Fundamentals of Astronomy

Prof Wladimir Lyra

Astronomy building, 202A

Office Hours: Tue 2pm - 3pm

Class hours: Tue/Thu 10:30am - 11:45am

Cume # 213
Bernard McNamara

2. The Hyades cluster is located at $\alpha = 4^h\ 32^m$ $\delta = +16^\circ$. When would this cluster be most suitable for ground based observation.

Positional Astronomy

Positional Astronomy

Learning Objectives

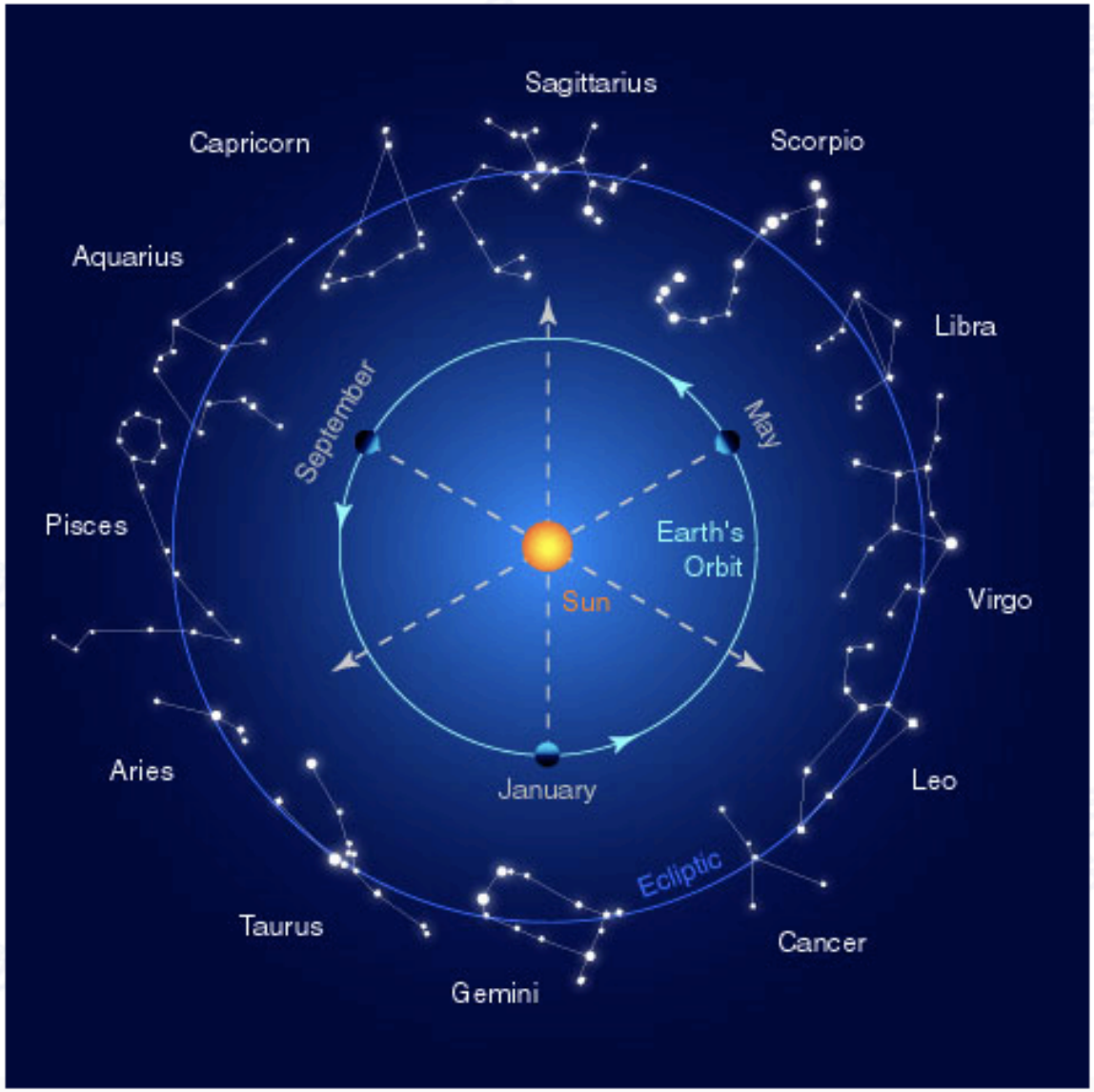
- Familiarity with circles and angles on the Celestial Sphere
- RA/Dec, coordinates
- Spherical trigonometry
- Astronomical time

Class 1

- Celestial Sphere
- Equatorial, horizontal and ecliptic coordinates

Class 2

- Hour coordinates
- Time
- Galactic coordinates
- coordinate transformation by spherical trigonometry.


Sagittarius
Capricorn
Scorpio
Aquarius
Libra
September
May
Pisces
Earth's
Orbit
Sun
Virgo
Aries
January
Leo
Ecliptic
Taurus
Cancer
Gemini

Loss of perception of depth

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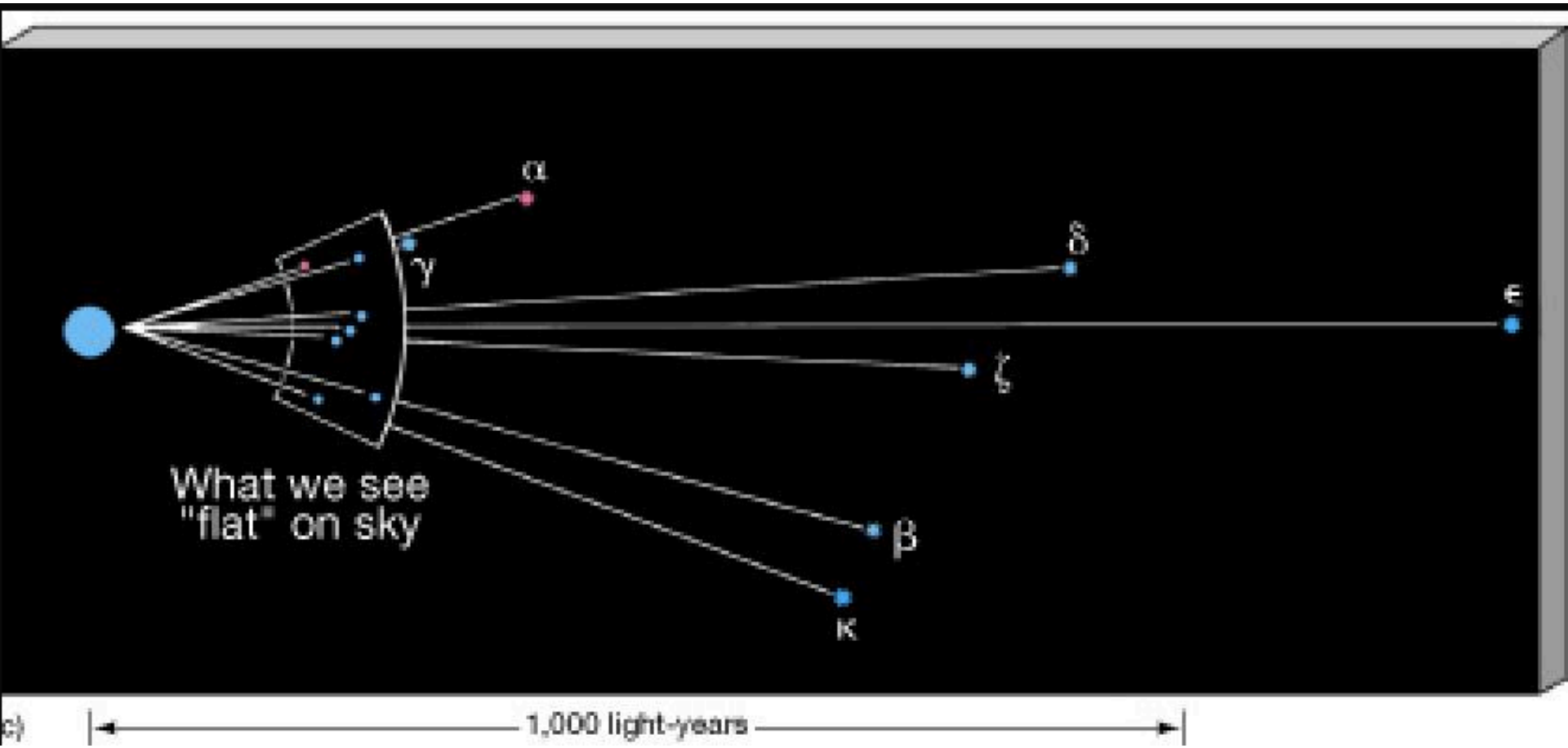
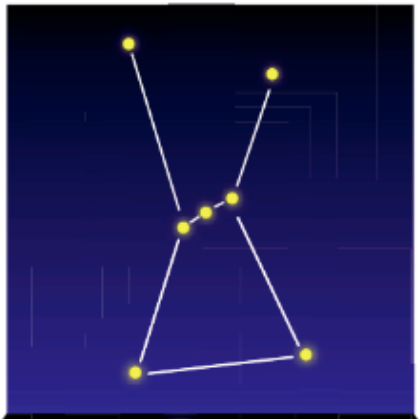
www.southernskyphoto.com


α
γ
δ
ε
ζ
What we see
"flat" on sky
β
κ
1,000 light-years

Distances to the stars of Orion

Orion might look like a flat blanket of stars, but its components are spread over hundreds of light years



Betelgeuse
Betelgeuse is a red supergiant that could explode as a supernova any day now, and is about 640 light years away.

Bellatrix
Just 250 light years away, Bellatrix is the third brightest star in Orion and the closest of its major stars.

1800
1600
1400
1200
1000
800
600
400
200

Orion nebula
The nebula forms the fuzzy tip of the 'sword' hanging from Orion's belt of three stars. It is a giant cloud of gas forming new stars and is 1,344 light years away.

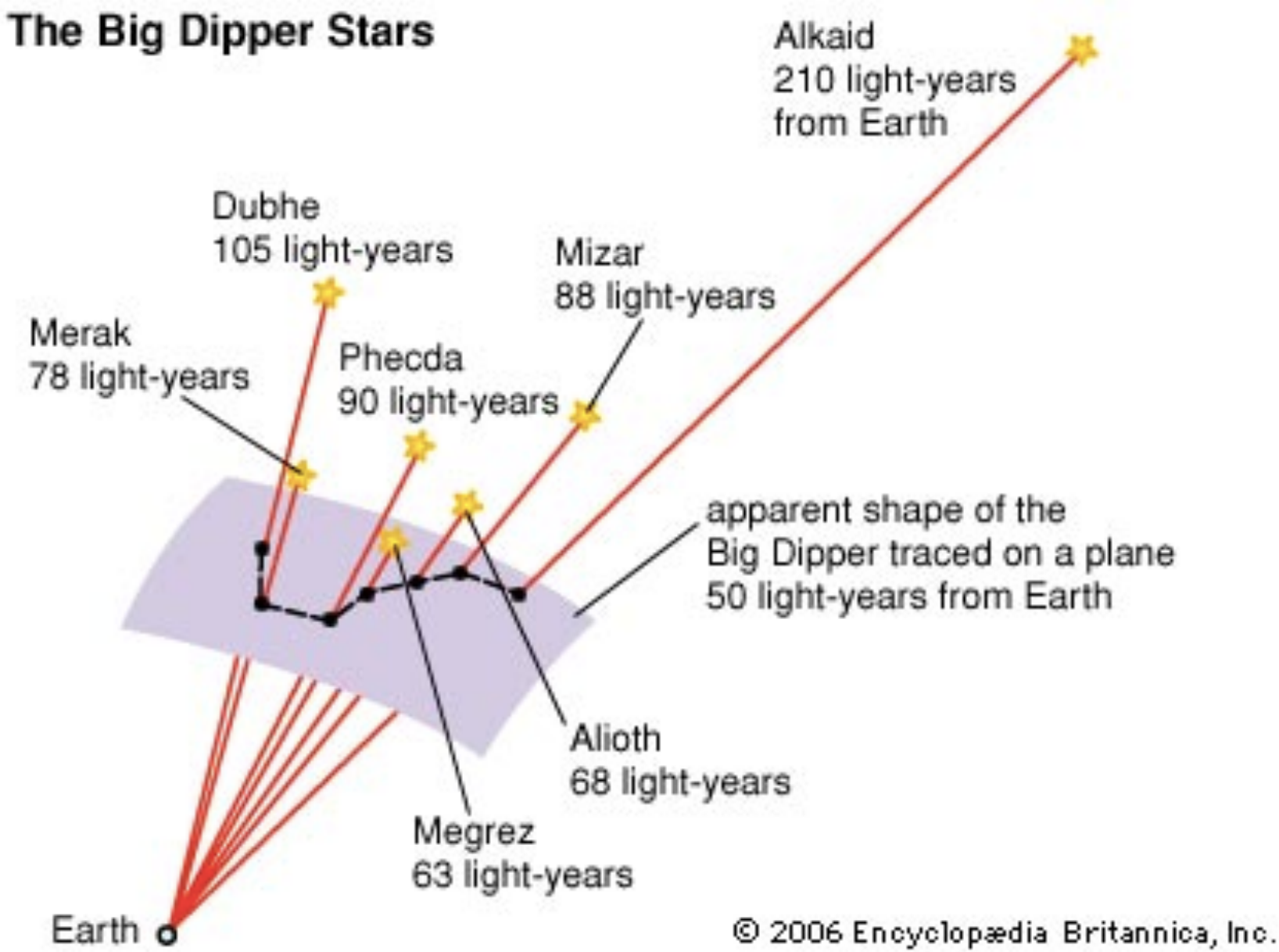
Orion's Belt
The three stars in Orion's Belt, from left to right, are Alnitak, Alnilam and Mintaka. Estimates place Alnitak at 800 light years away, Mintaka 1,300 light years away and Alnilam 900 light years away.

Saiph
At the lower-left 'knee' of Orion, Saiph is 650 light years away. It is a large star that, like Betelgeuse and Rigel, will one day blow up in a supernova.

Rigel
The brightest star in Orion is Rigel, a white supergiant, about 860 light years away.

This diagram illustrates the distances of each of Orion's stars, measured in light years

© NASA


The Big Dipper Stars
Alkaid
210 light-years
from Earth
Dubhe
105 light-years
Mizar
88 light-years
Merak
78 light-years
Phecda
90 light-years
apparent shape of the
Big Dipper traced on a plane
50 light-years from Earth
Alioth
68 light-years
Megrez
63 light-years
Earth
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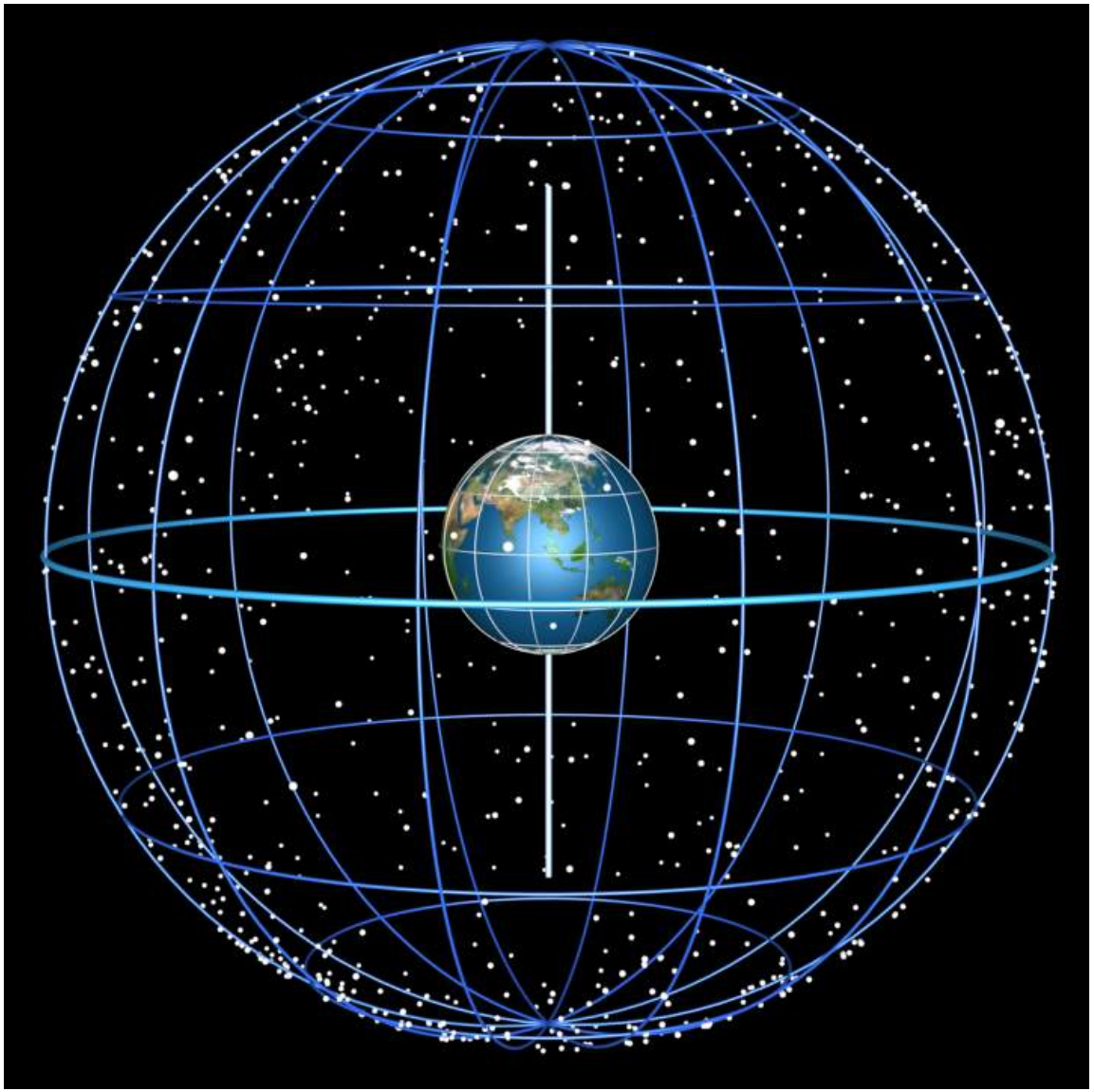
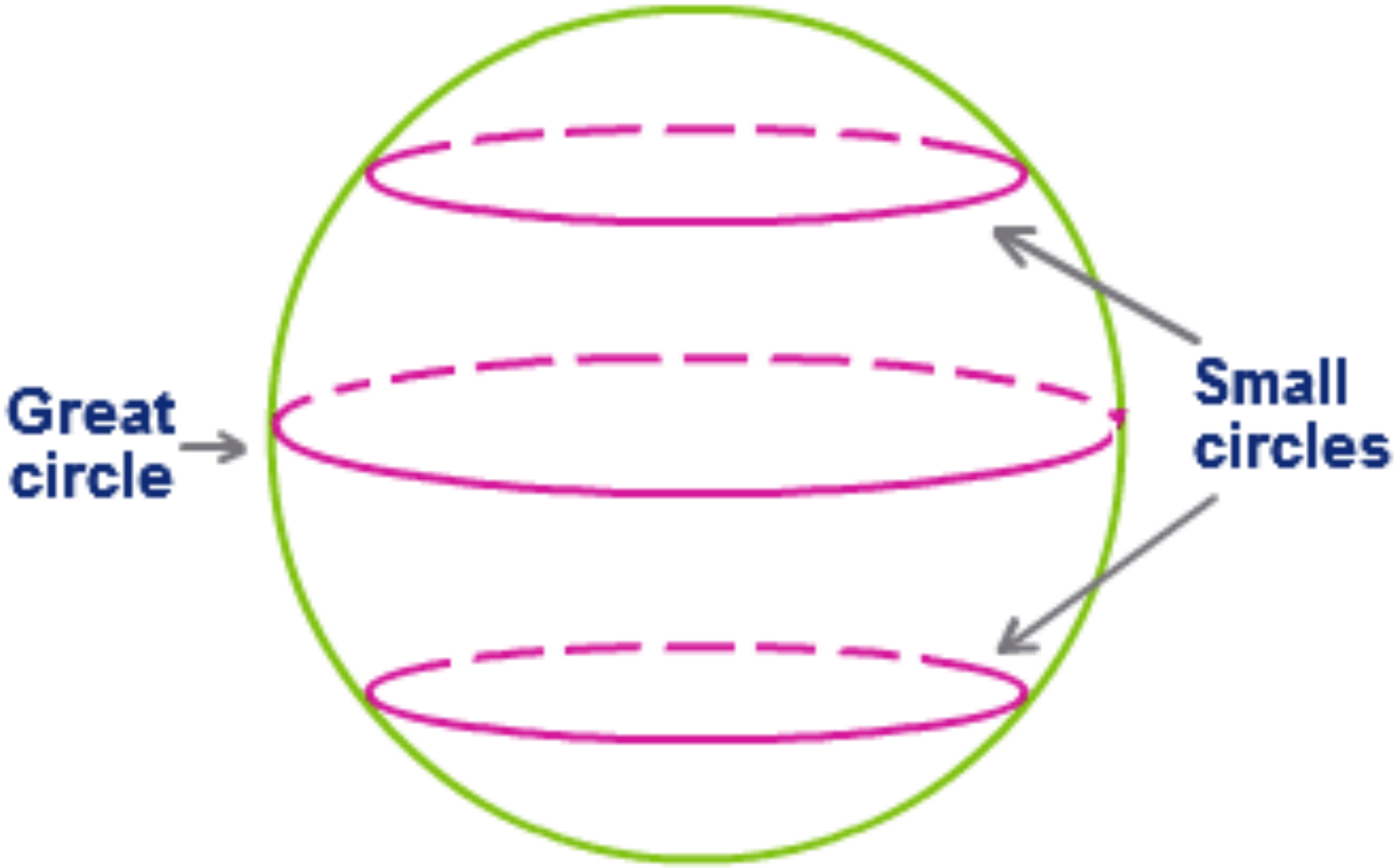
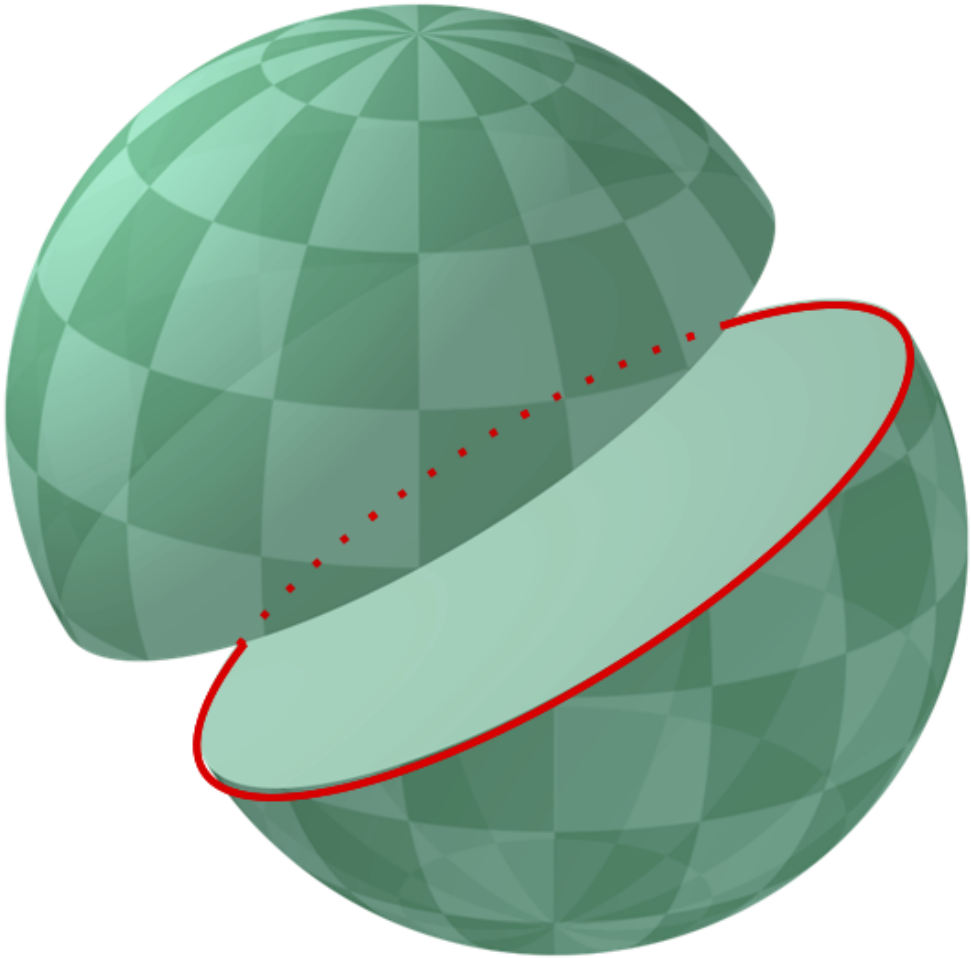
Diurnal motion

