

① $\Theta^2 = \Delta\delta^2 + \Delta\alpha^2 \cos^2(\delta_{avg})$

Alcor : 13: 25: 13.5378 , $54^\circ 59' 16.655''$

Mizar : 13: 23: 55.54 , $54^\circ 55' 31.3''$

$$\Delta\delta^2 = \left[\left(59' \cdot \frac{1^\circ}{60'} + 16.655 \cdot \frac{1^\circ}{3600''} \right) - \left(55' \cdot \frac{1^\circ}{60'} + 31.3'' \cdot \frac{1^\circ}{3600''} \right) \right]^2$$

$$\Delta\delta^2 = 3.92 \times 10^{-3}$$

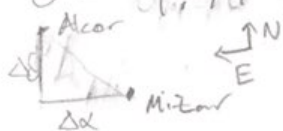
$$\delta_{avg} = 54.956^\circ$$

$$\Delta\alpha^2 \cos^2(\delta_{avg}) = \left[\left(25 \text{ min} \cdot \frac{1^\circ}{4 \text{ min}} + 13.5378 \text{ s} \cdot \frac{1^\circ}{240 \text{ s}} \right) - \left(23 \text{ min} \cdot \frac{1^\circ}{4 \text{ min}} + 55.54 \text{ s} \cdot \frac{1^\circ}{240 \text{ s}} \right) \right]^2$$

$$\times \cos^2(54.956^\circ)$$

$$(\Delta\alpha)^2 = 3.48 \times 10^{-20}$$

$$\Theta = 1.97 \times 10^{-1} \cdot \frac{3600''}{1^\circ} = 708''$$



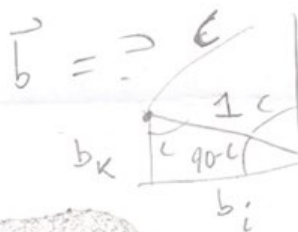
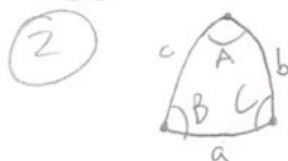
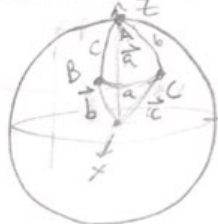
$$PA_{AM} = \tan^{-1}(\Delta\alpha/\Delta\delta) = \tan^{-1}\left(\frac{3.48 \times 10^{-20}}{3.92 \times 10^{-3}}\right)^{1/2} = 71^\circ$$

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

$$\vec{x} \cdot \vec{y} = |\vec{x}| |\vec{y}| \cos \Theta$$

Unit sphere so $|\vec{x}| = |\vec{y}| = |\vec{z}| = 1$

$$\vec{b} \cdot \vec{c} = |\vec{b}| |\vec{c}| \cos a$$

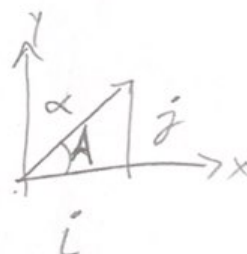
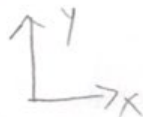
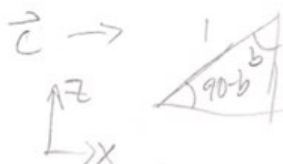


$$\sin(90-c) = b_k \rightarrow \cos c$$

$$\cos(90-c) = b_i \rightarrow \sin c$$

$$\vec{b} = b_i \hat{i} + b_j \hat{j} + b_k \hat{k}$$

$$\vec{b} = \sin c \hat{i} + 0 \hat{j} + \cos c \hat{k}$$



$$c_i \sin A = c_j \cos A = c_k$$

$$c_k = \cos b$$

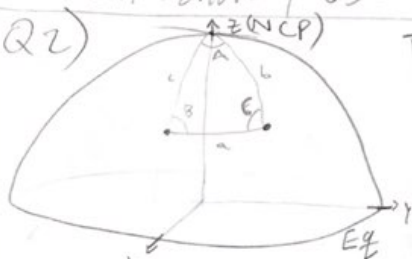
$$c_k = \cos b$$

$$\sin b = \alpha$$

$$\vec{c} = \sin b \cos A \hat{i} + \sin b \sin A \hat{j} + \cos b \hat{k}$$

Leni Schult / Obs Astro Her 1 / 30 Aug 2023 / 2

Q2)



$$\vec{b} = \begin{bmatrix} \sin c \\ \alpha \\ \cos c \end{bmatrix} \quad \vec{c} = \begin{bmatrix} \sin b \cos A \\ \sin b \sin A \\ \cos b \end{bmatrix}$$

$$\vec{b} \cdot \vec{c} = |\vec{b}| |\vec{c}| \cos a$$

$$\sin c \sin b \cos A + \alpha + \cos c \cos b = \cos a$$



$$\alpha_2 - \alpha_1 = A$$

$$b = 90 - \delta_2$$

$$c = 90 - \delta_1$$

$$\sin(90 - \delta_1) \sin(90 - \delta_2) \cos(\alpha_2 - \alpha_1) + \cos(90 - \delta_1) \cos(90 - \delta_2) = \cos a$$

$$\cos \delta_1 \cos \delta_2 \cos(\alpha_2 - \alpha_1) + \sin \delta_1 \sin \delta_2 = \cos a$$

$$\theta = \cos^{-1} [\cos \delta_1 \cos \delta_2 \cos(\alpha_2 - \alpha_1) + \sin \delta_1 \sin \delta_2]$$

