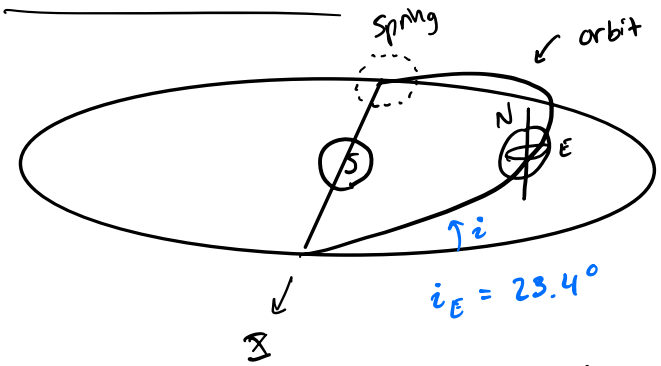
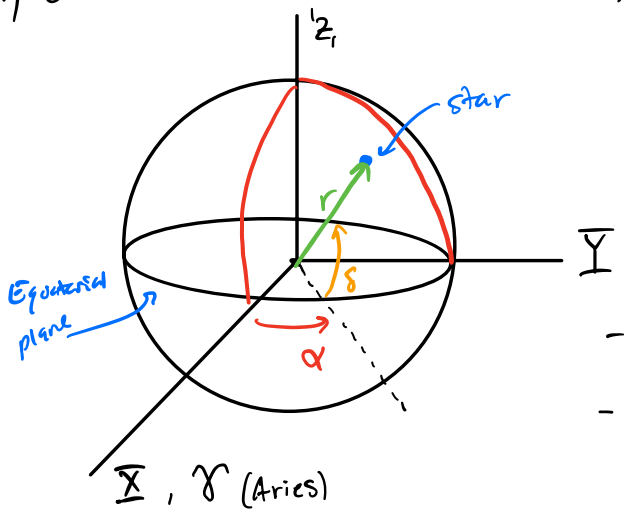
ECI cont'd

Ref. frames cont'd



1) Earth Centered Inertial (r, α, δ)



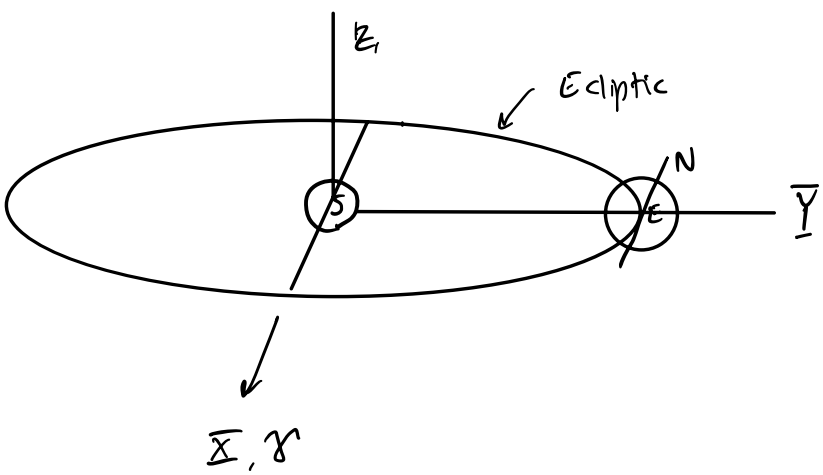
r = range

δ = declination (↑ above eq. plane)

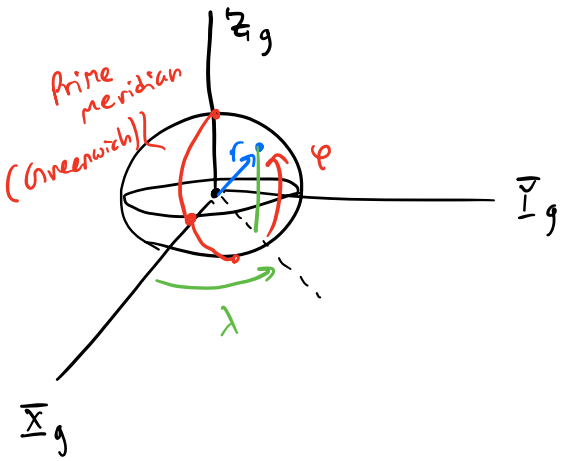
α = right ascension (↺ from x axis)

- Non-rotating!
- See slides for detail

2) Heliocentric C-sys (sun-centered) → Track planets



3) Geographic / Earth-fixed Geocentric (r, φ, λ



r = range

φ = latitude

λ = longitude

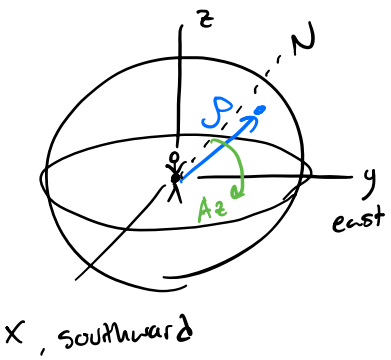
Madison, WI

43°N, 89°W

φ λ

4) Topocentric Coordinates (ρ, El, A_z)

