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Astro 8060 HW 1

1. angular distance?, Alcor + Mizar, star w/ RA + dec, PA?, assume plane

Alcor: 13h 25m 14s   Dec $+54° 59' 17''$

Mizar 13h 23m 56s   Dec: $+54° 55' 31''$

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

$\Delta\delta = 3' 46'' = 226''$ $\delta_{avg} = +54° 55' 31'' + 113'' = +54° 57' 24''$

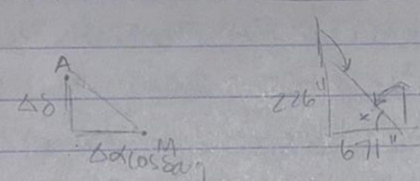
$= 54° + \frac{57}{60} + \frac{24}{3600} = 54.956°$

$\Delta\alpha = 1m\ 18s = 78s \cdot \frac{15\,arcsec}{sec} = 1170''$

$\theta = \sqrt{(226'')^2 + (1170'' \cdot \cos(54.956°))^2}$

$= \sqrt{502403.4552} = \boxed{708.804''}$

PA?

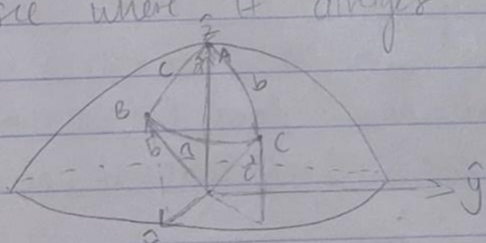


$\tan x = \frac{226''}{671''}$

$x = 18.61°$

$90 - x = \boxed{71.38°}$

2 Derive law of cosines, rewrite for RA and Dec, see where it diverges



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

generally, $\vec{x} \cdot \vec{y} = |\vec{x}||\vec{y}| \cos\theta$

set this sphere as unit sphere

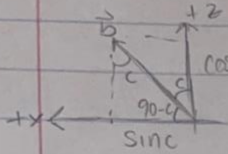
$\vec{b} \cdot \vec{c} = |\vec{b}||\vec{c}| \cos a = \cos a$

B is in x-z plane

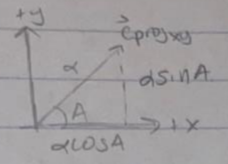
A is on z axis

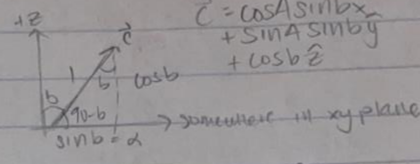
C is somewhere on sphere surface

Last part of Q2 is at end of assignment



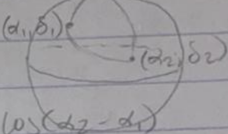
$\vec{b} = \sin c\,\hat{x} + \cos c\,\hat{z}$ $\qquad$ $\vec{a} = \hat{z}$





$\vec{c} = \cos A \sin b\,\hat{x} + \sin A \sin b\,\hat{y} + \cos b\,\hat{z}$

$\vec{b}\cdot\vec{c} = \sin b \sin c \cos A + \cos b \cos c = \cos a$ ✓



$\alpha_2 - \alpha_1 = A$; $90 - \delta_2 = b$; $90 - \delta_1 = c$

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

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

3. NASA/IPAC Extragalactic Database (NED) Coordinate Calculator, RA + Dec of

(0,0) Galactic center → RA: 17h45m37s Dec: -28.93°

Galactic anti-Center → RA: 5h45m37s Dec: +28.93°

(0,90) Galactic North Pole → RA: 12h51m26s Dec: 27.12°

(0,-90) Galactic South Pole → RA: 00h51m26s Dec: -27.12°

(266,-5) Ecliptic crossing Galatic Plane: RA: 8h33m 26s Dec: -48.45°

4. 9/1, KPNO, SBHB candidates from Chansi et. al 2016, local time, rise and set?, Sun's motions, minimum airmass?

