

1) Atmosfer

$$\cos \gamma = \frac{1}{X} \rightarrow X = \frac{1}{\cos \gamma} = \sec \gamma$$

$$X = ?$$

$$X = \sec \gamma$$

$$airmass = 1$$

$$X = 1$$

$$m \sim m_0$$

$$m = m_0 + \Delta m \cdot X$$

$$m = m_0 + \Delta m \cdot \sec \gamma$$

2) MAB $\rightarrow A_V = p \cdot E(B-V)$

$p \approx 3.2$ w/ MAB normal

$$A_V = 3.2 E(B-V)$$

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

$$m = -2.5 \log E + c \rightarrow m = -2.5 \log \frac{1}{4\pi(d)^2} + c$$

$$M = -2.5 \log \frac{L}{4\pi(d_0)^2} \rightarrow M = -2.5 \log \frac{1}{4\pi(d_0)^2} + c$$

$$m - M = -2.5 \left(\log \frac{1}{4\pi(d)^2} - \log \frac{1}{4\pi(d_0)^2} \right)$$

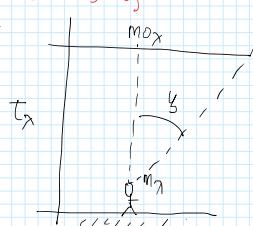
$$= -2.5 (2 \log d + 2 \log 10)$$

$$= -2.5 (-2 \log d + 2)$$

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

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

$$m_x - m_{ox} = 1.086 T_x \sec \gamma$$



$$m_1 - m_0 = 1.086 T_1 \sec \gamma_1$$

$$m_2 - m_0 = 1.086 T_2 \sec \gamma_2$$

$$m_1 - m_2 = 1.086 T_2 (\sec \gamma_1 - \sec \gamma_2)$$

i) standar \rightarrow ukur m & γ

$$m_{std, \gamma_1} - m_{std, \gamma_2} = 1.086 T_x (\sec \gamma_1 - \sec \gamma_2)$$

$$m_x - m_{ox} = 1.086 T_x \sec \gamma$$

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° , magnitudo semunya adalah 9,2, sedangkan pada waktu diamati pada jarak zenith 15° , magnitudo semunya adalah 9,0. Apabila pada jarak zenith 25° magnitudo bintang program adalah 8,9. Tentukan magnitudo bintang program ini sebelum mengalami penyerapan oleh atmosfer Bumi.

Dan hasil pengamatan pada sebuah bintang diperoleh magnitudo visualnya $V = 10,0$, dan magnitudo biru $B = 10,5$. Warna intrinsik untuk bintang ini adalah $(B-V)_0 = 0$ dan magnitudo mutlaknya $M_v = 0,8$. Apabila materi antar bintang di depan bintang ini normal tentukanlah:

- Magnitudo intrinsiknya untuk V dan B
- Jarak sebenarnya bintang tersebut

$$\begin{aligned} \gamma_1 &= 35^\circ \rightarrow m_1 = 9,2 \\ \gamma_2 &= 15^\circ \rightarrow m_2 = 9,0 \end{aligned} \Rightarrow m_1 - m_2 = 1.086 T_x (\sec 35^\circ - \sec 15^\circ)$$

$$g_2 - g_0 = 1.086 T_x \sec 35^\circ - \sec 15^\circ$$

$$\gamma = 25^\circ \rightarrow m = 8,9$$

$$m - m_0 = 1.086 T_x \sec \gamma$$

$$8,9 - m_0 = 1.086 (1) \sec 25^\circ$$

$$m_0 = 7,78$$

17. Dua bintang memiliki magnitudo +4,1 mag dan +5,6 mag. Bintang yang lebih terang memberikan 5×10^{-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 fotosfer matahari.

- Hitung jarak aphelion orbit satelit tersebut
- Berapa magnitudo perbedaan terang maksimum dan minimum satelit tersebut pengukuran fotometer ?

$$\boxed{17} \quad m_1 = 4,1 \rightarrow E_1 = 5 \times 10^{-9} \text{ W}$$

$$m_2 = 5,6 \rightarrow E_2 = ?$$

$$m_1 - m_2 = -2.5 \log \frac{E_1}{E_2} \Leftrightarrow \frac{E_1}{E_2} = 10^{(m_1 - m_2)}$$

$$\frac{5 \times 10^{-9}}{E_2} = 10^{(4,1 - 5,6)}$$

$$E_2 = 1.25 \times 10^{-9} \text{ W}$$

$$\boxed{18} \quad \text{sat orbit elips} \quad e = 0.5$$

$$r_p = 80 \times 10^6 \text{ km}$$

$$a) r_A$$

$$b) \Delta M$$

$$r_p = a - ae \Rightarrow a = \frac{r_p}{1-e}$$

$$a = \frac{80 \times 10^6}{1-0.5} \text{ km}$$

$$a) r_A + r_p = 2a$$

$$r_A = 2a - r_p$$

$$= 2(160 \times 10^6) - 80 \times 10^6 \text{ km}$$

$$= 320 \times 10^6 - 80 \times 10^6 \text{ km}$$

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

$$b) \Delta M = -2.5 \log \frac{E_{\max}}{E_{\min}}$$

$$E = \frac{L}{4\pi d^2} \rightarrow \frac{E_{\max}}{E_{\min}} = \frac{\frac{L}{4\pi d_{\min}^2}}{\frac{L}{4\pi d_{\max}^2}}$$

aksun : anggap sensor ada di pusat matahari (jauh dr pusat ke transfer << r_p, r_A)

misal :

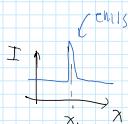
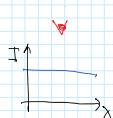
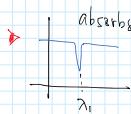
$$\begin{cases} d_{\min} = r_p \\ d_{\max} = r_A \end{cases} \rightarrow \frac{E_{\max}}{E_{\min}} = \left(\frac{r_A}{r_p}\right)^2 \text{ kg}$$

$$\Delta M = -2.5 \log \left(\frac{r_A}{r_p}\right)^2$$

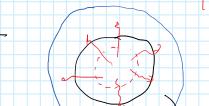
= ...

