e^2 - 1)}{e(-\cos\theta) - 1} = \frac{a(e^2 - 1)}{-(e\cos\theta + 1)}$$

$$\boxed{r_1 = \frac{a(1 - e^2)}{e\cos\theta + 1}}$$

$r_1 = 20$ AU
$e = 0{,}7$
$r_p = 0.6 \rightarrow a(1 - e) = 0{,}6$
$a(1 - 0{,}7) = 0{,}6$
$a = 2$ AU

$$20 = \frac{2(1 - 0{,}7^2)}{(0.7)\cos\theta + 1} \Rightarrow 0.7\cos\theta + 1 = \frac{2(1 - 0.7^2)}{20}$$

$\theta = \infty$?

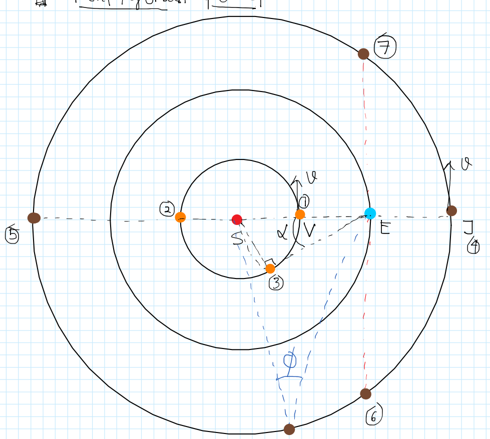
b). v saat $\boxed{r = 15 \text{ AU}}$

$$v = \sqrt{GM\left[\frac{2}{r} - \frac{1}{a}\right]}$$

$$= \sqrt{4\pi^2 \cdot (1)\left[\frac{2}{15} - \frac{1}{2}\right]}$$

$$v = 2\pi\sqrt{\left[\frac{2}{15} - \frac{1}{2}\right]} \text{ AU/tahun} \longrightarrow \text{km/s}$$

Konfigurasi planet



1. konjungsi inferior
2. —"— superior
3. Elongasi Maksimum ; sudut α ← elongasi
4. oposisi
5. konjungsi superior
6. kuadratur Timur
7. kuadratur Barat

ϕ = sudut fase

periode
- sideris ; → putaran penuh 360°
- sinodis → konfigurasi sama

$$\boxed{\frac{1}{S} = \frac{1}{P_1} - \frac{1}{P_2}}$$

1. Dua buah satelit memiliki orbit elips di sekitar Bumi dan keduanya memiliki setengah sumbu mayor yang besarnya sama. Perbandingan kecepatan kedua satelit saat di perigee adalah 3/2 dan eksentrisitas orbit satelit yang memiliki perigee lebih besar diketahui sebesar 0.5. Tentukan eksentrisitas orbit satelit yang lain dan tentukan perbandingan kecepatan kedua satelit di apogee.
2. Periode orbit satelit ke-5 Jupiter adalah 0.4982 hari dengan setengah sumbu mayor 0.001207 AU. Diketahui periode orbit dan setengah sumbu mayor jupiter berturut-turut adalah 11.86 tahun dan 5.203 AU. Cari rasio massa Jupiter terhadap Matahari.

$\boxed{2}$ $P_s = 0.4982^d =$
$a = 0{,}001207$ AU

$$\frac{\text{AU} \rightarrow a^3}{\text{thn} \rightarrow P^2} = M_J \longrightarrow \frac{(0.001207)^3}{\left(\frac{0.4982}{365.25}\right)^2} = M_J$$

M_J ← $M_\odot$

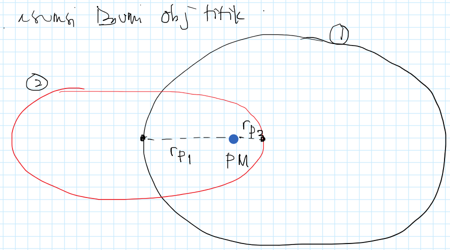
$$\boxed{M_J = 9.45 \times 10^{-4}\ M_\odot \quad \text{atau} \quad \frac{M_J}{M_\odot} = \frac{1}{1058}}$$

$\boxed{1}$. asumsi Bumi obj titik

adalah 11.86 tahun dan 5.203 AU. Cari rasio massa Jupiter terhadap Matahari.

$M_\odot$ ... 1058

1. asumsi Bumi obj titik



$a_1 = a_2$

$\frac{3}{2} = \frac{v_{p2}}{v_{p1}}$

$e_1 = 0{,}5$

$e_2 = ?$

$\left.\frac{V_2}{V_1}\right|_A = ? \Rightarrow \frac{V_{A2}}{V_{A1}} = ?$

$v = \sqrt{GM\left[\frac{2}{r} - \frac{1}{a}\right]}$

pergee $\rightarrow$ $r = r_p$

$$\boxed{V_p = \sqrt{GM\left[\frac{2}{r_p} - \frac{1}{a}\right]}}$$

$$\frac{v_{p2}}{v_{p1}} = \sqrt{\frac{\cancel{GM}\left[\frac{2}{r_{p2}} - \frac{1}{a}\right]}{\cancel{GM}\left[\frac{2}{r_{p1}} - \frac{1}{a}\right]}} = \sqrt{\frac{\frac{2a - r_{p2}}{a r_{p2}}}{\frac{2a - r_{p1}}{a r_{p1}}}} = \sqrt{\left(\frac{2a - r_{p2}}{2a - r_{p1}}\right)\cdot\left(\frac{\cancel{a} r_{p1}}{\cancel{a} r_{p2}}\right)} = \frac{3}{2}$$

$$\frac{2a - r_{p2}}{2a - r_{p1}} \cdot \frac{r_{p1}}{r_{p2}} = \frac{9}{4}$$

$r_{p1} = a(1 - e_1)$

$r_{p2} = a(1 - e_2)$

$$\frac{2a - [a(1-e_2)]}{2a - [a(1-e_1)]} \cdot \frac{1-e_1}{1-e_2} = \frac{9}{4}$$

$$\frac{\cancel{a}(2 - (1-e_2))}{\cancel{a}(2 - (1-e_1))}\left(\frac{1-e_1}{1-e_2}\right) = \frac{9}{4}$$

$$\frac{2 - (1-e_2)}{2 - (1-0.5)}\left(\frac{1-0.5}{1-e_2}\right) = \frac{9}{4}$$

$$\frac{1+e_2}{1.5} \cdot \frac{0.5}{1-e_2} = \frac{9}{4}$$

$$\frac{0.5 + 0.5e_2}{1.5 - 1.5e_2} = \frac{9}{4}$$

$2 + 2e_2 = 13.5 - 13.5e_2$

$15.5e_2 = 11.5$

$$\boxed{e_2 = 0.74}$$

b) $\cancel{V}_A = \sqrt{GM\left[\frac{2}{r_A} - \frac{1}{a}\right]}$; $r_A = a(1+e)$

$$\frac{V_{A2}}{V_{A1}} = \sqrt{\frac{\cancel{GM}\left[\frac{2}{r_{A2}} - \frac{1}{a}\right]}{\cancel{GM}\left[\frac{2}{r_{A1}} - \frac{1}{a}\right]}} = \sqrt{\frac{\frac{2}{a(1+e_2)} - \frac{1}{a}}{\frac{2}{a(1+e_1)} - \frac{1}{a}}} = \sqrt{\frac{\frac{2 - (1+e_2)}{\cancel{a}(1+e_2)}}{\frac{2 - (1+e_1)}{\cancel{a}(1+e_1)}}}$$

$$= \sqrt{\left(\frac{1-e_2}{1+e_2}\right)\cdot\left(\frac{1+e_1}{1-e_1}\right)}$$

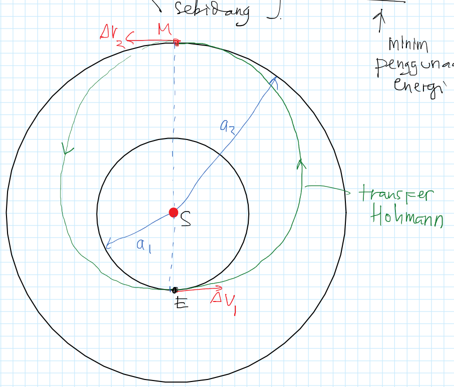
$$= \sqrt{\left(\frac{1-0.74}{1+0.74}\right)\left(\frac{1+0{,}5}{1-0{,}5}\right)}$$

$$\boxed{\frac{V_{A2}}{V_{A1}} = 0.669}$$

2. Transfer orbit

syarat: lingkaran, sebidang } orbit efisien (Hohmann)