UM 269 RA: 10.83° Dec: 0.85°

PDS 898 RA: 234.24° Dec: 34.53°

PKS 2203-215 RA: 331.67° Dec: -21.32°

Assume autumnal equinox (we're close)
Sun is @ RA: 12h Dec: 0° @ 6 am
Assume 12 hr day, 12 hr night (AE)
λ @ KPNO ~ 32°N 225

$\frac{360°}{24h} = 15°/hr$ $\frac{15°}{60m} = \frac{1}{4}°/min$

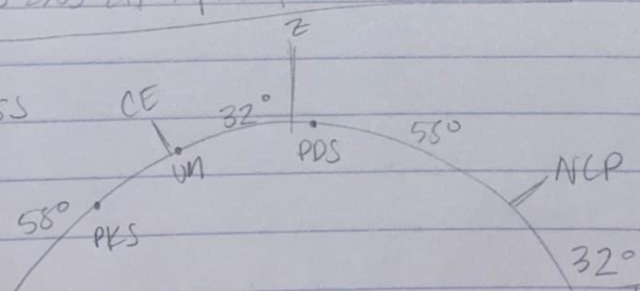
UM ~10° @ $\frac{4 \text{ min}}{1°}$ = 40 min after sunset @ 6pm (rise)
+12 hr for set → 6:40am set

PDS ~235° → 55° after 6am sunrise
55° @ $\frac{4 \text{ min}}{1°}$ = 220 min = 3hr 40m → 9:40 am rise
+12 hr for set → 9:40pm set

PKS ~330° → 60° after 12:00 pm noon
$60° = 4 \cdot 15° \cdot \frac{hr}{15°} = 4$ hr → 4 pm rise
+12 hr for set → 4 am set