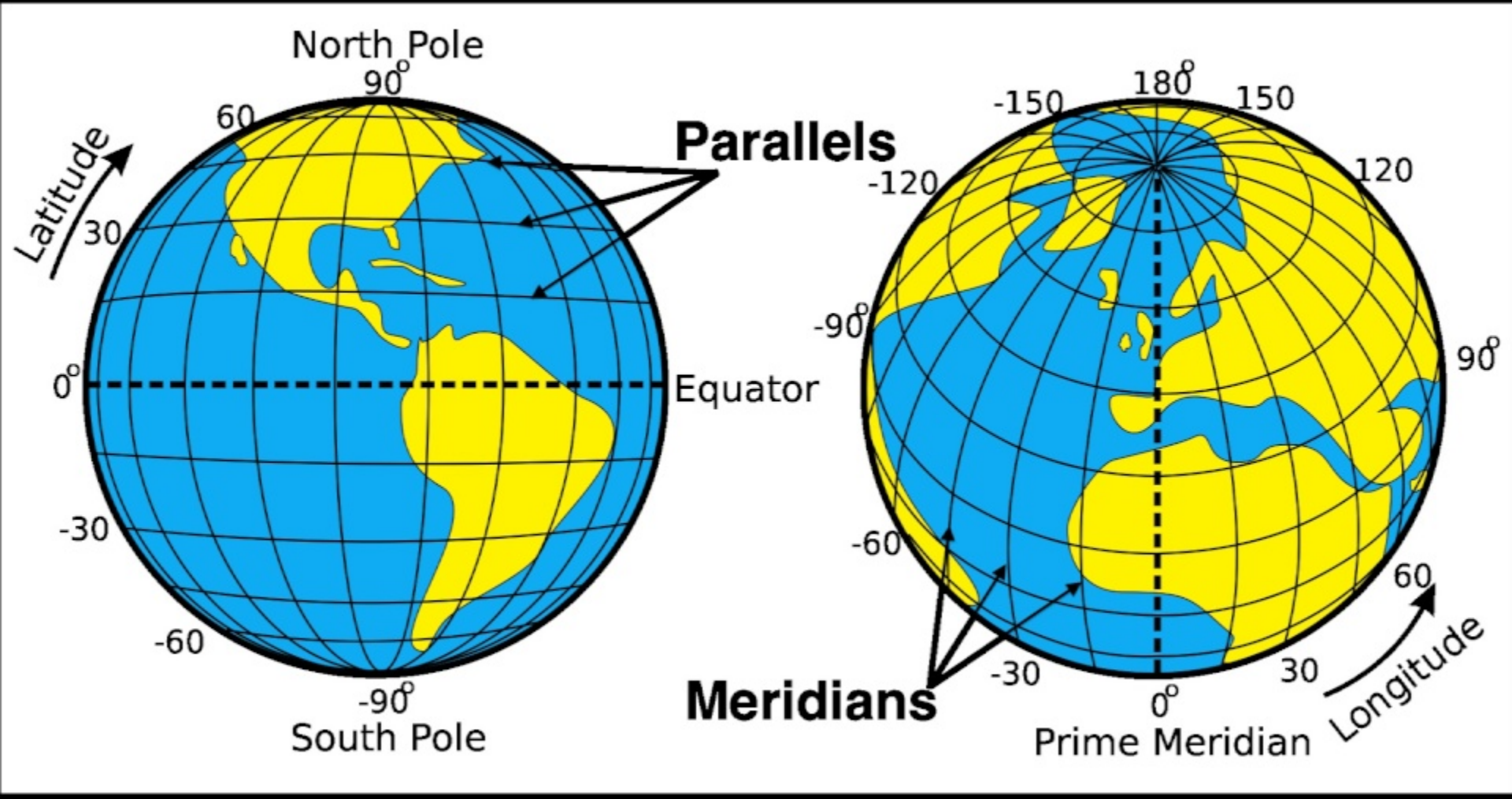
Celestial Sphere



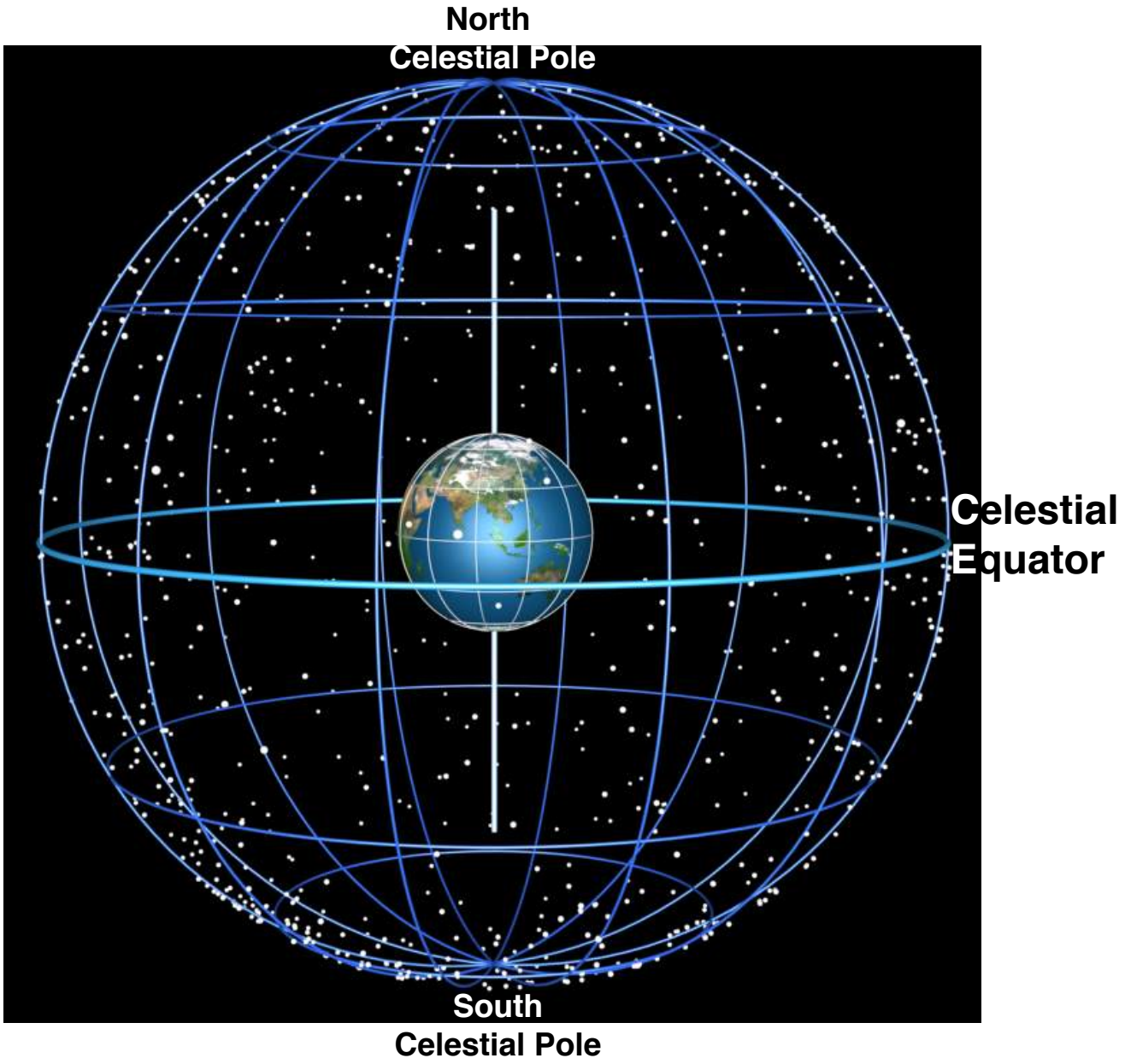

Great circle
Small circles

Great Circle

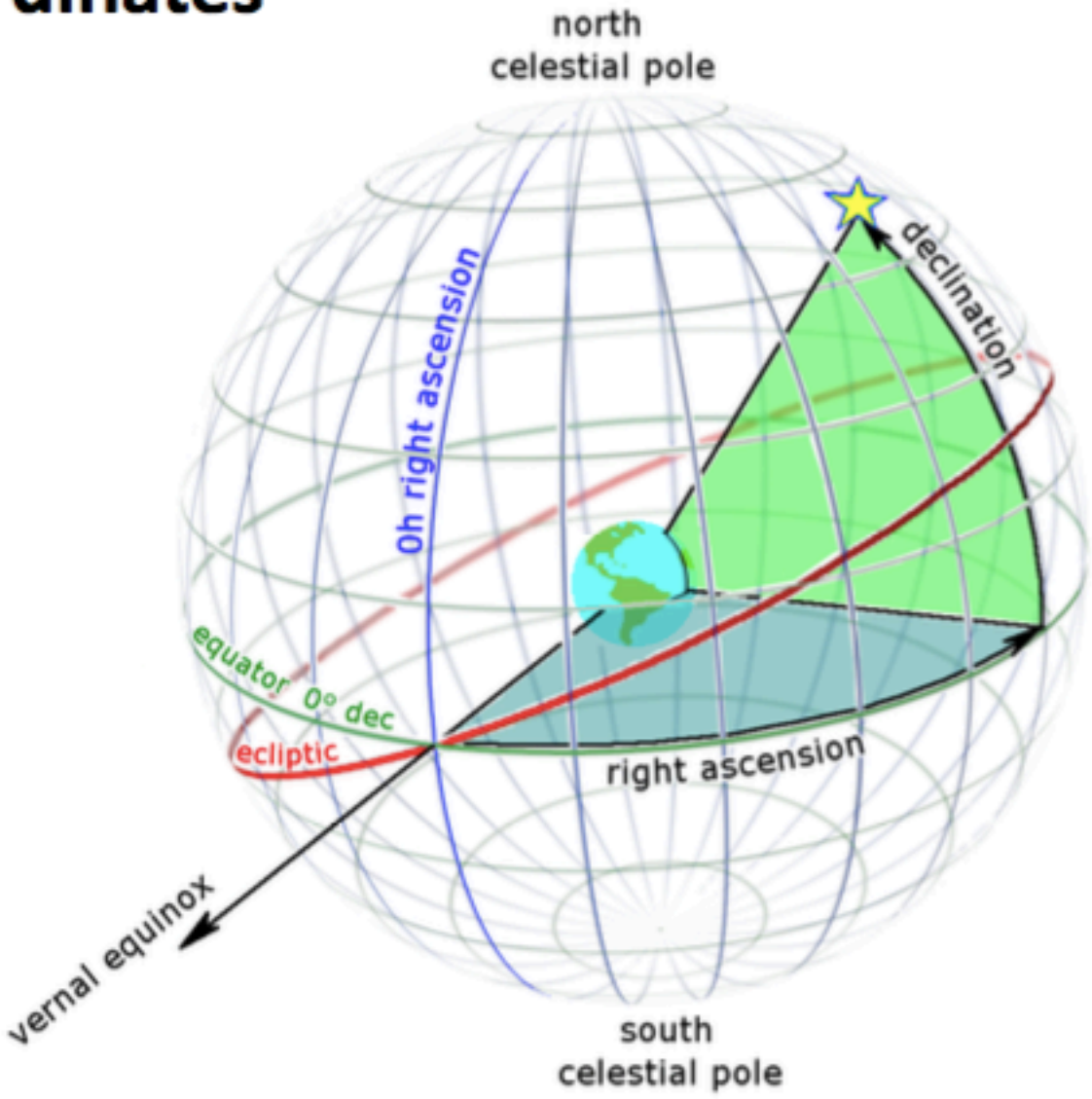



North Pole
90°
60
30
0°
-30
-60
-90°
South Pole
Latitude
Parallels
Equator
180°
-150
150
-120
120
-90°
90°
-60
60
-30
30
0°
Prime Meridian
Meridians
Longitude

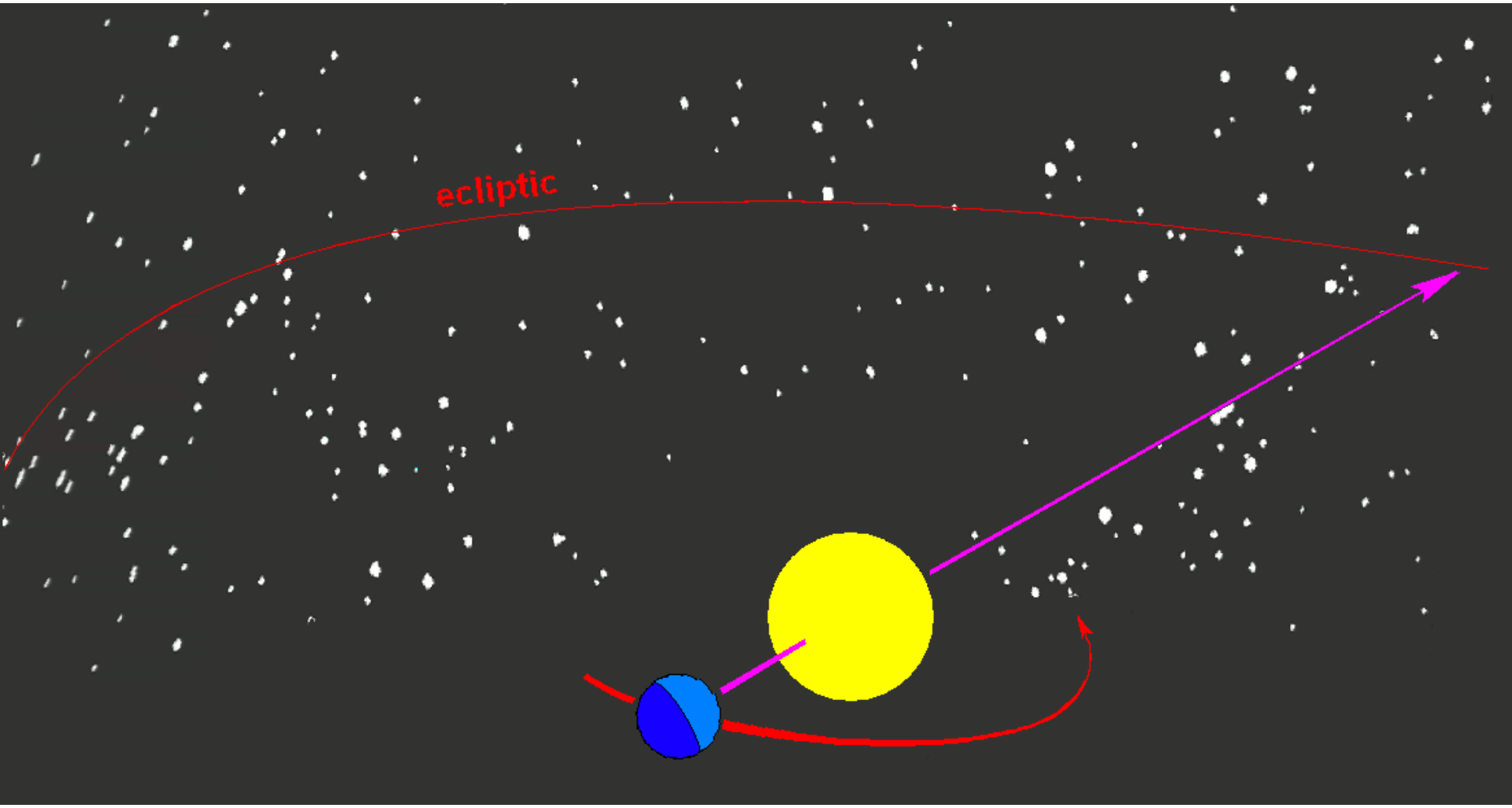
Celestial Sphere



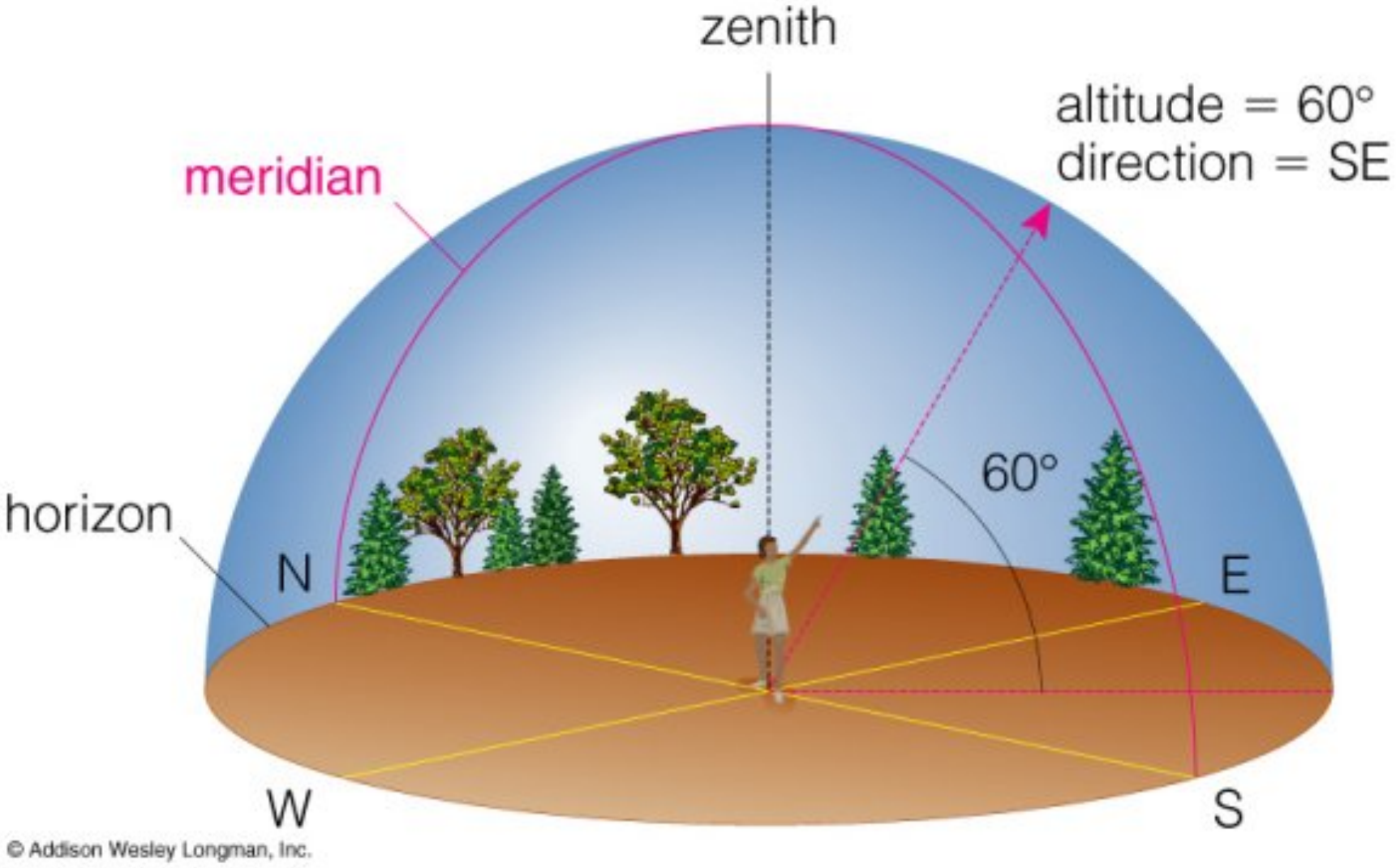
Equatorial coordinates



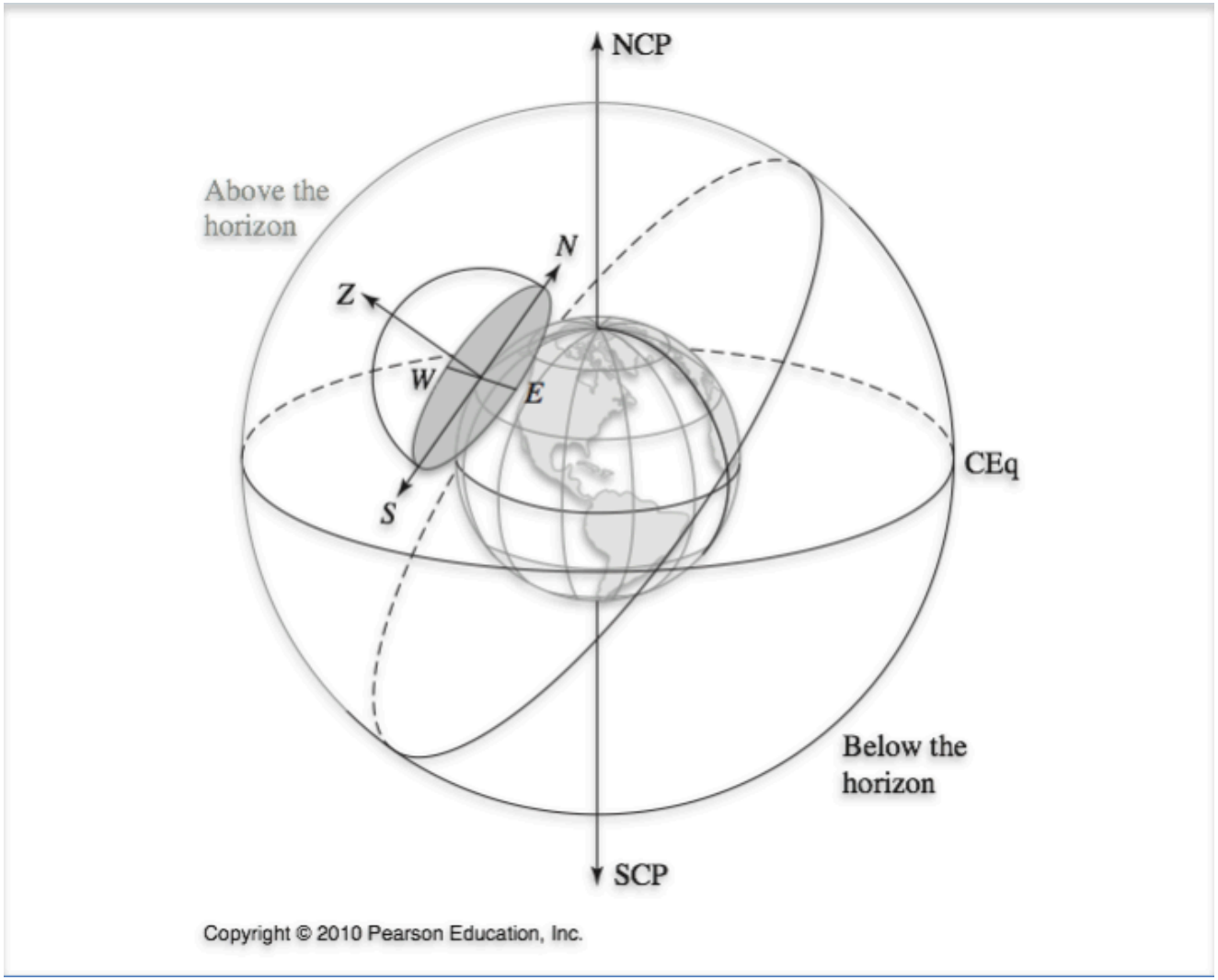
Ecliptic



Our perception of the sky



Our perception of the sky



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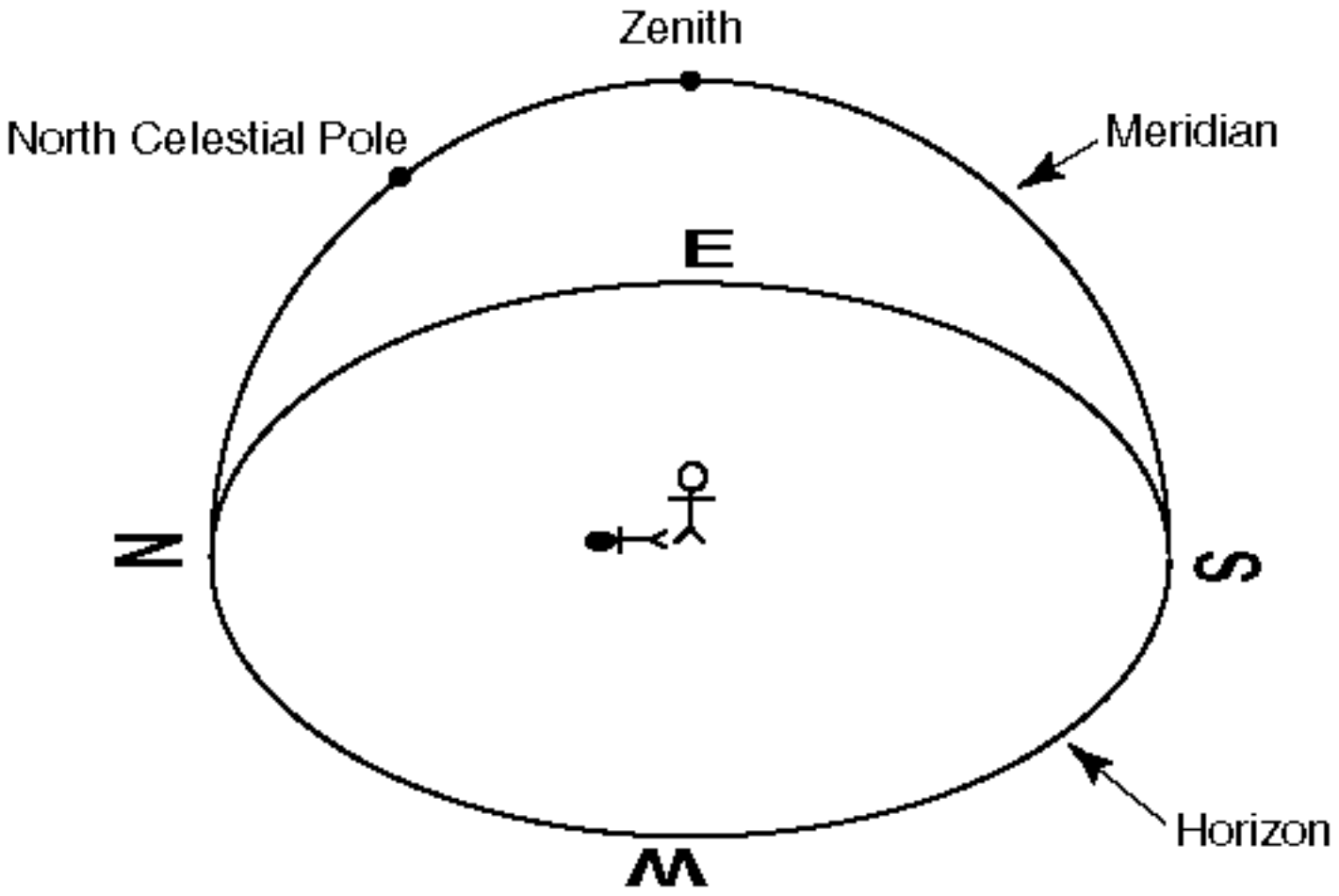
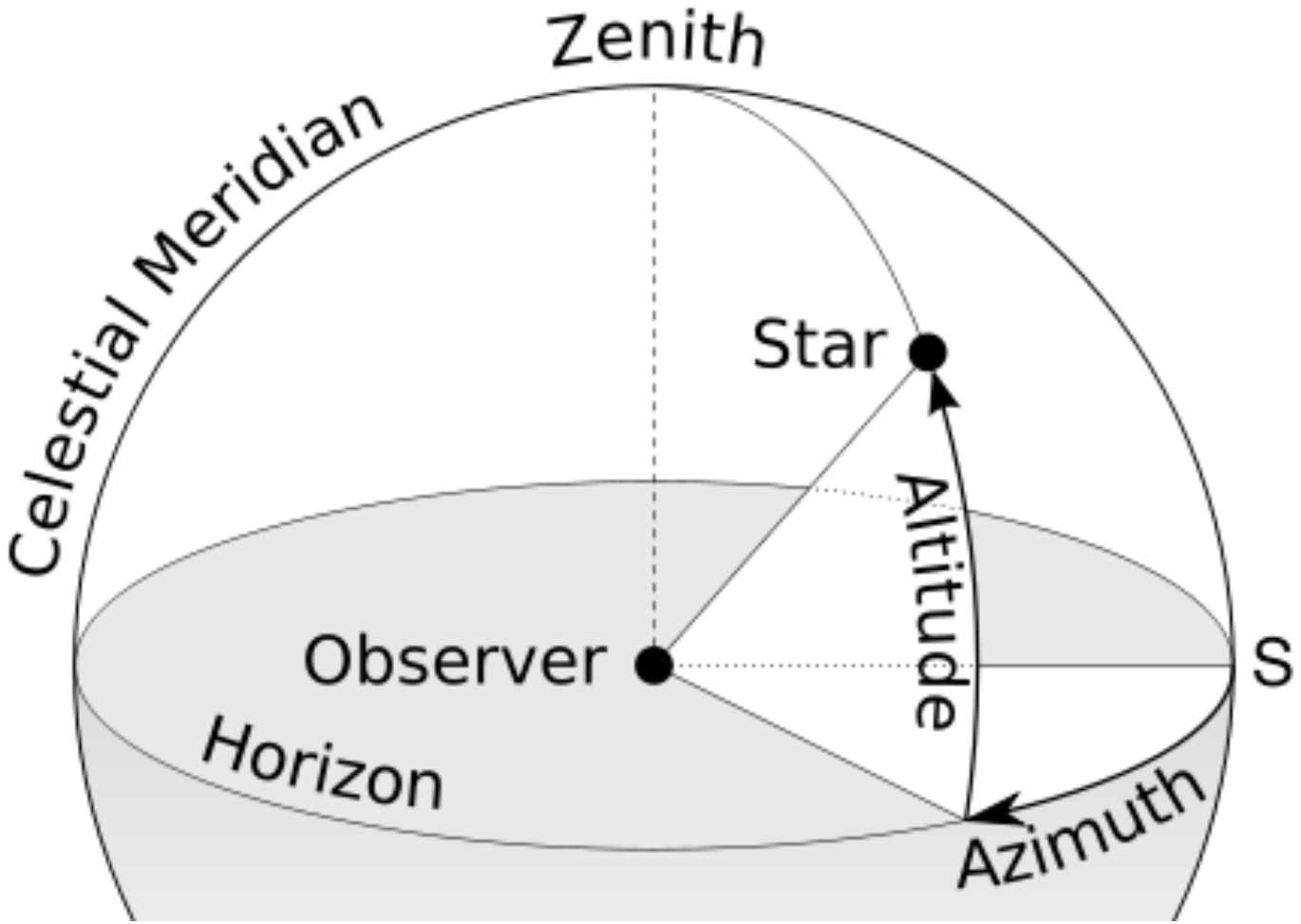
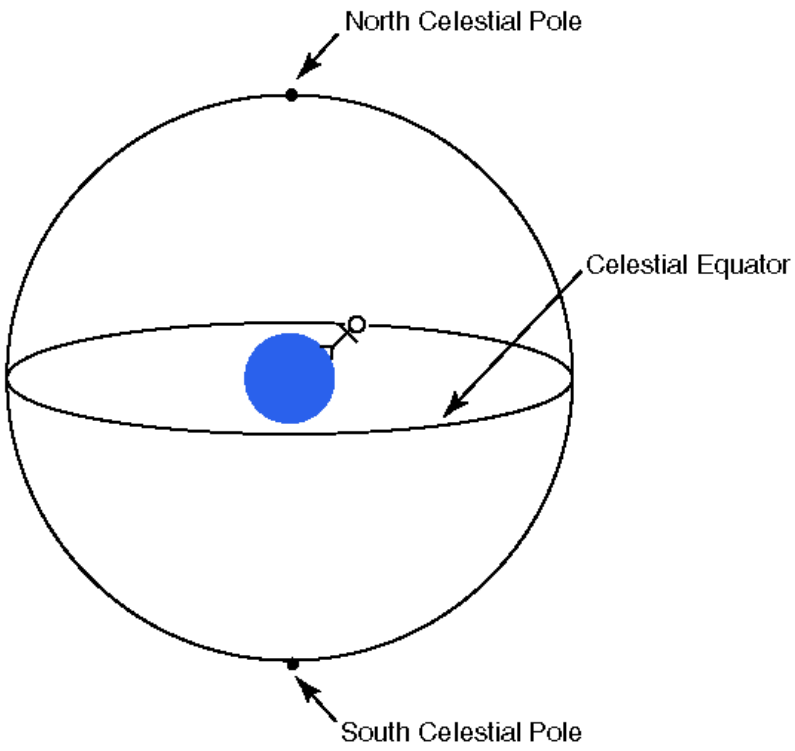
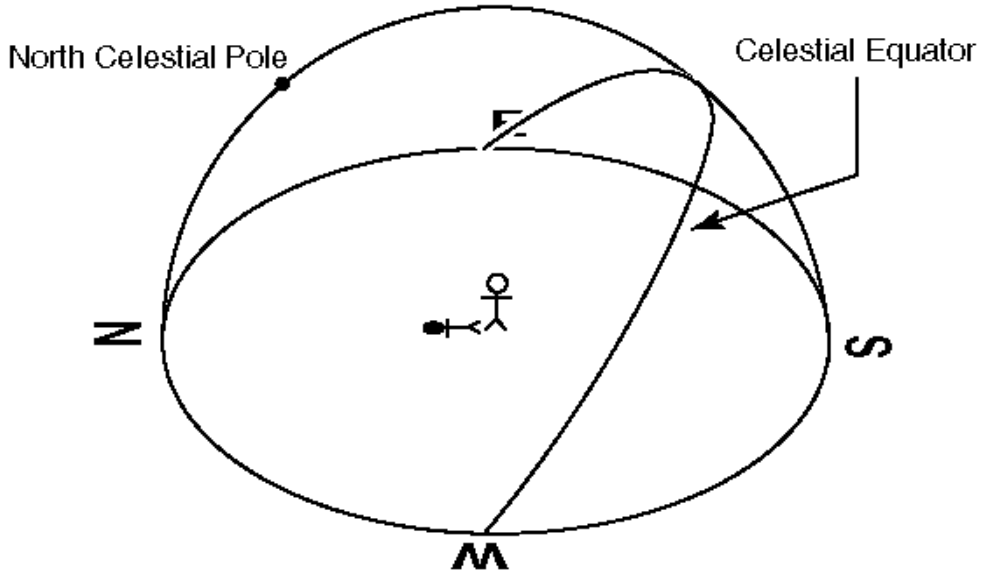

