Lecture 1/2

Topics: observing seasons, celestial motions, coordinates, time, precession, proper motion

Sources: Chromey Ch. 3

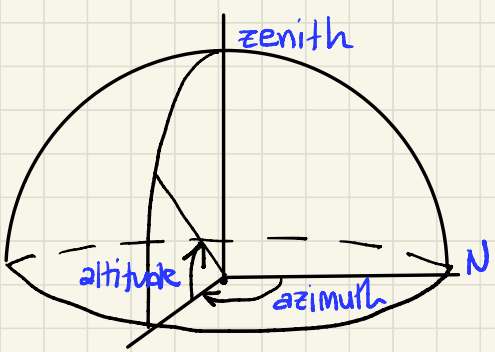
Coordinate Systems

Basic Definitions:

zenith: the point at 90° elevation
nadir: the point at −90° elevation
meridian: the great circle intersecting the south celestial pole, north celestial pole, and local zenith
hour angle: the time before (−) or after (+) an object crosses the local meridian
celestial equator: projection of the Earth's equator onto the sky
celestial north pole: the point above the north pole of the Earth
ecliptic: the plane defined by the orbital plane of the Earth around the sun
galactic plane: plane which passes through the disk of the Galaxy

Azimuthal coordinates:

azimuth: degrees east of north along the horizon
0° – 360°
altitude or elevation: angle from the horizon, 0°–90°
zenith angle: $z = 90° - \text{altitude}$



$$\text{airmass} = X = \sec z = \frac{1}{\cos z}$$

z (deg)	X
0	1.00
10	1.02
30	1.15
45	1.41
60	2.00
70	2.92
80	5.75

↳ this eqn. is for a plan-parallel atmosphere (i.e. constant density, ignore curvature of Earth). It breaks down at $z \sim 75°$. At greater angles $X \to \infty$, when really the maximum on the horizon is usually < 40.

minimum airmass occurs when an object is on the meridian
the minimum zenith angle is given by:

$$z_{min} = |\text{observatory latitude} - \text{source declination}|$$

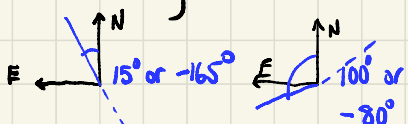
Equatorial Coordinates:

δ declination: the angle north or south of the celestial equator
α right ascension: time, in hours, minutes, seconds (sexigesimal) from the vernal Equinox (RA = 0), increases E

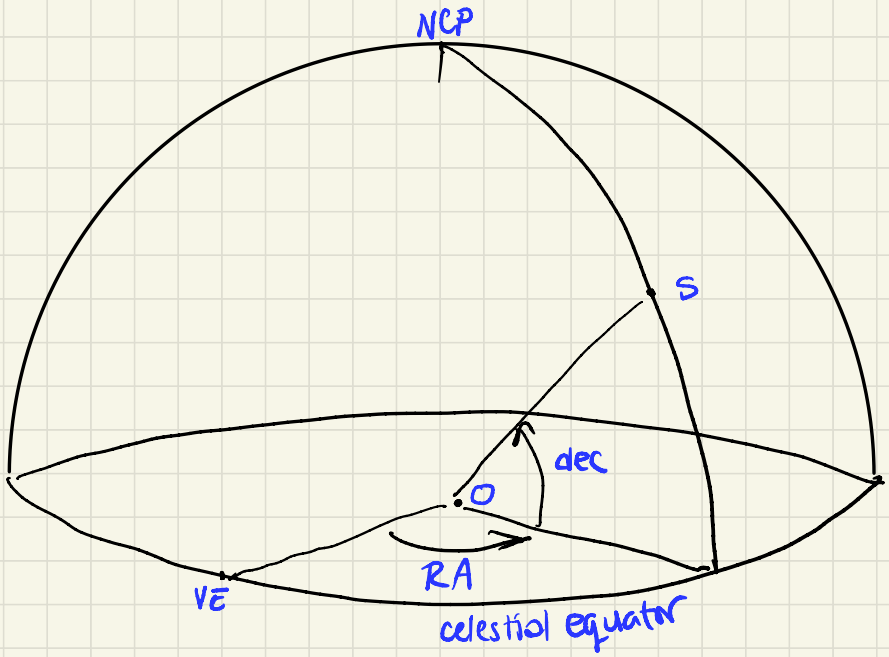
RA = 0, dec = 0 in Pisces is where the Sun is located on March 21