$\uparrow$ minim penggunaan energi



1) Stgh sumbu mayor transfer orbit (a)

$$\boxed{a = \frac{a_1 + a_2}{2}}$$

2) Lamanya transfer orbit (τ)

$\tau = \frac{1}{2} P$

$\frac{a^3}{P^2} = \frac{G}{4\pi^2} M_{pusat} \rightarrow P = \sqrt{\frac{a^3 \cdot 4\pi^2}{G M_{pusat}}}$

$= 2\pi\sqrt{\frac{a^3}{G M_{pusat}}}$

$\tau = \frac{1}{\cancel{2}} \cdot \cancel{2}\pi \sqrt{\frac{a^3}{G M_{pusat}}}$

$$\boxed{\tau = \pi\sqrt{\frac{a^3}{G M_{pusat}}}}$$

3) eksentrisitas transfer orbit (e)

SE = $r_p = a(1-e) = a_1$

SM = $r_A = a(1+e) = a_2$

$\frac{a_1}{a_2} = \frac{\cancel{a}(1-e)}{\cancel{a}(1+e)}$

$a_1 + a_1 e = a_2 - a_2 e$

$a_1 e + a_2 e = a_2 - a_1$

$$a_1 + a_1 e = a_2 - a_2 e$$

$$a_1 e + a_2 e = a_2 - a_1$$

$$\boxed{e = \frac{a_2 - a_1}{a_2 + a_1}}$$

4) ΔV_1 & ΔV_2

$$\Delta V_1 = V_{elips} - V_{lingkar} \Rightarrow \Delta V = \sqrt{GM_{pusat}\left[\frac{2}{r} - \frac{1}{a}\right]} - \sqrt{\frac{GM_{pusat}}{r}}$$

$$\boxed{\Delta V_1 = \sqrt{GM_{pusat}\left[\frac{2}{a_1} - \frac{1}{a}\right]} - \sqrt{\frac{GM_{pusat}}{a_1}}}$$

$$\Delta V_2 = V_{lingkar} - V_{elips} \Rightarrow \boxed{\Delta V_2 = \sqrt{\frac{GM_{pusat}}{a_2}} - \sqrt{GM_{pusat}\left[\frac{2}{a_2} - \frac{1}{a}\right]}}$$

5) Lama misi

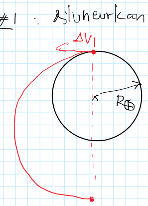
$$t_{misi} = 2\tau + t_{tunggu}$$

$\uparrow$ P sinodis

1. Hitung total perubahan kecepatan sebuah wahana dari saat di permukaan Bumi, lalu mengorbit Bumi pada ketinggian 400 km di atas permukaan Bumi, sampai dia mengorbit planet Mars pada ketinggian 2000 km (diketahui jarak Matahari - Mars = 1.52 AU; Massa Mars = 6.39 x 10^23 kg). Jangan lupa ilustrasikan masalah ini dengan gambar. Diameter Mars adalah 6779 km.
2. Jika wahana ini diluncurkan mendekati Matahari dari ketinggian 400 km di atas permukaan Bumi dan mengorbit Matahari pada jarak 1000000 km dari permukaan Matahari, berapakah total perubahan kecepatannya. Bandingkan dengan jawaban no. 1

$\boxed{1}$ $\Delta V_{TOT} = ?$

step #1 : diluncurkan $\rightarrow h = 400$ km



$$\Delta V_1 = V_{elips} - V_0$$

$$= \sqrt{GM_\oplus\left[\frac{2}{R_\oplus} - \frac{1}{a}\right]} - 0$$

$$\Delta V_1 = \sqrt{GM_\oplus\left[\frac{2}{R_\oplus} - \frac{1}{a}\right]}$$

$$a = \frac{2R_\oplus + h}{2}$$

$$= \frac{2(6378) + 400}{2} \text{ km}$$

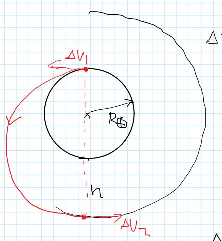
$$a = 6578 \text{ km}$$

$$= 6578 \times 10^3 \text{ m}$$

$$\Delta V_1 = \sqrt{6.673\times10^{-11} \times 6\times10^{24}\left[\frac{2}{6378\times10^3} - \frac{1}{6578\times10^3}\right]}$$

$$\Delta V_1 = 8042.62 \text{ m/s}$$

$$\boxed{\Delta V_1 = 8,04 \text{ km/s}}$$



$$\Delta V_2 = V_c - V_e$$

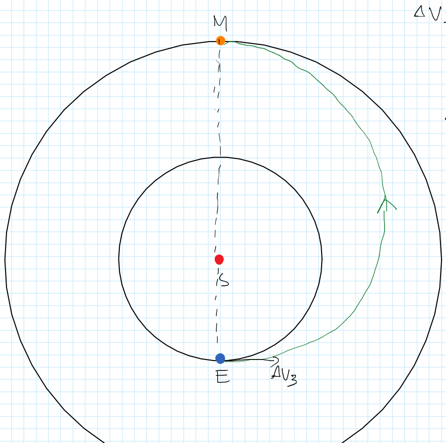
$$= \sqrt{\frac{GM_\oplus}{(R_\oplus + h)}} - \sqrt{GM_\oplus\left[\frac{2}{(R_\oplus + h)} - \frac{1}{a}\right]}$$

$$= \sqrt{\frac{6.673\times10^{-11} \cdot 6\times10^{24}}{6778\times10^3}} - \sqrt{6.673\times10^{-11} \cdot 6\times10^{24}\left[\frac{2}{6778\times10^3} - \frac{1}{6578\times10^3}\right]}$$

$$\Delta V_2 = 7685.73 - 7567.99 \text{ m/s}$$

$$\boxed{\Delta V_2 = 117.74 \text{ m/s} \longrightarrow 0.118 \text{ km/s}}$$

step #2 : Bumi - Mars



$$\Delta V_3 = V_e - V_c$$

$$= \sqrt{GM_\odot\left[\frac{2}{SE} - \frac{1}{a}\right]} - \sqrt{\frac{GM_\odot}{SE}}$$

$$a = \frac{SE + SM}{2} = \frac{1 + 1.52}{2} = 1.26 \text{ AU}$$

$$SE = 1 \text{ AU}$$

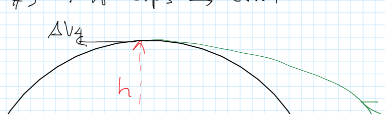
$$\Delta V_3 = \sqrt{4\pi^2(1)\left[\frac{2}{1} - \frac{1}{1.26}\right]} - \sqrt{\frac{4\pi^2(1)}{1}} \quad \text{AU/tahun}$$

$$= 6.9 - 6.2832$$

$$\Delta V_3 = 0,6168 \text{ AU/tahun} = \frac{0,6168 \times 1.4959\times10^8}{365.25\times24\times3600} \frac{\text{km}}{\text{s}}$$