D) Spektrofotomi . Kirchhoff .

$$\frac{I}{I_0} =$$



$$T = \frac{0.289P}{\lambda_{\max}}$$

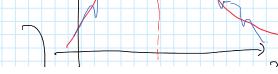


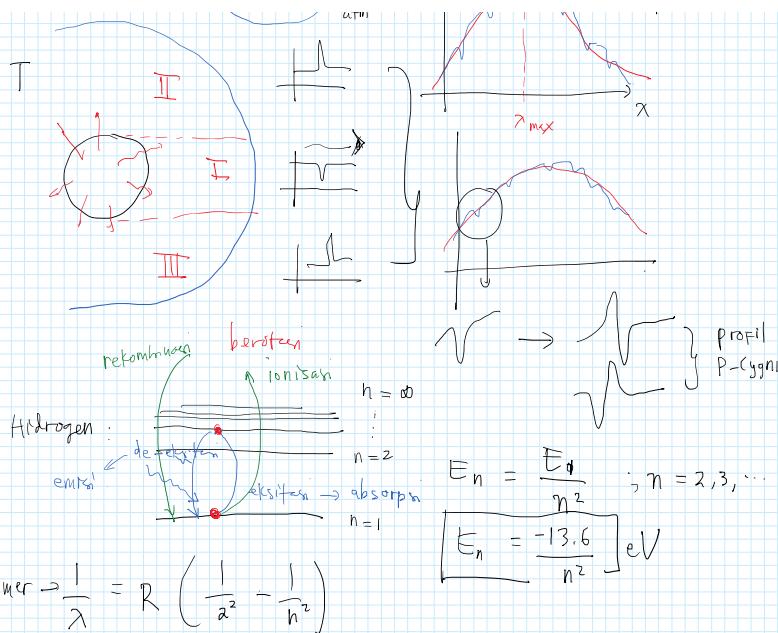
$$SED$$



T

II





Zeeeman effect

median magnet \perp

median magnet \parallel

$$\Delta\lambda = \frac{e H \lambda^2}{4\pi M_e c^2}$$

Kuat medan magnet B_{mag} Gauss

Doppler Effect

$$H_d = 6563 \text{ Å}$$

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v_R}{c} \rightarrow \frac{\lambda_{d1} - \lambda_0}{\lambda_0} = \frac{v_R}{c}$$

15. Bagaimana kita membedakan gerak diri bintang (proper motion) dengan paralaksnya ? Jelaskan !

16. Panjang gelombang maksimum spektrum sebuah bintang adalah $2,898 \times 10^3 \text{ Å}$. Berapakah temperatur bintang tersebut? Dapatkan kamu menentukan termasuk kelas apakah bintang tersebut ?

17. Dari hasil penyelidikan diketahui bahwa bintang P termasuk kelas A0 III dan bintang Q kelas A5 III. Jelaskanlah apa yang dimaksud kelas A0 V dan A5 V. Tentukan juga persamaan dan perbedaan kedua bintang tersebut dan bintang manakah yang radiusnya paling besar ? Jelaskan jawabannya.

8. If a star is moving away from the Earth at very high speed, will the star have a continuous spectrum that appears hotter or cooler than it would if the star were at rest? Explain.

9. A quasar is observed and it is found that a line whose rest wavelength is 3000 Å is observed at 15000 Å. Estimate:

- a) How fast is the quasar receding?
- b) How far away is it if its distance is given by the Hubble relation? (The Hubble constant is $H = 75 \text{ km/s/Mpc}$)

58. Sebuah nova diamati dengan teknik spektroskopi pada panjang gelombang diam 6563 Å teramat pada panjang gelombang 6563,49 Å. Jika diketahui gerak dirinya adalah $0'',01/\text{tahun}$, hitunglah sudut paralaks dari nova tersebut !

$$\frac{\Delta\lambda}{\lambda} = \sqrt{\frac{1 + v_R/c}{1 - v_R/c}} - 1$$

$$\frac{12000}{3000} = \sqrt{\frac{1 + v_R/c}{1 - v_R/c}} - 1$$

$$v_R = -\frac{12}{13} c$$

$$v_R = 2.77 \times 10^5 \text{ km/s}$$

33. Sebuah nova ~~diukur~~ dengan teknik spektroskopi pada panjang gelombang diam 6563 Å teramati pada panjang gelombang 6563,49 Å. Jika diketahui gerak dirinya adalah 0'',015/tahun, hitunglah sudut paralaks dari nova tersebut !

34. Sebuah bintang mempunyai kecepatan radial sebesar -0,95 km/s. Deklinasi bintang ini $-13^{\circ}41'$ dan paralaksnya $0''.028$. Bila gerak diri dalam arah asensiorekta dan deklinasi sebesar $0'',088 / \text{tahun}$ dan $0'',213 / \text{tahun}$, hitunglah:
- Gerak diri bintang
 - Kecepatan bintang
 - Berapakah panjang gelombang yang tercatat pada pengamatan spektrum bintang ini bila dicocokkan pada panjang gelombang 4360 Å ?

$$V_R = \frac{-12}{13} c$$
$$\boxed{V_R = 2,77 \times 10^5 \frac{\text{km}}{\text{s}}}$$

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Pelatihan Akbar Jelang OSP 2019

Bidang Studi : Astronomi
Tanggal : 27 Maret 2019
Materi : AsDas, Fotometri, Spektroskopii

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.



$$D_p = 5 \text{ cm} \\ D_A = 4.2 \text{ cm}$$

2. The Ring Nebula (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 20 km/s. How long ago did the central star shed its layers?
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.
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.
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 $\frac{T_A}{T_B}$.