Zenith
North Celestial Pole
Meridian
E
N
S
W
Horizon

Alt-azimuthal (Horizontal) Coordinates

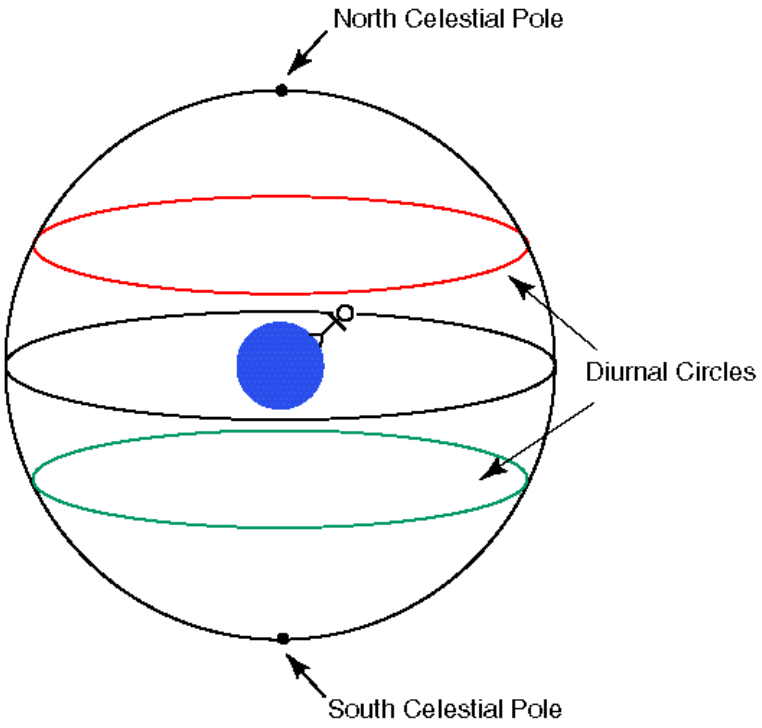


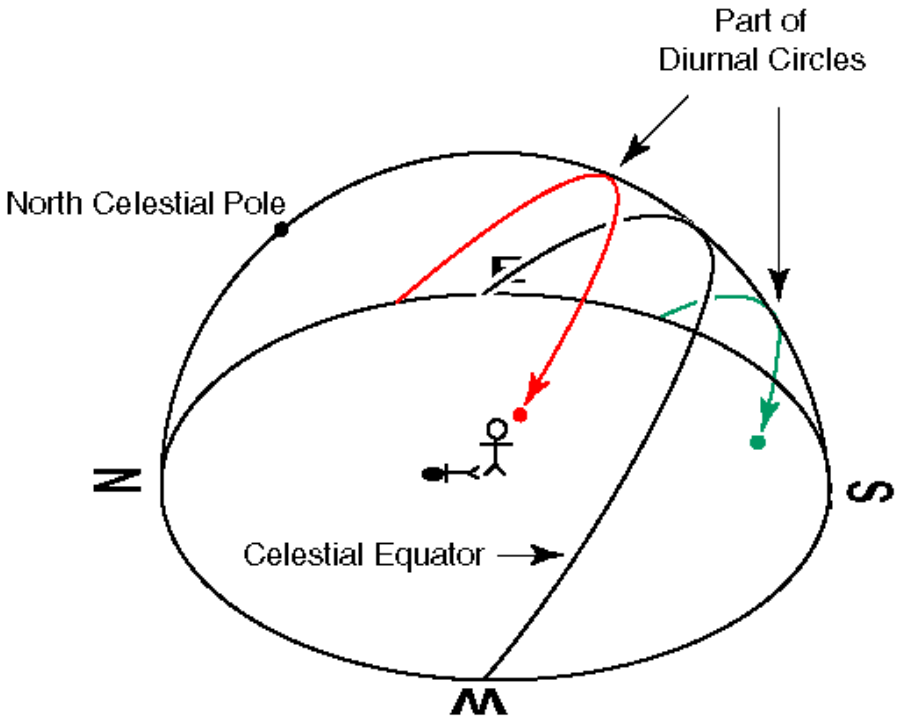
Celestial Equator



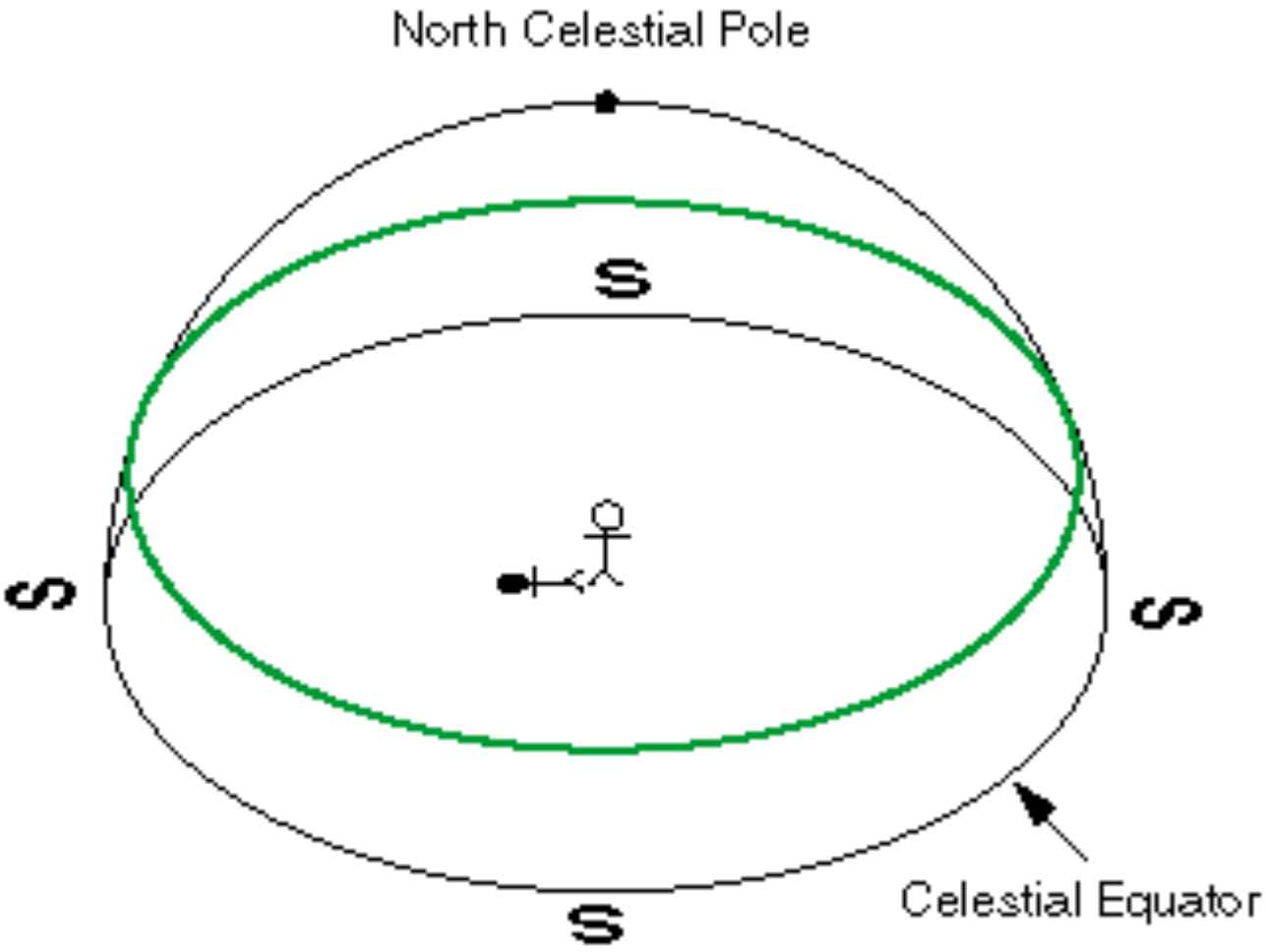


Diurnal Motion

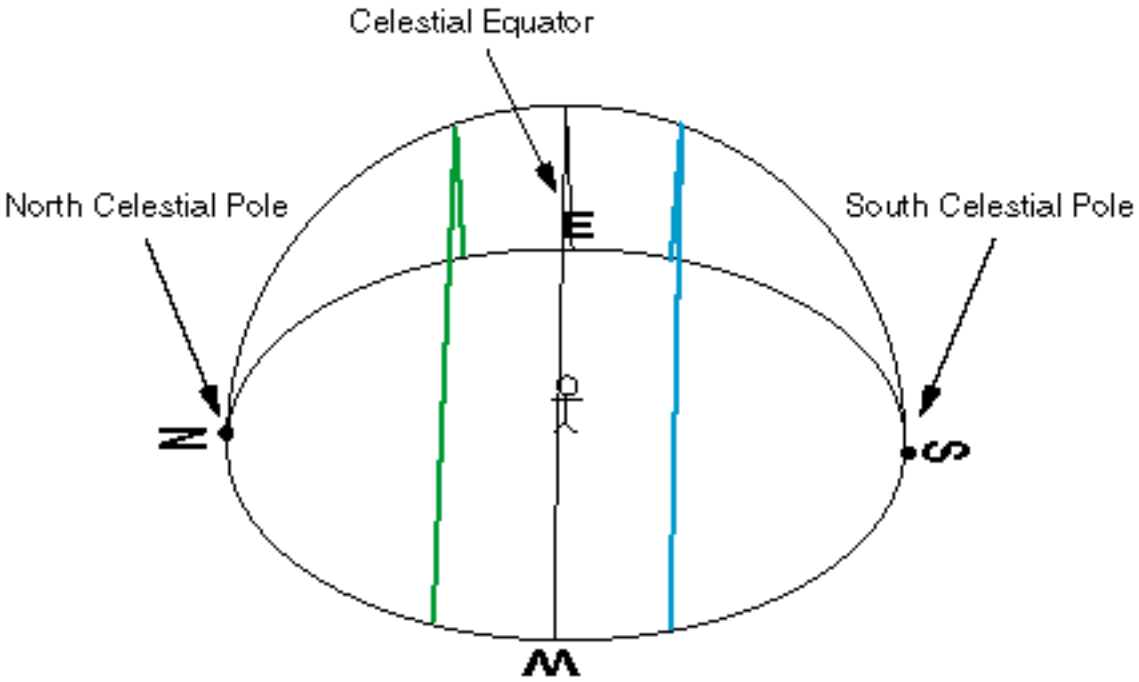




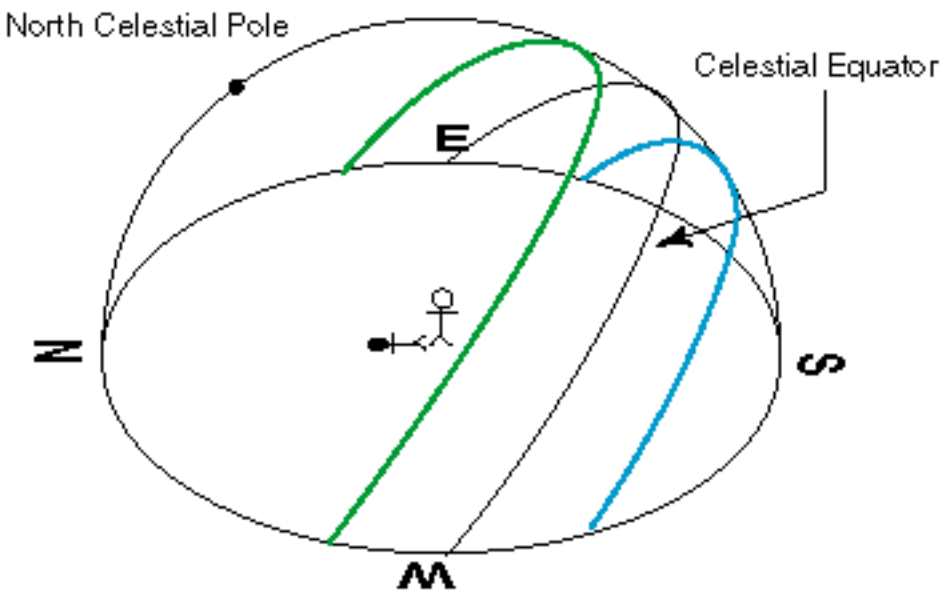
Observer at the pole

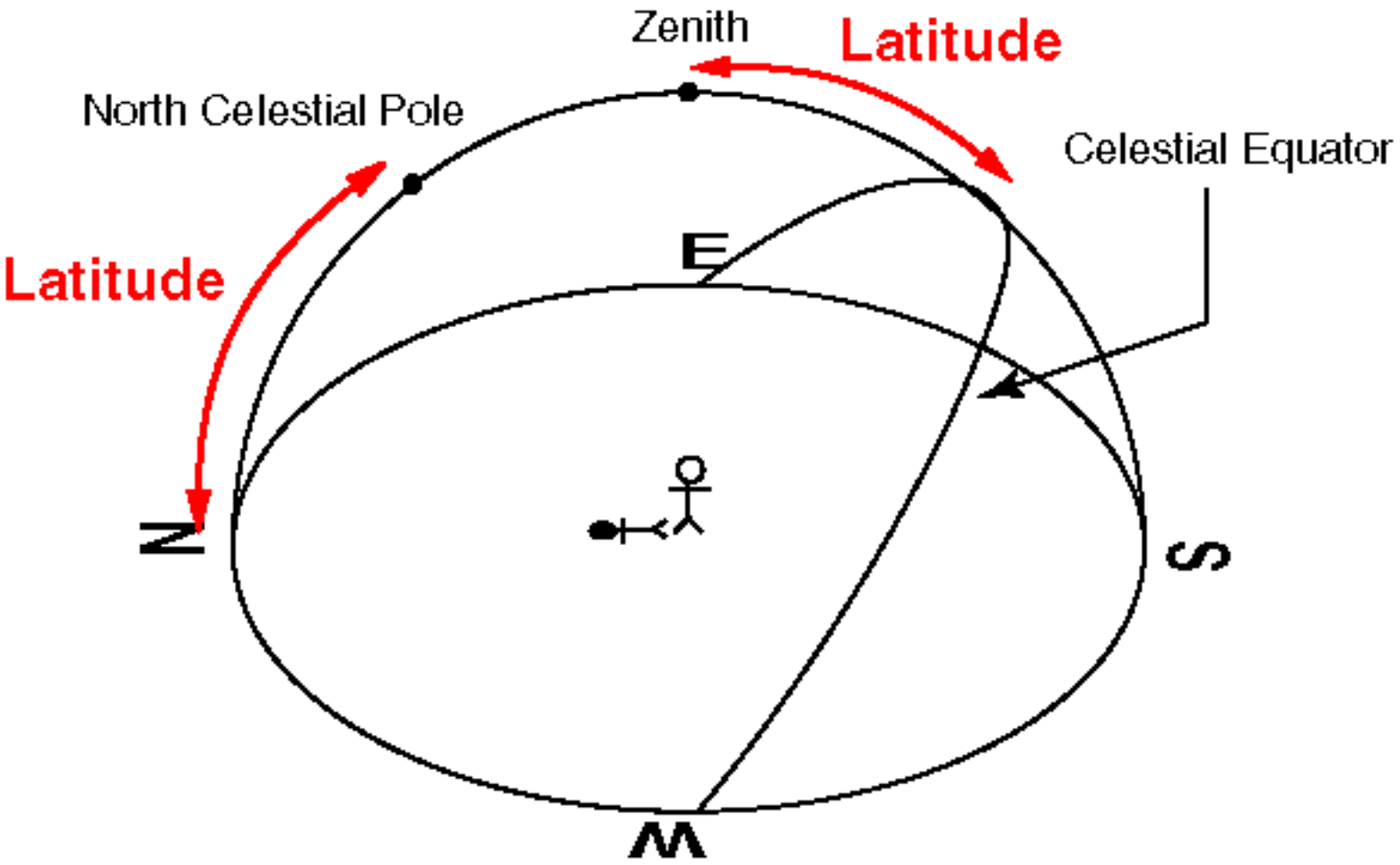


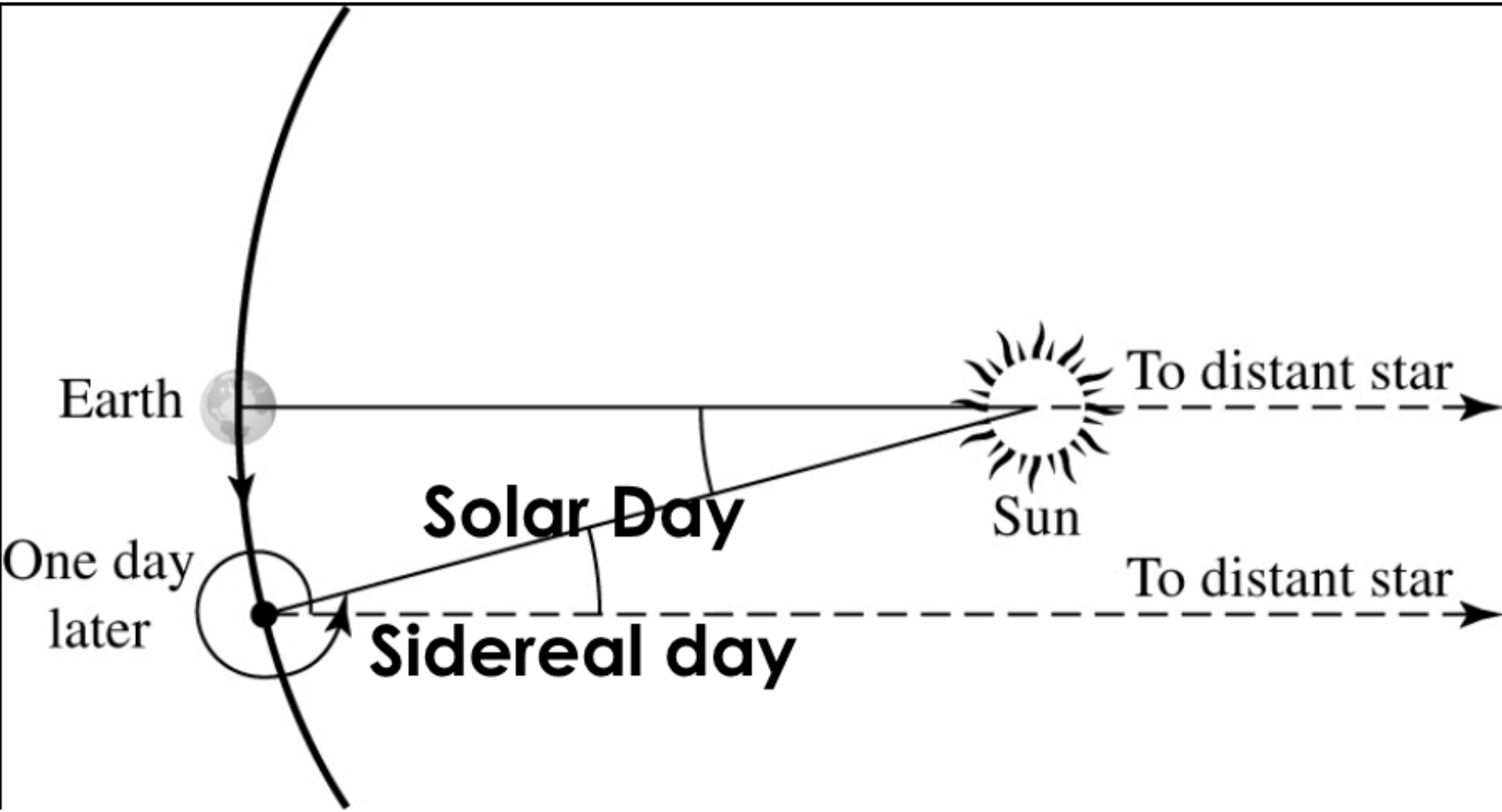
Observer on equator

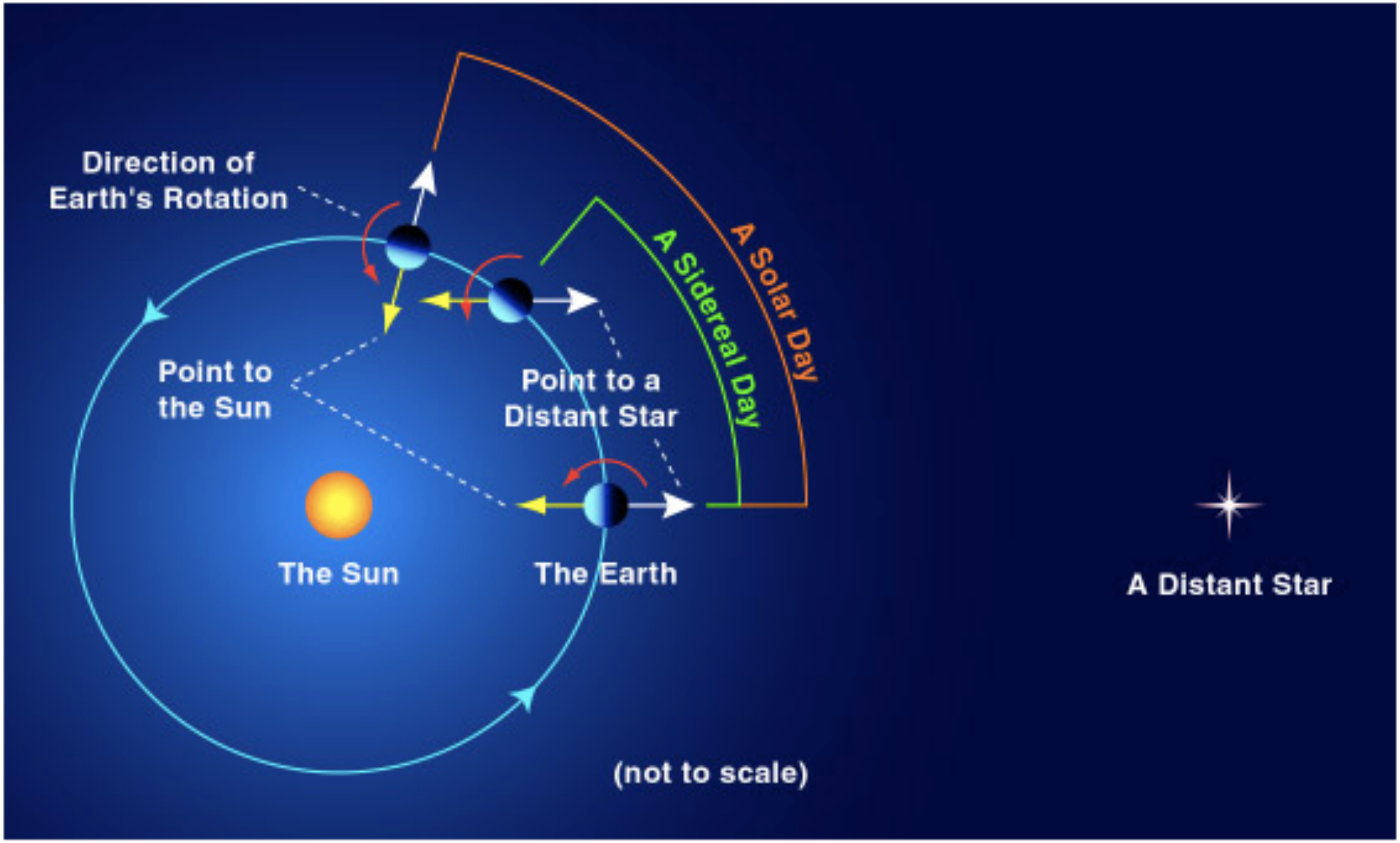


Observer at arbitrary latitude

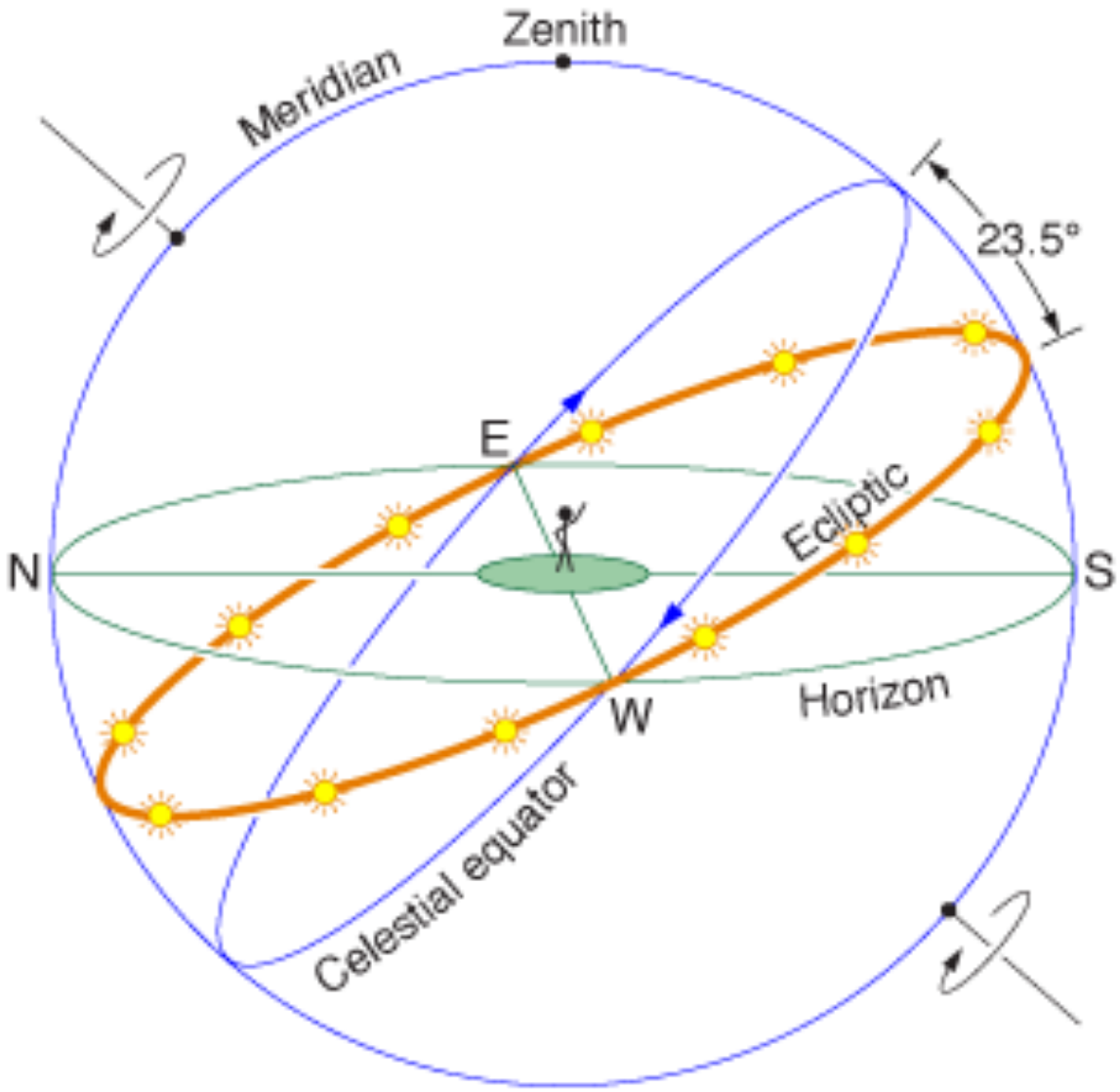



Zenith
Latitude
North Celestial Pole
Celestial Equator
Latitude
E
N
S
W

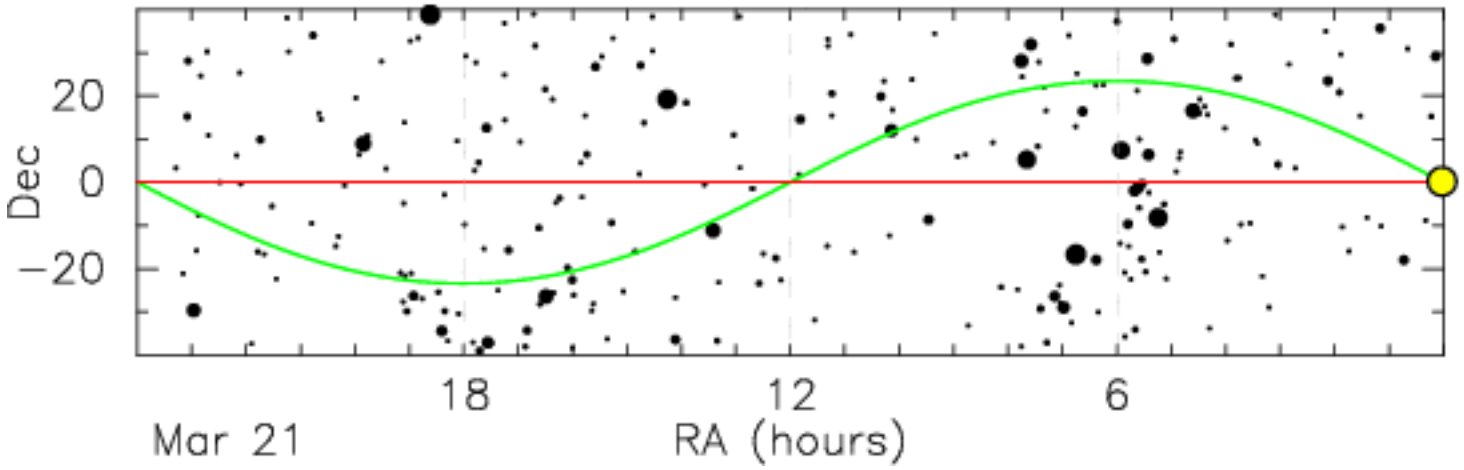

Earth
To distant star
Solar Day
Sun
One day
later
To distant star
Sidereal day


Direction of
Earth's Rotation
A Solar Day
A Sidereal Day
Point to
the Sun
Point to a
Distant Star
The Sun
The Earth
A Distant Star
(not to scale)