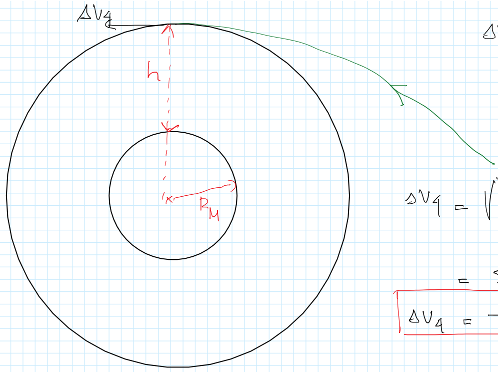
$$\boxed{\Delta V_3 = 2,92 \text{ km/s}}$$

step #3 : dr elips $\rightarrow$ orbit Mars



$$\Delta V_4 = V_c - V_e$$

$$= \sqrt{\frac{GM_M}{\ldots}} - \sqrt{GM_M\left[\frac{2}{\ldots} - \frac{1}{\ldots}\right]}$$



$$\Delta V_4 = V_c - V_e$$

$$= \sqrt{\frac{GM_M}{R_M + h}} - \sqrt{GM_M\left[\frac{2}{R_M + h} - \frac{1}{a}\right]}$$

$$a = 1{,}26 \text{ AU} = 1{,}885 \times 10^{11} \text{ m}$$

$$\Delta V_4 = \sqrt{\frac{6{,}673 \times 10^{-11} \cdot 6{,}39 \times 10^{23}}{5389{,}5 \times 10^3}} - \sqrt{6{,}673 \times 10^{-11} \cdot 6{,}39 \times 10^{23}\left[\frac{2}{5389{,}5 \times 10^3} - \frac{1}{1{,}885 \times 10^{11}}\right]}$$

$$= 2812{,}79 - 3977{,}85 \text{ m/s}$$

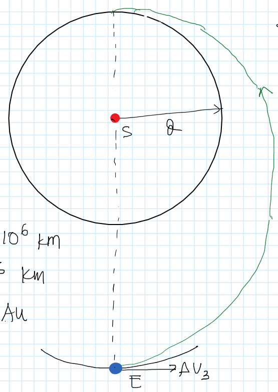
$$\boxed{\Delta V_4 = -1165{,}06 \text{ m/s} \Rightarrow -1{,}16 \text{ km/s}}$$

$$\therefore \Delta V_{TOT} = |\Delta V_1| + |\Delta V_2| + |\Delta V_3| + |\Delta V_4|$$

$$= 8{,}09 + 0{,}118 + 2{,}92 + 1{,}16$$

$$\boxed{\Delta V_{TOT} = 12{,}238 \ \frac{\text{km}}{\text{s}}}$$

2.



$$r = R_\odot + 10^6$$

$$= 7 \times 10^5 + 10^6 \text{ km}$$

$$= 1{,}7 \times 10^6 \text{ km}$$

$$r = 0{,}0114 \text{ AU}$$

$$\Delta V_3 = V_e - V_c$$

$$= \sqrt{GM_\odot\left[\frac{2}{SE} - \frac{1}{a}\right]} - \sqrt{\frac{GM_\odot}{SE}}$$

$$= \sqrt{4\pi^2(1)\left[\frac{2}{1} - \frac{1}{0{,}506}\right]} - \sqrt{\frac{4\pi^2(1)}{(1)}}$$

$$a = \frac{r + SE}{2} = \frac{0{,}0114 + 1}{2} = 0{,}506 \text{ AU}$$

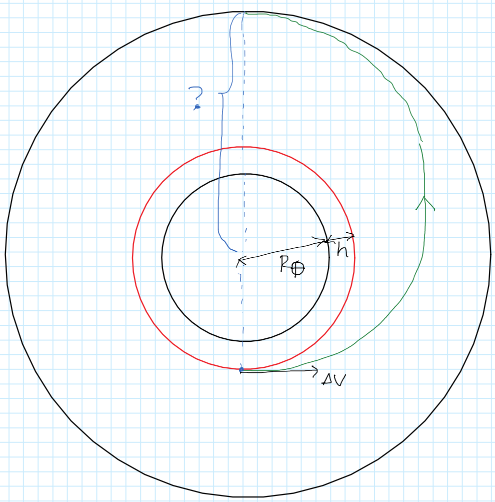
1. Sebuah satelit telekomunikasi akan diletakkan pada sebuah orbit melingkar di atas ekuator, sedemikian sehingga dia berada tetap di satu titik di atas Brazil dengan deklinasi nol. Saat ini, satelit parkir pada ketinggian 320 km di atas permukaan Bumi, dan akan melakukan transfer orbit untuk naik ke orbit tetapnya.

   (a) Hitung radius orbit satelit akhir saat dia tepat di atas Brazil

   (b) Hitung setengah sumbu mayor, eksentrisitas orbit transfer, dan lamanya transfer orbit.

   Diketahui periode sideris rotasi Bumi adalah 23^h56^m dan periode revolusi satelit di ketinggian parkir adalah 90 menit.

$h = 320$ km



$$\left.\begin{aligned} P_{parkir} &= 90^m \\ P_{akhir} &= 23^h 56^m \end{aligned}\right\} \quad \frac{a^3}{P^2} = \frac{G}{4\pi^2} M_\oplus$$

$$\left.\frac{a^3}{P^2}\right|_{parkir} = \left.\frac{a^3}{P_2}\right|_{final}$$

$$\left(\frac{a_{final}}{a_{parkir}}\right)^3 = \left(\frac{P_{final}}{P_{parkir}}\right)^3$$

$$a_{final} = \sqrt[3]{a_{parkir}^3 \cdot \left(\frac{P_{final}}{P_{parkir}}\right)^2}$$

$$= a_{parkir} \cdot \left(\frac{P_{final}}{P_{parkir}}\right)^{2/3}$$

$$a_{parkir} = R_\oplus + h = 6378 + 320 = 6698 \text{ km}$$

$$= 6698 \cdot \left(\frac{23^h 56^m}{0^h 90^m}\right)^{2/3}$$

a) $\boxed{a_{final} = 42450{,}85 \text{ km}}$

b) a, e, τ

$$a = \frac{a_{parkir} + a_{final}}{2} = \frac{6698 + 42450{,}85}{2} \text{ km}$$

$$\boxed{a = 24574{,}43 \text{ km}}$$

$$a_{parkir} = a(1-e)$$
$$6698 = 24574(1-e) \longrightarrow 0{,}272\ldots = 1-e$$

$$e = 1 - 0{,}272\ldots$$

$$\boxed{e = 0{,}727}$$

$$\tau = \frac{1}{2}P = \frac{1}{\cancel{2}} \cdot \cancel{2}\pi\sqrt{\frac{a^3}{GM_\oplus}} = \pi\sqrt{\frac{a^3}{GM_\oplus}} = \pi\sqrt{\frac{(24574{,}43 \times 10^3)^3}{6{,}673 \times 10^{-11} \cdot 6 \times 10^{24}}} \text{ s}$$

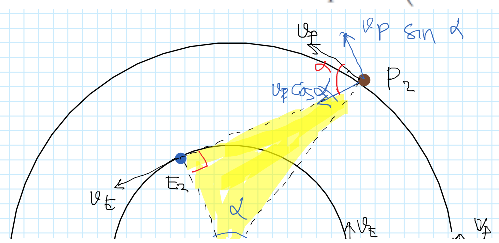
$$\frac{a^3}{P^2} = \frac{G}{4\pi^2} M_\oplus \longrightarrow P = \sqrt{\frac{4\pi^2 \cdot a^3}{GM_\oplus}} = 2\pi\sqrt{\frac{a^3}{GM_\oplus}}$$

$$\tau = 19126{,}647\ldots \text{ s}$$

$$\boxed{\tau = 5^h 18^m 46{,}65^s}$$

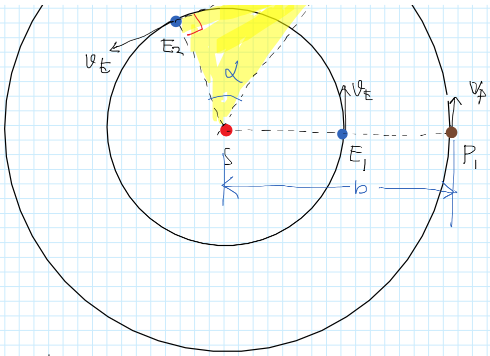
2. Saat oposisi, sebuah planet yang merupakan planet superior memiliki jarak dari Matahari sebesar b AU, memiliki kecepatan sudut sideris $-\omega_1$ derajat per hari, dilihat dari pengamat di Bumi. Pada kuadratur berikutnya, kecepatan sudut siderisnya adalah $+\omega_2$ derajat per hari. Buktikan bahwa

$$\frac{\omega_2}{\omega_1} = \frac{1}{b}\left(\frac{b-1}{b^{1/2}-1}\right)$$



$$\omega_{P_1} = -\omega_1 = \frac{v_P - v_E}{E_1 P_1}$$

$$\boxed{-\omega_1 = \frac{v_P - v_E}{b-1}}$$



$$\boxed{-\omega_1 = \frac{v_p - v_E}{b-1}}$$

$$\omega_{P_2} = +\omega_2 = \frac{v_p \sin\alpha}{E_2P_2} \rightarrow \boxed{+\omega_2 = \frac{v_p \frac{\sqrt{b^2-1}}{b}}{\sqrt{b^2-1}}} \Rightarrow \boxed{\omega_2 = \frac{v_p}{b}}$$