[3] bintang X $\rightarrow \gamma = 0.2''$
 $\theta = 2.67 \times 10^{-3}''$ } $\mu = ?$

$$\lambda_{\text{peak}} = 3864 \text{ Å}$$

$$d = \frac{1}{\gamma} \text{ pc} \Rightarrow f = \frac{1}{0.2} \text{ pc} \\ f = 5 \text{ pc}$$



$$\theta \ll \tan \theta \approx \theta$$

$$\theta = \frac{D}{f} \times 206265$$

arcsec

$$D = \frac{0.2}{206265} \text{ pc} \\ = \frac{2.67 \times 10^{-3} \cdot 5}{206265} \text{ pc}$$

$$M - M_0 = -2.5 \log \frac{L}{L_0}$$

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

$$T = \sqrt{\frac{0.2898}{\lambda}} = \sqrt{\frac{6.2898}{3864 \times 10^{-8}}} \quad [k = 7300 \text{ K}]$$

$$M - M_0 = -2.5 \log \frac{L}{L_0} \Rightarrow M - 4.7g = -2.5 \log \left(\frac{2.25 \times 10^{27}}{3.9 \times 10^{26}} \right)$$

$$M = 2.89$$

[4] M32 $\rightarrow N = 250 \times 10^6$

$$m_{\text{TOT}} = g \rightarrow E_{\text{TOT}} = E_1 \cdot N \\ m_1 = ? \quad = 250 \times 10^6 E_1 \quad \boxed{\frac{E_{\text{TOT}}}{E_1} = 250 \times 10^6}$$

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

II

$$\text{if } \theta \ll \tan \theta \approx \theta$$

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

$$\frac{\theta_p}{\theta_A} = \frac{D_p}{D_A}$$

$$\frac{\theta_p}{\theta_A} = \frac{D_p}{D_A} = \frac{5}{4.2}$$

$$\frac{a(1+e)}{a(1-e)} = \frac{5}{4.2}$$

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

$$9.2e = 0.8$$

$$e = 0.09$$

[2] $d = 2700 \text{ ly}$

$$\theta = 1.4 \times 1 \text{ arcmin/h}$$

$$V_R = 20 \text{ km/s}$$

$$\Delta t = ?$$



assume that this nebula is concentric

\rightarrow pick the biggest ang. diameter for initial value of $\Delta t \rightarrow \theta = 1.9 \text{ arcmin}$

$$\theta \ll \tan \theta \approx \theta$$

$$\theta = \frac{D}{f} \Rightarrow \theta = \frac{D}{f} \times 206265$$

arcsec

$$D = \frac{\theta \cdot f}{206265} \text{ ly} \rightarrow D = \frac{(84) \cdot (2700)}{206265} \text{ ly}$$

$$D = 1.1 \text{ ly}$$

$$R = 0.55 \text{ ly}$$

$$= 0.55 \times 360 \cdot 1.5 \times 24 \times 3600 \times 3 \times 10^5 \text{ km}$$

$$\leftarrow R = 5.2 \times 10^{12} \text{ km}$$

$$\Delta t = \frac{R}{V_R}$$

$$= \frac{5.2 \times 10^{12}}{20} \text{ s}$$

$$\Delta t = 8250 \text{ tahun}$$

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

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

$$= 4\pi (10^9)^2 (5.17 \times 10^{-8}) (7500)^4$$

$$L = 2.25 \times 10^{27} \text{ W}$$

$$M - M_0 = -2.5 \log \frac{L}{L_0} \Rightarrow M - 4.7g = -2.5 \log \left(\frac{2.25 \times 10^{27}}{3.9 \times 10^{26}} \right)$$

$$M = 2.89$$

[4] M32 $\rightarrow N = 250 \times 10^6$

$$m_{\text{TOT}} = g \rightarrow E_{\text{TOT}} = E_1 \cdot N \\ m_1 = ? \quad = 250 \times 10^6 E_1 \quad \boxed{\frac{E_{\text{TOT}}}{E_1} = 250 \times 10^6}$$

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

$$m_1 = ? = 250 \times 10^{-3} t_1$$

$$\frac{E_{\text{tot}}}{E_1} = 2.5^{1/2} - (n_{\text{tot}} - m_1)$$

$$250 \times 10^6 = 2.5^{1/2} - (g - m_1) \Rightarrow m_1 \approx 30$$

5. A $\not\propto$ B \rightarrow b) A & B both MAD
B clear } $E_A = 8 E_B$

$$(a) P = \frac{1}{8} \rightarrow \frac{\delta_A}{\delta_B} = \frac{T_B}{T_A} = \frac{0.05}{0.1} = 0.5$$

$$b) T_A = R_B \quad \left. \begin{array}{l} L_A = \frac{4\pi G R_A^2 \sigma T_A^4}{c^3} \\ T_A = 2T_B \end{array} \right\} \frac{L_A}{L_B} = \frac{4\pi G R_A^2 \sigma T_A^4}{4\pi G R_B^2 \sigma T_B^4} = \left(\frac{T_A}{T_B} \right)^4 = 16$$

$$c) \frac{E_{A\text{true}}}{E_{A\text{obs}}} = ? \quad \left. \begin{array}{l} E_A|_{\text{obs}} = 8 E_B|_{\text{obs}} \\ E_A|_{\text{true}} = ? E_B|_{\text{true}} \end{array} \right\} \frac{E_{A\text{true}}}{E_{A\text{obs}}} = \frac{64}{8} = 8$$

$$\frac{E_A|_{\text{true}}}{E_B|_{\text{true}}} = \frac{\frac{L_A}{L_B}}{\frac{4\pi G R_A^2}{4\pi G R_B^2}} = \frac{L_A}{L_B} \cdot \left(\frac{R_B}{R_A} \right)^2 = 16 \cdot (2)^2$$

$$\frac{E_A|_{\text{true}}}{E_B|_{\text{true}}} = 64$$

$$6. M = 7.66 \\ P = 0.26'' \\ V_R = 50 \text{ km/s}$$

$$\Rightarrow \delta = \frac{1}{P} = \frac{1}{0.26}$$

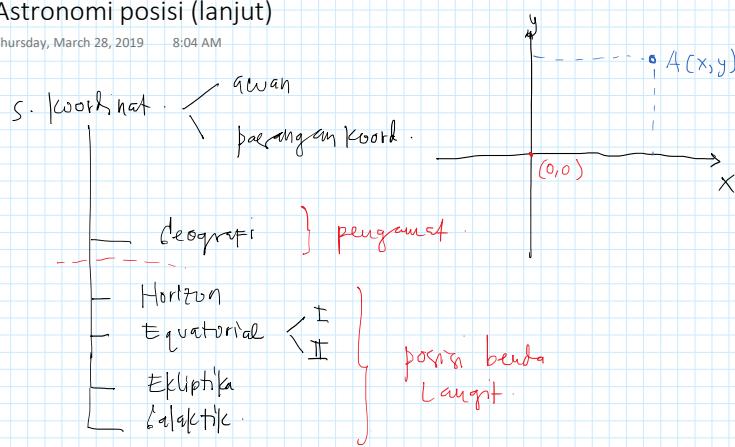
$$a) \text{Redshift, } z \\ \frac{\Delta \lambda}{\lambda} = z = \frac{V_R}{c} = \frac{50}{3 \times 10^5} = 1.67 \times 10^{-4}$$

