ORBITAL MECHANICS

f = Earth's oblateness

$$\boxed{f = \frac{R_E - R_P}{R_E}} \quad (2.57)$$

$R_P \sim R_E - 30$ km

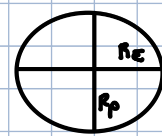
$f \sim 0{,}00335$

GEOGRAFICAL LONGITUDE = GEOCENTRIC LONGITUDE.

$$R_P = R_E \sqrt{1 - e^2_{ellipse}}$$

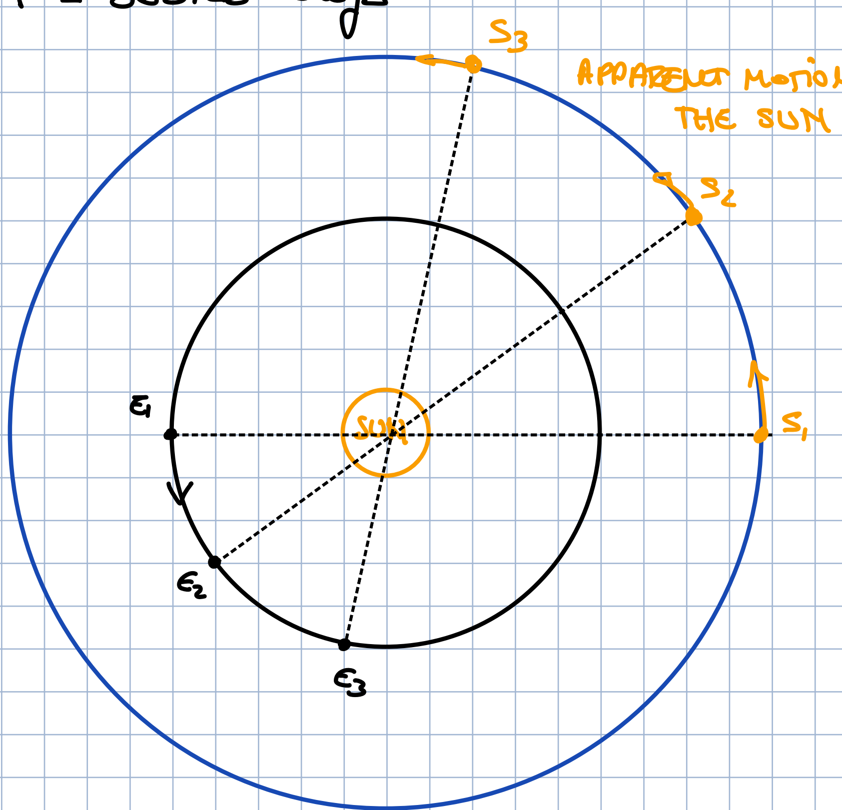
ellipse → reffers to the Earth shape.

$$\boxed{f = 1 - \sqrt{1 - e^2_{ellipse}}} \quad (2.58)$$

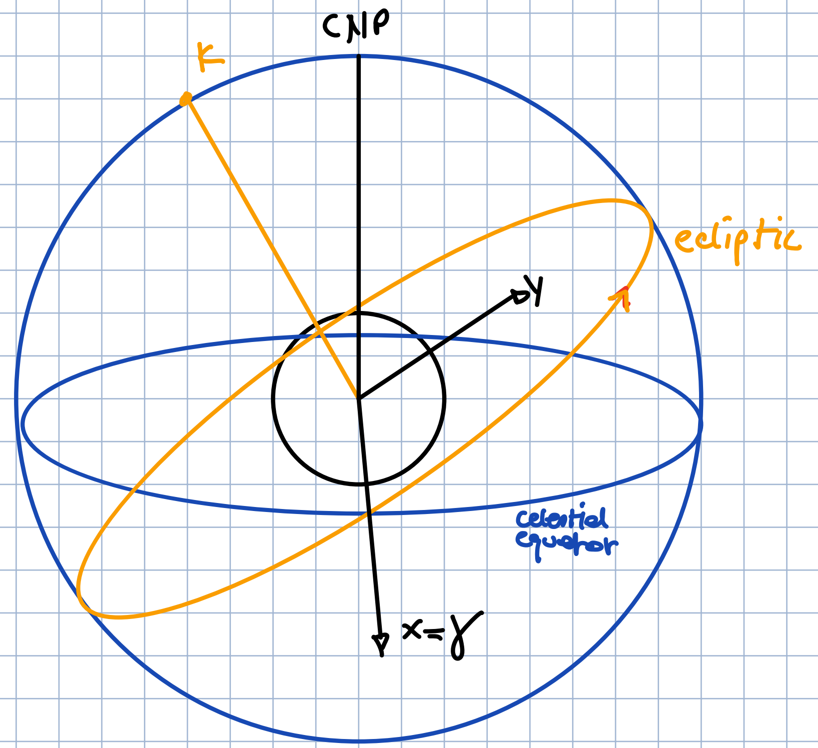


EARTH MOVEMENTS

$T = 365.25$ days



We can project the sun on the celestial sphere. We can observe the apparent motion of the sun due to the movement of the Earth around the sun.