$$E_2P_2^2 = SP_2^2 - SE_2^2$$
$$= b^2 - 1$$
$$E_2P_2 = \sqrt{b^2-1}$$

Ingat! $v \sim \frac{1}{\sqrt{r}}$

$\therefore v_p \sim \frac{1}{\sqrt{b}}$

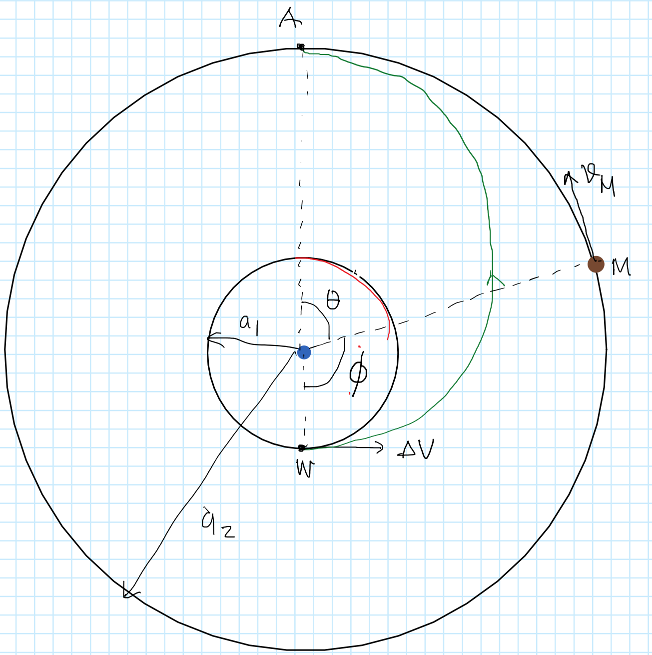
$v_E \sim \frac{1}{\sqrt{1}}$

$$\frac{\omega_2}{\omega_1} = -\frac{v_p}{b} \cdot \frac{(b-1)}{v_p - v_E}$$
$$= -\frac{1}{b\sqrt{b}} : \frac{(b-1)}{\left(\frac{1}{\sqrt{b}} - 1\right)}$$
$$= -\frac{b-1}{b - b\sqrt{b}}$$
$$= -\frac{b-1}{b(1-\sqrt{b})}$$
$$\boxed{\frac{\omega_2}{\omega_1} = \frac{b-1}{b(\sqrt{b}-1)}}$$

Kelas malam 2

Thursday, April 4, 2019 8:04 PM

Rendezvous Problem



$$\phi = \pi - \theta$$
$$= \pi - \omega_M \cdot t \qquad ; \; t = \tau = \frac{1}{2}P$$
$$= \frac{1}{\cancel{2}} \cdot \cancel{2}\pi \sqrt{\frac{a^3}{GM_\oplus}}$$
$$a = \frac{a_1 + a_2}{2}$$
$$= \pi - \omega_M \cdot \pi \sqrt{\frac{a^3}{GM_\oplus}}$$
$$\omega_M = \frac{2\pi}{P}$$
$$\omega_M = \frac{2\pi}{T}$$
$$\omega_M = \frac{V_M}{a_2}$$
$$= \pi - \frac{V_M}{a_2} \cdot \pi \sqrt{\frac{a^3}{GM_\oplus}}$$
$$= \pi - \frac{\sqrt{\frac{GM_\oplus}{a_2}}}{a_2} \cdot \pi \sqrt{\frac{a^3}{GM_\oplus}}$$
$$= \pi - \sqrt{\frac{GM_\oplus}{a_2^3}} \cdot \pi \cdot \sqrt{\frac{a^3}{GM_\oplus}}$$
$$= \pi - \pi \sqrt{\frac{\cancel{GM_\oplus} \cdot a^3}{a_2^3 \cdot \cancel{GM_\oplus}}}$$

Sebuah pesawat luar angkasa mengorbit Bumi pada ketinggian 400 km. Tentukan sudut phi yang memastikan Bulan berada di tempat saat pesawat sampai di orbitnya dengan transfer Hohmann. (diketahui jarak rata-rata Bumi-Bulan adalah 384000 km)

$$\theta = \omega_M \cdot t$$
$$\phi = \pi - \theta$$
$$= \pi - \omega_M \cdot t$$
$$= \pi - \sqrt{\frac{GM_\oplus}{a_2^3}} \cdot t$$

$$V_M = \sqrt{\frac{GM_\oplus}{a_2}} \qquad \omega_M = \frac{V_M}{a_2} \qquad \omega_M = \frac{\sqrt{\frac{GM_\oplus}{a_2}}}{a_2}$$

$$t = \tau = \frac{1}{2}P = \frac{1}{\cancel{2}} \cdot \cancel{2}\pi \sqrt{\frac{a^3}{GM_\oplus}} \qquad ; \; a = \frac{a_1 + a_2}{2}$$

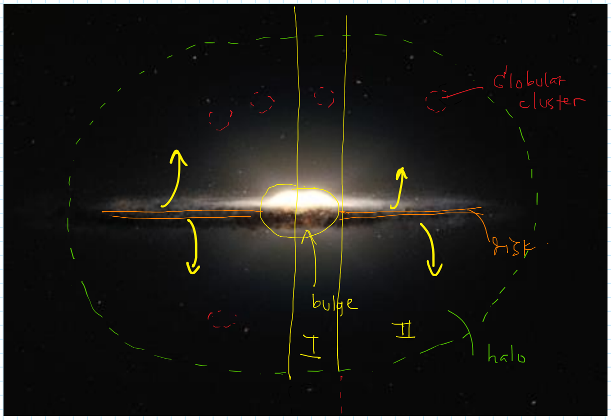
$$\phi = \pi - \sqrt{\frac{\cancel{GM_\oplus}}{a_2^3}} \cdot \pi \sqrt{\frac{a^3}{\cancel{GM_\oplus}}}$$
$$= \pi - \pi \sqrt{\frac{a^3}{a_2^3}}$$

$$\boxed{\phi = \pi \left[1 - \sqrt{\left(\frac{a}{a_2}\right)^3} \right]}$$

$$\phi = \pi \left[1 - \sqrt{\left(\frac{\frac{a_1 + a_2}{2}}{a_2}\right)^3} \right]$$

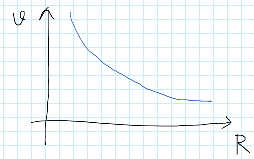
$$\boxed{\phi = \pi \left[1 - \sqrt{\left(\frac{a_1 + a_2}{2a_2}\right)^3} \right]}$$

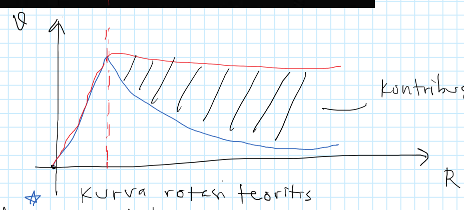
Galaksi — kumpulan bintang (N > 506')
__Kurva rotasi Galaksi__



I. bersifat spt benda tegar

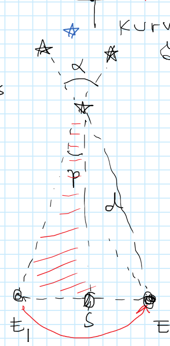
II. Diferensial Non-keplerian





Kurva rotasi teoritis Galaksi

Jarak : 1) __paralaks__



$p = \frac{1}{2}\alpha$

$p \ll \longrightarrow \tan p \simeq p$

$p = \frac{SE_1}{d}$ ← rad

$p = \boxed{\frac{SE_1}{d}} \times 206265$ ← arc sec; AU

$p = \frac{1}{d} \times 206265$ ← arcsec; AU

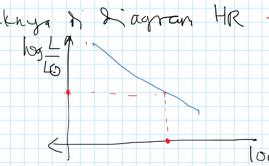
$p = \frac{1}{d} \times \frac{\cancel{206265}}{\cancel{206265}}$ ← pc

arcsec $\boxed{p = \frac{1}{d}}$ ← pc

2). ∴ paralaks spektroskopi & MS fitting
(Diagram HR)

1) Amati mag semu (m) & definisikan __kelas spektrum__ ← suhu (T)

2) Plot letaknya di diagram HR → dapat Luminositas



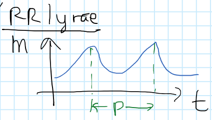
3) Hitung Mag-mutlaknya → $M = -2{,}5 \log L + \text{konstanta}$