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

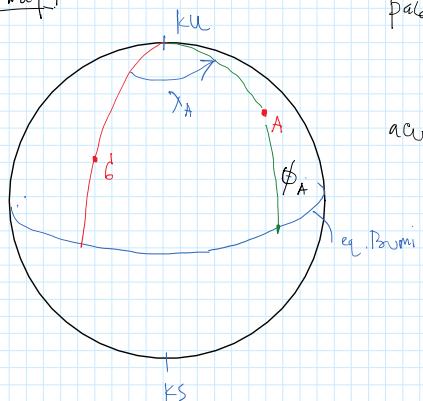
$$M = 8.73 \\ c) \frac{L}{L_0} = 2.5^{1/2} - (M - M_0) \\ = 2.5^{1/2} (8.73 - 4.73) \\ = 0.03 \rightarrow L = 0.03 L_0$$

Astronomi posisi (lanjut)

Thursday, March 28, 2019 8:04 AM



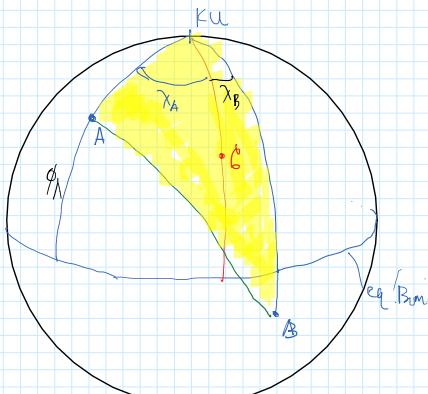
D) Geografi



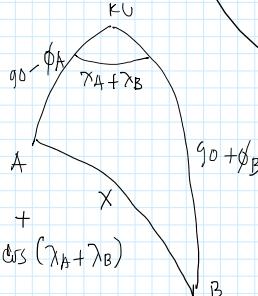
penerangan : λ, ϕ

awam : λ, ϕ
bujur : lintang \leftarrow eq. Bumi

awam : Greenwich



Tentukan jarak antara kota A (bujur=50 W, lintang=50 N)
ke kota B (bujur=20 E, lintang=10 S)



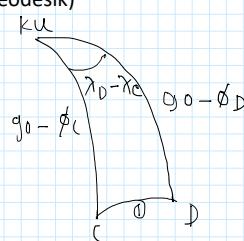
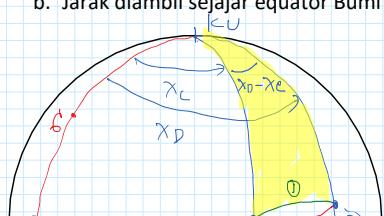
$$\begin{aligned} \cos x &= \cos(90 - \phi_A) \cos(90 + \phi_B) + \\ &\quad \sin(90 - \phi_A) \sin(90 + \phi_B) \cos(\lambda_A + \lambda_B) \\ &= \cos(90 - 50) \cos(90 + 10) + \\ &\quad \sin(90 - 50) \sin(90 + 10) \cos(50 + 20) \end{aligned}$$

$$\text{Dlm 1cm } \rightarrow \boxed{1' = 1 \text{ mil laut} = 1.82 \text{ km}}$$

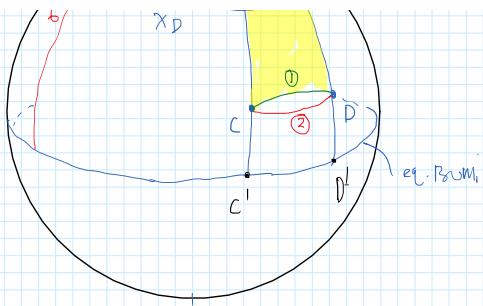
$$\begin{aligned} x &= 85^\circ 12' 40.1'' \\ &= 5112.67' = 5112.67 \text{ mil laut} = \underline{\underline{9305 \cdot \text{ km}}} \end{aligned}$$

Tentukan jarak kota C dan D yang dua-duanya memiliki lintang 30 N,
dan bujur masing-masing adalah 100 E dan 145 E apabila:

- a. Jarak diambil melewati lingkaran besar (geodesik)
- b. Jarak diambil sejajar equator Bumi



$$\phi_C = \phi_D = \phi = 30^\circ N$$

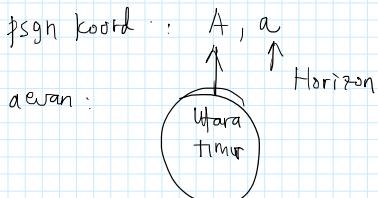
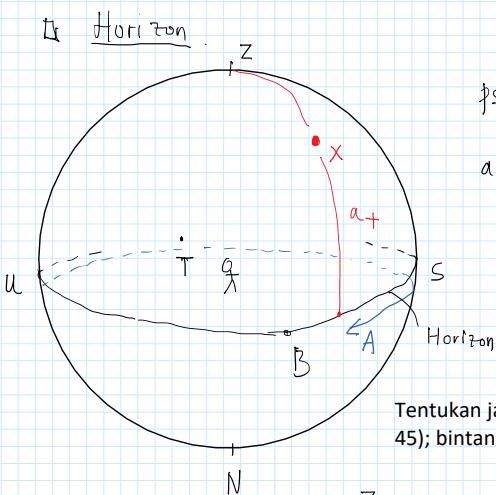


$$\begin{aligned}\cos CD &= \cos(90 - \phi) \cos(90 - \theta) + \\ &\quad \sin(90 - \phi) \sin(90 - \theta) \cos(\chi_D - \chi_C) \\ &= \cos(60) \cos(60) + \sin(60) \sin(60) \cos(45)\end{aligned}$$

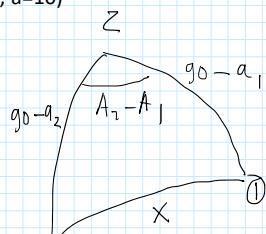
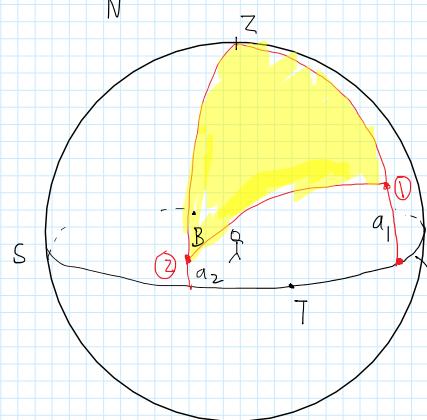
a) $CD = 4227.09 \text{ km}$

$$\begin{aligned}b) \quad CD &= C'D' \cos \phi \\ &= (\chi_D - \chi_C) \cos \phi \\ &= 45 \cdot \cos(30)\end{aligned}$$