Object	Rise	Set
UM 269	6:40pm	6:40am
PDS 898	9:40am	9:40pm
PKS 2203-215	4 pm	4am

airmass



UM $32 - 0.85 = 31.15° \rightarrow \frac{1}{\cos(31.15°)} = \boxed{1.16}$

PDS $34.53 - 32 = 2.53 \rightarrow \frac{1}{\cos(2.53°)} = \boxed{1.00}$

PKS $32 + 21.32 = 53.32 \rightarrow \frac{1}{\cos(53.32°)} = \boxed{1.67}$

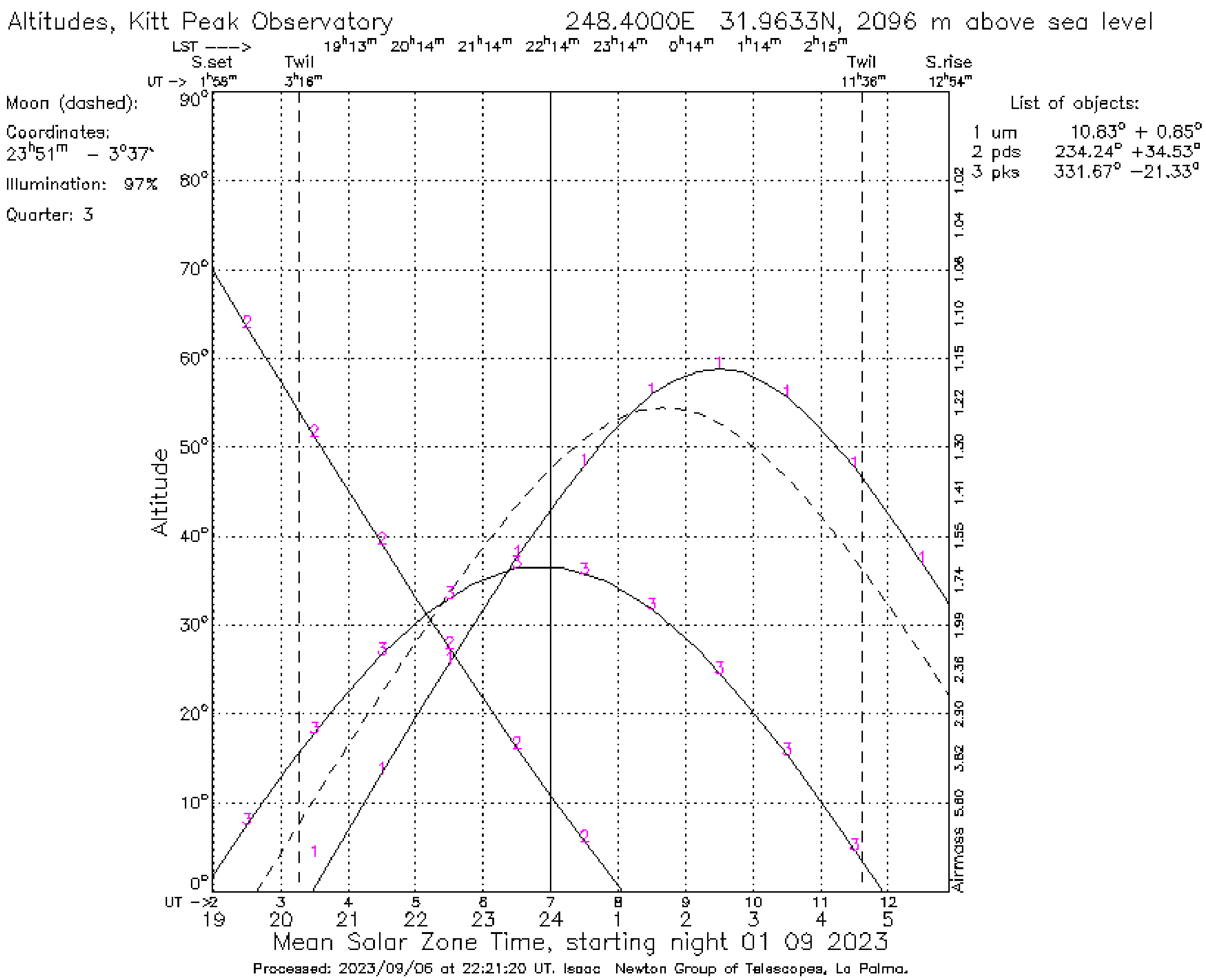
3 Check my answers

UM 269 rise ~ 8:30pm set ~ 8:30am $X \sim 1.16$

PDS 898 rise ~ 1:00pm set ~ 1:00am $X \sim 1.01$

PKS 2203-215 rise ~ 6:30pm set ~ 5:00am $X \sim 1.74$

My calculated X was more accurate than my calculated rise/set times.



Q6

Telescope	Full Name	Location	Aperture Size	Operational Wavelength Range/Photometric Bands	Website Link
Nu-STAR	Nuclear Spectroscopic Telescope Array	Near-equatorial orbit	191mm radius	3-79 keV (X-ray)	https://www.nustar.caltech.edu
Chandra	Chandra X-ray Observatory	139000 km above Earth in orbit	1145 sq cm	ACIS (0.2-10 keV) HRC (0.1-10 keV) LETGS (0.09-3 keV) HETGS (0.4-10 keV)	https://chandra.harvard.edu
HST	Hubble Space Telescope	535 km above Earth in orbit	2.4m	ACS (1150-1700 Å, 3500-11000 Å), COS (90-215 nm, 170-320 nm), STIS (1150-10300 Å), WFC3 (200-1000 nm, 850-1700 nm)	https://www.nasa.gov/mission_pages/hubble/main/index.html
Gemini	Gemini Observatory (Gemini North & Gemini South)	Hawaii & Chile	8.1 meters (aperture for both telescopes)	Optical and Infrared (0.3 - 27 microns)	https://www.gemini.edu/
SOAR	Southern Astrophysical Research Telescope	Chile	4.1 meters	Optical and Near-Infrared (0.32 - 2.4 microns)	https://noirlab.edu/science/programs/ctio/telescopes/soar-telescope
LCO	Las Cumbres Observatory	Varies (HQ in California)	Varies for different telescopes	Optical and Infrared (320 - 1000 nm)	https://lco.global/
Spitzer	Spitzer Space Telescope	Trailing behind Earth/Caltech	85cm diameter	Infrared (24-160 microns)	https://www.spitzer.caltech.edu/
JWST	James Webb Space Telescope	L2	25 sq m	Infrared (0.6-28.5 microns)	https://webb.nasa.gov/index.html
ALMA					
NOEMA	Northern Extended Millimeter Array	Plateau de Bure, Hautes-Alpes, France	15 m (diameter of antennae)	Radio (3 - 0.8 mm)	https://iram-institute.org/observatories/noema/
VLBA	Very Long Baseline Array	St. Croix – U.S. Virgin Islands	25 m (antennae)	Radio (90 cm - 3 mm)	https://public.nrao.edu/telescopes/vlba/
		Hancock – New Hampshire			
		North Liberty – Iowa			
		Fort Davis – Texas			
		Los Alamos – New Mexico			
		Pie Town – New Mexico			
		Kitt Peak – Arizona			
		Owens Valley – California			
		Brewster – Washington			
		Mauna Kea – Hawaii			
VLA	Very Large Array	San Agustin Plains, New Mexico	25 m	Radio (300 - 6 mm)	https://public.nrao.edu/telescopes/vla/#design

Q7

The Kitt Peak Direct Imaging Manual

https://noirlab.edu/science/sites/default/files/media/archives/documents/scidoc0110-en.pdf

This is a manual that describes the instrumentation available at Kitt Peak. It describes the telescopes and their capabilities, as well as how to operate them. There is also a section on common mistakes and how to avoid them.