4) dgn modulus jarak → dpt jarak

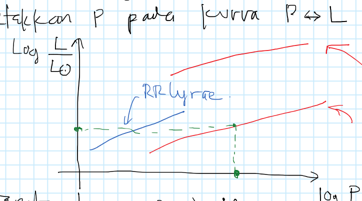
$$\boxed{m - M = -5 + 5\log d + AV}$$

3). __Bintang Variabel__ __intrinsik Cepheid__ / __RR lyrae__

1) ukur periodenya → P



2) Letakkan P pada kurva P ↔ L



3) dapat L → cari M

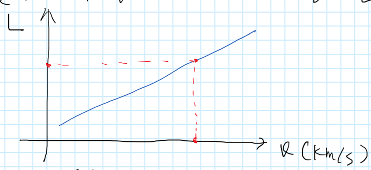
$M = -2{,}5 \log L + C$

4) cari jarak $\boxed{m - M = -5 + 5 \log d + A_V}$

4). Hubungan Tully - Fisher

1) ukur kec. rotasi galaksi (v)

2) plot v ke dalam kurva hub. v dgn L



3) cari mag. mutlak

$M = -2{,}5 \log L + C$

4) cari jarak : $\boxed{m - M = -5 + 5 \log d + A_V}$

5) Supernova tipe Ia

1) amati SNe Ia $\rightarrow L$

2) cari M : $M = -2{,}5 \log L + C$

3) cari jarak $\rightarrow \boxed{m - M = -5 + 5 \log d + A_V}$

□ Kosmologi

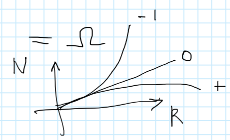
- homogen → tempat
- isotropik → arah

$\rho = \dfrac{M}{V}$? → density universe $= \Omega$

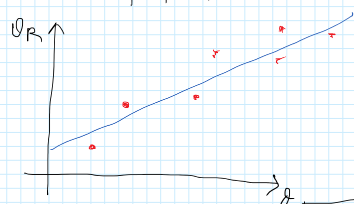
a) kurvatur $= 0$ → flat universe

b) —"— $= +1$ → closed —"—

c) —"— $= -1$ → open universe



H. Hubble → plot v_R dgn d



$v_R \sim d$

$\boxed{v_R = H_0 \cdot d}$

km/s / Mpc

usia alam semesta → $\boxed{t = \dfrac{1}{H_0}}$ → asumsi tidak materi dlm alam semesta ⇒ tdk ada grav. yg mengerem pengembangan alam semesta ($\Omega = 0$)

$\Omega_c = ?$ persamaan Friedmann

$$\boxed{\left(\frac{\dot R}{R}\right)^2 - \frac{8}{3}\pi G \rho = -\frac{k}{R^2}}$$

$\rho = \rho_c$?

$$\boxed{R = \left(6\pi G \rho_c\right)^{\frac{1}{3}} \cdot t^{\frac{2}{3}}}$$

definisi $\boxed{\rho_c = \dfrac{3H_0^2}{8\pi G}}$

$$R = \left(\frac{3}{2} H_0 \, t\right)^{\frac{2}{3}}$$

utk 'now' → $R = 1$

$$\boxed{t = \frac{2}{3}\frac{1}{H_0}}$$

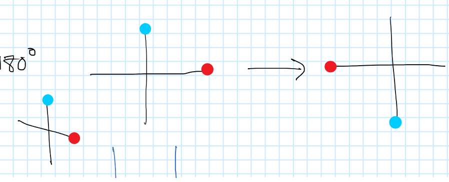
□ Instrumentasi

- kolektor → pengumpul
- analisator → memilah
- detektor → deteksi / rekam

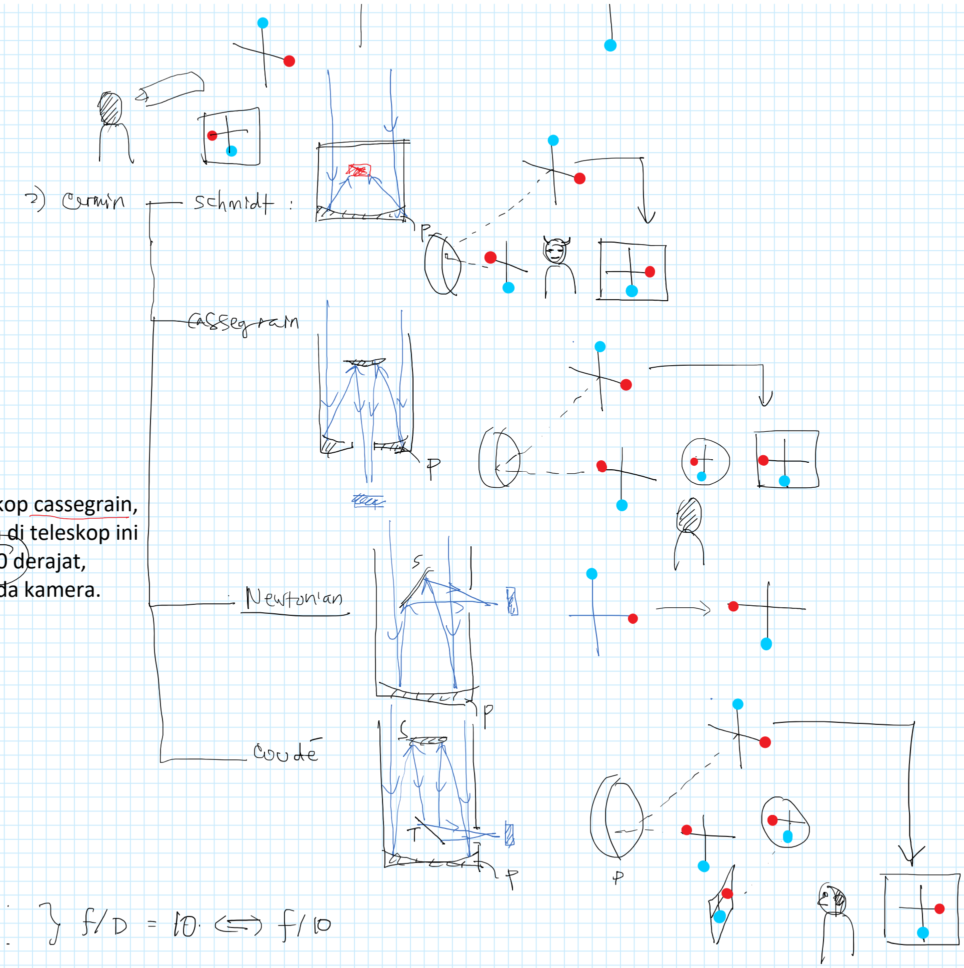
teleskop → optik
- lensa (refraktor)
- cermin (reflektor)

sifat bayangan

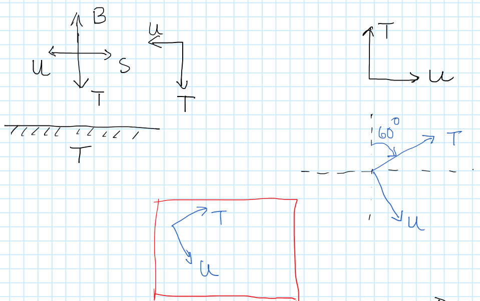
1) lensa → rotasi $180°$



detektor → deteksi / rekam



Sebuah obyek diamati oleh sebuah teleskop cassegrain, dekat dengan horizon Timur. Jika kamera di teleskop ini diputar berlawanan jarum jam sebesar 60 derajat, tentukan orientasi arah Utara - Timur pada kamera.