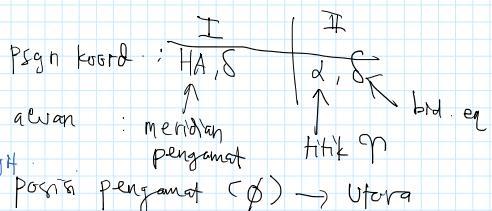
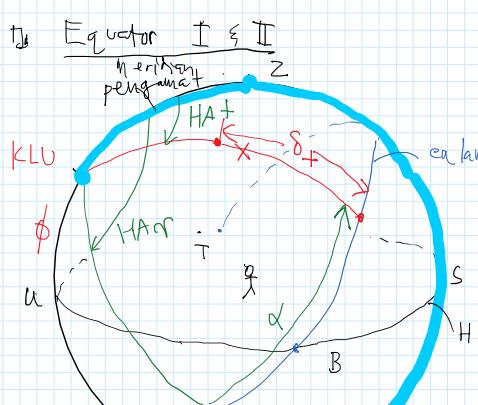
$CD = 4255.65 \text{ km}$



Tentukan jarak sudut 2 bintang yg memiliki koord: bintang 1 ($A = 30, a = 45$); bintang 2 ($A = 120, a = 10$)

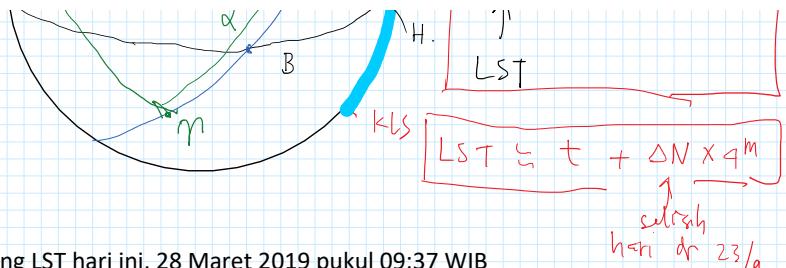


$$\begin{aligned}\cos x &= \cos(g_0 - a_1) \cos(g_0 - a_2) + \\ &\quad \sin(g_0 - a_1) \sin(g_0 - a_2) \cos(A_2 - A_1) \\ &= \cos(45) \cos(80) + \\ &\quad \sin(45) \sin(80) \cos(90) \\ x &= 82^\circ 56' 49.12''\end{aligned}$$



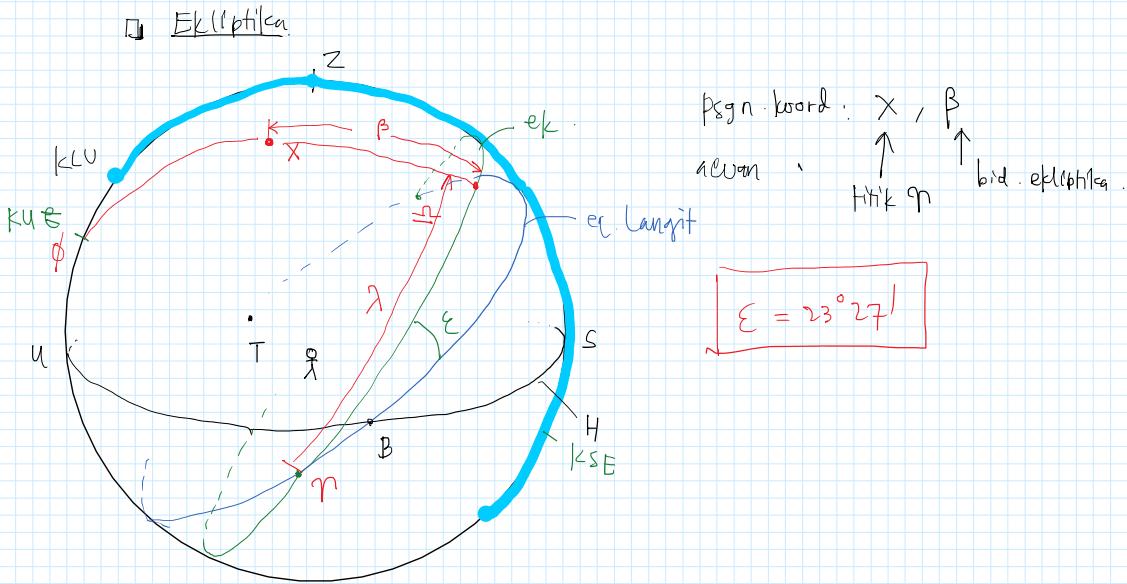
$$\begin{array}{|c|} \hline HA_{\gamma} = HA_x + \alpha_x \\ \hline \end{array}$$

LST



Hitung LST hari ini, 28 Maret 2019 pukul 09:37 WIB

$$\begin{aligned}
 LST &\leq t + \Delta N \times q^m \\
 &= 9^h 37^m + 187 \times 9^m \\
 LST &= 22^h 5^m \quad HA_{\gamma} = 22^h 5^m \\
 LST_{S/W} &= 22^h 12^m
 \end{aligned}$$