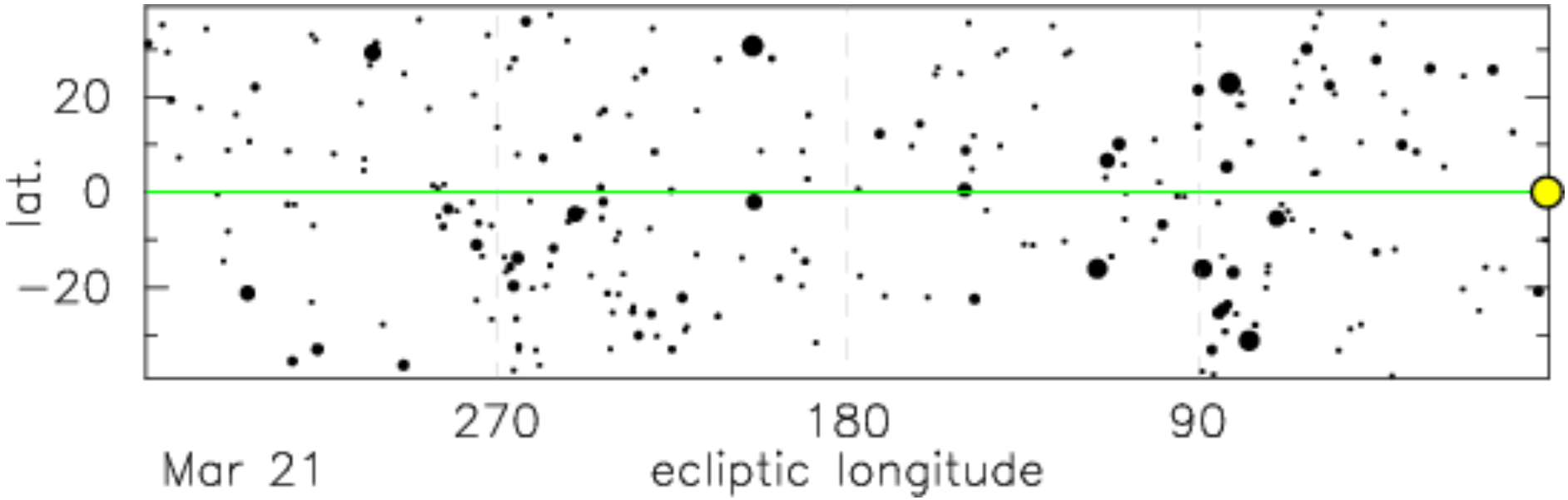
Ecliptic


Zenith
Meridian
23.5°
E
N
S
W
Ecliptic
Horizon
Celestial equator

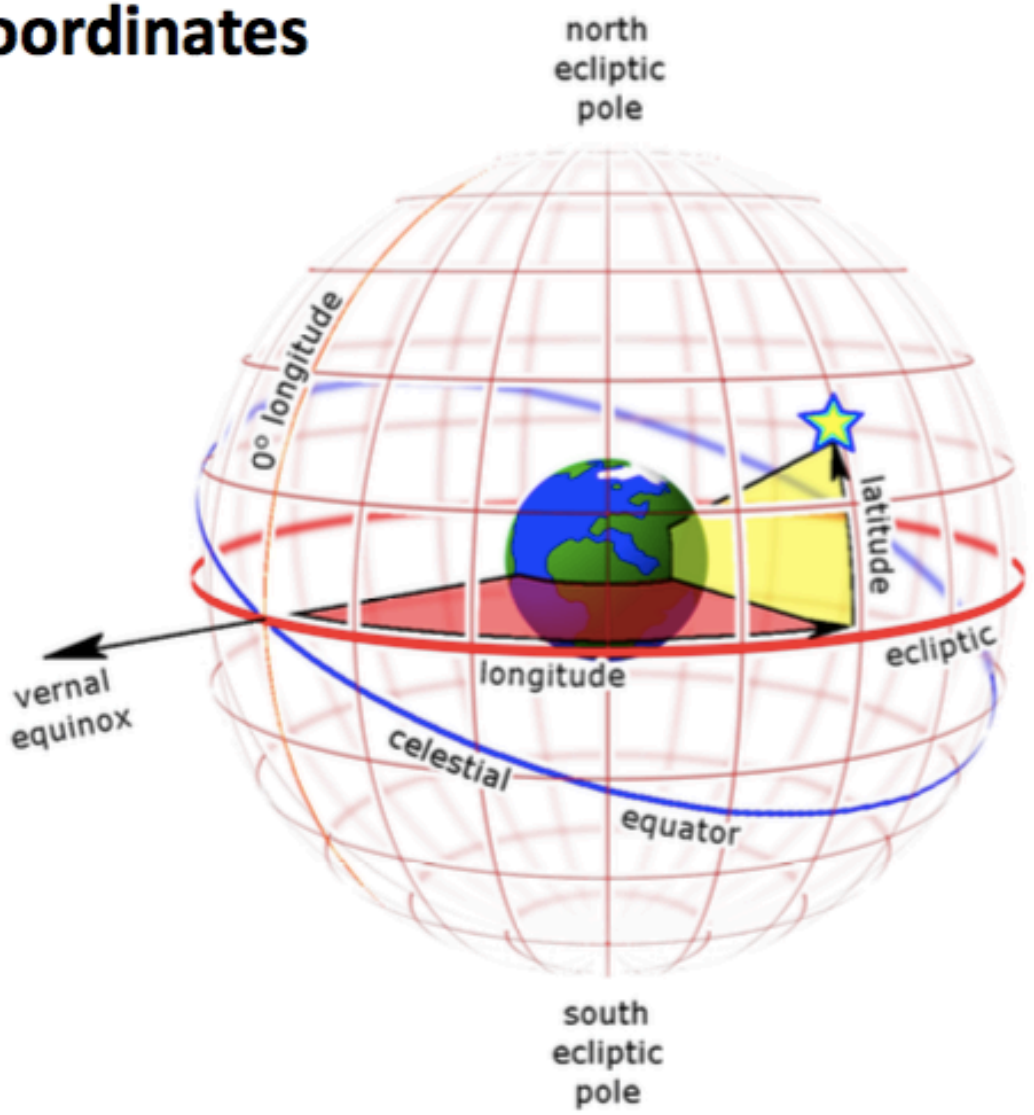
Solar path in Equatorial Coordinates



Solar path in Ecliptic coordinates

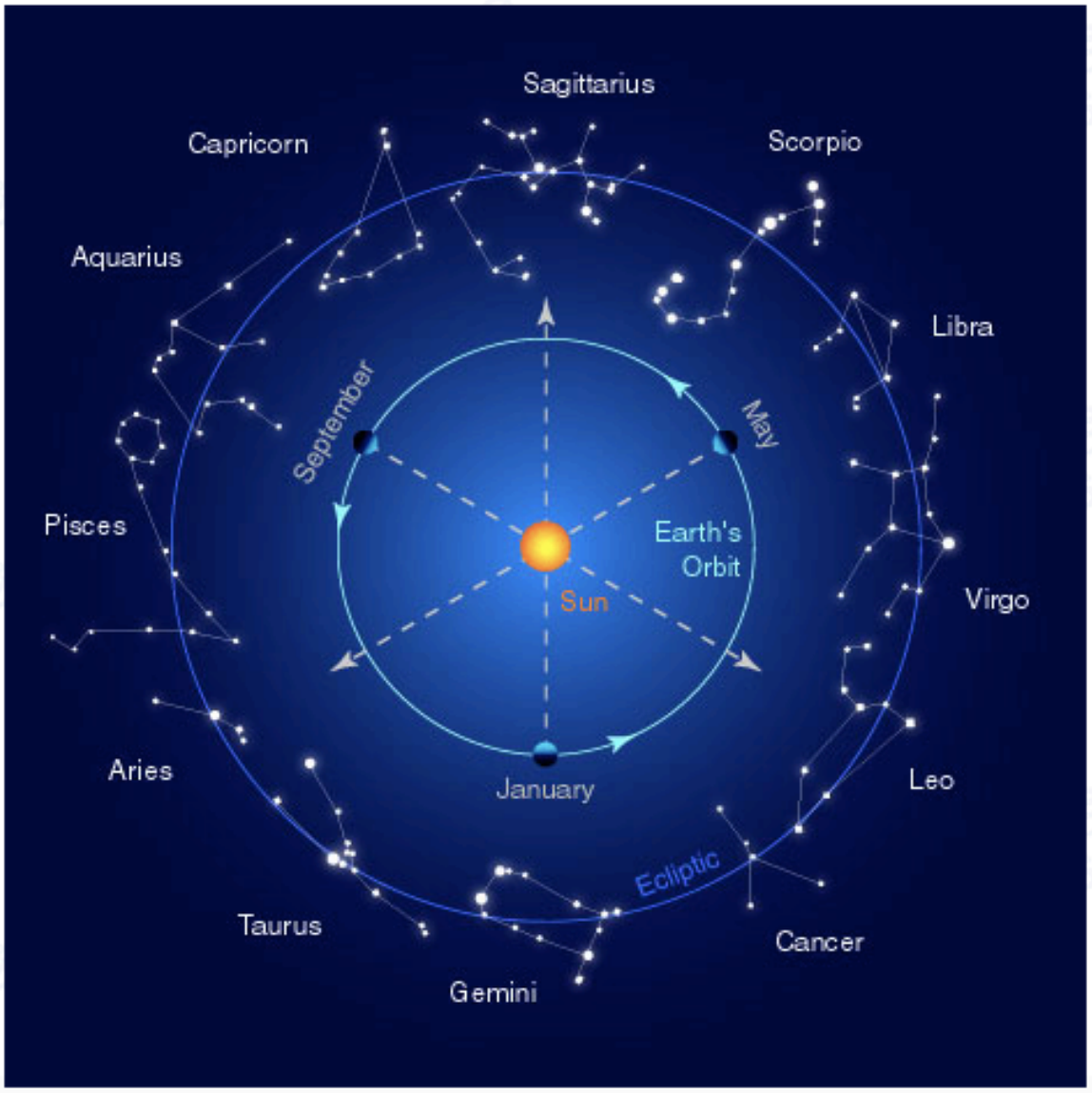


Ecliptic coordinates

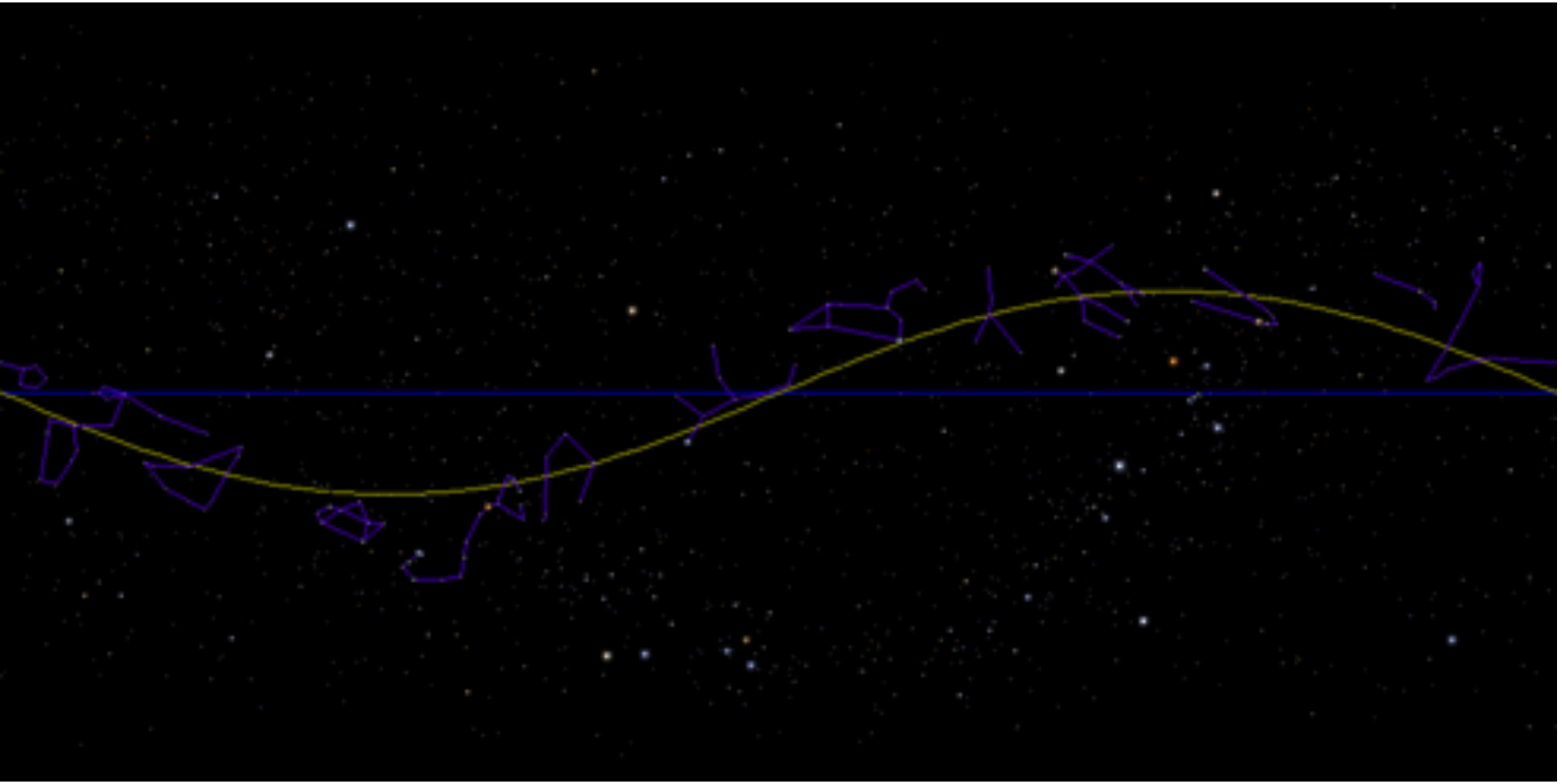


https://en.wikipedia.org/wiki/Ecliptic_coordinate_system

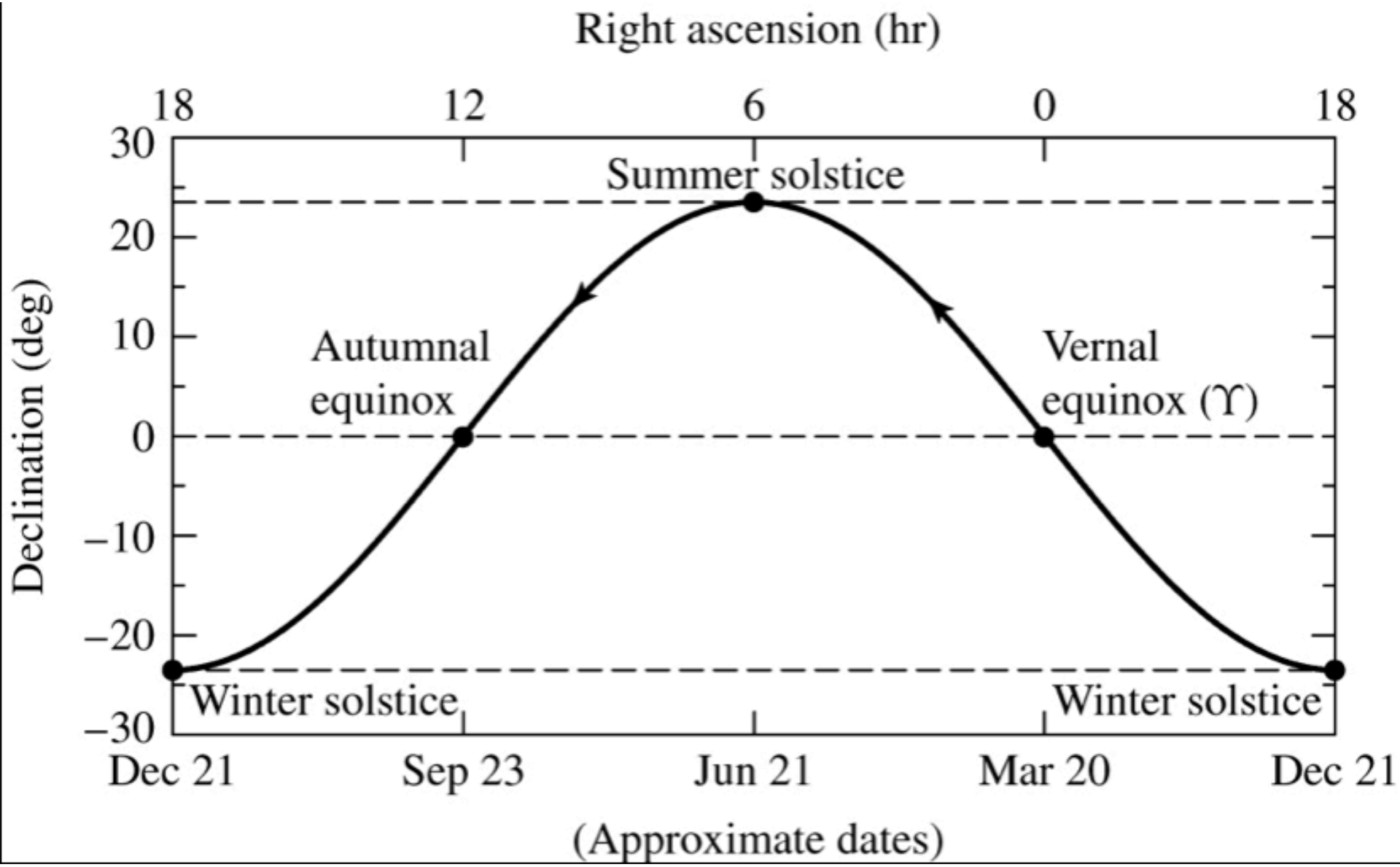
The Zodiac : Constellations arbitrarily defined on the Ecliptic



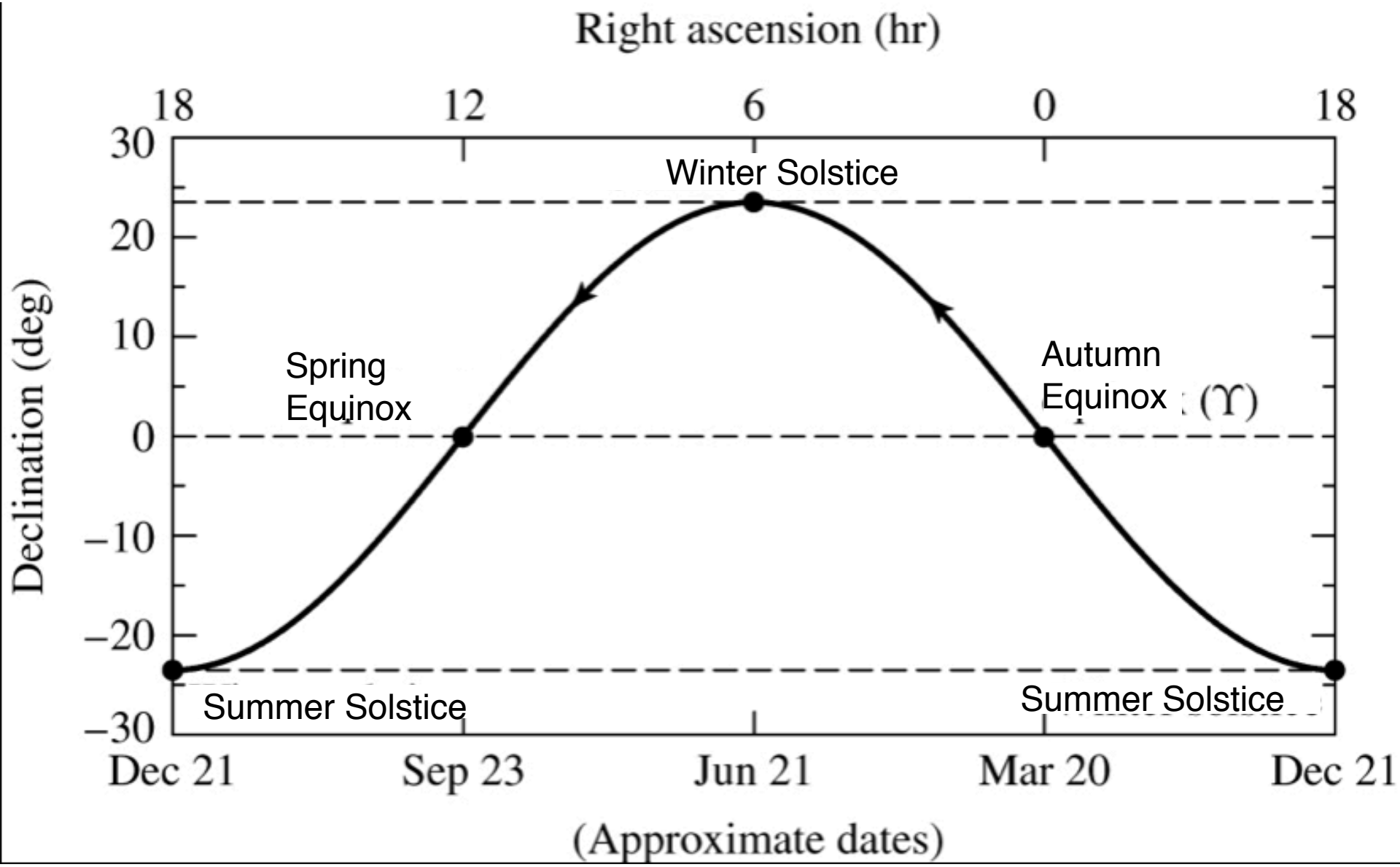
Ecliptic



Northern Hemisphere Seasons



Southern Hemisphere Seasons



N.M.S.U. Astronomy Department: Cumulative Exam #299

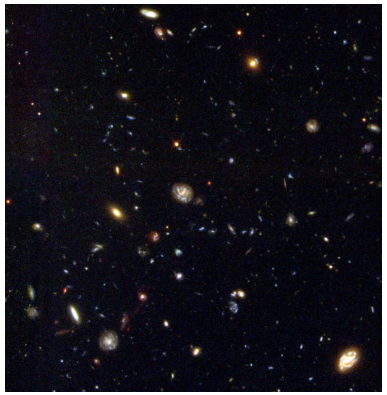
24^{th} April, 2004

Paper: *The Las Campanas Infrared Survey: Early-Type Galaxy Progenitors Beyond $z = 1$*, P. J. McCarthy et al. 2001, ApJ, 560, 131.

1. (a) **At midnight on November 12, one of the four target fields lay overhead at Las Campanas. What is its right ascension and its declination? (5 pts)**

For style points and extra respect: name the field.

Hubble Deep Field South

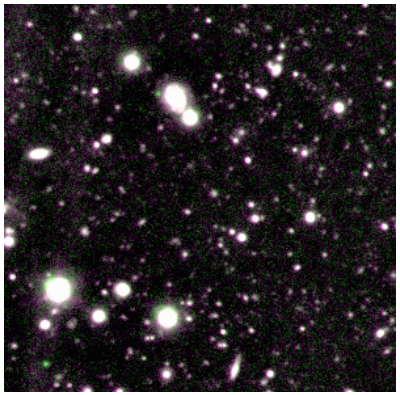


$\alpha = 22^h\ 33^m$
$\delta = -60°\ 33'$

Chandra Deep Field South

$\alpha = 3^h\ 32^m$
$\delta = -27°\ 48'$

SSA 22



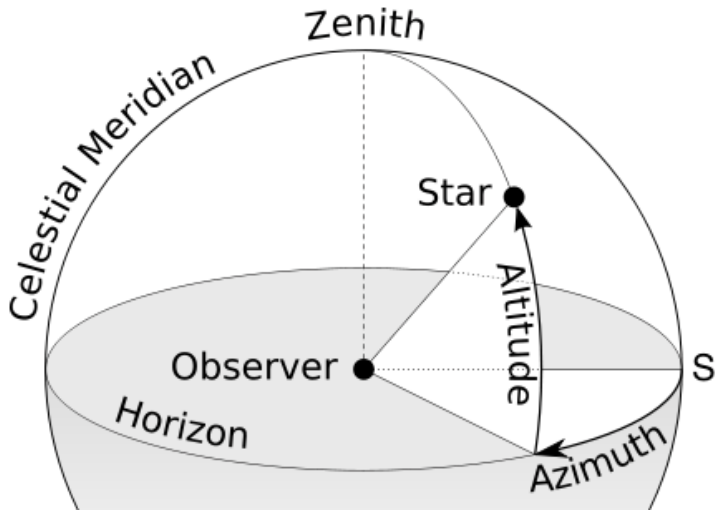
$\alpha = 22^h\ 17^m$
$\delta = +00°\ 15'$

NTT Deep Field

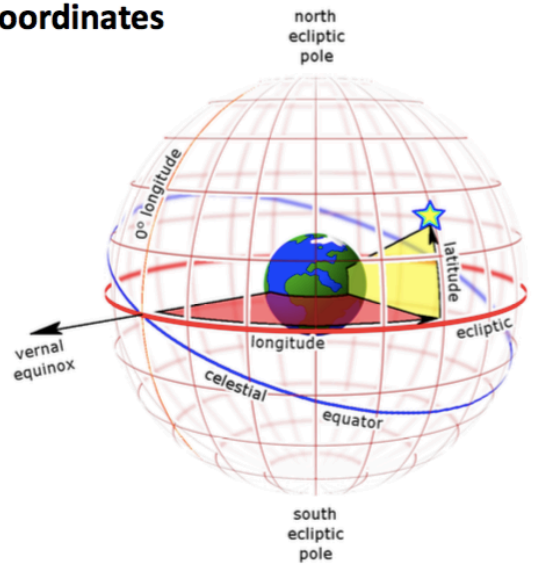
$\alpha = 12^h\ 05^m$
$\delta = -07°\ 44'$