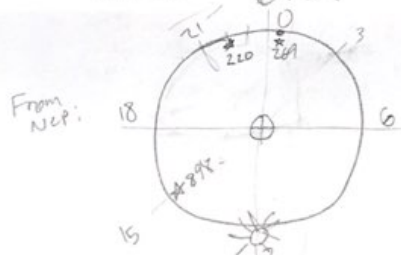
Q4)

Sun @ 12h RA for Sept. 1
UM 269 : $\alpha: 10.8322440$ $\delta: 0.8542910^\circ$
convert to hms $\rightarrow 00:43:19.73$ $0^\circ 51' 15.44''$

KPNO
 $\lambda = 32^\circ$

Sunrise ~ 6 AM

Sunset ~ 6 PM



Rise ~ 6:43 PM
Set ~ 6:43 AM

min Airmass: $z = |\lambda - \delta|$
 $= 32^\circ - 0.85^\circ \Rightarrow 31.15^\circ$
 $X = \frac{1}{\cos(z)} = 1.17$

PDS 898 = $\alpha: 234.2429720$ $\delta: 34.5304110$

$\rightarrow 15:36:58.31$ $34^\circ 31' 49.47''$

Sunset @ 18:00 \rightarrow 12h RA so 898 rises 3h 36min earlier \Rightarrow Rise @ 14:24 + set 12h later: 2:24
min Airmass $z = |\lambda - \delta| = 32^\circ - 34.53^\circ = -2.53^\circ$ $X = \frac{1}{\cos(z)} = 1$

PKS 2203-215 = $\alpha: 331.6725000$ $\delta: -21.3277778$

$\rightarrow 22:06:41.40$ $-21^\circ 19' 40.00''$

rises 10h 6min ahead of Sun
Rise $\rightarrow 19:54$ set $\rightarrow 7:54$

min $X = \frac{1}{\cos(|\lambda - \delta|)} \Rightarrow 1.67$

Using website

UM 269 sunrise			PDS 898			PKS 220		
R	S	X	R	S	min X	R	S	min X
20:30	05:44	1.16	13:00	1:00	1.08	16:55	4:55	1.70

③ Gal Center: $\alpha: 17:45:37$ $\delta: -28^\circ 56' 10''$

Gal anti center: $\alpha: 05:45:37$ $\delta: +28^\circ 56' 10''$

Gal North Pole: $\alpha: 12:51:26$ $\delta: +27^\circ 07' 42''$

Gal. South Pole: $\alpha: 00:51:26$ $\delta: -27^\circ 07' 41''$

Ecliptic X Gal Plane:

⑦ Kitt Peak Direct Imaging Manual: Has all the nitty gritty details of CCDs, filters, exposure times etc. Everything you need for observing @ KPNO other than a target. Also trouble shooting procedures & useful equations/calculations.

Photometric Standards: This is a paper w/ a ton of calibration measurements for stars in filters used by observatories around the world. With these numbers on hand, one can calibrate telescope data, ensuring accurate equipment characterization for the duration of the night's observations.

User's guide to Stellar CCD Photometry w/ IRAF: This document gives instructions for how to take raw data from the telescope and extract photometric information for stars within it. Crucially it also explains how to calibrate photometric info using the Standard stars described in Landolt (193) - photometric standards.

CCD Reductions w/ IRAF → This is more useful instrument calibration using software - Has examples for spectroscopy & direct imaging.

Acronym	Telescope Name	Location	Aperture (m)	Wavelength min (m)	Wavelength Max (m)	Website Link		
Nu-STAR	Nuclear Spectroscopic Telescope Array	LEO: equatorial orbit	1.91E-01	1.50E-11	4.10E-10	nustar.caltech.edu		
Chandra	Chandra X-Ray Observatory	elliptical earth orbit	1.2	1.24E-10	1.38E-08	chandra.harvard.edu		
HST	Hubble Space Telescope	LEO	2.4	1.15E-07	2.50E-06	https://www.nasa.gov		
Gemini	International Gemini Observatory	Maunakea, Hawai'i, Cerro Pachón, Chile	8.1	3.60E-07	5.40E-06	gemini.edu		
SOAR	Southern Astrophysical Research Telescope	Cerro Pachón, Chile	4.1	3.10E-07	2.40E-06	https://noirlab.edu		
LCO	Las Cumbres Observatory	Hawai'i, Chile, Texas, Canary Islands, Australia	0.4-2	3.20E-07	1.00E-06	https://lco.global/		
Spitzer	Spitzer Space Telescope	earth trailing heliocentric orbit	0.85	3.00E-06	1.80E-04	https://www.spitzer.caltech.edu		
JWST	James Webb Space Telescope	L2	6.5	6.00E-07	2.85E-05	https://webb.nasa.gov		
ALMA	Atacama Large Millimeter Array	Atacama Desert, Chile	54*12m, 12*7	3.20E-04	3.60E-03	https://www.alma.edu		
NOEMA	Northern Extended Millimetre Array	Plateau de Bure, France	12*15m	8.00E-04	3.00E-03	https://iram-institute.org		
VLBA	Very Long Baseline Array	NH, IA, TX, NM, AZ, CA, WA, HI USVI	10*25m	3.00E-03	9.00E-01	https://public.nrao.edu		
VLA	Very Large Array	Socorro, NM	27*25m	6.00E-03	4.10E+00	https://science.nrao.edu	4band(5.5m) TO Qband(.005m)	