□ parameter teleskop $\left\{ \begin{array}{l} D = \dots \\ f = \dots \end{array} \right\} f/D = 10 \Longleftrightarrow f/10$

1) Magnifikasi :

$$\boxed{M = \frac{f_{ob}}{f_{ok}} = \frac{f}{f_{eyepiece}}}$$

2) Medan pandang

$$\boxed{FOV = \frac{FOV_{semu}}{M} = \frac{50^\circ}{M}}$$

3) Daya pisah/resolusi

$$\boxed{\theta = 1{,}22\,\frac{\lambda}{D} \times 206265} \;;\; \boxed{\theta = \frac{120}{D}}$$

arcsec — θ (arcsec) ; D ← mm

4) Batas magnitudo

$$\boxed{m_{lim} = 6 + 5\log\frac{D}{8}} \quad D \leftarrow \text{mm}$$

5) Daya kumpul radiasi (LGP)

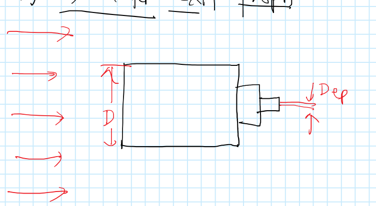
$$\boxed{LGP = \left(\frac{D}{d_{pupil}}\right)^2} \quad d_{pupil} = 7\text{–}8\ \text{mm}$$

6) Skala bayangan (PS)

$$\boxed{PS = \frac{206265}{f}}$$

arcsec/mm ; f ← mm

7) Diameter exit pupil



$$\boxed{D_{ep} = \frac{D}{M}}$$

1. Diketahui ukuran sudut galaksi Andromeda adalah 3 kali diameter sudut bulan Purnama. Jika galaksi ini dipotret dengan kamera dengan lensa f = 85mm, tentukan ukuran galaksi Andromeda di kamera (dalam pixel) jika 1 pixel berukuran 5 x 5 mikron.
2. Jika sebuah lubang hitam memiliki massa 100 x 10^6 massa Matahari, tentukan diameter teleskop yang bisa digunakan untuk memotret lubang hitam ini supaya terlihat jelas diameternya. Jarak lubang hitam ini adalah 5 pc. Asumsikan pengamatan pada panjang gelombang 5000 A.
3. Apakah pernyataan berikut ini benar dan jelaskan kenapa demikian: "galaksi akan terlihat paling terang jika diamati dengan mata telanjang, tanpa teleskop"

1 . → Diameter Sudut = 3 purnama $\simeq 1{,}5^\circ$

$f = 85$ mm

Ukuran Andromeda (dlm pixel)

$PS = \frac{206265}{f} = \frac{206265}{85} \frac{\text{arcsec}}{\text{mm}}$

$= 2426{,}65\ ''/\text{mm}$

← Diameter sudut : $1{,}5^\circ \times 3600''$

$= 5400''$

∴ Ukuran Andromeda di kamera

$\frac{5400}{2426{,}65}$ mm $= 2{,}225$ mm

$\square\, 5 \rightarrow 5 \times 10^{-3}$ mm

∴ jml pixel yg ditempati A di

$= \frac{2{,}225}{5 \times 10^{-3}}$ pixel

$= \boxed{445 \text{ pixel}}$

2 . Blackhole → $M_{BH} = 100 \times 10^6\ M_\odot$

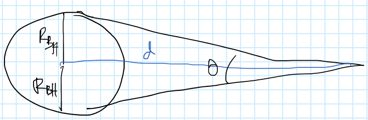
$D = ?$ spy lubang hitam teramati dgn jelas diameternya

Blackhole → $v_{esc} = c$

$= \sqrt{\frac{2GM_{BH}}{R}}$ $\quad c = \sqrt{\frac{2GM_{BH}}{R_{BH}}}$

$c = 3 \times 10^5$ km/s

$3 \times 10^5 \times 10^3 = \sqrt{\frac{2 \cdot 6{,}673 \times 10^{-11} \cdot 100 \times 10^6 \times 1{,}989 \times 10^{30}}{R_{BH}}}$



$R_{BH} = 2{,}949 \times 10^{11}$ m $\simeq 3 \times 10^{11}$ m

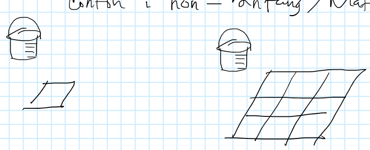
$\theta = \frac{2R_{BH}}{d} = 1{,}22 \frac{\lambda}{D}$

$\frac{2 \cdot 3 \times 10^{11}}{5 \times 206265 \times 1{,}4959 \times 10^{11}} = 1{,}22 \cdot \frac{5000 \times 10^{-10}}{D}$

$D = 0{,}15$ m

benda Langit

- obj. titik
  contoh : bintang
- obj. membentang (ext. obj)
  contoh : non-bintang / Matahari



Tes 4

Friday, April 5, 2019 4:37 PM

1. Sebuah lubang hitam supermasif memiliki massa $150 \times 10^6\ M_\odot$ berada pada jarak 20 kpc. Tentukan panjang fokus teleskop minimum yang bisa digunakan supaya lubang hitam ini bisa terpotret dengan baik dan membentang di sensor kamera sepanjang 2 mm.

$M_{SMBH} = 150 \times 10^6\ M_\odot$ ✓

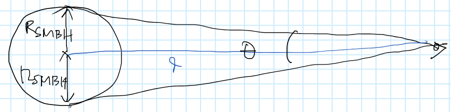
$d = 20\ \text{kpc} = 20 \times 10^3\ \text{pc}$

$f = ?$

$R_{SMBH} = \dfrac{2GM_{SMBH}}{c^2} = \dfrac{2 \cdot 6{,}673 \times 10^{-11} \cdot 150 \times 10^6 \cdot 1{,}989 \times 10^{30}}{(3 \times 10^8)^2}$

$R_{SMBH} = 4{,}424 \times 10^{11}$ m

$R_{SMBH} = 2{,}958$ AU



$\theta = \dfrac{2\, R_{SMBH}}{d} \times 206265 \Rightarrow \theta = \dfrac{2 \cdot 2{,}958}{20 \times 10^3 \times \cancel{206265}} \times \cancel{206265}$ arcsec

arcsec

$\theta = 2{,}958 \times 10^{-4}$ arcsec $\longrightarrow$ 2 mm

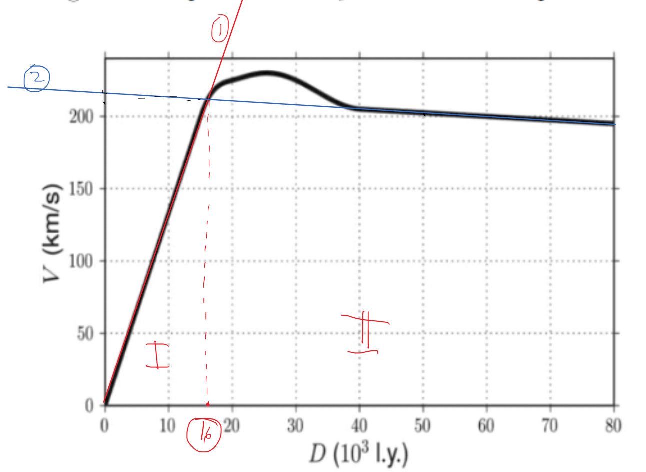
? $\longrightarrow$ 1 mm

$PS = \theta = \dfrac{2{,}958 \times 10^{-4}\ \text{arcsec}}{2}$

$PS = \dfrac{206265}{f} = \dfrac{2{,}958 \times 10^{-4}}{2}$ mm

$f = 1{,}39 \times 10^9$ mm $\rightarrow \sim \boxed{1394\ \text{km}}$

2. Astronom mempelajari sebuah galaksi spiral yang memiliki ~~inklinasi~~ 90° dan terang semu 8.5. Mereka mengukur kecepatan rotasinya dan membuat plot kurva rotasinya.



$y = mx + c$

(a) Buat fungsi yang terdiri dari dua persamaan garis lurus untuk mendekati kurva rotasi galaksi pada gambar di atas.