Coordinate Systems

Horizontal Coordinates

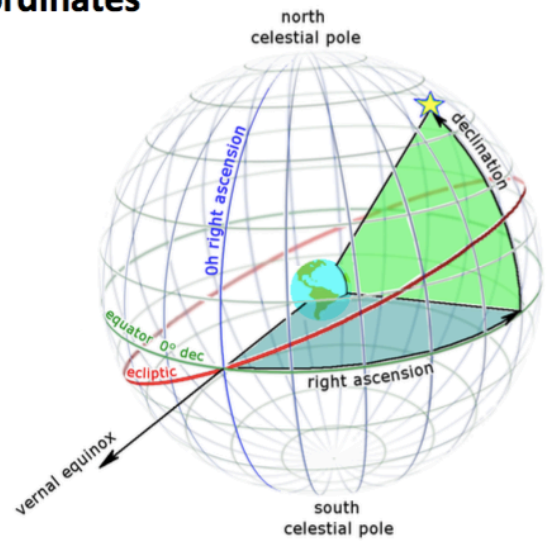


Ecliptic coordinates



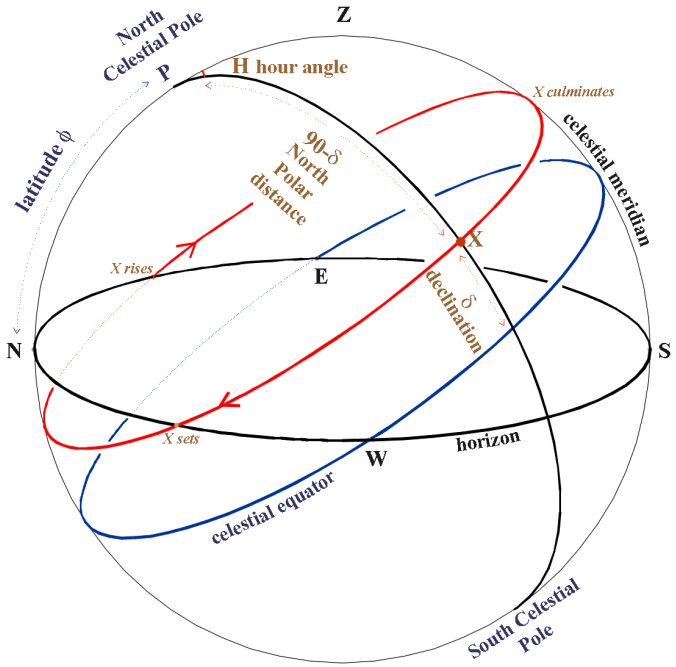
g/wiki/Ecliptic_coordinate_system

Equatorial coordinates

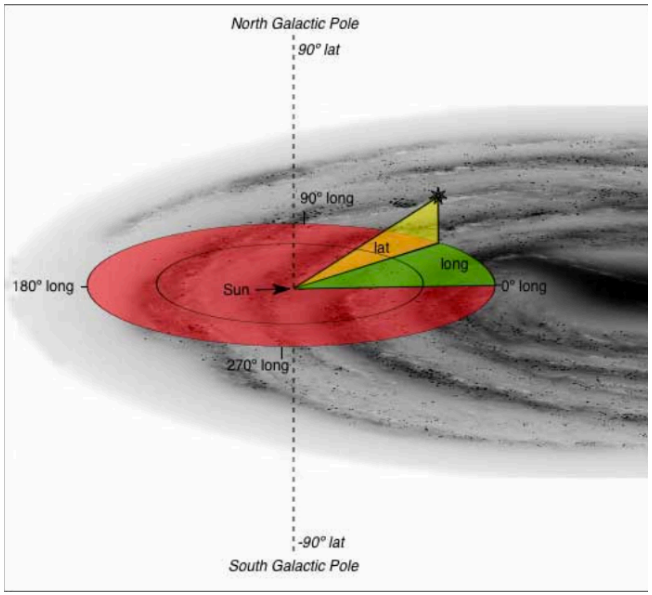


Coordinate Systems

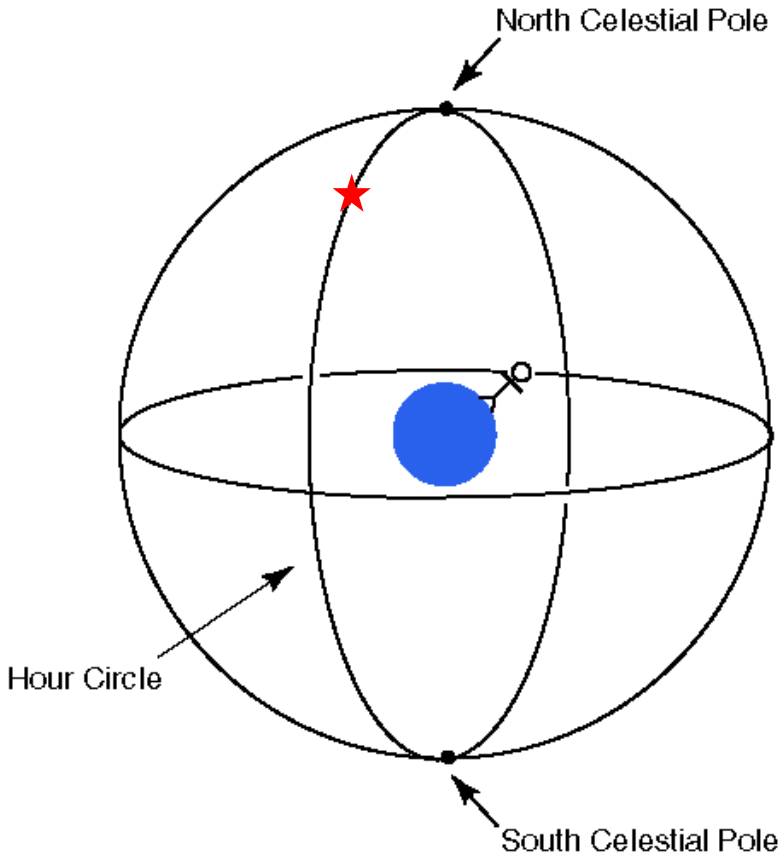
Hour coordinates

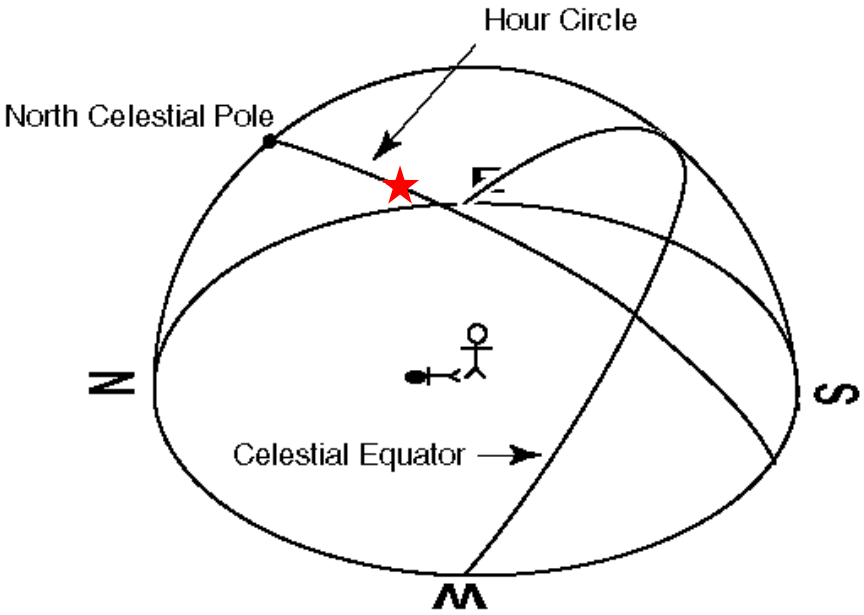


Galactic coordinates

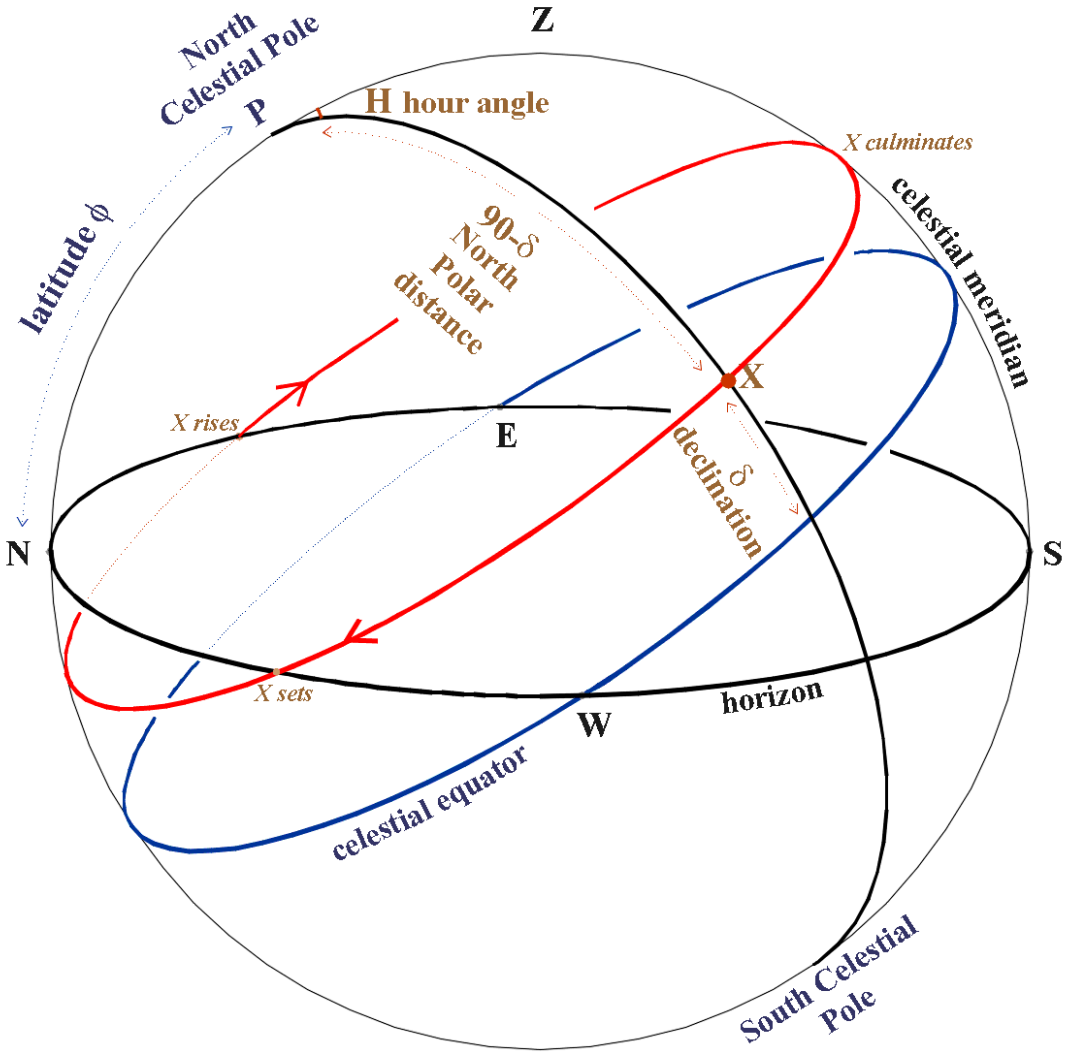


Hour Circle

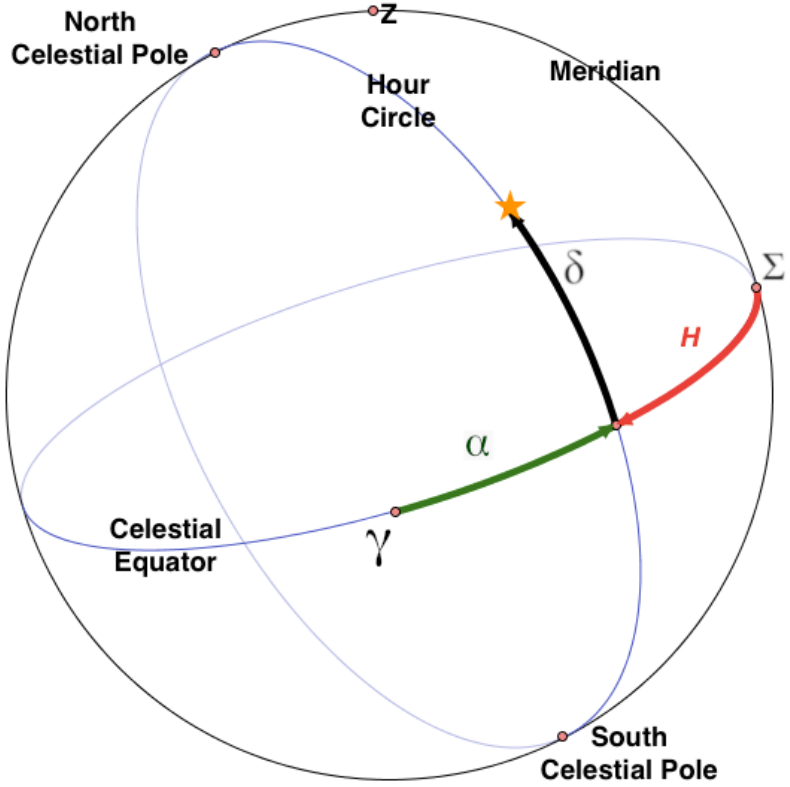

North Celestial Pole
Hour Circle
South Celestial Pole

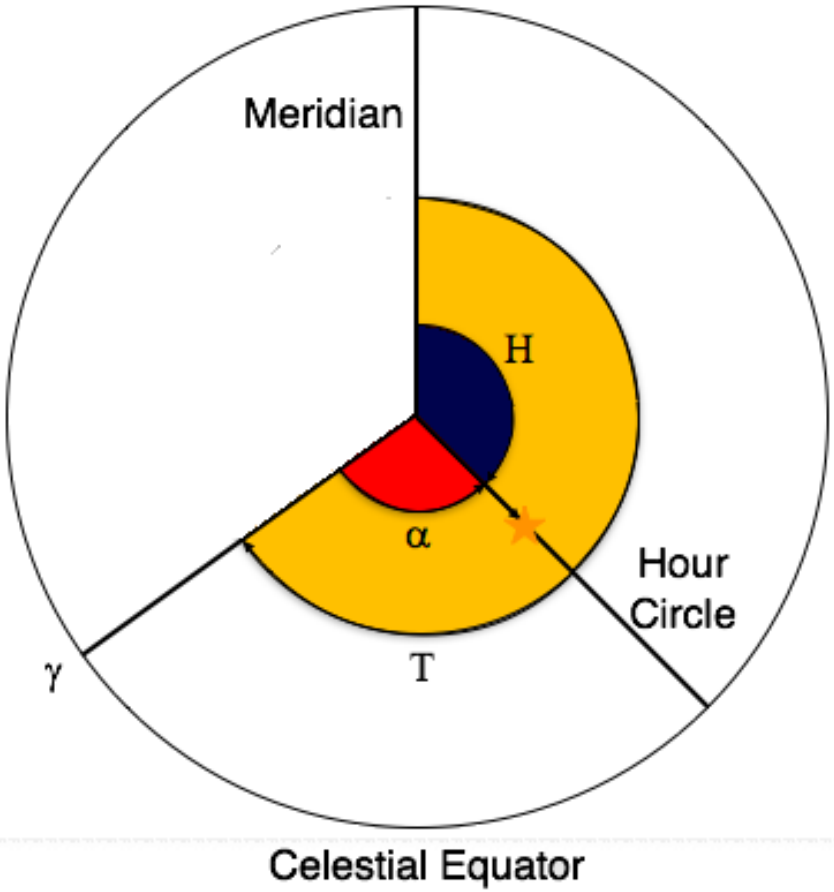

Hour Circle
North Celestial Pole
N
S
Celestial Equator

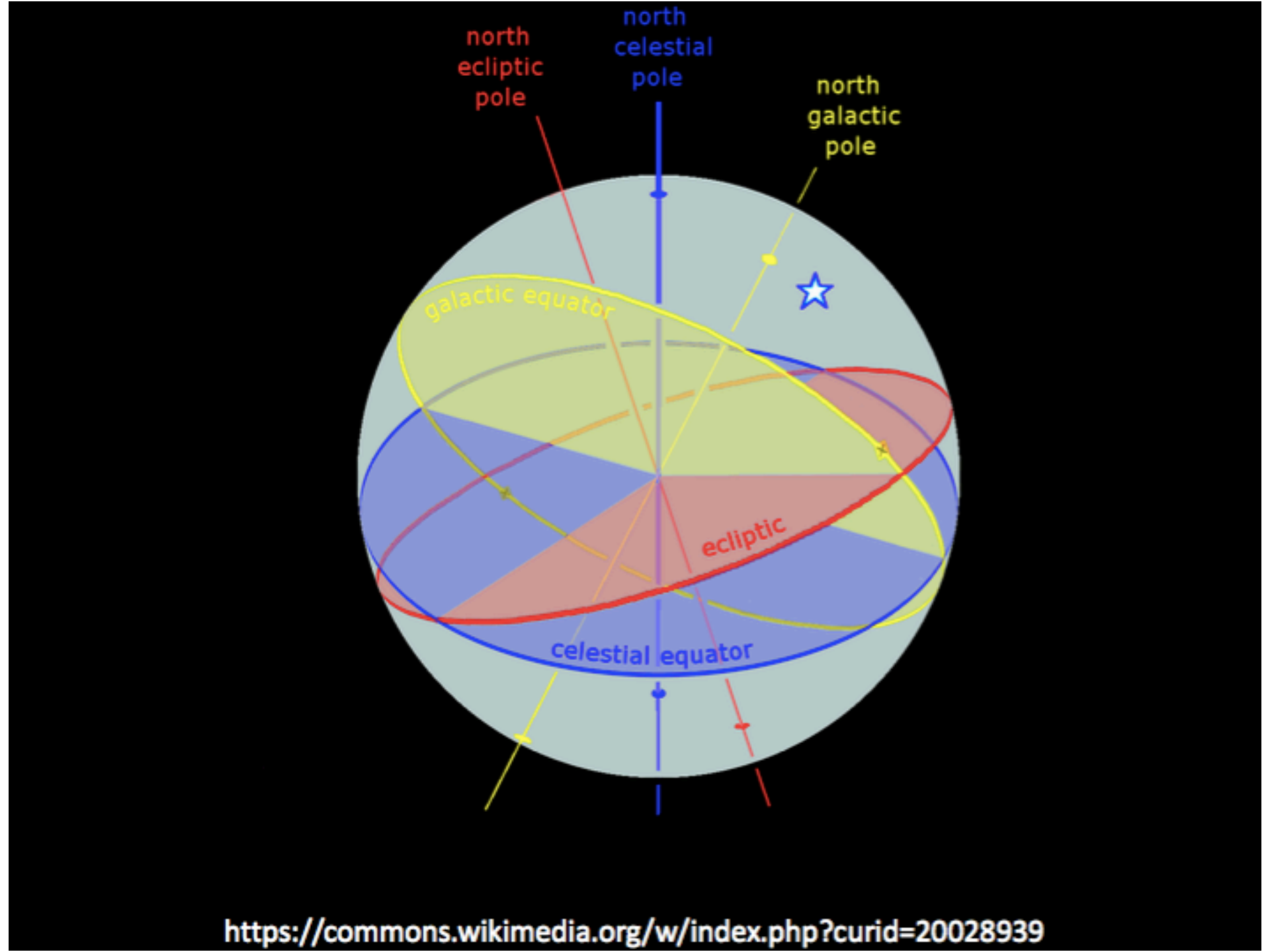
Hour Coordinates



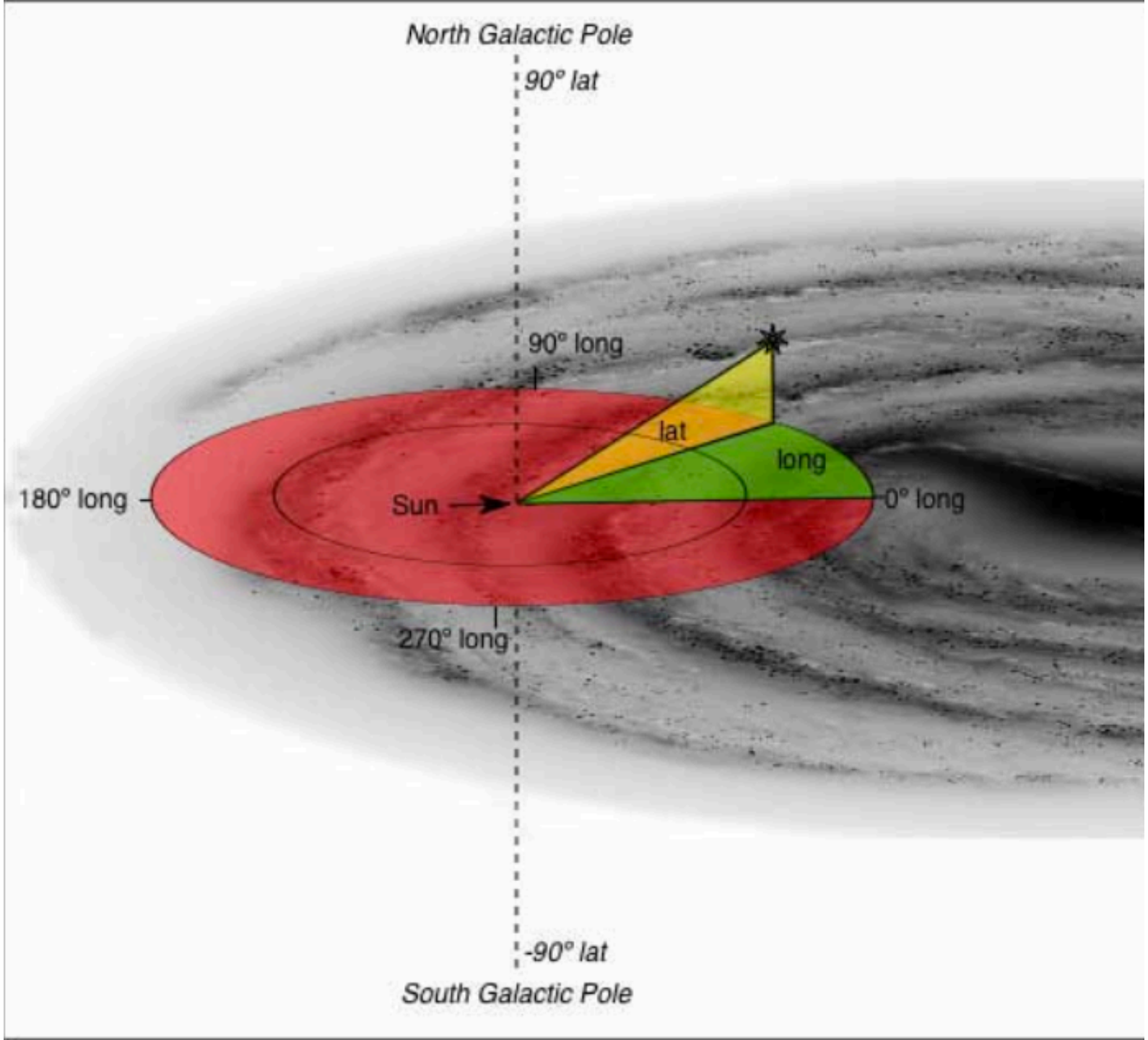
Local Sidereal Time



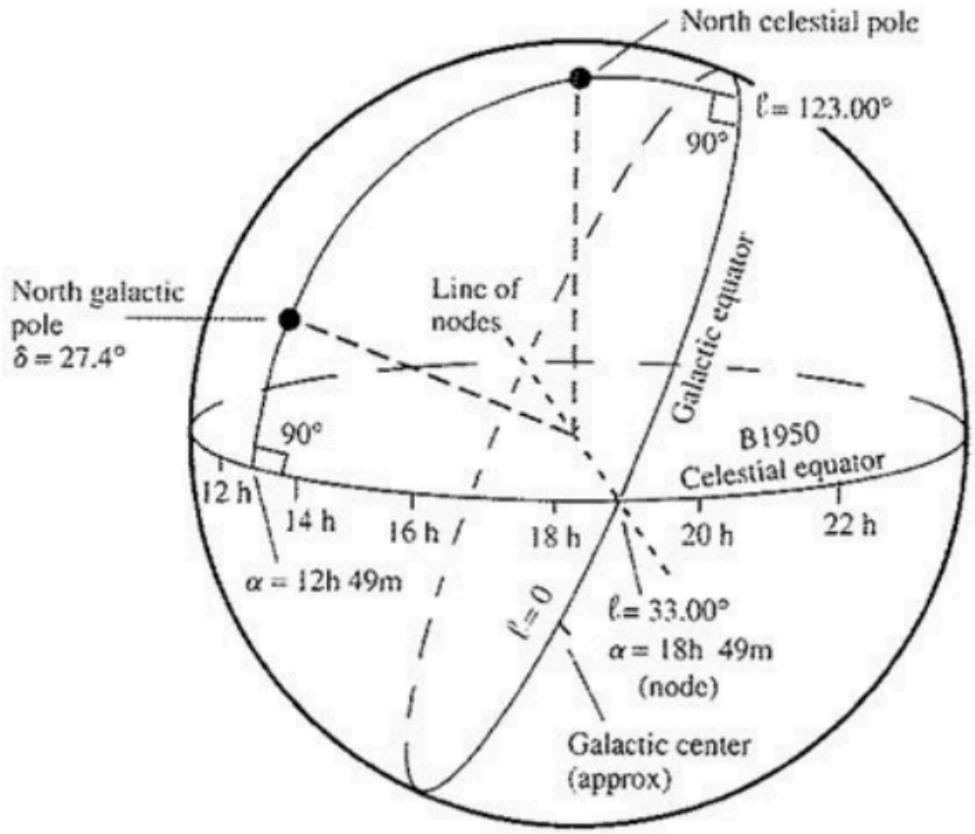


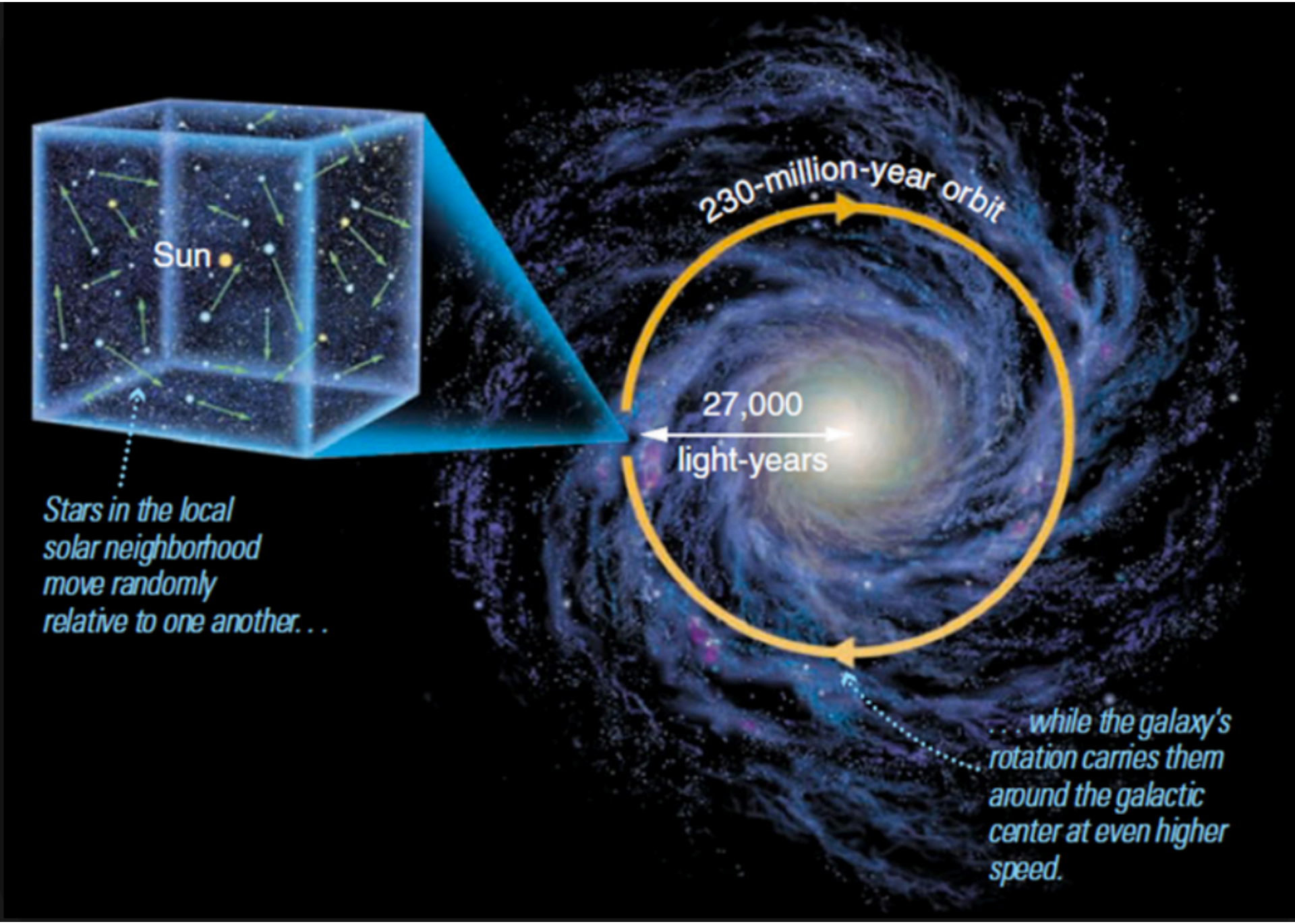


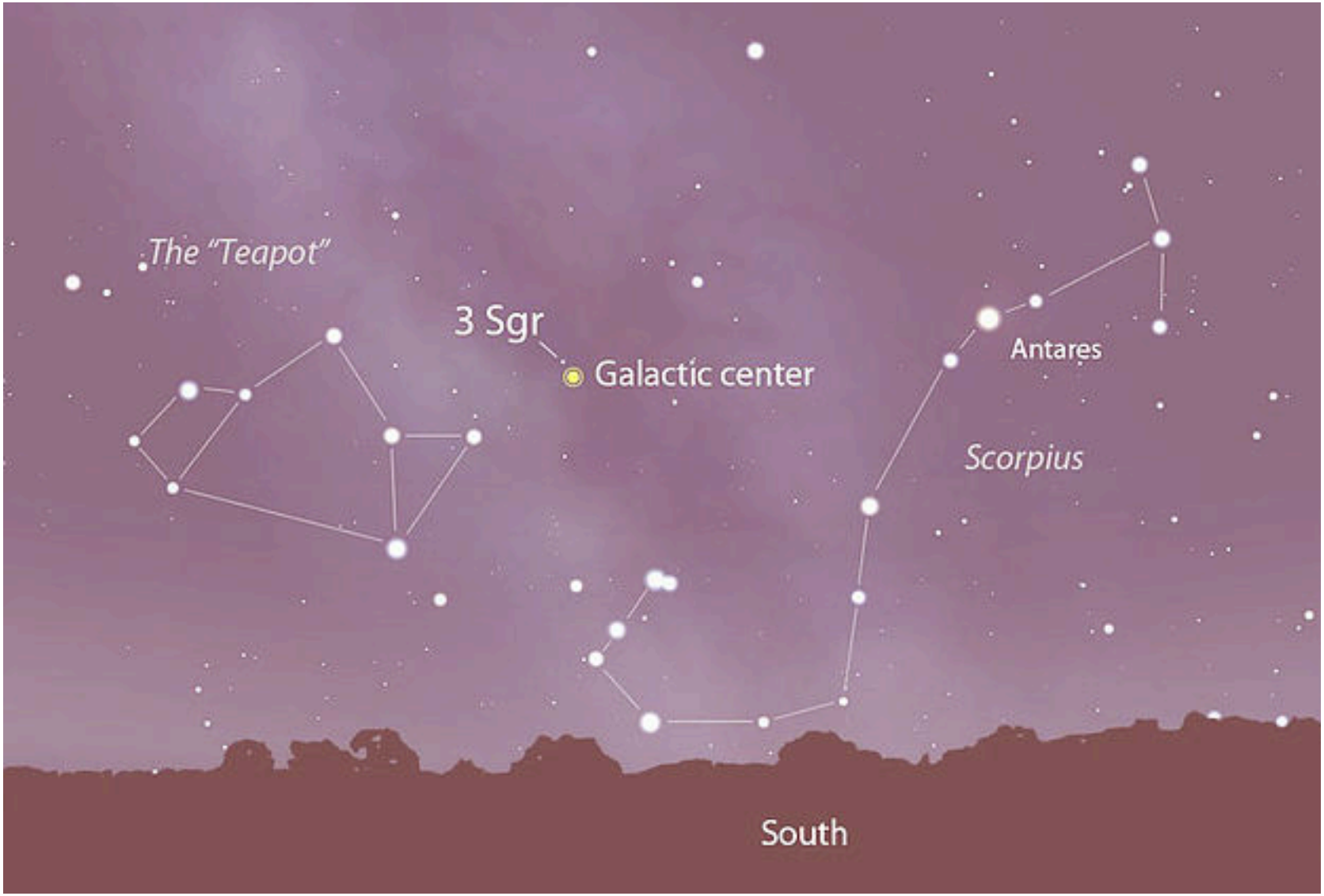
https://commons.wikimedia.org/w/index.php?curid=20028939

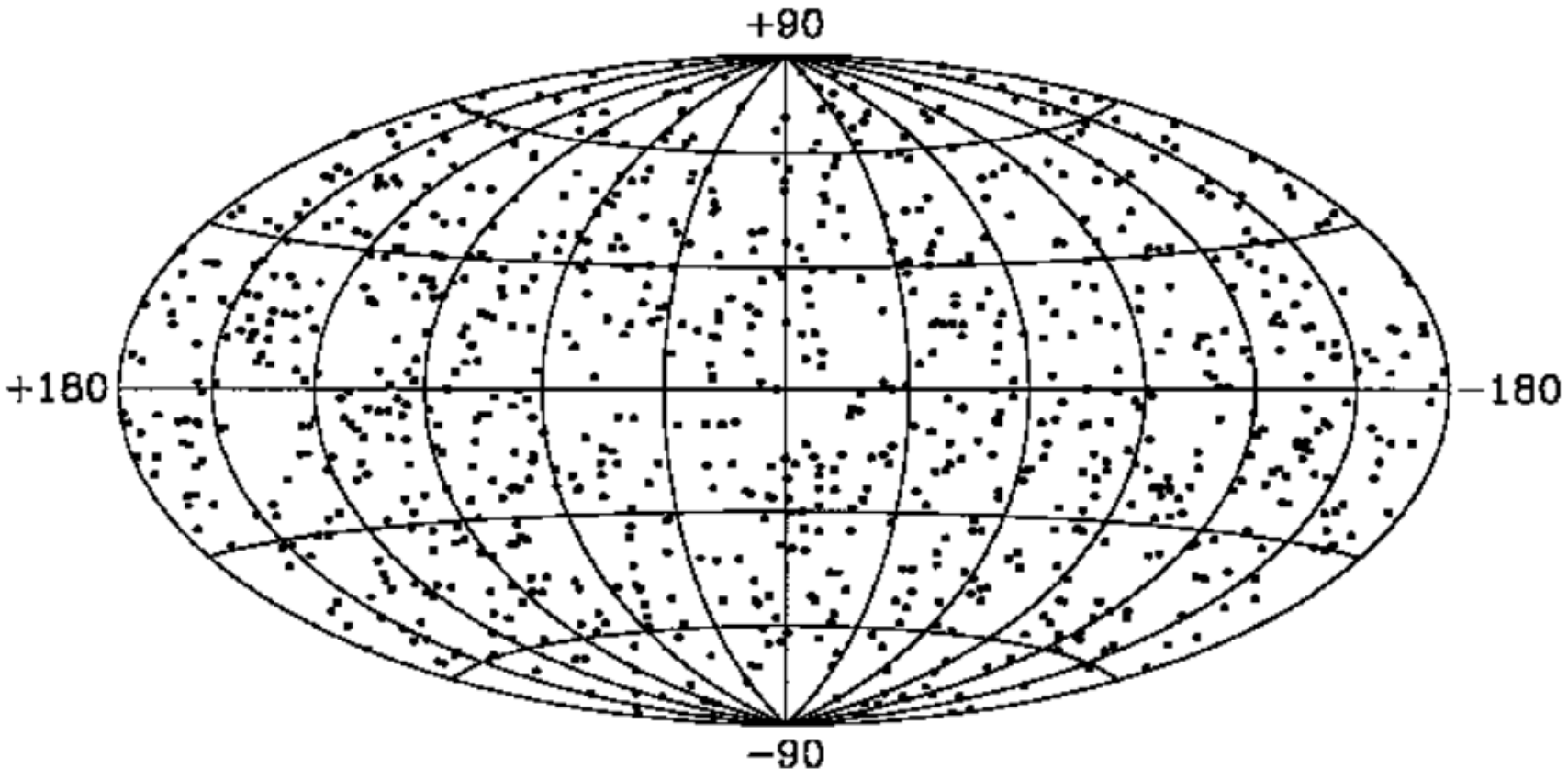

North Galactic Pole
90° lat
90° long
lat
long
180° long
Sun
0° long
270° long
-90° lat
South Galactic Pole