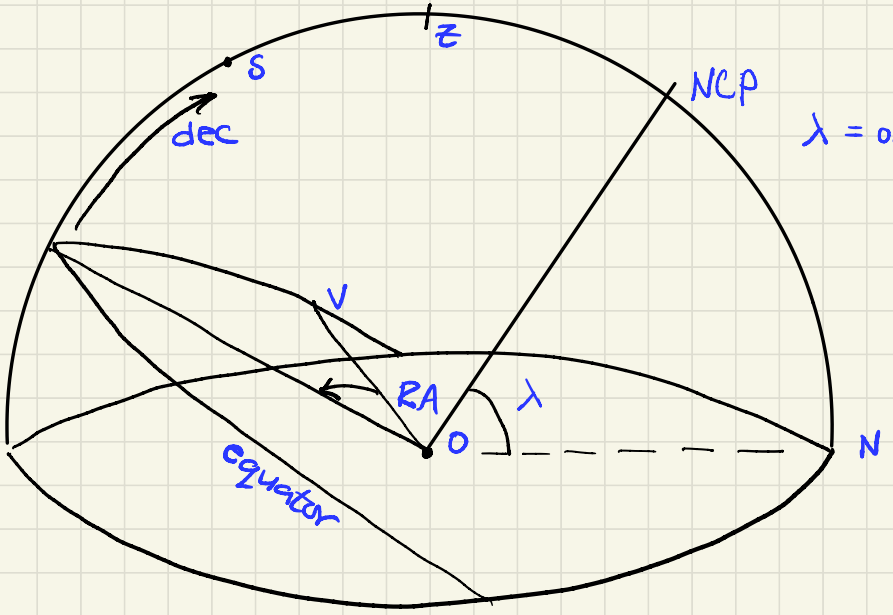
Epoch of coordinates: B1950 (Besselian; FK4) or
J2000 (Julian; FK5)
to correct for precession of Earth's axis

Position angle: the angle East of North onto the sky
(0° to 180° or 0° to −180°)



1 hour of RA = 15 degrees at the celestial equator
1 minute of RA = 15 arcminutes at the celestial equator
1 second of RA = 15 arcseconds at the celestial equator
at other dec, 1 hour of RA = $15° \cos\delta$; similarly for min, sec


NCP
S
dec
O
RA
VE
celestial equator


Z
S
dec
NCP
λ = obs. lat.
V
RA
λ
O
N
equator

For very small separations, you can approximate the spherical surface of the sky as a plane and use the Pythagorean theorem, with a correction for declination.

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

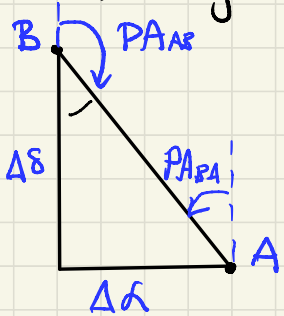
E.g.
Source A has position $\alpha = 13:00:00$, $\delta = 00:00:00$ and source B has position $\alpha = 13:01:30$, $\delta = 00:00:00$. What is the angular distance between these sources?

$\Delta\alpha = 13h\,00m\,00s - 13h\,01m\,30s = 1m\,30s = 90s$ of RA

we are at the equator so $\Delta\delta = 0$ and $\cos\delta = 1$

$\theta = 90s \cdot 15\ ^{arcsec}/_{s} = 1350$ arcsec

Source A has position $\alpha = 13:00:00$, $\delta = 40:30:01$ and source B has position $\alpha = 13:01:02$, $\delta = 40:32:20$. What is the angular distance between these sources?



↱ for small separations

$\Delta\alpha = (\alpha_B - \alpha_A) \cdot \cos\delta_{avg}$
$= 1m\,2s \cdot 15\ ^{arcsec}/_{s} \cdot \cos(40.5196°)$
$= 706.971$ arcsec ≈ 707 arcsec

$\Delta\delta = 40d\,32m\,20s - 40d\,30m\,01s$
$= 2m\,19s = 139$ arcsec

$\theta = \sqrt{707\ \text{arcsec}^2 + 139\ \text{arcsec}^2}$

$\theta \approx 720.535$ arcsec

PA of B relative to A? $PA_{BA} = \tan^{-1}(\Delta\alpha/\Delta\delta) = \tan^{-1}\left(\frac{707}{139}\right) = 79°$
PA of A relative to B? $PA_{AB} = -(180° - PA_{BA}) = -101°$