(b) Dengan menggunakan data yang sama, astronom ini memperkirakan bahwa **periode rotasi dari gelombang tekanan pada piringan galaksi (P_{wave}) adalah setengah dari periode rotasi dari massa piringan galaksi (P_{mass})**. Tentukan periode yang diperlukan satu lengan spiral galaksi (P_{spiral}) untuk mengelilingi pusat galaksinya. (Petunjuk: kecepatan sudut spiral merupakan selisih kecepatan sudut tercepat dan terlambat pada gelombang tekanan pada piringan galaksi)

a) I : $V(D) = \dfrac{215}{16} D \quad ; \quad 0 < D < 16$

II : $V(D) = -\dfrac{30}{50} D + 230 \quad ; \quad D > 16$

$V(D) \begin{cases} \dfrac{215}{16} D \ ; 0 < D < 16 & \rightarrow \text{bulge} \\ -\dfrac{30}{50} D + 230 \ ; D \geq 16 & \rightarrow \text{disk} \end{cases}$

b) $P_{wave} = \dfrac{1}{2} P_{mass}$

$P = \dfrac{2\pi}{\omega}$; $P_{wave} = \dfrac{2\pi}{\omega_{wave}}$; $P_{mass} = \dfrac{2\pi}{\omega_{mass}}$

$\cancel{2\pi}$ $\quad \dfrac{1}{\ } \ \cancel{2\pi}$

b) $P_{wave} = \frac{1}{2} P_{mass}$ $\quad P = \frac{2\pi}{\omega}$ $\quad P_{wave} = \frac{2\pi}{\omega_{wave}}$, $\quad P_{mass} = \frac{2\pi}{\omega_{mass}}$

$$\frac{\cancel{2\pi}}{\omega_{wave}} = \frac{1}{2}\frac{\cancel{2\pi}}{\omega_{mass}} \qquad \omega = \frac{v}{D}$$

$$\omega_{wave} = 2\,\omega_{mass} = 2\cdot\frac{V(D)}{D}$$

$$\boxed{\omega_{wave} = 2\,\frac{V(D)}{D}}$$

$$P_{spiral} = \frac{2\pi}{\omega_{spiral}}$$

$$\omega_{spiral} = \omega_{wave}\Big|_{Fastest} - \omega_{wave}\Big|_{slowest}$$

$$= \frac{2V(D)}{D}\Big|_{D=16} - \frac{2V(D)}{D}\Big|_{D=80}$$

$$= 2\left[\frac{-\frac{3}{5}D + 230}{D}\Big|_{D=16} - \frac{-\frac{3}{5}D + 230}{D}\Big|_{D=80}\right]$$

$$\omega_{spiral} = 2\left[\frac{1}{D}\left(-\frac{3}{5}D + 230\right)\Big|_{D=16} - \frac{1}{D}\left(-\frac{3}{5}D + 230\right)\Big|_{D=80}\right]$$

$$\omega_{spiral} = 2\left[\frac{1}{16}\left(-\frac{3}{5}(16) + 230\right) - \frac{1}{80}\left(-\frac{3}{5}(80) + 230\right)\right]$$

$$= 2\left[\cancel{-\frac{3}{5}} + \frac{230}{16} \cancel{+\frac{3}{5}} - \frac{230}{80}\right]$$

$$= 2\left[\frac{230}{16} - \frac{230}{80}\right]$$

$$= 2\left[\frac{230}{1,515\times10^{17}} - \frac{230}{7,574\times10^{17}}\right]$$

$$\omega_{spiral} = 2,429 \times 10^{-15} \text{ rad}$$

$$D = 16 \text{ kly} = 16\times10^3 \times 365,25 \times 24 \times 3600 \times 3\times10^5 \text{ km}$$

$$= 1,515 \times 10^{17} \text{ km}$$

$$D = 80 \text{ kly} = 80\times10^3 \times 365,25 \times 24 \times 3600 \times 3\times10^5 \text{ km}$$

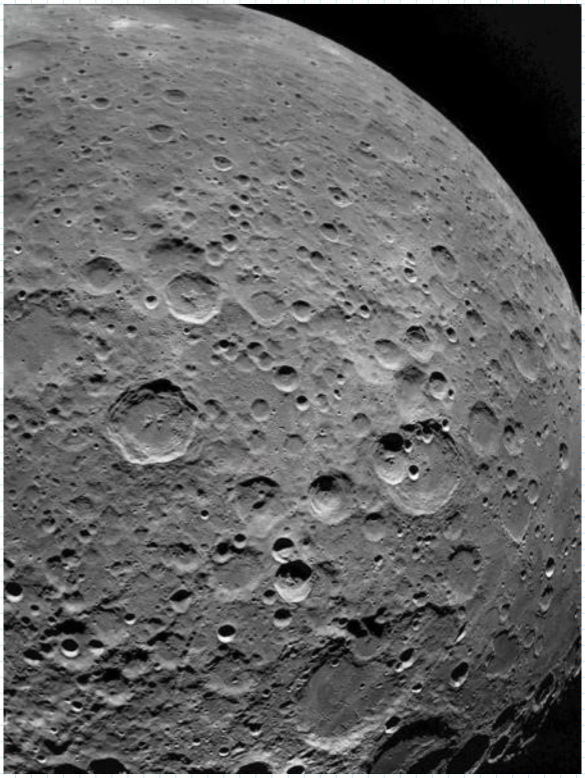
$$= 7,574 \times 10^{17} \text{ km}$$

$$P_{spiral} = \frac{2\pi}{\omega_{spiral}} = \frac{2\pi}{2,429\times10^{-15}} \text{ s}$$

$$= 2,587 \times 10^{15} \text{ s} = \boxed{8,197\times10^7 \text{ tahun}}$$

Pembahasan simulasi OSP

Friday, April 5, 2019 8:30 PM



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URL: http://pelatihan-osn.com
Kompleks Sawangan Permai Blok A5 No.12A,
Sawangan, Depok 16511
Telp. 021-2951 1160
CP : 0-878787-1-8585 / 0813-8691-2130

Pelatihan Akbar Jelang OSP 2019

Bidang Studi : Astronomi
Tanggal : 6 April 2019
Materi : Simulasi OSP 2019

1 Pilihan Ganda

1. Astronom tidak berharap menemukan kehidupan di planet yang mengorbit bintang bermassa besar karena . . .

   (a) Bintang bermassa besar terlalu tinggi total energinya
   (b) Kala hidup bintang bermassa besar terlalu singkat
   (c) Bintang bermassa besar terlalu panas sehingga kehidupan tidak bisa terbentuk
   (d) Planet tidak bisa memiliki orbit stabil dalam mengelilingi bintang bermassa besar

2. Matahari terbenam di kota A ($\phi = +51°30'; \lambda = 0°8'$ W) pada 21:00 UT. Jam berapakah (dalam UT) Matahari terbenam di kota B ($\phi = +51°30'; \lambda = 3°11'$ W) pada hari yang sama?

   $\Delta\lambda = 3^\circ 11' - 0^\circ 8' = 3^\circ 3' \Rightarrow \Delta t = \frac{8^\circ 3'}{15^\circ} \approx 12^m$

   (a) 21:12
   (b) 21:00
   (c) 20:48
   (d) 20:58

3. Sebuah komet memiliki orbit elips dengan jarak terjauh dan terdekat masing–masing 31.5 AU dan 0.5 AU. Periode komet ini adalah . . .

   r_A r_P

   $\frac{a^3}{P^2} = M_\odot \rightarrow a^3 = P^2$ AU tahun

   $a = \frac{r_A + r_P}{2} = \frac{31.5 + 0.5}{2} = 16$ AU

   $P = \sqrt{16^3}$

   (a) 181 tahun
   (b) 16 tahun
   (c) 64 tahun
   (d) 6.3 tahun

4. Di tempat manakah berikut ini yang memberikan panjang hari terpendeknya setara dengan separuh dari malam terpanjangnya?

   dingin $\delta_\odot = +23^\circ 27'$ dingin
   $-23^\circ 27'$

   (a) $\phi = +25°$
   (b) $\phi = +52°$
   (c) $\phi = -23°$
   (d) $\phi = +70°$

   $\cos HA = -\tan(26)\tan(-23^\circ 27') \Rightarrow HA = 5^h 13^m 19^s$

   $\rightarrow 2HA = \boxed{10^h 26^m 38.45^s} \leftarrow$ siang

   Malam $= 24^h - 10^h 26^m 38.45^s = \boxed{13^h 33^m 22^s}$

5. Wahana Magellan bisa melihat tembus awan di atmosfer Venus dan memetakan permukaannya, dengan panjang gelombang . . .

   (a) Ultraviolet
   (b) Infrared
   (c) Radio
   (d) Visual

6. WMAP memberikan nilai konstanta Hubble sebesar $H_0 = 69.3$ km/s/Mpc. Maka usia alam semesta kita untuk model alam semesta datar dan dominan materi adalah . . .

   (a) 11.7 Gyr
   (b) 9.4 Gyr
   (c) 7.9 Gyr
   (d) 4.2 Gyr

$t = \frac{2}{3} \cdot \frac{1}{H_0} = \frac{2}{3} \frac{1}{69,3 \text{ km/s/Mpc}} = \frac{10^6 \times 206265 \times 1,4959 \times 10^8}{69,3}$ s

$= \ldots$ s

7. Kesalahan sebesar 10% dalam penentuan magnitudo tampak sebuah bintang akan menyebabkan kesalahan penentuan jarak sebesar . . .