Galactic coordinates - elements

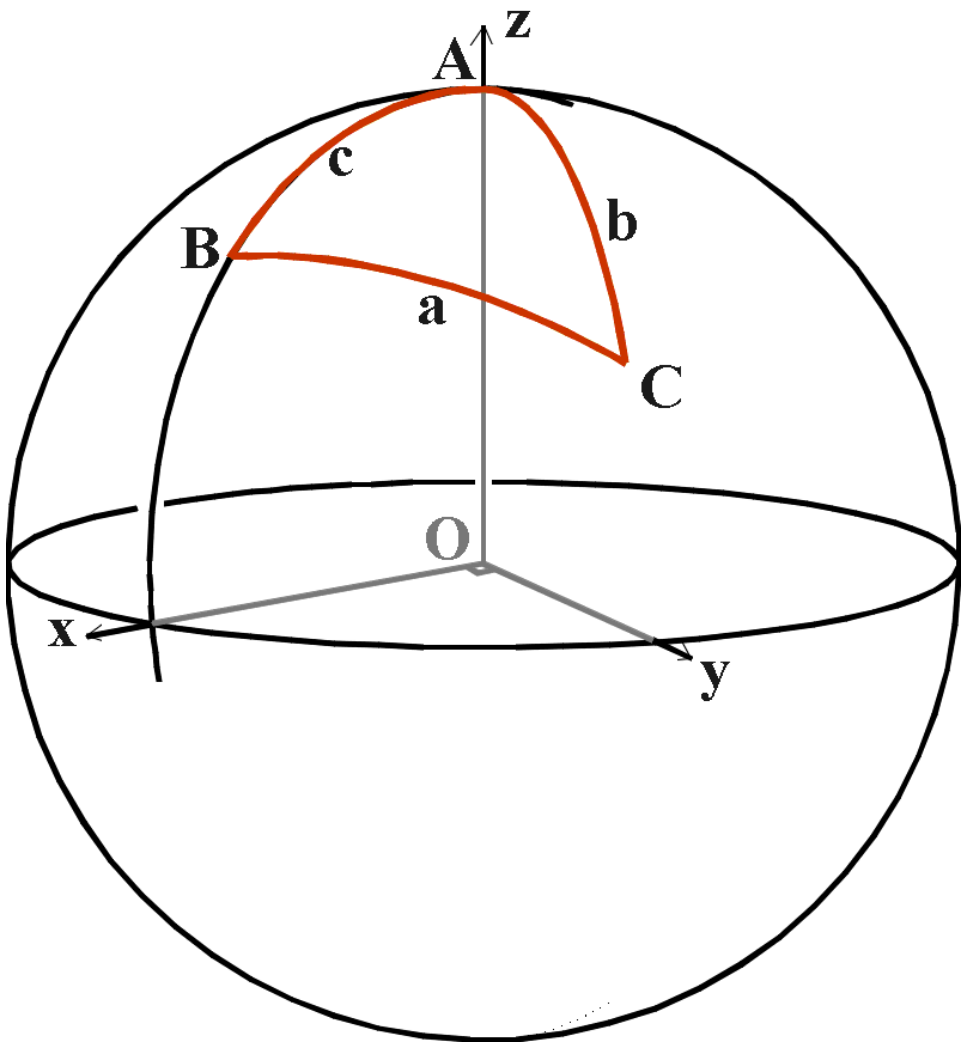


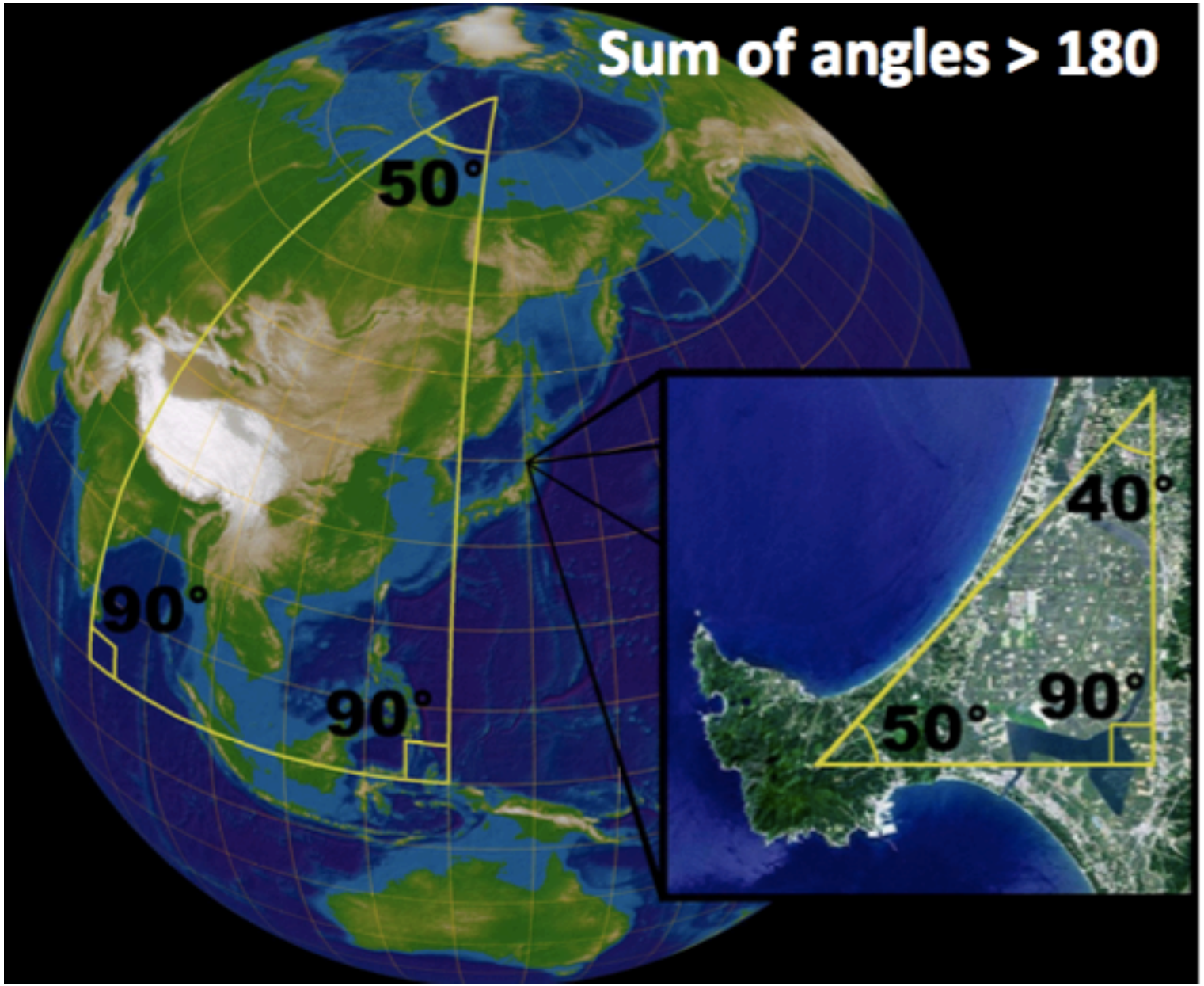

Sun
230-million-year orbit
27,000
light-years
Stars in the local solar neighborhood move randomly relative to one another. . .
. . . while the galaxy's rotation carries them around the galactic center at even higher speed.