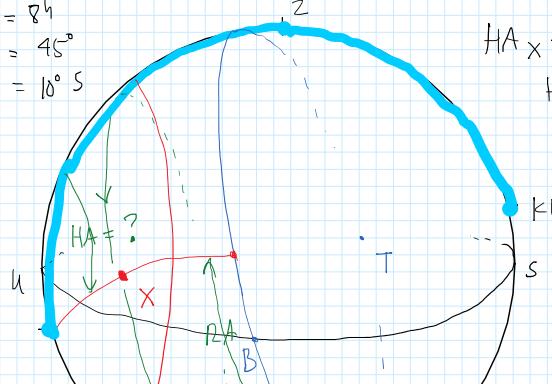


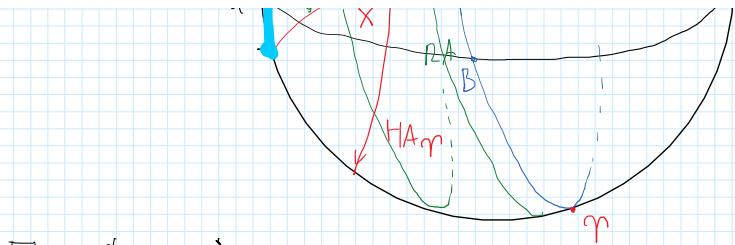
1. Tentukan HA sebuah obyek langit (RA=8h, dec=+45) jika dilihat oleh pengamat pada lintang 10 S, pada tanggal 21 Maret tengah malam.
2. Gambarkan orientasi bidang ekliptika relatif terhadap bidang equator langit untuk pengamat di lintang 30 N untuk hari ini pukul 10:30 waktu lokal
3. Perkirakan bujur ekliptika dan lintang ekliptika Matahari hari ini. (hint: cari dulu RA dan DEC Matahari dari perhitungan)

II 21 Maret tengah malam → $HA_{\gamma} = 12^h$

$$\begin{aligned}
 RA &= 8^h \\
 \delta &= 45^\circ \\
 \phi &= 10^\circ S
 \end{aligned}$$

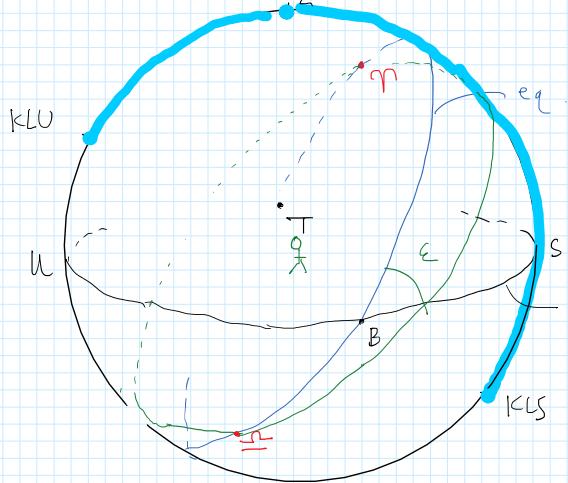
$$\begin{aligned}
 HA_x + RA_x &= HA_{\gamma} \\
 HA_x &= HA_{\gamma} - RA_x \\
 &= 12^h - 8^h \\
 HA_x &= 4^h
 \end{aligned}$$



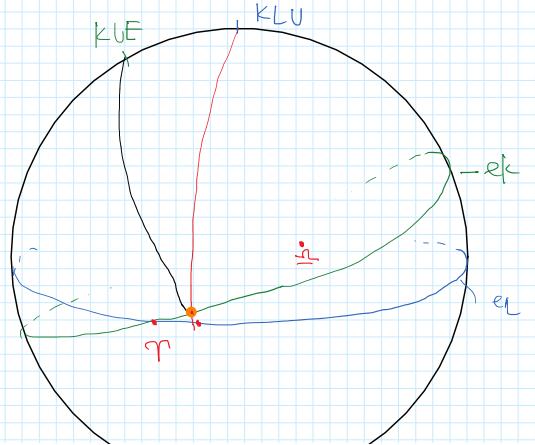
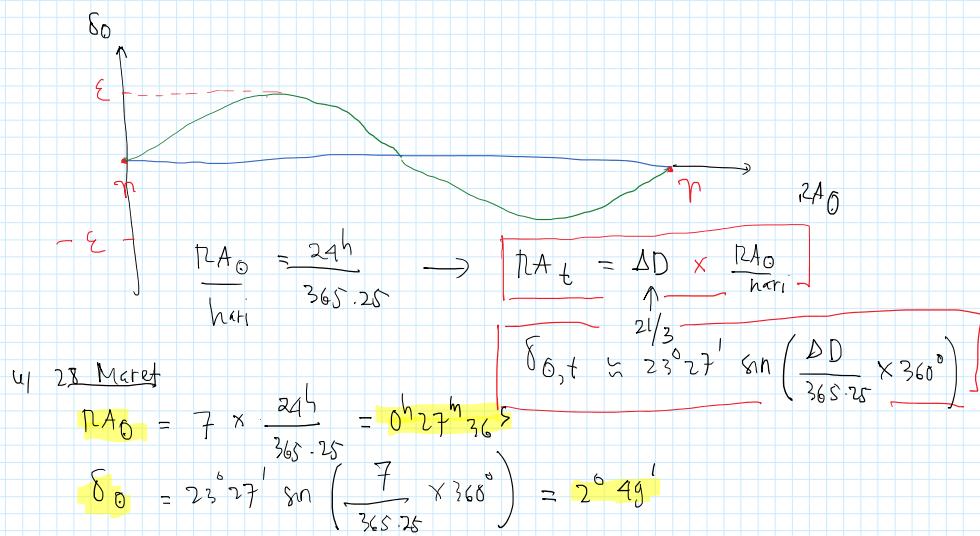


[2] $\phi = 30^\circ N$
28 Maret pukul 10:30 LT

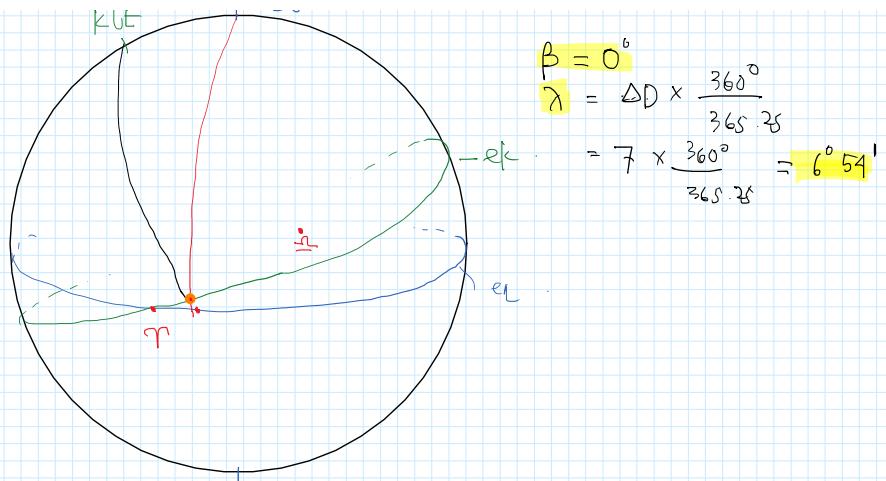
$$\begin{aligned} LST &= HA_\gamma + \Delta N \times 4^m \\ &= 10^h 36^m + 187 \times 4^m \\ &= 22^h 58^m \end{aligned}$$