APPARENT MOTION OF THE SUN ALONG THE ECLIPTIC.

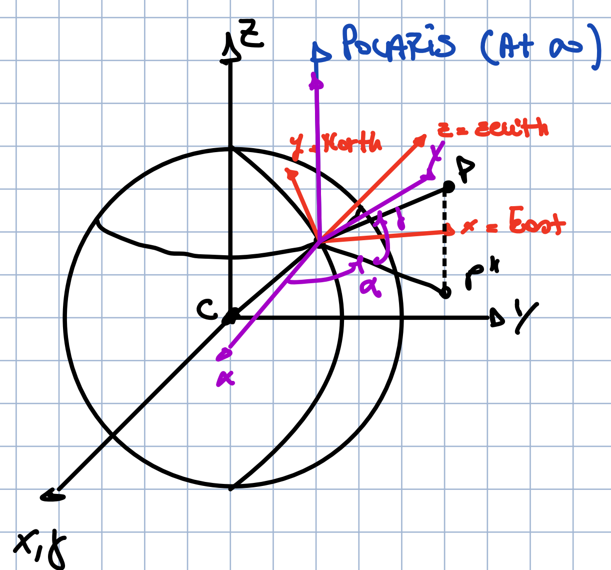
Due to precession NP produces a cone in 26000 years around K

ECLIPTIC: apparent great circle of the path of sun on the celestial sphere during 1 years.

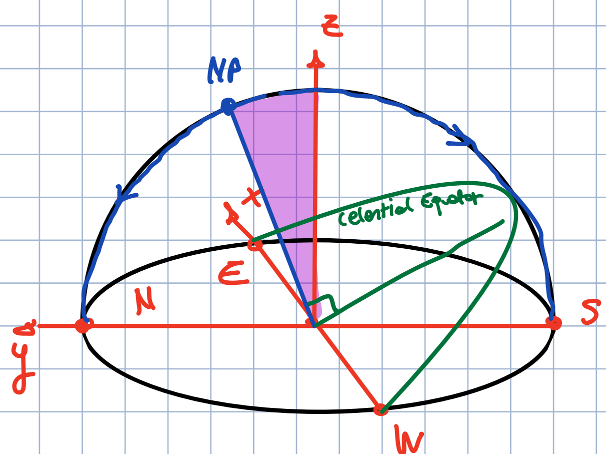
PLANE OF ECLIPTIC: plane of Earth's orbit around Sun

CELESTIAL EQUATOR: equator projected on the celestial sphere.

TOPOCENTRIC EQUATORIAL COORDINATE SYSTEM



centred at the observer



The arc of a great circle that goes $\overset{\frown}{N\,P_N\,Z\,S}$ = observer meridian

CELESTIAL EQUATOR : plane $\perp$ to the PN that intersect the celestial sphere and horizon by identify the points East and West.

Demonstration

Let's call s the line of intersection between the celestial equator and the horizon.

s $\in$ celestial equator plane

s $\in$ horizon plane s $\perp$ $\overline{OZ}$

if s is $\perp$ to both directions $\Rightarrow$ s $\perp$ plane define by these two direction $\Rightarrow$ s $\perp$ plane defined by O, Z, PN

s $\perp$ to any straight line $\in$ to that plane.

$\Rightarrow$ s $\perp$ to line $\overline{NS}$ and $\overline{NS}$ $\in$ O, Z, PN

$\Rightarrow$ s is the direction $\overline{WE}$

$\Rightarrow$ intersection between horizon and celestial equator identifies W and E.