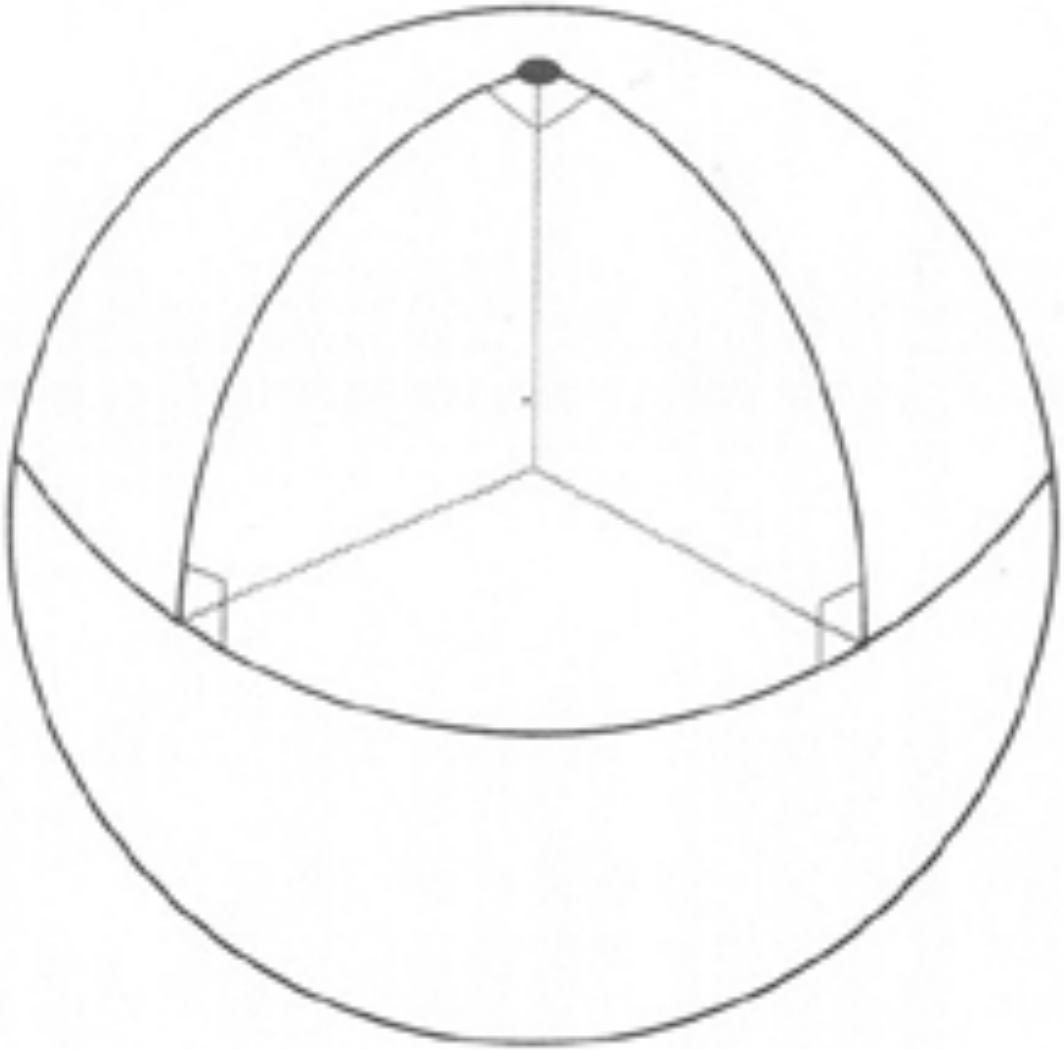

The "Teapot"
3 Sgr
Galactic center
Antares
Scorpius
South

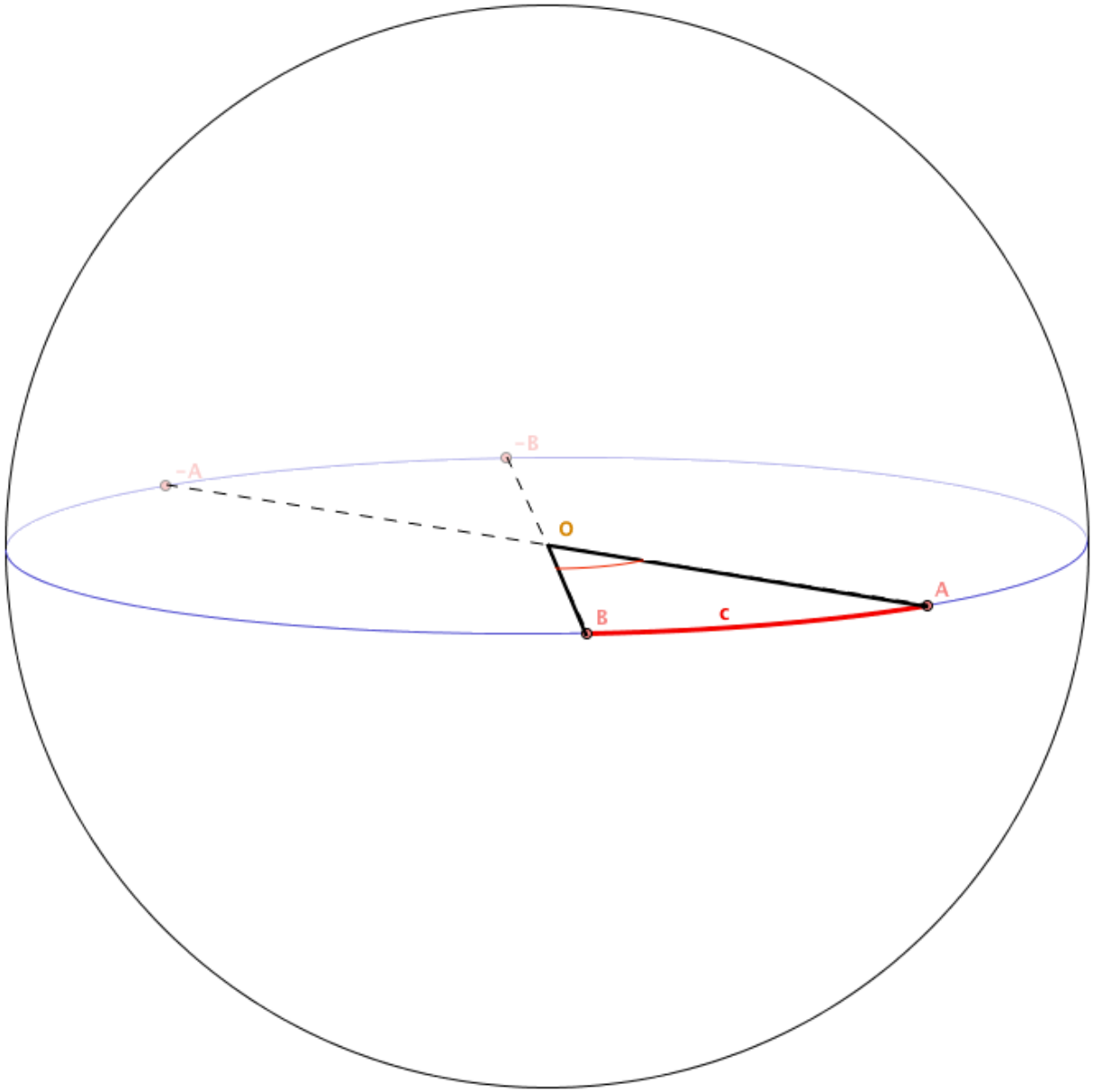

921 BATSE Gamma-Ray Bursts
+90
+180
-180
-90
Galactic Coordinates

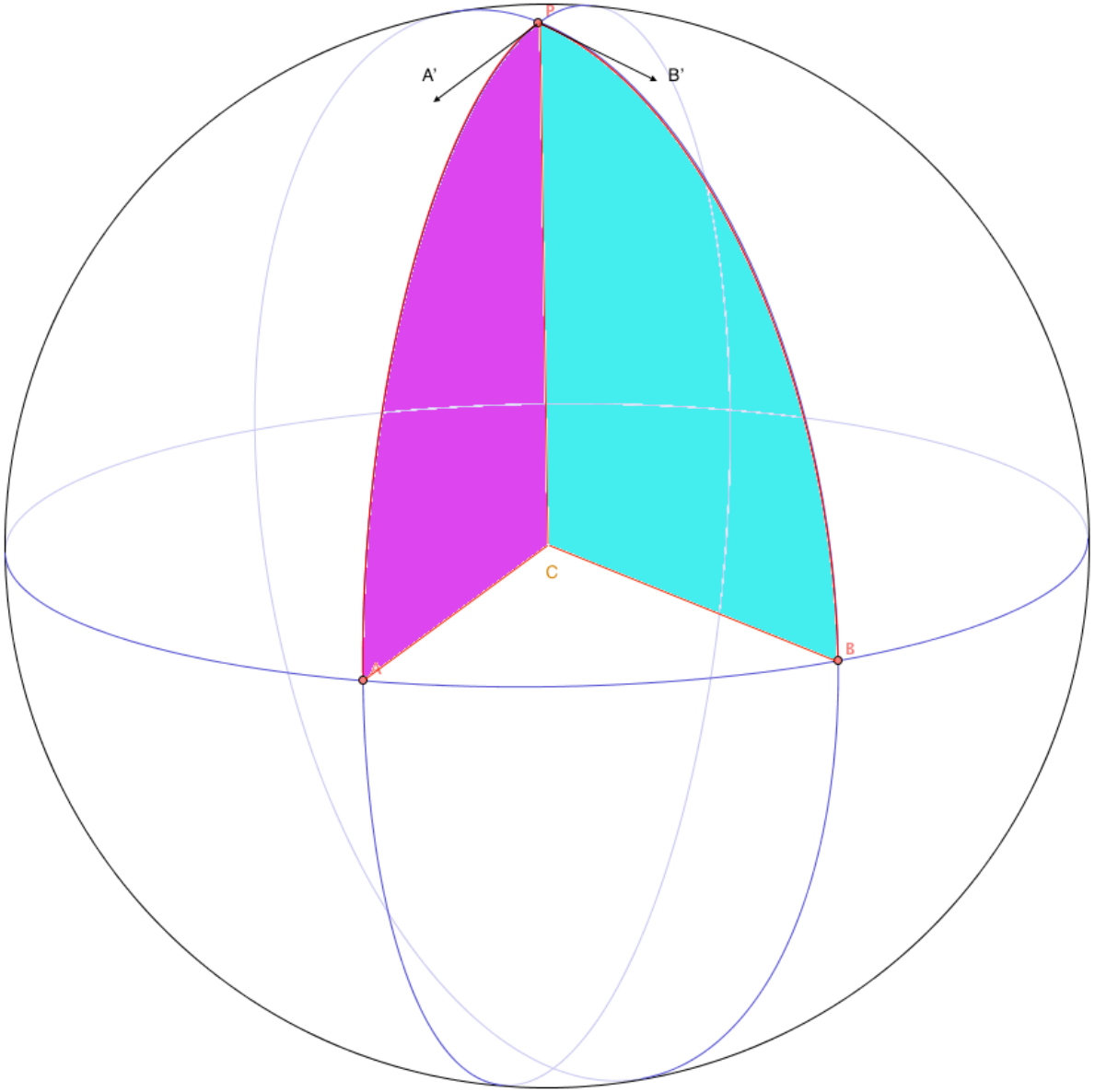
The Spherical Triangle

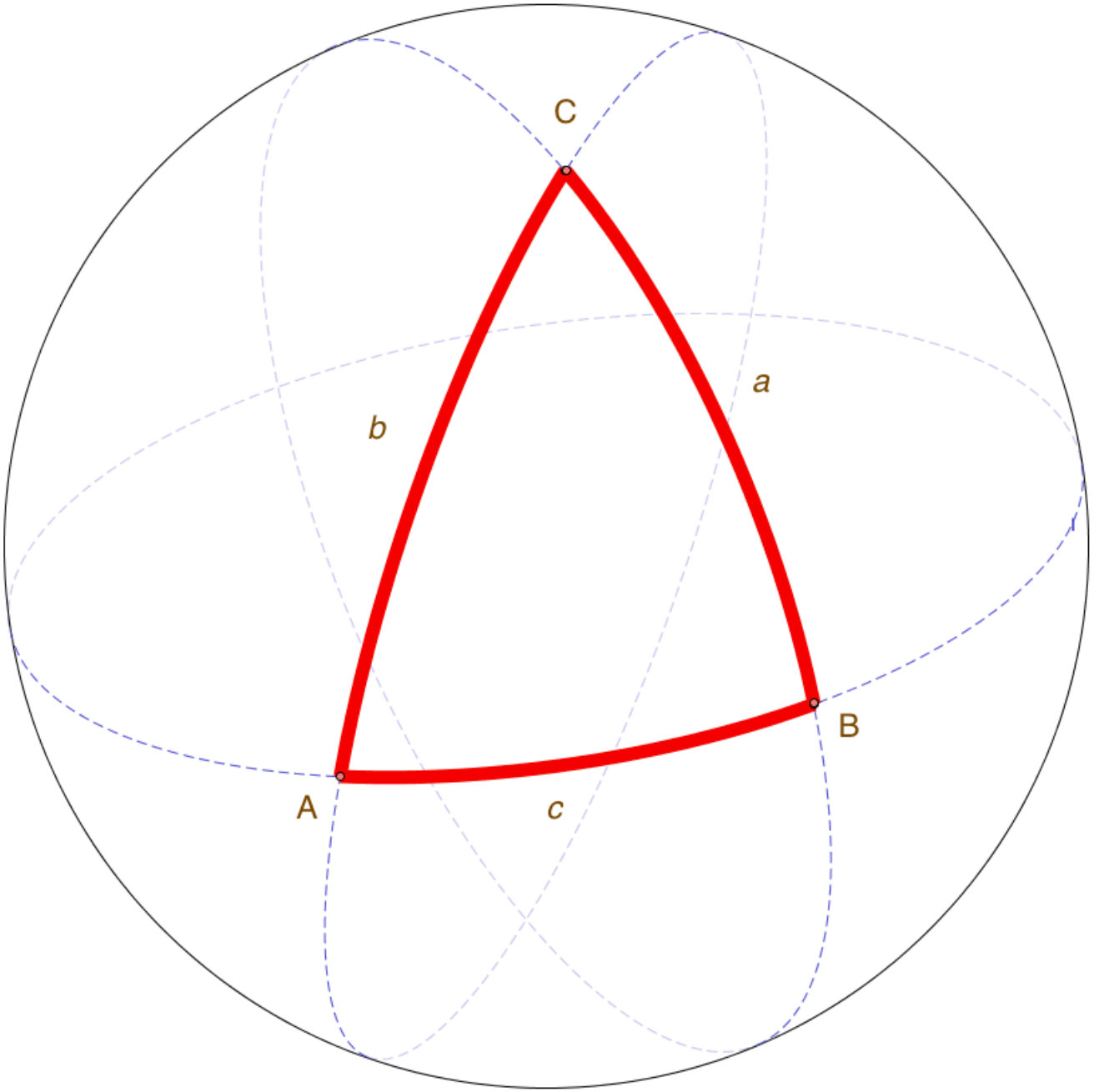


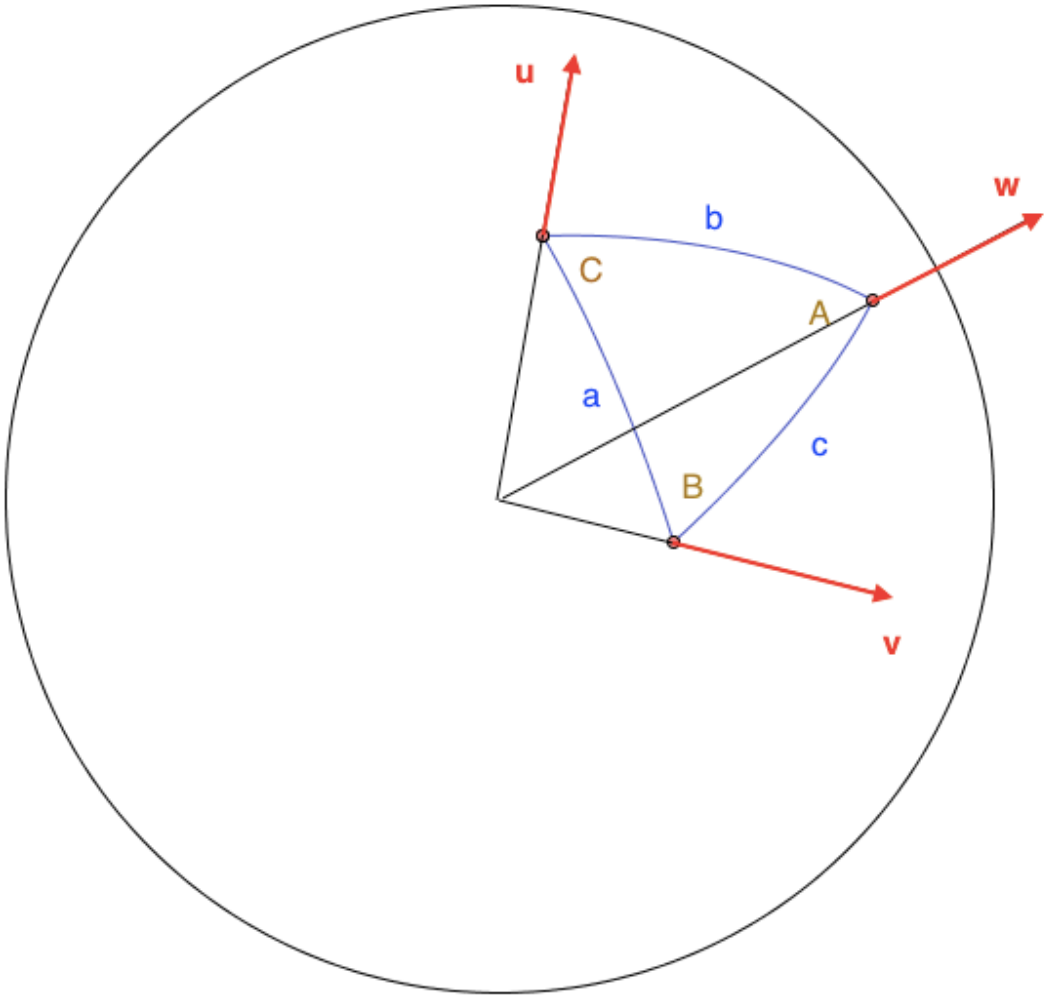

Sum of angles > 180
50°
90°
90°
40°
50°
90°

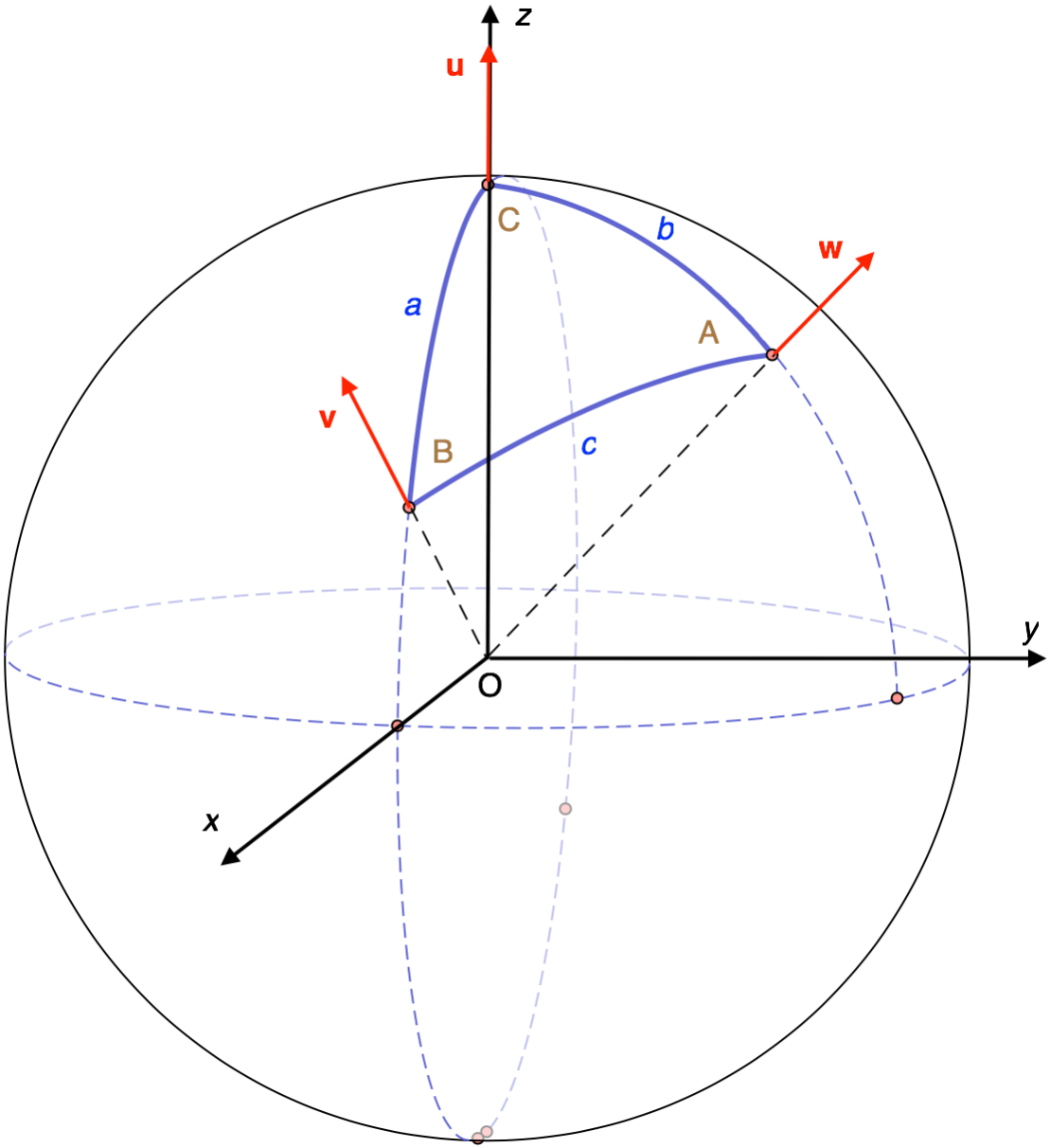



−A
−B
O
A
B
c

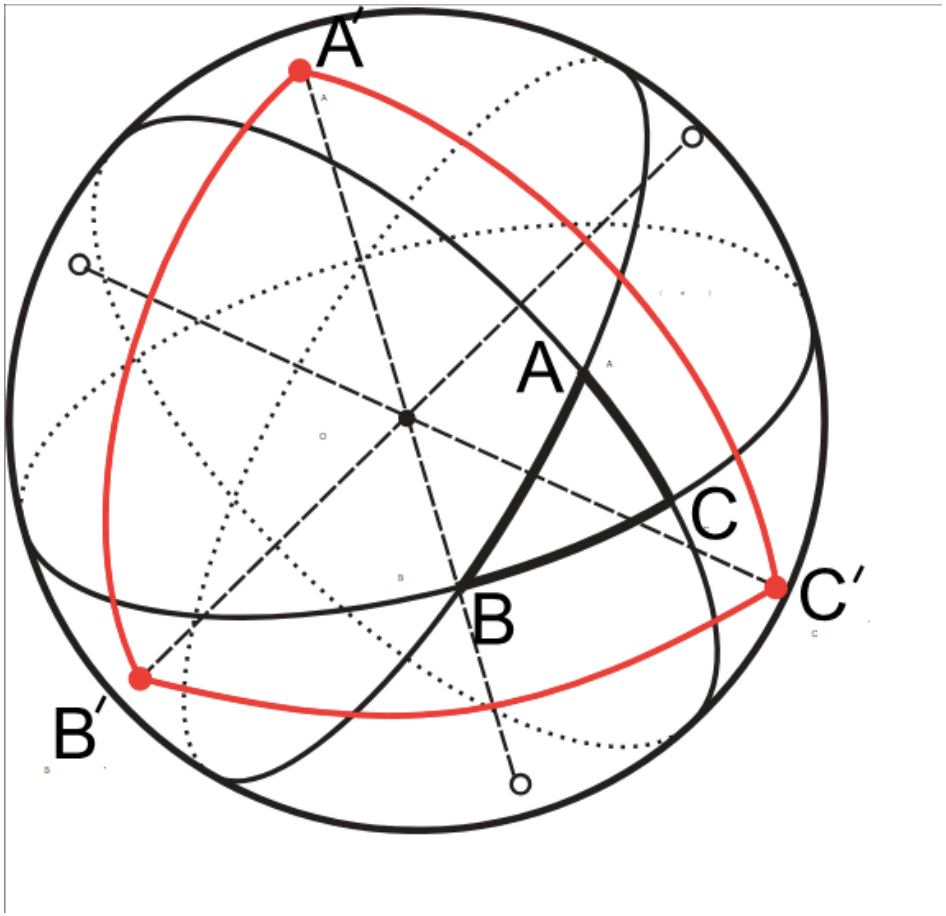

P
A'
B'
C
A
B

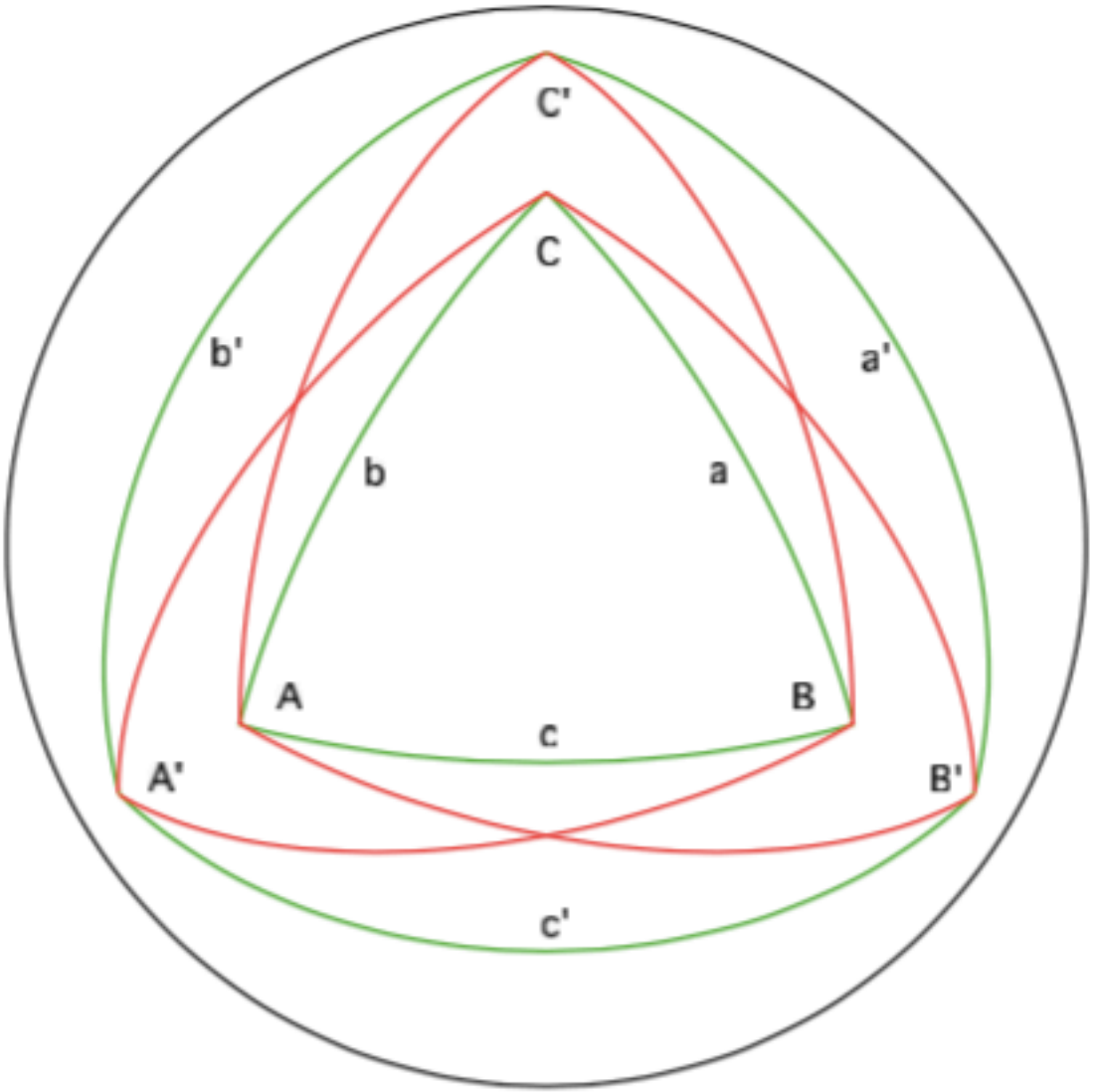

C
a
b
B
A
c

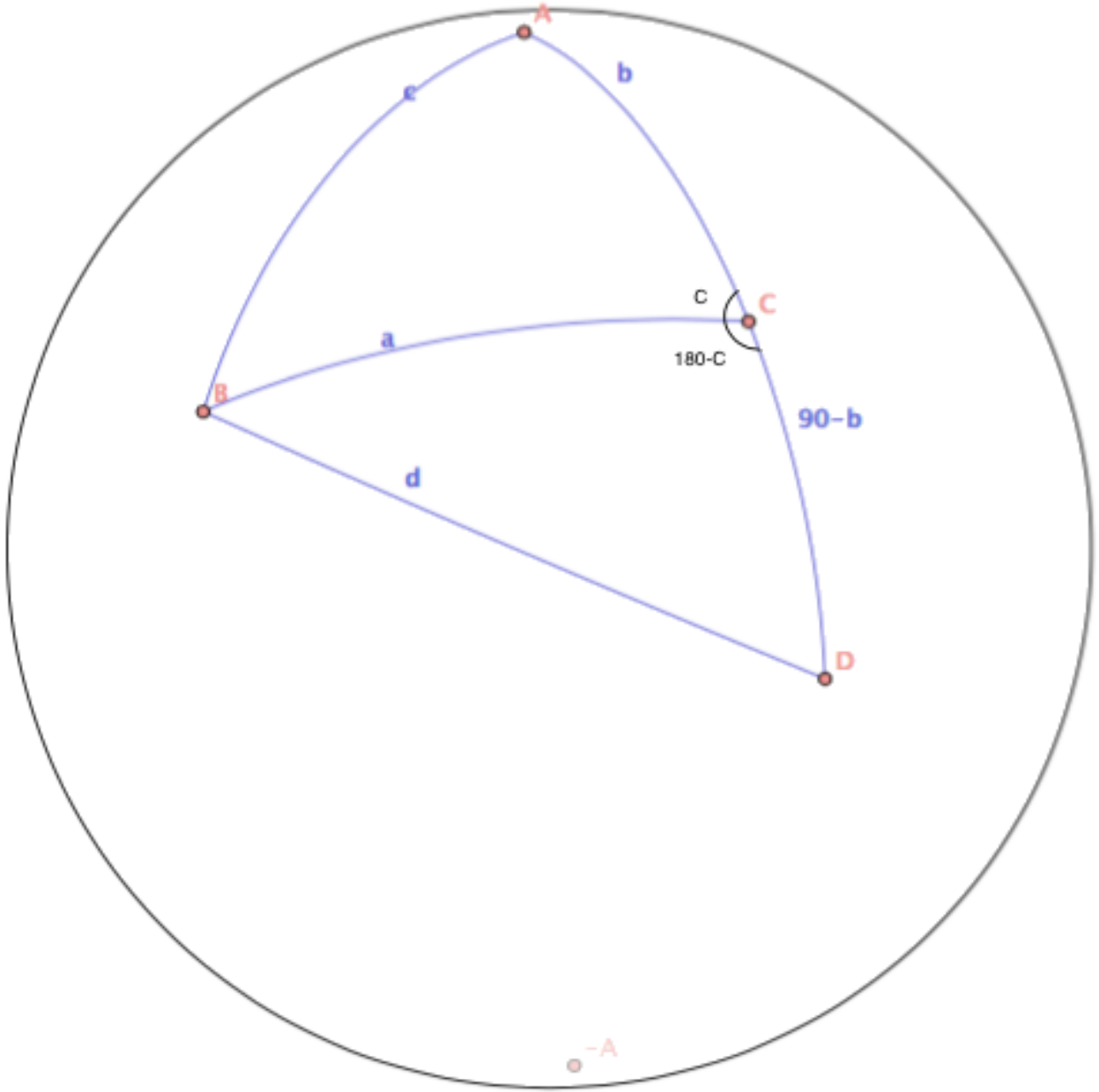

u
w
b
C
A
a
c
B
v


z
u
C
b
w
a
A
v
B
c
y
O
x

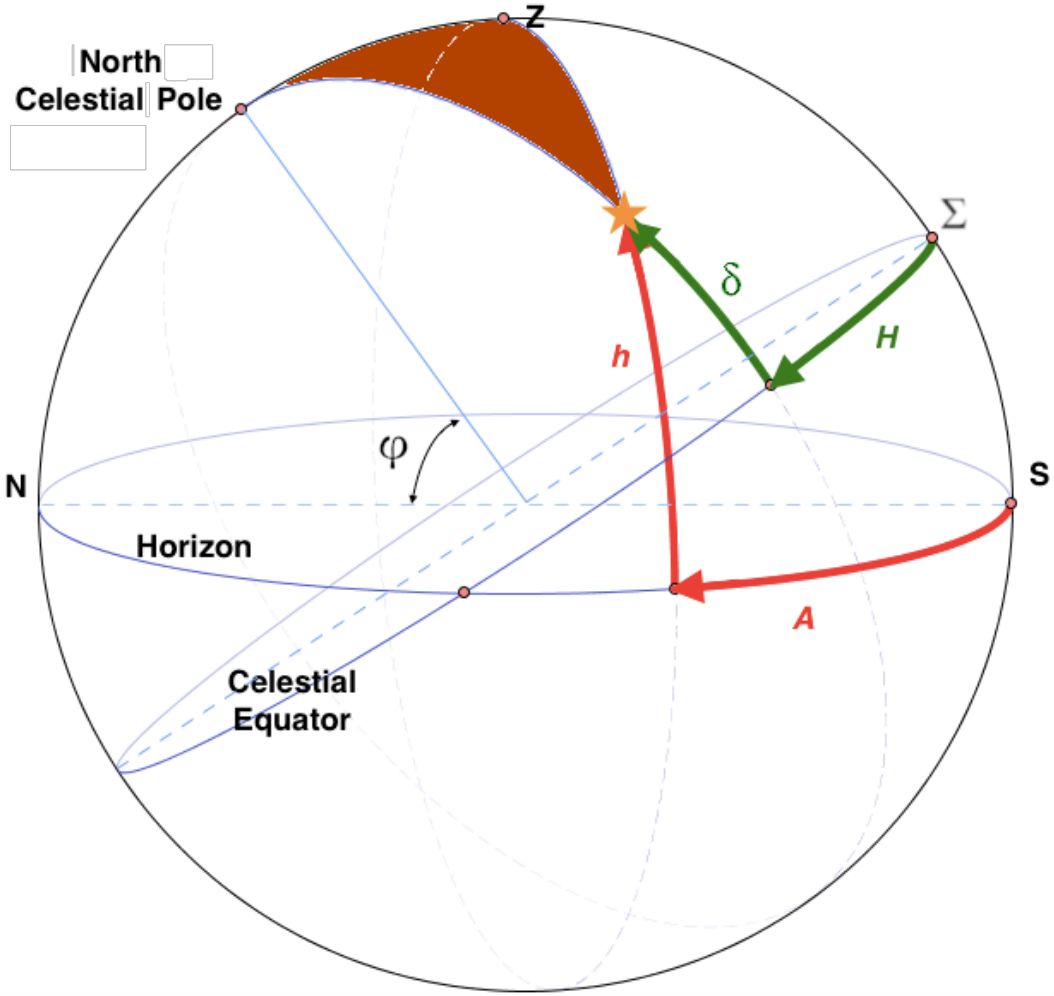
The dual triangle



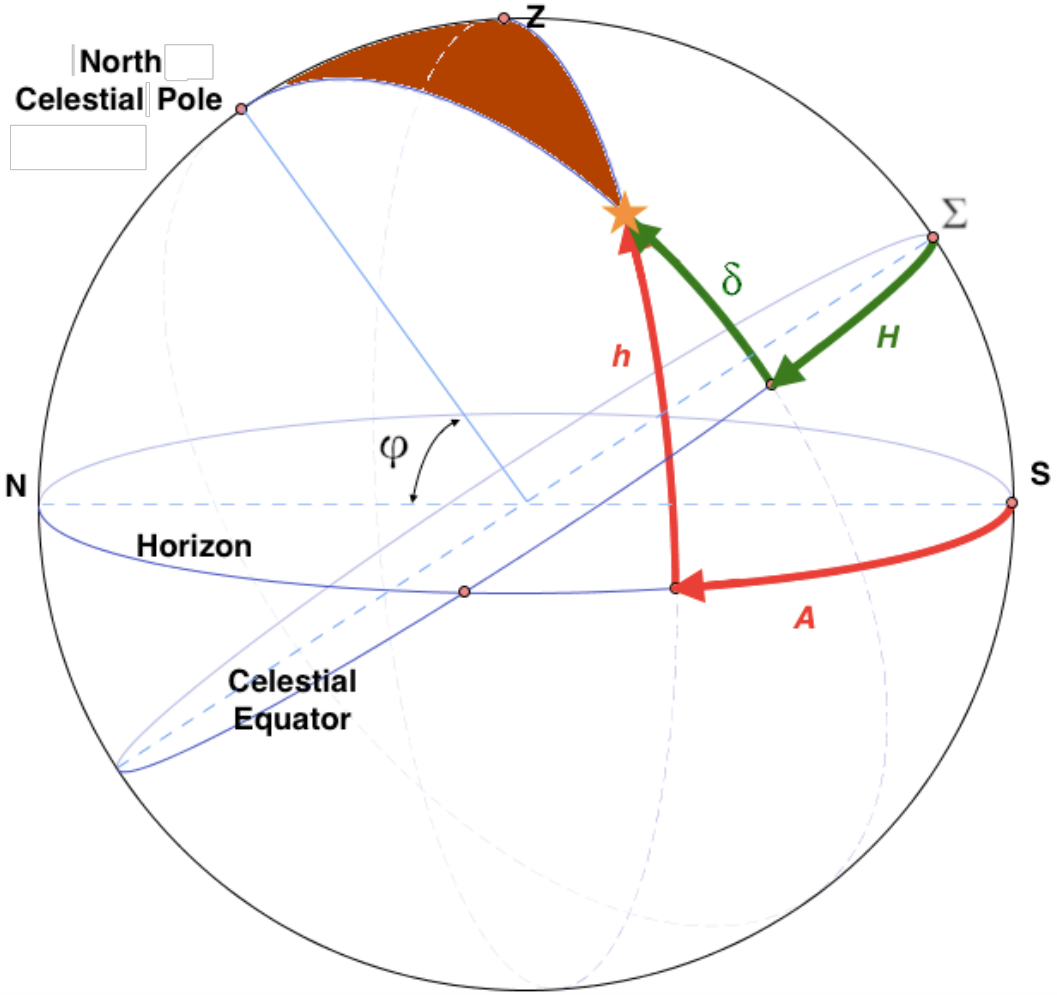

C'
C
b'
a'
b
a
A
B
c
A'
B'
c'

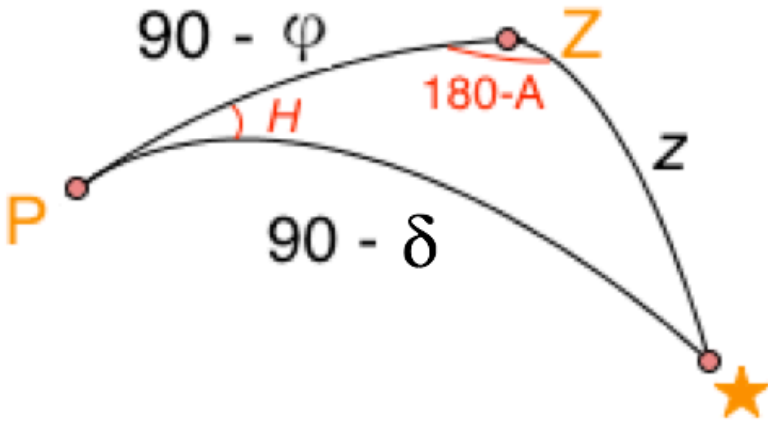

A
b
c
C
C
180-C
a
B
90-b
d
D
-A

Hour Coordinates and Horizontal Coordinates

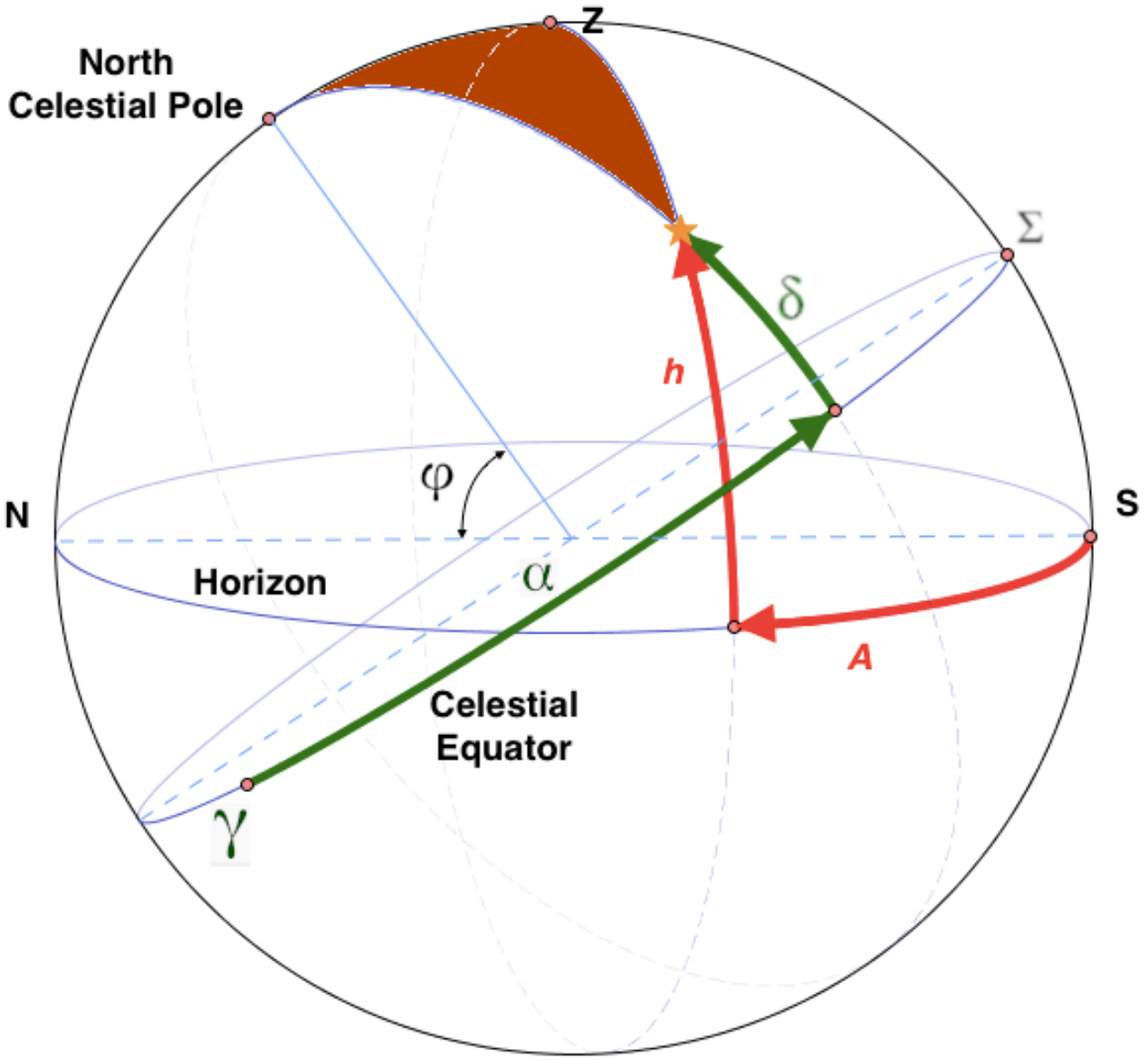


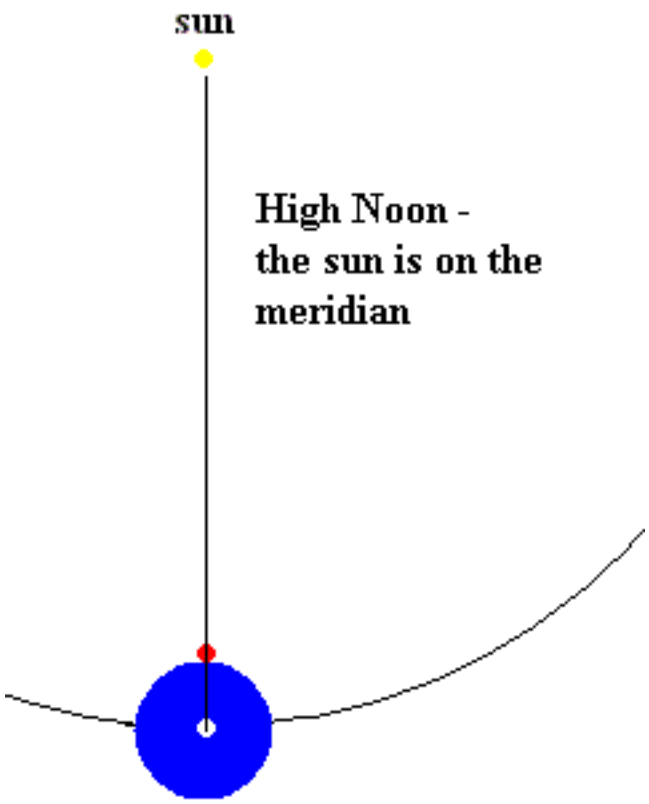
Hour Coordinates and Horizontal Coordinates

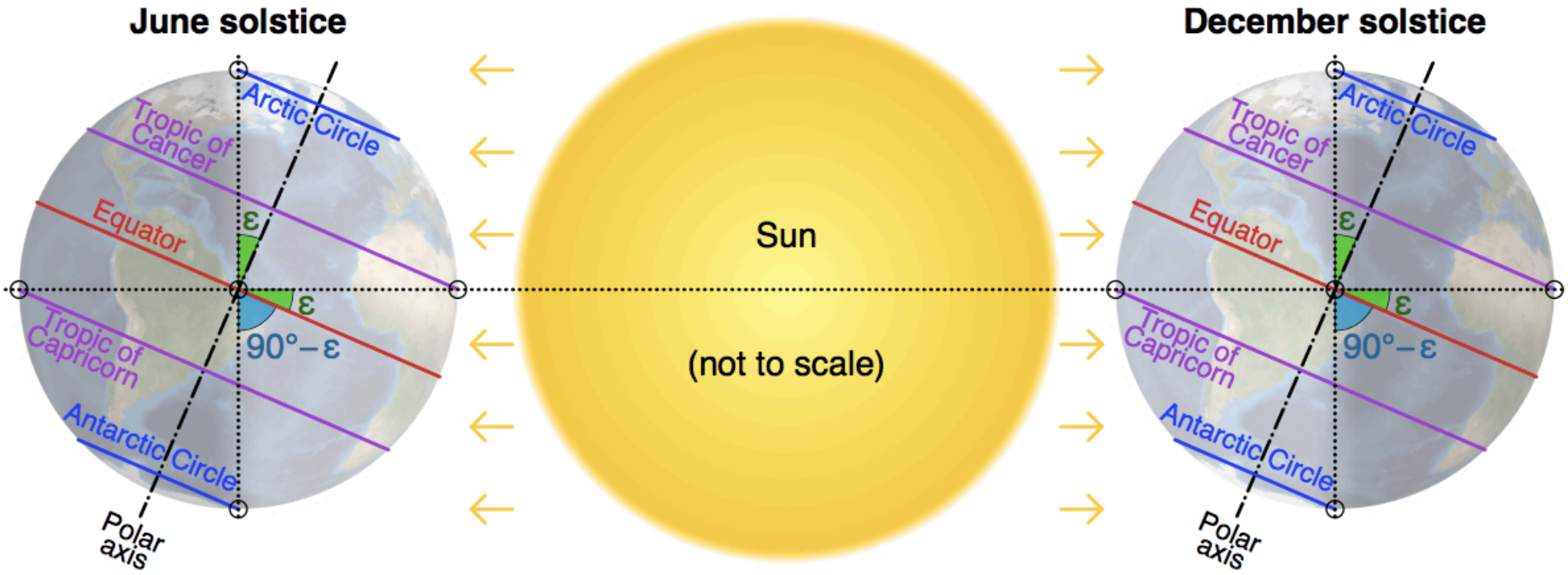


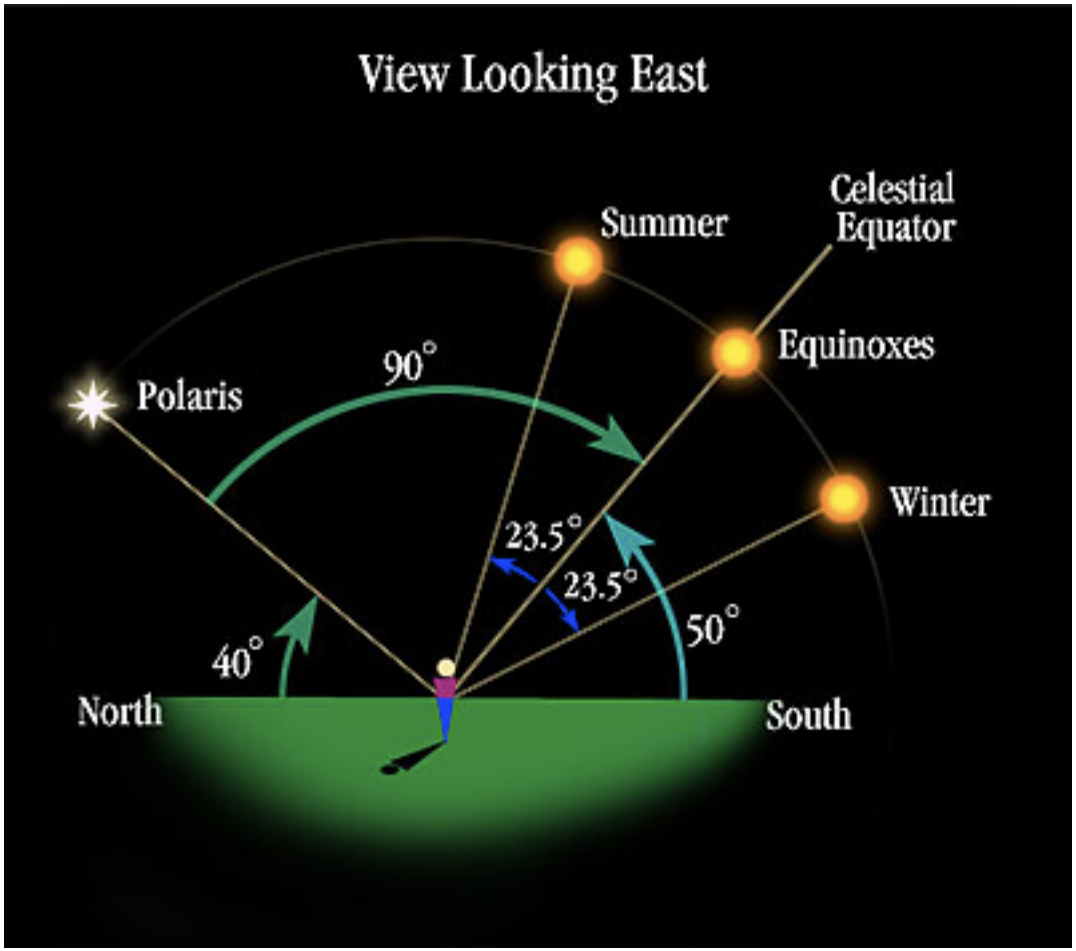


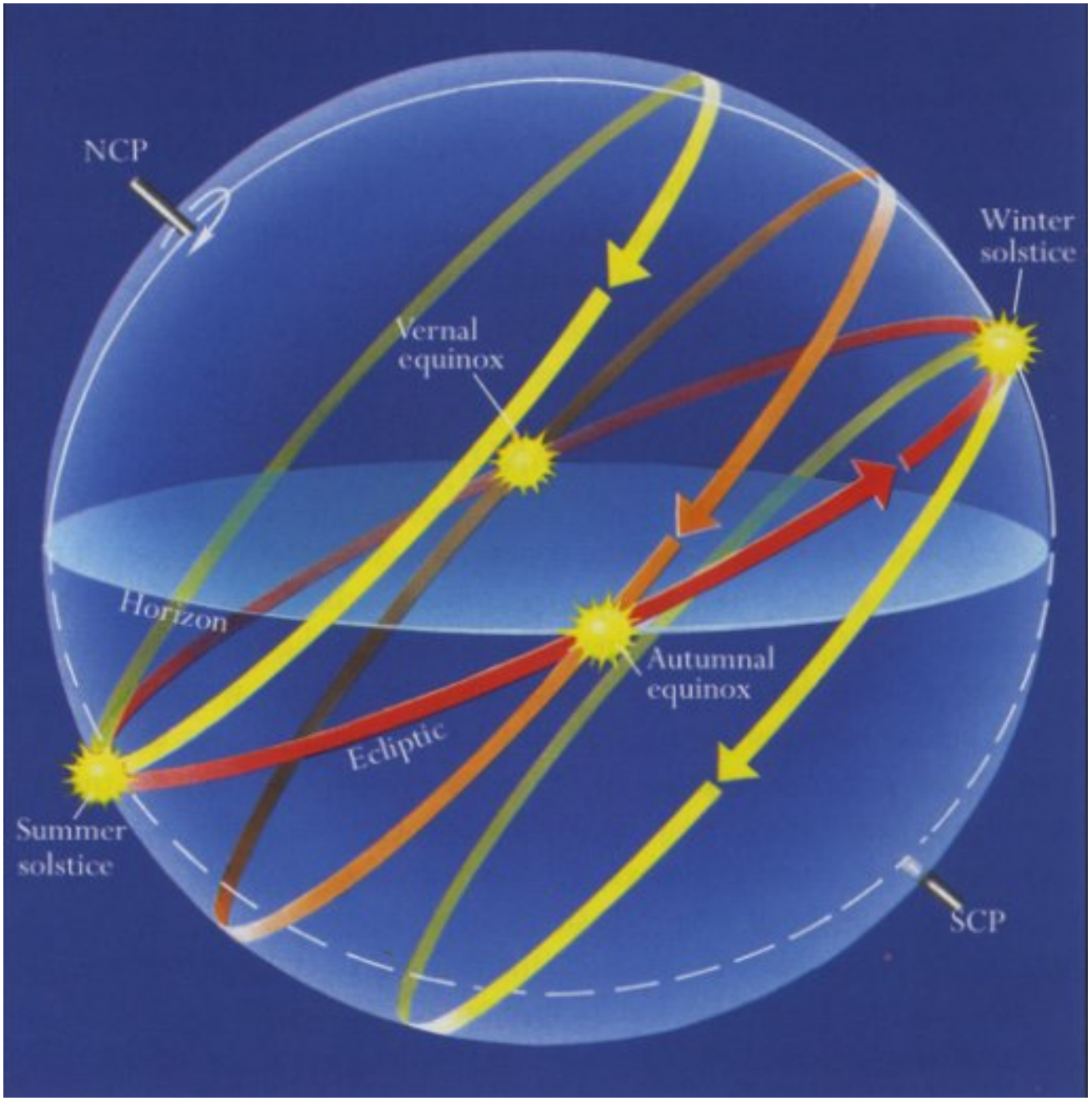
Horizontal Coordinates and Equatorial Coordinates