[3] tgl 28 Maret $\rightarrow \frac{HA_0}{\delta_0} \text{ ?}$



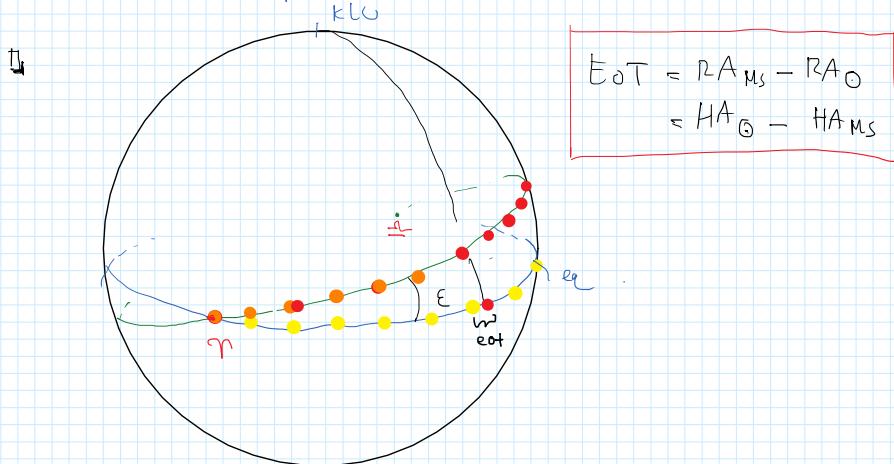
$$\begin{aligned} \beta &= 0^\circ \\ \gamma &= \Delta D \times \frac{360^\circ}{365.25} \\ &= 7 \times \frac{360^\circ}{365.25} = 6^\circ 54' \end{aligned}$$



$$\beta = 0^\circ$$

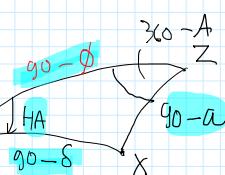
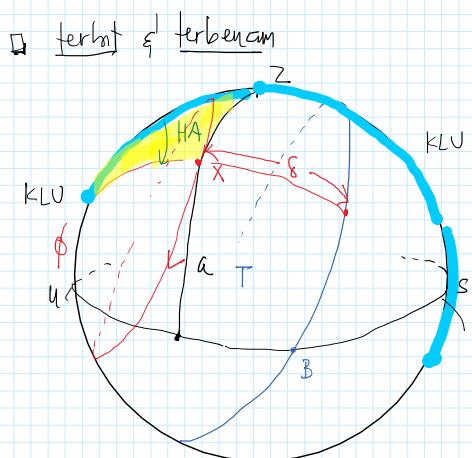
$$\gamma = \Delta D \times \frac{360^\circ}{365.25}$$

$$= 7 \times \frac{360^\circ}{365.25} = 6^\circ 54'$$



$$EOT = RA_{MS} - RA_0$$

$$= HA_0 - HA_{MS}$$



$$\cos(\eta_0 - \alpha) = \cos(\eta_0 - \phi) \cos(\eta_0 - \delta) +$$

$$\sin(\eta_0 - \phi) \sin(\eta_0 - \delta) \cos HA$$

H. terhj / terbenam $\rightarrow \alpha = 0$

$$\cos \eta_0 = \sin \phi \sin \delta + \cos \phi \cos \delta \cos HA$$

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

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

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

$$\begin{aligned} \phi &= 7^\circ LS \\ \delta &= +2^\circ 49' \end{aligned} \quad \begin{aligned} \cos HA &= -\tan \phi \tan \delta \\ &= -\tan(-7^\circ) \tan(+2^\circ 49') \end{aligned}$$

$$\begin{aligned} HA &= 89^\circ 39' 19'' \\ &= 5^h 58^m 37^s \end{aligned}$$

Lamanya siang = 2 HA

$$= 5^h 58^m 37^s$$

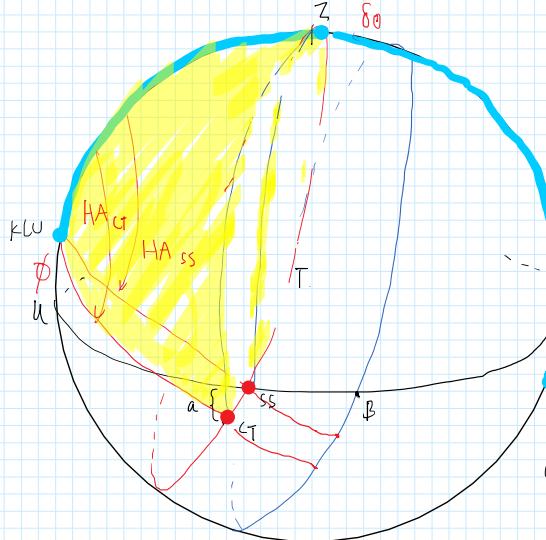
Lamanya siang = $2 H_A$

$$= 11^h 57^m 19^s$$

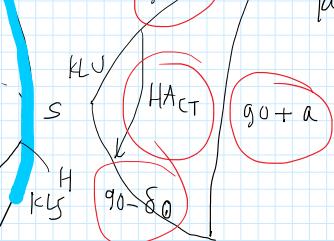
Twilight (Pagi/Senja)