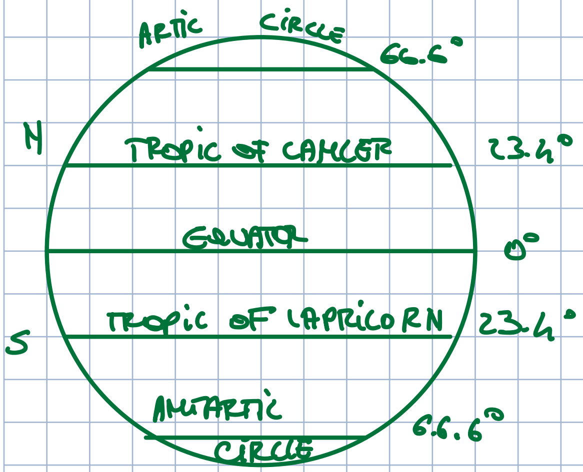
N: search polaris star project down from Z to horizon

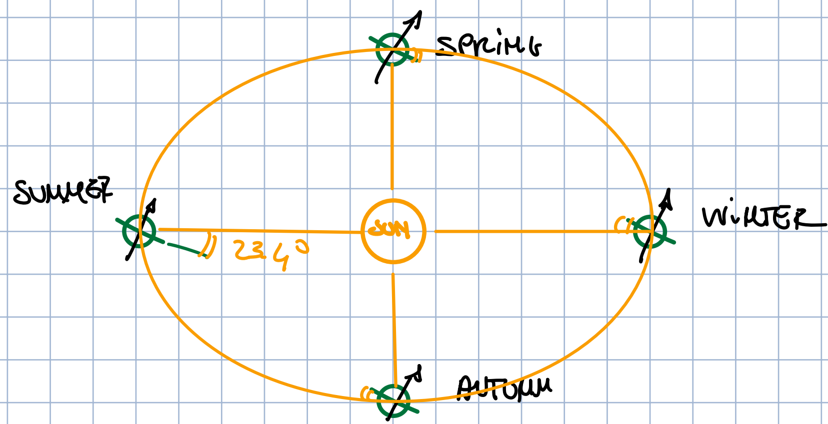
S: the direction of maximum altitude of sun during the day.

W, E $\perp$ (N-S) on horizon you can see two points $\in$ to celestial equator (virtual line).

Sun rises and sets at E and W twice a year (equinoxes)

Sun rises and sets at $\neq$ points because the ecliptic is inclined of 23.4° on the Equator.





IN SUMMER THE SUN IS GOING TO HIT ⊥ THE TROPIC OF CANCER

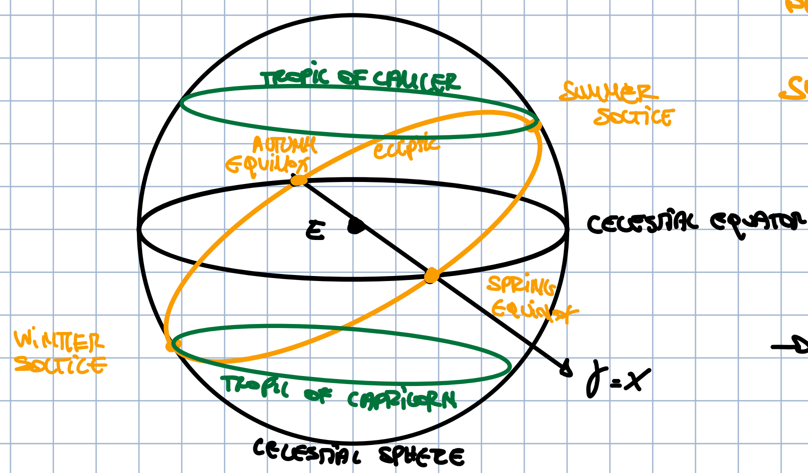
IN WINTER THE SUN IS GOING TO HIT ⊥ THE TROPIC OF CAPRICORN.

$$66.6° + 23.4° = 90°$$

Above and below 66.6° the sun is going to be above the horizon for a full day 24 h at least one time per year.

Above and below 23.4° latitude sun never rises up to 90°.

ECEF = Earth inertial earth fixed

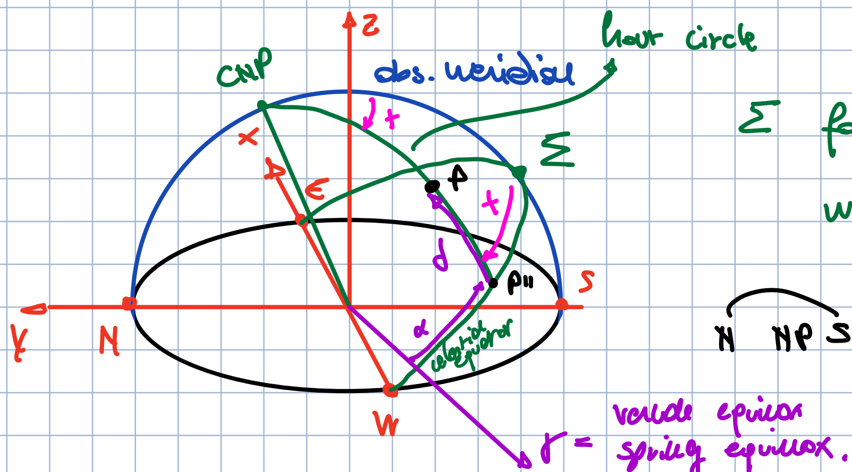


on spring and autumn the sun rises and sets at E, W

→ At sun rise and sunset (★ S) ∈ horizon, ecliptic, celestial equator

This is an inertial reference frame ⇒ We are not considering the rotation of the Earth