Photometric Standards: Landolt, 1992, AJ, 104, 340

https://articles.adsabs.harvard.edu/pdf/1992AJ....104..340L

This paper describes some of the stars on the celestial equator that can be used as standards for observation. They were observed several times and allow for photometric comparisons. They range from $11.5 < V < 16.0$ and $-0.3 < (B-V) < +2.3$.

A User's Guide to Stellar CCD Photometry with IRAF: Massey & Davis, 1992

https://www.mn.uio.no/astro/english/services/it/help/visualization/iraf/daophot2.pdf

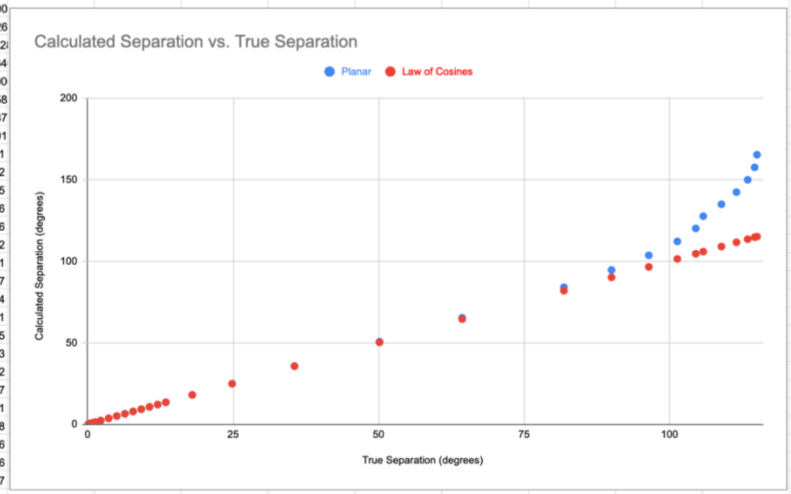
This paper discusses the ways to use a software called IRAF to do photometry with stars. It gives two main paths to go down: either an uncrowded frame, which is more simple, or a crowded frame, which creates more computational difficulty.

A User's Guide to CCD Reductions with IRAF: Massey, 1997

https://home.ifa.hawaii.edu/users/meech/a399/handouts/ccduser3.pdf

Q2 last part

RA1	Dec1	RA2	Dec2	Planar separation	Law of cosines	Difference
0	0	0.1	0.1	0.1414213293	0.1414213203	0.000000008975
0	0	0.2	0.2	0.2828424971	0.2828424253	0.000000071800
0	0	0.3	0.3	0.4242633417	0.4242630994	0.000000242326
0	0	0.5	0.5	0.7071034156	0.7071022937	0.000001121932
0	0	1	0.8	1.280605818	1.280599474	0.000006344364
0	0	2	1	2.235999864	2.235977147	0.000022716600
0	0	3	2	3.605171109	3.605044192	0.000126916558
0	0	4	3	4.998903508	4.99853688	0.000366627637
0	0	5	4	6.400746099	6.39994926	0.000796839801
0	0	6	5	7.805863473	7.80438989	0.001473582981
0	0	7	6	9.212262829	9.209808671	0.002454158172
0	0	8	7	10.6189207	10.61512329	0.003797408995
0	0	9	8	12.02521754	12.01965353	0.005564003146
0	0	10	9	13.4307266	13.42290988	0.007816717886
0	0	15	10	17.98029122	17.96386013	0.01643108622
0	0	20	15	24.86332973	24.8142169	0.04911282531
0	0	30	20	35.6771871	35.53134776	0.145839337
0	0	45	25	50.54835936	50.14429257	0.4040667954
0	0	60	30	65.25983241	64.34109373	0.9187386881
0	0	80	35	83.94216188	81.82226723	2.11989465
0	0	90	45	94.54513453	90	4.545134533
0	0	100	50	103.5081545	96.40864631	7.099508192
0	0	110	55	112.0050777	101.3133542	10.69172357
0	0	120	60	120	104.4775122	15.52248781
0	0	130	65	127.4602852	105.7627003	21.69758498
0	0	140	65	134.7837489	108.8895204	25.89422846
0	0	150	65	142.2302902	111.4690235	30.76126666
0	0	160	65	149.7815534	113.3989619	36.38259157
0	0	170	65	157.4224694	114.5947666	42.82770284
0	0	180	65	165.1405942	115	50.14059416



Separation of about 100 degrees on the sky is where planar calculations and law of cosines calculations diverge.