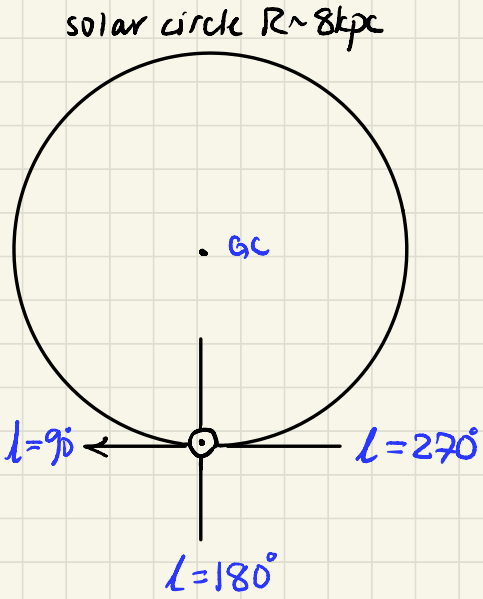
Galactic Coordinates (l, b):

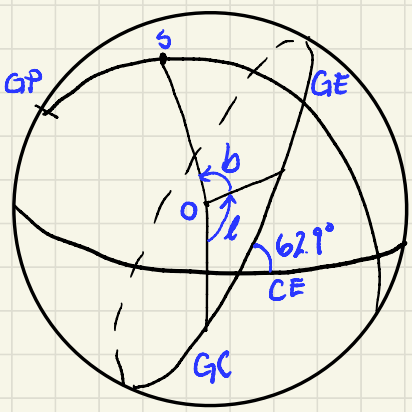
Galactic Plane ($b = 0$): plane formed by the disk of the Milky Way. Inclined by 63° to the Celestial Equator.

Galactic North Pole ($b = 90°$): located in Coma Berenices at RA = 12:51, dec = +27

Galactic South Pole ($b = -90°$): located in Dorado at RA = 00:51, dec = −27

Galactic Center ($l = 0, b = 0$): located in Sagittarius at RA = 17:45, dec = −28:56



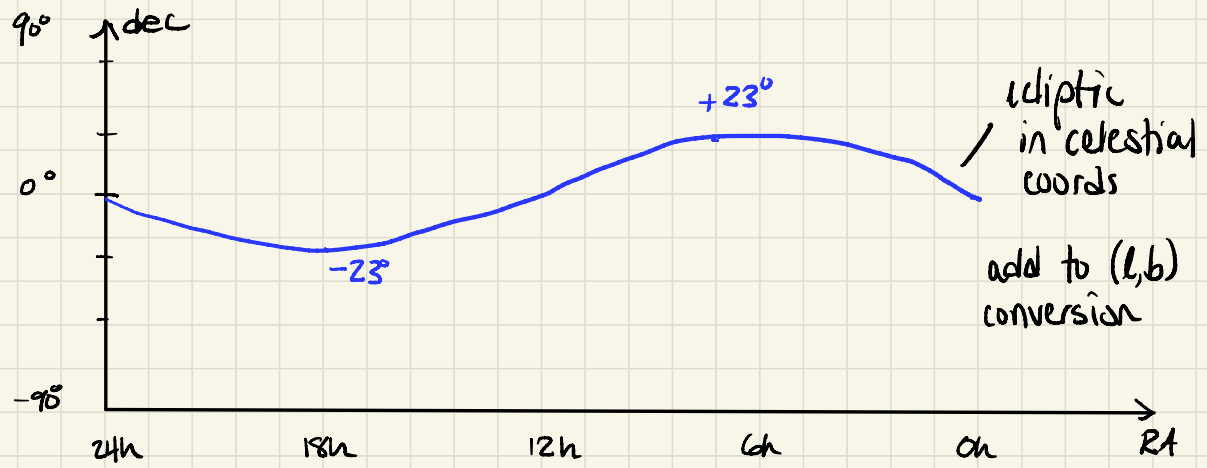


e.g.

By reading the handout chart, what is the RA and dec of a Galactic HII region at $l = 30°$, $b = 0°$? RA = 16h, dec = −10°

If you are observing in the Galactic Plane, where are asteroids most likely to cause confusion?

where the Galactic Plane crosses the Ecliptic plane.



- looking at the conversion chart the ecliptic plane and galactic plane cross at RA ~ 17.5h, dec ~ −22° and RA ~ 5.5h and dec ~ 22°.

Ecliptic Coordinates:

- so named because eclipses occur in this plane
- the plane of the solar system, inclined 23.5° to celestial eq.

Ecliptic north: located in Draco, RA = 18:00:00, dec = +66°
Ecliptic south: located in Dorado, RA = 6:00:00, dec = −66°
Ecliptic lon = 0, lat = 0 located at RA = 00:02:33, dec = 00:16:41
Galactic center is at Ecliptic lon = 266°, lat = −5°