Let's go back to topocentric horizon coordinate system.



t = local hour angle

Σ foot of the observer meridian wrt the celestial equator

N NP S observer meridian

Whenever we want to trace the position of a star it is necessary to trace the arc of a great circle passing through CNP and the star P

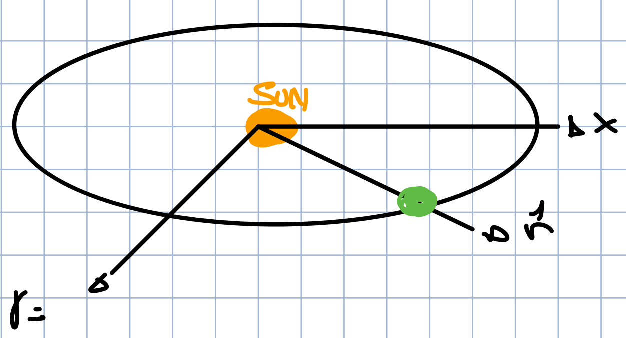
NP P P'' hour circle = great circle that passes through NP and P

δ = declination distance to the celestial equator along the hour circle

α = angular distance from the vernal equinox to P''

$-\frac{\pi}{2} \leq \delta \leq \frac{\pi}{2}$ $\quad 0 \leq \alpha < 2\pi$

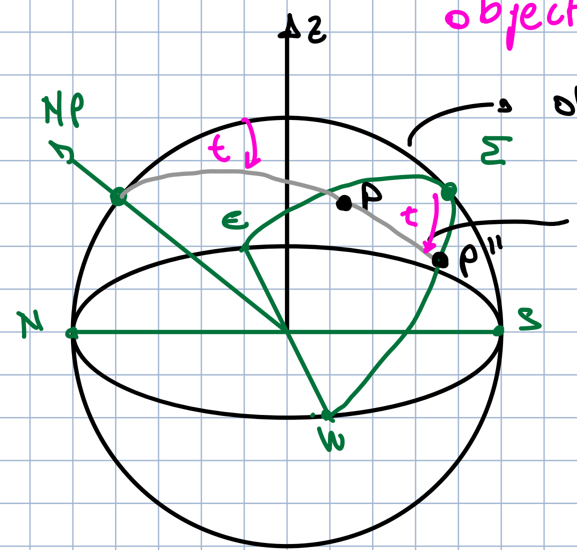
The star in the sky appears to rotate due to the Earth's rotation around the axis but α, δ are fixed while A and h are function of time A(t), h(t). Also P and γ appear to rotate



PISCES CONSTELLATION
(before γ Aries)

δ, α are not influenced by the position of the observer located on the celestial sphere. δ, α change only to the rotation introduced by the precession.

LOCAL HOUR ANGLE $\stackrel{D}{=}$ angle measured west along the equator from the observer meridian ($\overset{\frown}{NMPS}$) to the hour circle ($\overset{\frown}{NPPP''}$) through the celestial object



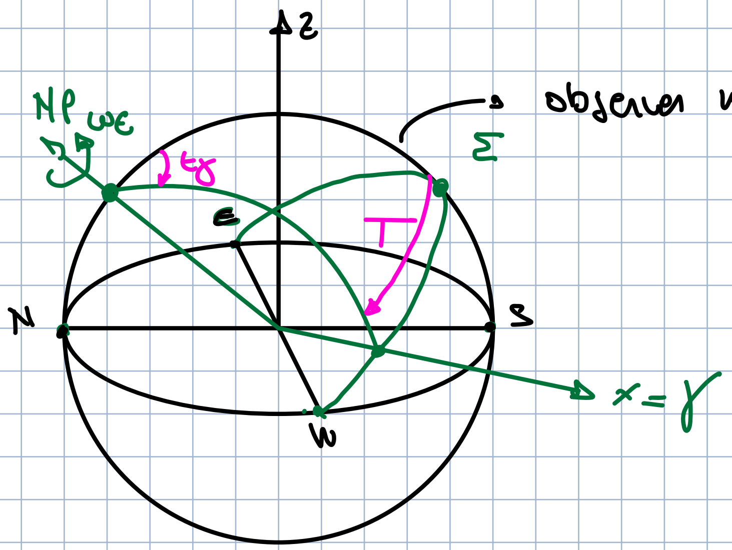
As Earth rotates counter clock wise $\Rightarrow$ P appears to rotate from E to W $\Rightarrow$ angle t increases linearly with THE local

Another way to link the observer and the celestial system is

system is using a very specific star $\rightarrow \gamma$

Because γ is fixed in space.