   (a) 5%
   (b) 10%
   (c) 15%
   (d) 20%

$\boxed{m} - M = -5 + 5 \log \boxed{d}$ $\Rightarrow \log d = \frac{\ln d}{\ln 10} \approx \frac{\ln d}{2,3}$

$\boxed{\sigma_m = \left(\frac{dm}{dd}\right) \sigma_d}$

$m - M = -5 + 5 \log d$

$\frac{dm}{dd} = \frac{5}{2,3} \frac{1}{d} = \frac{2,17}{d}$ $\Rightarrow \sigma_m = \frac{2,17}{d} \cdot \sigma_d$

$10\% = \frac{2,17}{d} \sigma_d$

$\frac{10\%}{2,17} = \frac{\sigma_d}{d}$

$\sim 5\% = \frac{\sigma_d}{d}$

$\sigma_d = \boxed{5\%}\, d$

8. Tahun galaksi adalah waktu yang diperlukan Matahari untuk mengitari pusat galaksi. Jika jarak Matahari ke pusat galaksi adalah 8.5 kpc dan kecepatan orbitnya adalah 220 km/s, maka usia Matahari (sekitar 5 Gyr) jika dinyatakan dalam tahun galaksi adalah . . .

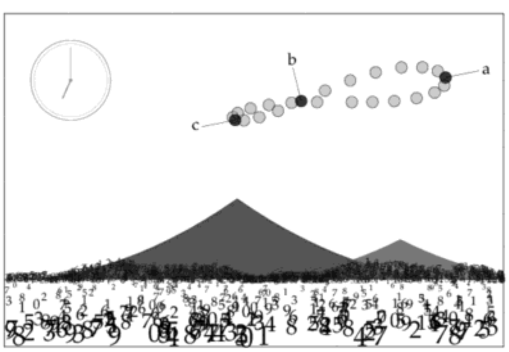
   (a) 107 tahun galaksi
   (b) 234 tahun galaksi
   (c) 21 tahun galaksi
   (d) 88 tahun galaksi

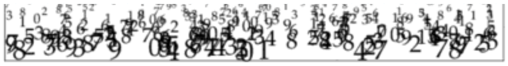
$v = \frac{2\pi R}{P} \rightarrow P = \frac{2\pi R}{v} = \frac{2\pi \cdot 8,5 \times 10^3 \times 206265 \times 1,4959 \times 10^8}{220}$ s

$P = 7,49 \times 10^{15}$ s $= 2,37 \times 10^8$ yr

thn galaksi Matahari $= \frac{5 \times 10^9}{2,37 \times 10^8} = 21,0 \ldots$

9. Gambar berikut ini merupakan gabungan foto panorama yang diambil seorang pengamat pada pukul 07:00 waktu lokal setiap kurang lebih 15 hari sekali. Lingkaran berwarna abu-abu adalah piringan Matahari dengan posisi semu yang berubah sepanjang tahun, membentuk pola unik yang disebut sebagai *analemma*. Fenomena ini terjadi sebagai akibat dari orbit Bumi yang elips serta kemiringan sumbu rotasi Bumi.



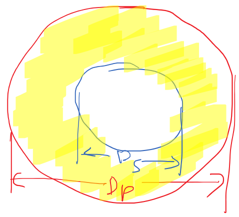


Lingkari pernyataan yang betul.

1. Pengamat ada di barat Greenwich.
2. Huruf a dan c adalah posisi semu Matahari di titik balik selatan dan utara.
3. Huruf b adalah posisi semu Matahari di bulan Januari.
4. Posisi pengamat ada di lintang selatan.

10. Sebuah teleskop Schmidt–Cassegrain memiliki cermin primer dan sekunder dengan diameter berturut–turut 35.6 cm dan 16.5 cm. Jika efisiensi pantul cermin primer dan sekunder dianggap 100%, maka jumlah cahaya yang sampai detektor adalah . . .

   (a) $\sim 76\%$
   (b) $\sim 54\%$
   (c) $\sim 88\%$
   (d) $\sim 96\%$



Jml chy ke detektor $= \dfrac{L \text{ daerah arsir}}{L \text{ primer}}$

$= \dfrac{\frac{1}{4}\pi D_p^2 - \frac{1}{4}\pi D_s^2}{\frac{1}{4}\pi D_p^2}$

$= \dfrac{\cancel{\tfrac{1}{4}\pi}\,(D_p^2 - D_s^2)}{\cancel{\tfrac{1}{4}\pi}\, D_p^2}$

$= \dfrac{35{,}6^2 - 16{,}5^2}{35{,}6^2} \simeq 0{,}78$

$= 78\%$

2 Essay

1. Pusat galaksi kita ditunjukkan oleh posisi Sgr A*, yaitu sebuah lubang hitam bermassa $4 \times 10^6\ M_\odot$. Lubang hitam ini berlokasi di $\alpha(2000) = 17^{\mathrm{h}}45^{\mathrm{m}}, \delta(2000) = -29°00'$. Jarak dari Matahari ke Sgr A* sekitar 8 kpc dan ekses warnanya adalah $E(B - V) = 10$.

   (a) (5 Poin) Perkirakan **bulan terbaik** untuk mengamati pusat galaksi ini (yaitu saat pusat galaksi berada di sekitar meridian saat tengah malam). **berapa lama** pusat galaksi ini bisa diamati dari posisi pengamat $\phi = 40.75°$

   (b) (5 poin) Bisakah lubang hitam ini **diamati dengan baik** pada panjang gelombang visual dengan teleskop berdiameter 30 m? Jelaskan jawaban anda.

2. Sebuah nova meledak di konstelasi Sagittarius. Ledakan ini berakhir dalam 90 hari, dan pada saat itu obyek ini memiliki magnitudo semu bolometrik sebesar 6. Hasil studi spektroskopi menunjukkan bahwa material dari nova ini terlontar dengan kecepatan ~ 500 km s^{-1}. Dua tahun berikutnya adalah terakhir kalinya lontaran material ini bisa terdeteksi pada 5000 Å dengan batas difraksi (atau daya pisah) teleskop Hubble (diameter 2.4 m).

Daftar Konstanta

Besaran	**Simbol**	**Nilai**
Luminositas Matahari	$L_\odot$	$3,9 \times 10^{26}$ W
Magnitudo semu Matahari (visual)	$m_\odot = V_\odot$	$-26,78$
Magnitudo mutlak Matahari (visual)	$M_{V,\odot}$	4,79
Magnitudo mutlak bolometrik matahari	$M_{\mathrm{bol},\odot}$	4,72
Fluks Matahari	$E_\odot$	1340 $\mathrm{Wm^{-2}}$
Temperatur efektif matahari	T_{eff}	5785 K
Konstanta Stefan–Boltzmann	σ	$5,67 \times 10^{-8}$ $\mathrm{Wm^{-2}K^{-4}}$
Konstanta Planck	h	$6,6261 \times 10^{-34}$ Js
Konstanta Boltzmann	k	$1,3807 \times 10^{-23}$ $\mathrm{J\ K^{-1}}$
Satuan Astronomi	AU	$1,4959 \times 10^{11}$ m
Parsec (atau parsek)	pc	$3,08 \times 10^{16}$ m $= 206265$ AU $= 3,26$ ly
Konstanta gravitasi	G	$6,673 \times 10^{-11}$ $\mathrm{m^3kg^{-1}s^{-2}}$
Radius Bumi	$R_\oplus$	6378 km
Radius Matahari	$R_\odot$	$6,96 \times 10^{8}$ m
Massa Matahari	$M_\odot$	$1,989 \times 10^{30}$ kg
Massa Bumi	$M_\oplus$	6×10^{24} kg
Massa Bulan	$M_{☾}$	$7,348 \times 10^{22}$ kg
Radius Bulan	$R_{☾}$	$1,738 \times 10^{6}$ m
Konstanta Hubble	H_0	$73,24 \pm 1,74$ km $\mathrm{s^{-1}}$ $\mathrm{Mpc^{-1}}$

Konversi	
1 Å	$= 10^{-10}$ m
1 erg	$= 10^{-7}$ J
1 erg $\mathrm{s^{-1}}$	$= 10^{-7}$ W