Observer's POV (at origin)



look up → z axis
"zenith"

x axis - southward

y axis - Eastward

ρ = range

El = angle above horizon

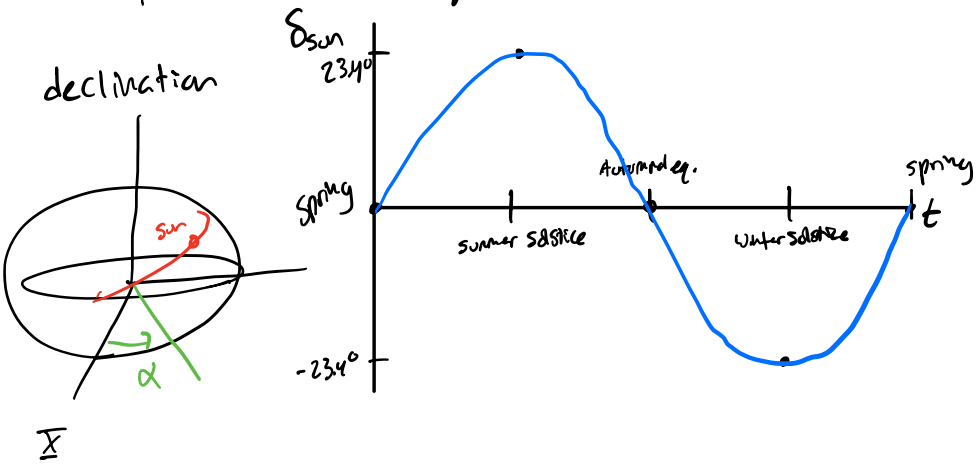
A_z = Eastward angle from north

5) Celestial sphere - concept for the "heavens" / night sky

Similar to topocentric → See L2 S24

Examples w/ C-Sys

make a plot of sun's angle above equatorial plane vs. 1 yr



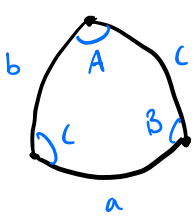
L3 slide 1 -> add to notes

Example: observer @ latitude φ measures Az & El. Find δ & H

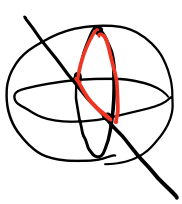
H ≡ hour-angle, time between meridians (long. lines)

φ	Az, El	δ, H
Geocentric	Topocentric	Celestial sphere

-> need spherical trig:

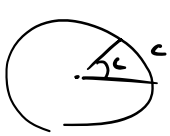


Lines are "arcs" that are part of great circles



A, B, C - angles of orientation between curves

a, b, c - angles of arcs @ center of great circle



Properties

1) Sum of two sides > third side
2) $A+B+C > 180^\circ$
3) $A, B, C < 180^\circ$

Law of Sines $\quad \frac{\sin A}{\sin a} = \frac{\sin B}{\sin b} = \frac{\sin C}{\sin c}$

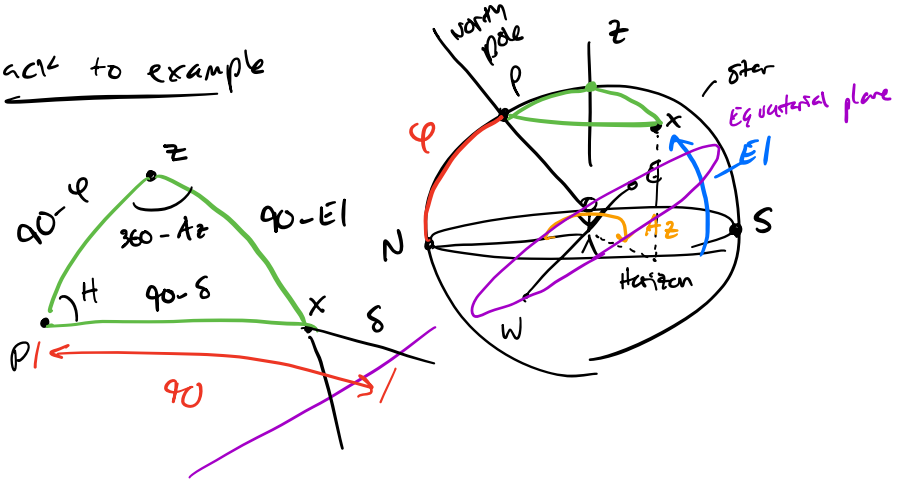
Law of cosines $\rightarrow$ L3 S7

$\rightarrow$ relate side & opp. angle

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

$\rightarrow$ relate angles w/ angles & opp. side

Back to example



Apply trig to solve

use cosine formula to get side PX

$$\cos(90-\delta) = \cos(90-\varphi)\cos(90-El) + \sin(90-\varphi)\sin(90-El)\cos(360-Az)$$

$\cos(90-\theta) = \sin\theta$, $\quad \sin(90-\theta) = \cos\theta$ $\quad \cos(360-\theta) = \cos\theta$

simplify

$$\boxed{\sin\delta = \sin\varphi \sin El + \cos\varphi \cos El \cos Az}$$

Solve

Next: Law of sines or cosines → H

$$\cos(d_0 - El) = \cos(90 - \varphi)\cos(90 - \delta) + \sin(90 - \varphi)\sin(d_0 - \delta)\cos H$$

$$\sin El = \sin\varphi \sin\delta + \cos\varphi \cos\delta \cos H$$

Solve for H