For γ = $\alpha = 0$
$\delta = 0$

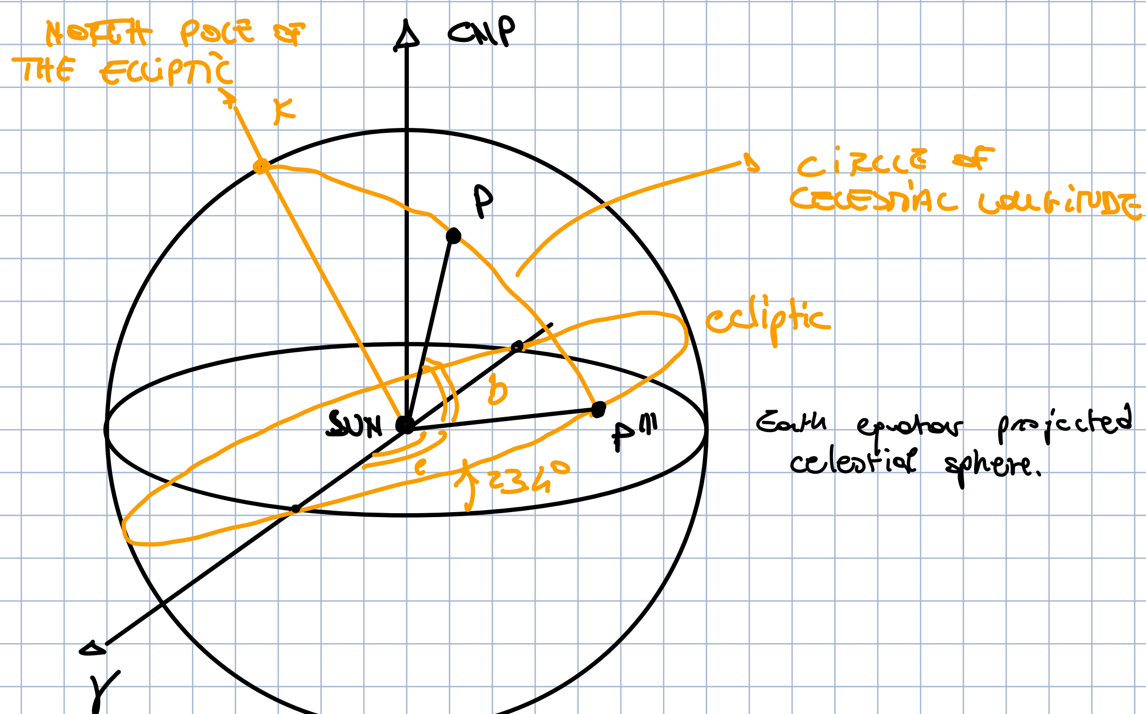


$t_\gamma = T$ = sidereal Time

while Earth rotates around NP, z describes a cone around NP and topocentric horizon ref frame follows z, T increases from 0 to 2π

CELESTIAL LATITUDE LONGITUDE AND HELIOCENTRIC COORDINATES

to describe another phenomena in the solar system, it is convenient to use the elliptic system.



ℓ = CELESTIAL LONGITUDE (from γ to P''' on the ecliptic)

$0 \leq \ell < 2\pi$

b = CELESTIAL LATITUDE $\quad -\frac{\pi}{2} \leq b \leq \frac{\pi}{2}$

ℓ and b as α and δ are almost fixed

REFERENCE FRAME	POLE	LATITUDE-LIKE	LONGITUDE-LIKE
HORIZON	z = ZENITH	$h(t)$ = ALTITUDE	$A(t)$ = AZIMUTH Clock wise from N
CELESTIAL EQUATOR	CNP = CELESTIAL NORTH POLE	δ = DECLINATION for an observer on earth	α = RIGHT ASCENSION λ = Longitude ϕ = latitude geograph φ = geodetic latitude.
ECLIPTIC	K = NORTH POLE ECLIPTIC	b = CELESTIAL LATITUDE	ℓ = CELESTIAL LONGITUDE.