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

Alcor : 13 : 25 : 13.5378 , 54° 59′ 16.655″

Mizar : 13 : 23 : 55.54 , 54° 55′ 31.3″

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

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

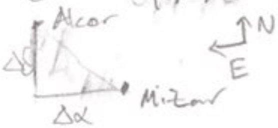
$\delta_{avg} = 54.956^\circ$

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

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

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

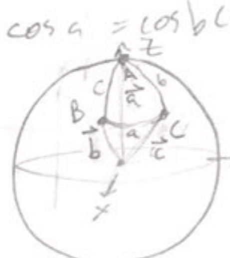
$\theta = 1.97 \times 10^{-1\,\circ} \cdot \frac{3600''}{1^\circ} = 708''$



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

(2)

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

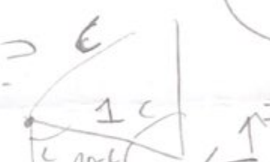


$\vec{x} \cdot \vec{y} = |X||Y| \cos\theta$

unit sphere so $|\,| = |\,| = 1$

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

$\vec{b} = ?$



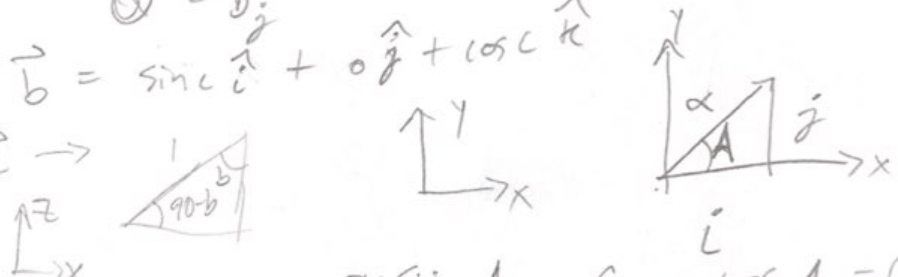
$\sin(90-c) = b_k \rightarrow \cos c$

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

$0 = b_j$

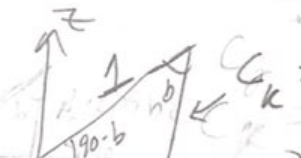
$\vec{b} = \sin c\,\hat{i} + 0\,\hat{j} + \cos c\,\hat{k}$

$\vec{c} \rightarrow$



$\alpha \cdot \sin A = C_j \quad \alpha \cdot \cos A = C_i$

$C_K =$

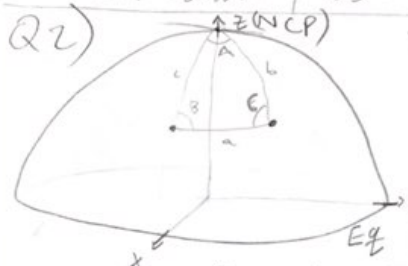


$C_k = \cos b$

$\sin b = \alpha$

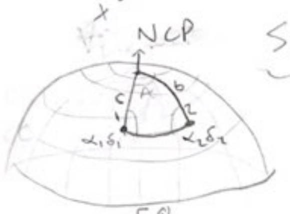
$\vec{C} = \sin b \cos A\,\hat{i} + \sin b \sin A\,\hat{j} + \cos b\,\hat{k}$

Q2)



$$\vec{b} = \begin{bmatrix} \sin c \\ 0 \\ \cos c \end{bmatrix} \begin{matrix} i \\ j \\ k \end{matrix} \qquad \vec{c} = \begin{bmatrix} \sin b \cos A \\ \sin b \sin A \\ \cos b \end{bmatrix}$$

$$\vec{b}\cdot\vec{c} = \cancel{|\vec{b}|}^{1}\,\cancel{|\vec{c}|}^{1} \cos a$$



$$\sin c \sin b \cos A + 0 + \cos c \cos b = \cos a \quad !$$

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

$\alpha_2 - \alpha_1 = A$

$b = 90 - \delta_2$

$c = 90 - \delta_1$

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

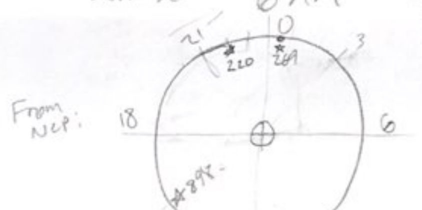
$$\theta = \cos^{-1}\left[\cos\delta_1\cos\delta_2\cos(\alpha_2-\alpha_1) + \sin\delta_1\sin\delta_2\right]$$

Q4) Sun @ 12h RA for Sept. 1 KPNO $\lambda = 32^\circ$

UM269 : α: 10.8322440° δ: 0.8542910°

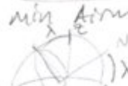
convert to hms/dms → 00:43:19.73 $0^\circ 51' 15.44''$

Sunrise ~ 6AM Sunset ~ 6PM



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 = α: 234.2429720 δ: 34.530410

→ 15:36:58.31 $34^\circ 31' 49.47''$

Sunset @ 18:00 → 12h RA so 898 rises 3h 36min earlier ⟹ 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 = α: 331.6725000 δ: -21.3277778

→ 22:06:41.40 $-21^\circ 19' 40.00''$

rises 10h 6min ahead of Sun

Rise → 19:54 set → 7:54

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

Using website

UM269 (sunrise)			PDS 898			PKS 220		
R	S	min X	R	S	min X	R	S	min X
20:30	5:54	1.16	1300	1:00	1.08	16:55	4:55	1.70

(3) Gal Center: α: 17:45:37 δ: $-28° 56' 10''$
Gal anti center: α: 05:45:37 δ: $+28° 56' 10''$
Gal North Pole: α: 12:51:26 δ: $+27° 07' 42''$
Gal. South Pole: α: 00:51:26 δ: $-27° 07' 41''$
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 ☆s described in Landolt (#3) - photometric standards.

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