- civil
- nautical
- Astronomical

$$\begin{aligned} \text{pada } \theta &\Rightarrow a = -6^\circ \\ a &= -12^\circ \\ a &= -18^\circ \end{aligned}$$



$$\cos HA_{ss} = -\tan \phi \tan \delta_0 \rightarrow HA_{ss} = \dots$$



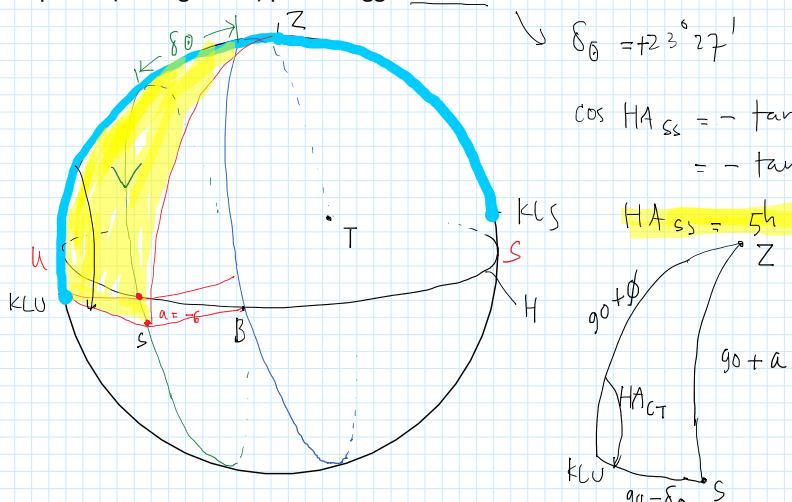
$$\begin{aligned} \cos(90 + \alpha) &= \cos(90 - \phi) \cos(90 - \delta_0) + \\ &\quad \sin(90 - \phi) \sin(90 - \delta_0) \cos HA_{ct} \end{aligned}$$

$$-\sin \alpha = \sin \phi \sin \delta_0 + \cos \phi \cos \delta_0 \cos HA_{ct}$$

$$\cos HA_{ct} = \frac{-\sin \alpha - \sin \phi \sin \delta_0}{\cos \phi \cos \delta_0} \rightarrow HA_{ct} = \dots$$

$$\boxed{\Delta t = HA_{ct} - HA_{ss}}$$

Tentukan durasi waktu dari sunset sampai civil twilight untuk tempat ini (lintang = 7 LS) pada tanggal 21 Juni 2019.



$$\delta_0 = +23^\circ 27'$$

$$\begin{aligned} \cos HA_{ss} &= -\tan \phi \tan \delta_0 \\ &= -\tan(-7^\circ) \tan(+23^\circ 27') \end{aligned}$$

$$HA_{ss} = 5^h 47^m 47^s$$

$$\begin{aligned} \cos(90 + \alpha) &= \cos(90 + \phi) \cos(90 - \delta_0) + \\ &\quad \sin(90 + \phi) \sin(90 - \delta_0) \cos HA_{ct} \end{aligned}$$

$$-\sin \alpha = -\sin \phi \cdot \sin \delta_0 + \cos \phi \cdot \cos \delta_0 \cos HA_{ct}$$

$$\begin{aligned} \cos HA_{ct} &= \frac{-\sin \alpha + \sin \phi \sin \delta_0}{\cos \phi \cos \delta_0} \\ &= -\sin(+6^\circ) + \sin(+7^\circ) \sin(23^\circ 27') \end{aligned}$$

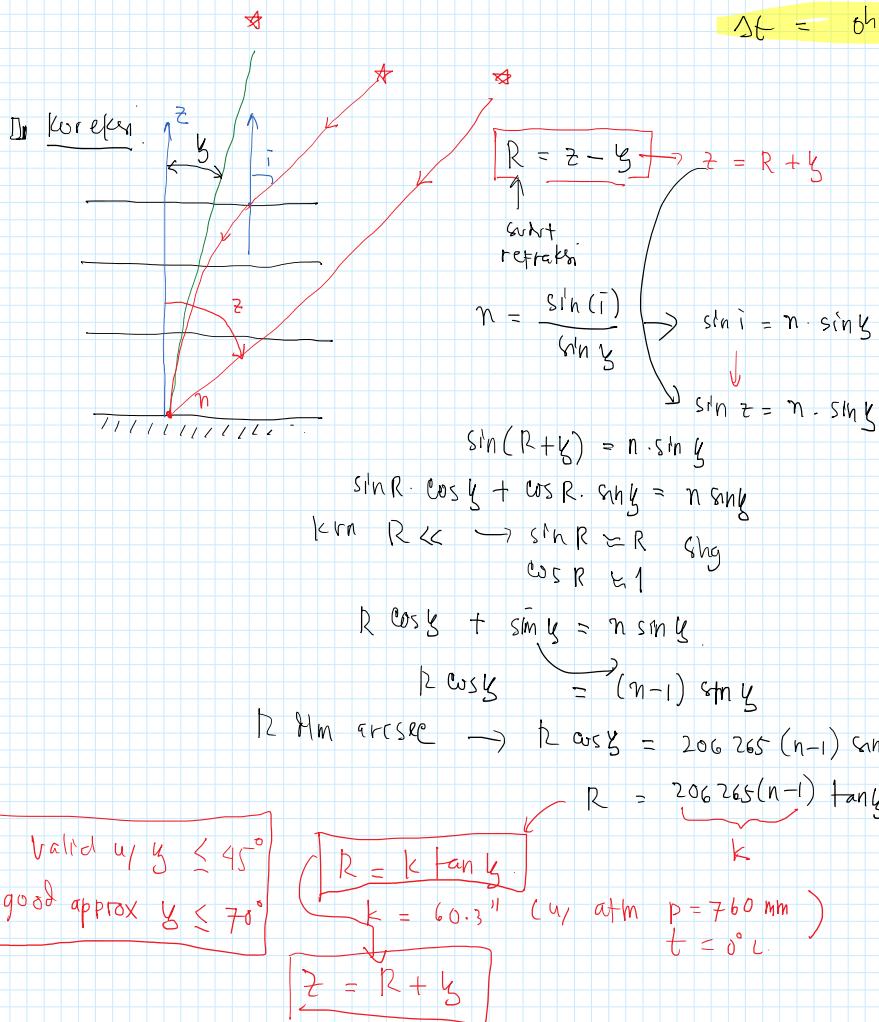
$$HA_{ct} = 6^h 14^m 7^s$$

$$\begin{aligned} \Delta t &= HA_{ct} - HA_{ss} \\ &= 6^h 14^m 7^s - 5^h 47^m 47^s \end{aligned}$$

$$\boxed{\Delta t = 0^h 26^m 20^s}$$



$$\Delta t = 6^h 26^m 20s$$



II) Refraksi Horizontal

$$a = 0^\circ \Rightarrow 35^{\frac{1}{2}} 21''$$

Tentukan panjang hari ini di lokasi ini (lintang 7 LS) kalau refraksi horizontal diperhitungkan