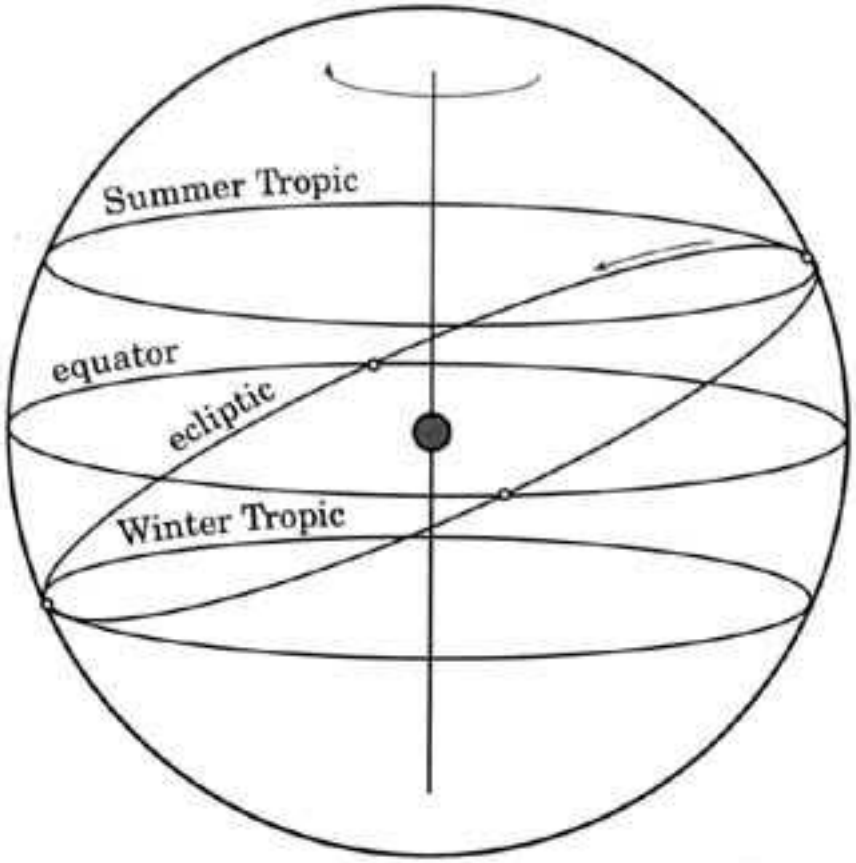



sun
High Noon -
the sun is on the
meridian


June solstice
December solstice
Sun
(not to scale)
Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
Polar axis
ε
90°−ε

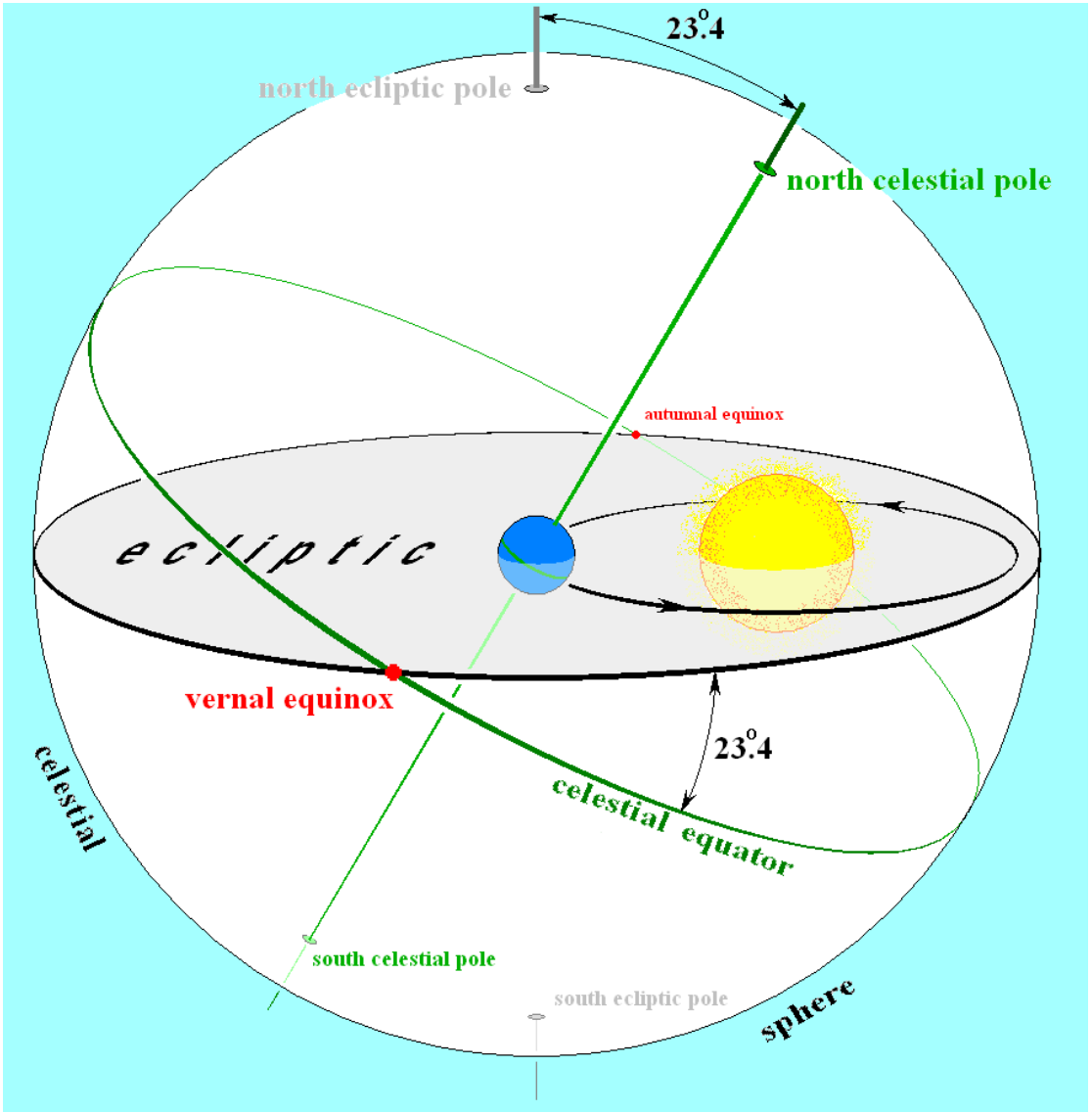

View Looking East
Summer
Celestial Equator
Equinoxes
Polaris
90°
Winter
23.5°
23.5°
50°
40°
North
South


NCP
Winter solstice
Vernal equinox
Horizon
Autumnal equinox
Ecliptic
Summer solstice
SCP

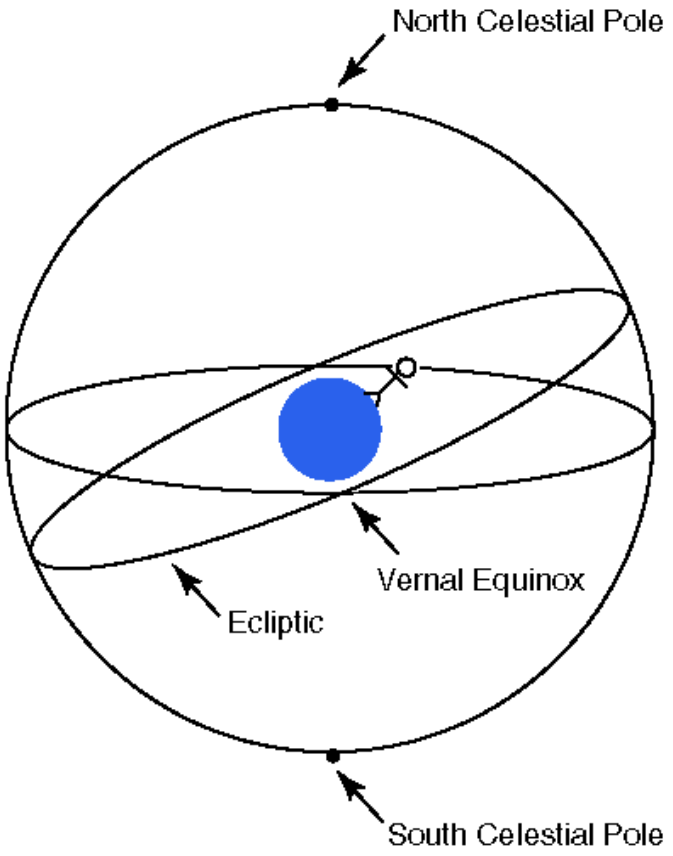


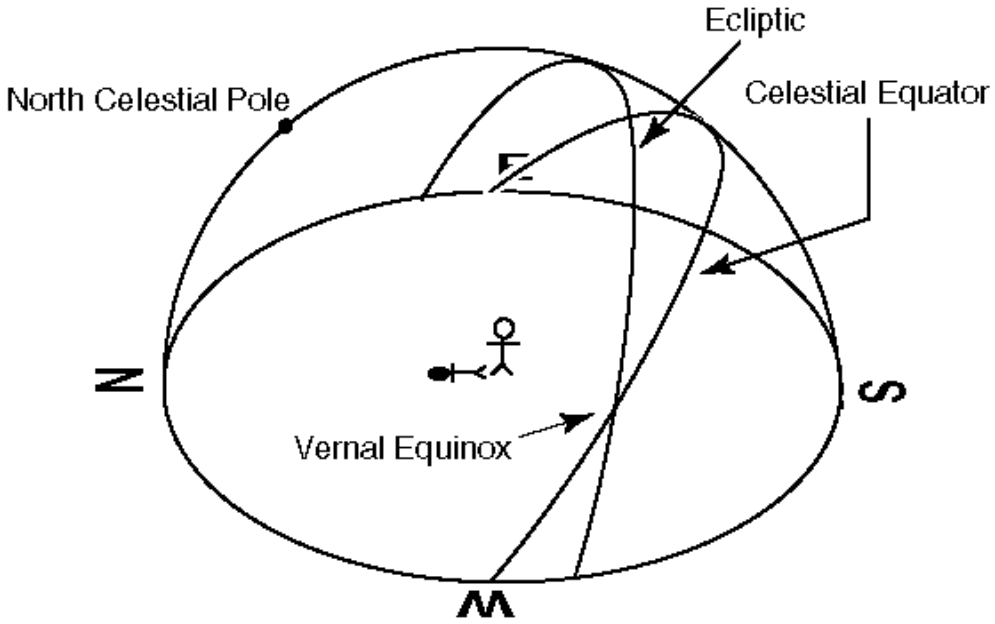
The ecliptic and tropic circles

Ecliptic


23.4°
north ecliptic pole
north celestial pole
autumnal equinox
ecliptic
vernal equinox
23.4°
celestial equator
celestial sphere
south celestial pole
south ecliptic pole

Ecliptic


North Celestial Pole
Vernal Equinox
Ecliptic
South Celestial Pole


Ecliptic
North Celestial Pole
Celestial Equator
N
S
Vernal Equinox
W

N.M.S.U. Astronomy Department: Cumulative Exam #368
18^{th} February 2012 – Nicole Vogt

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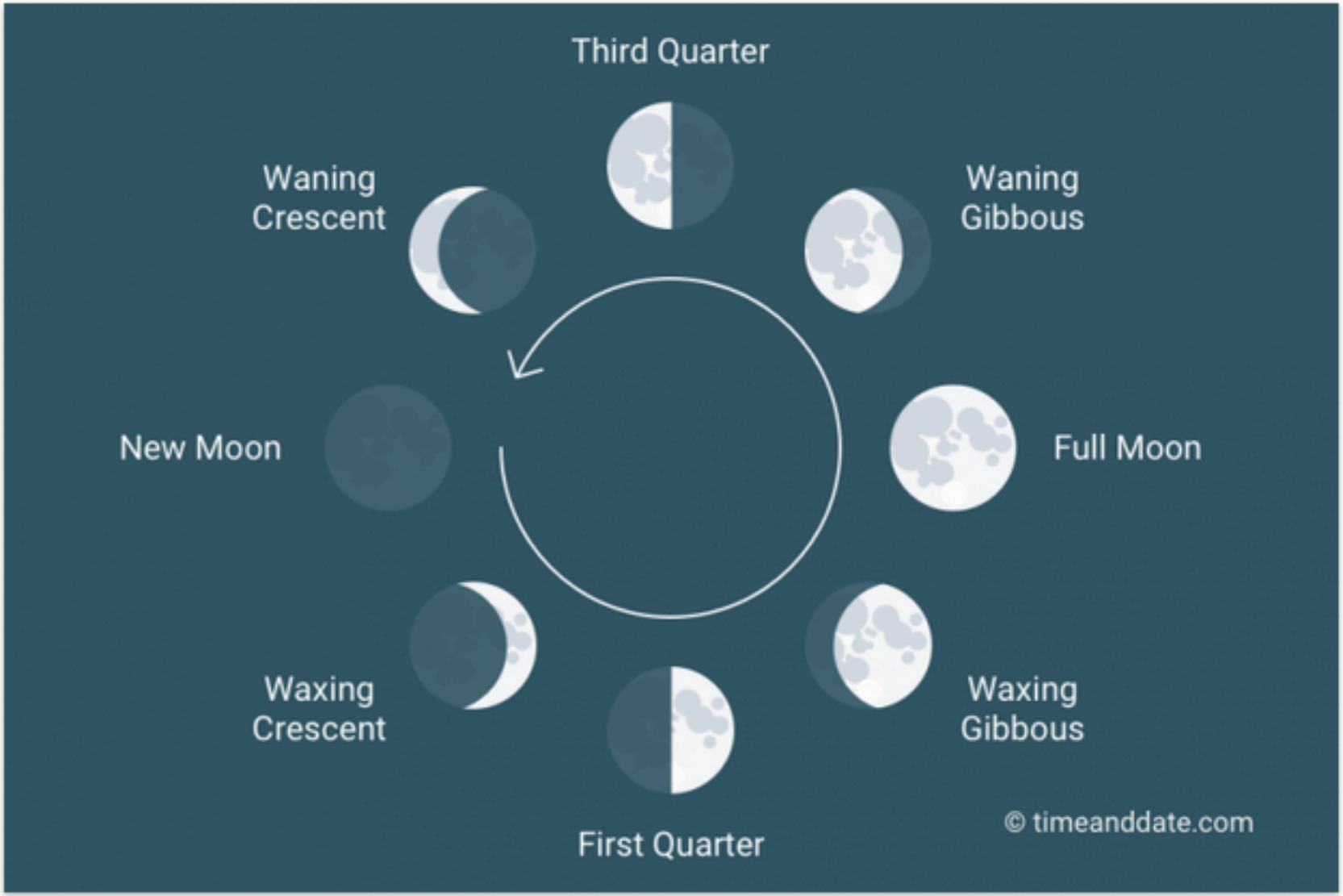
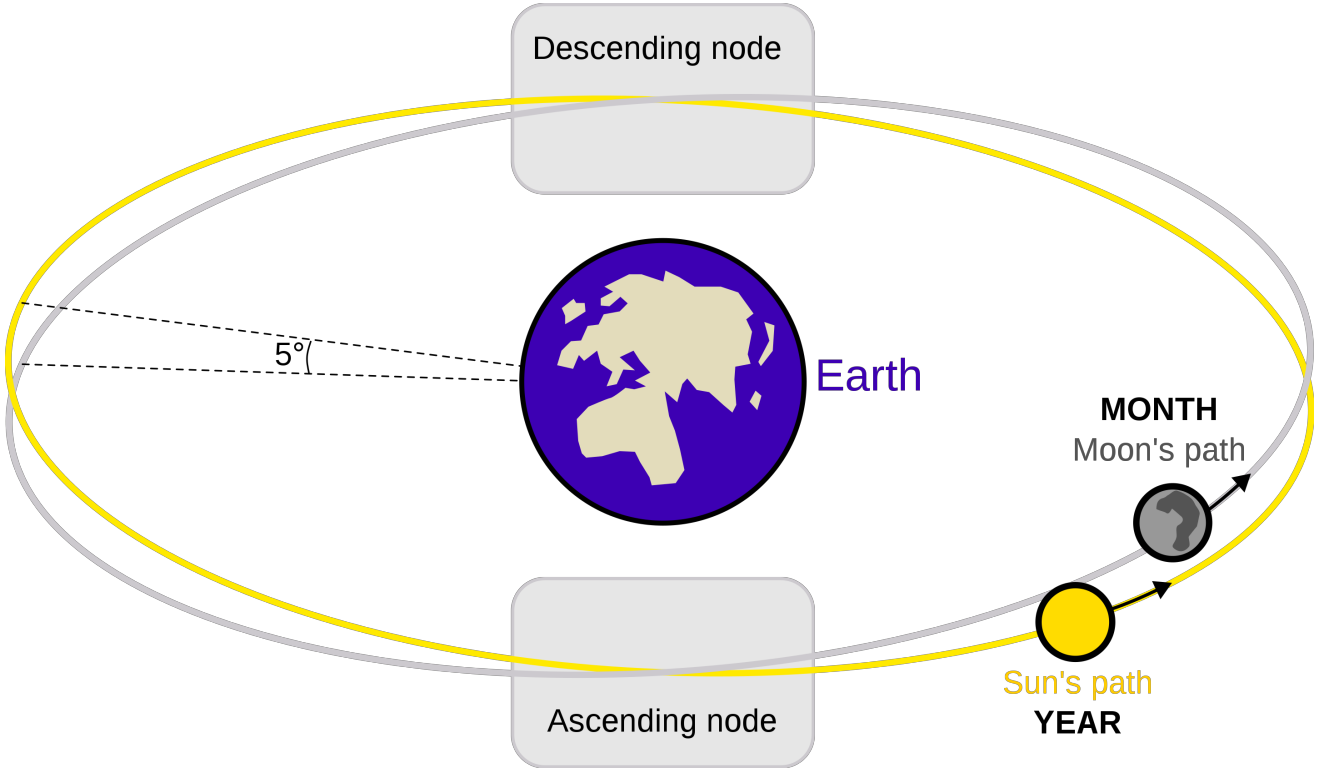
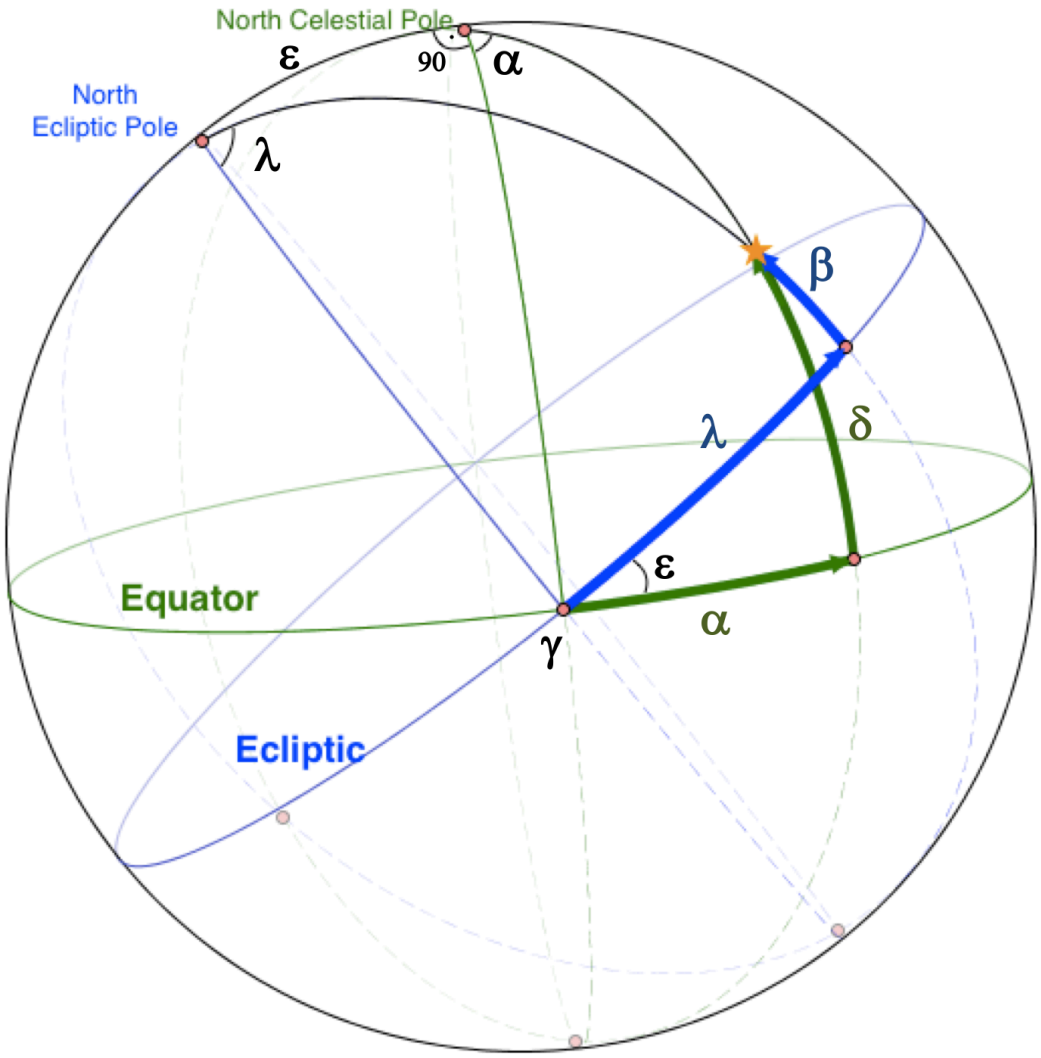
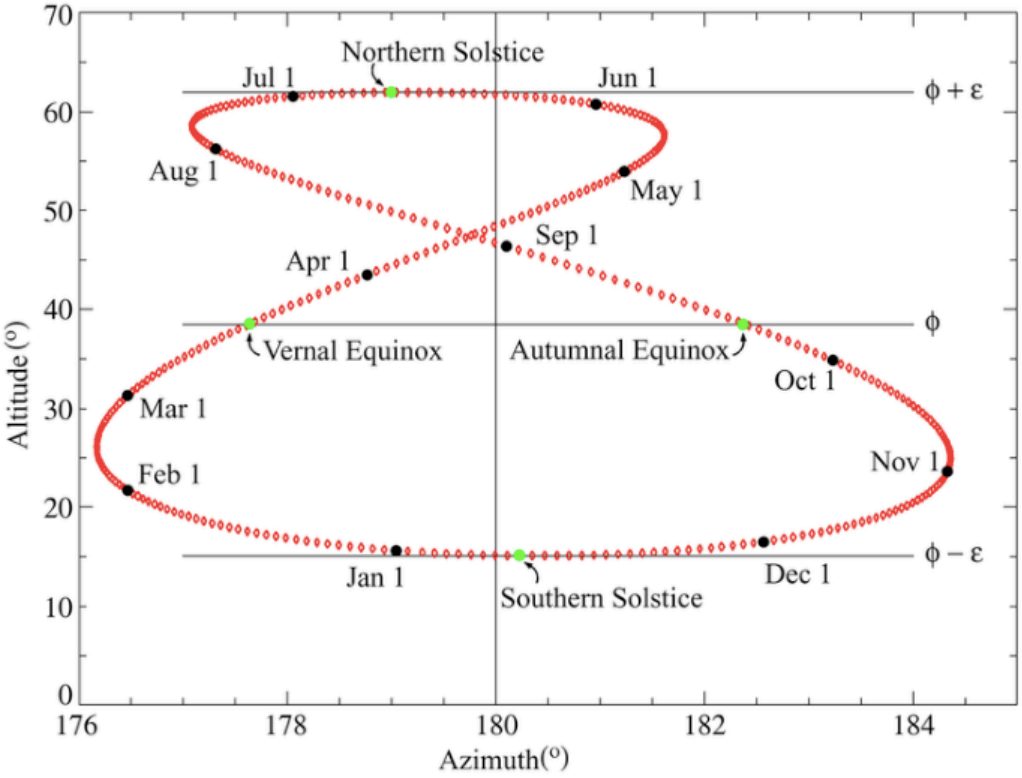

Third Quarter
Waning Crescent
Waning Gibbous
New Moon
Full Moon
Waxing Crescent
Waxing Gibbous
First Quarter
© timeanddate.com


Descending node
5°
Earth
MONTH
Moon's path
Sun's path
YEAR
Ascending node

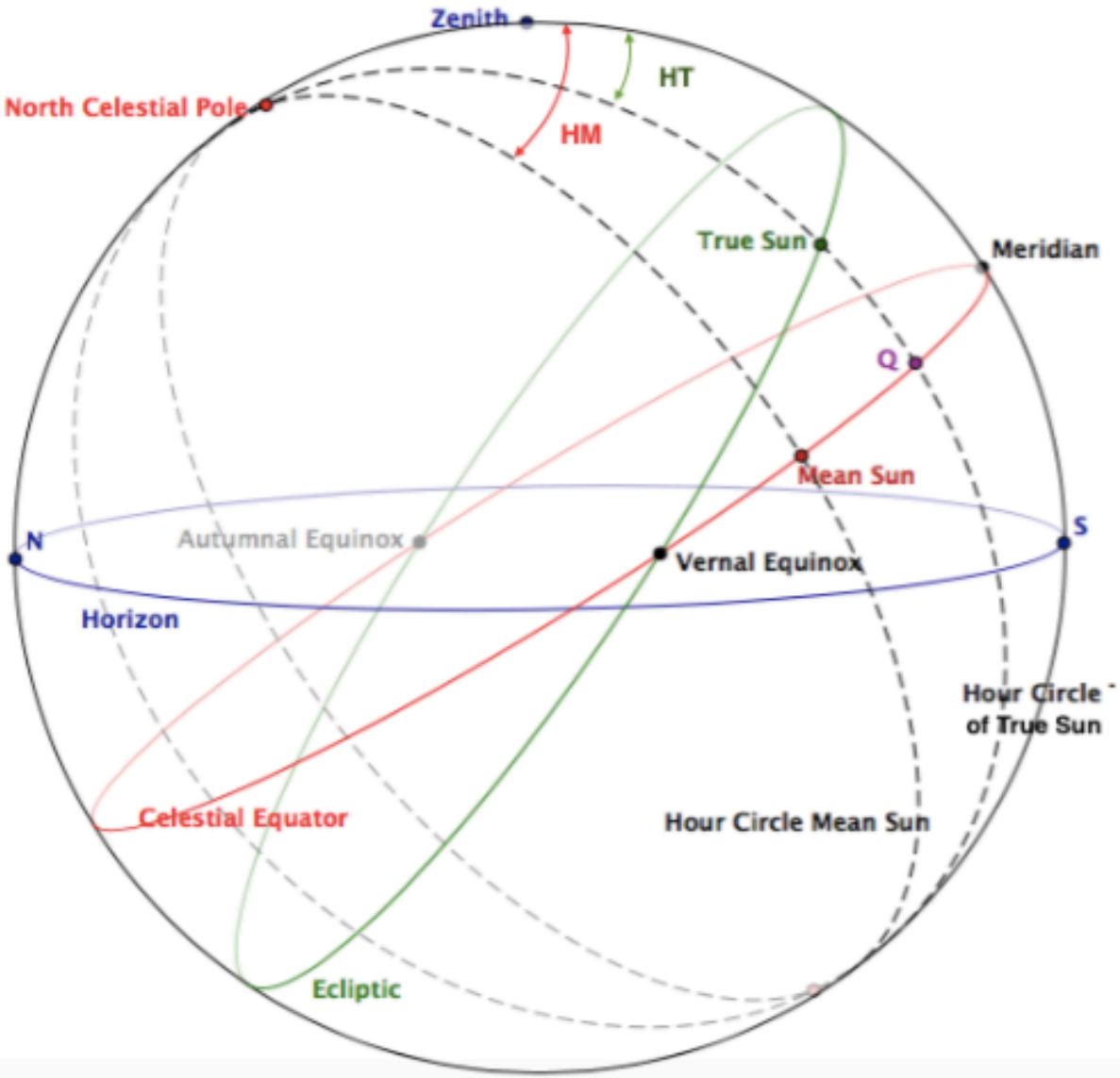
Equatorial to Ecliptic



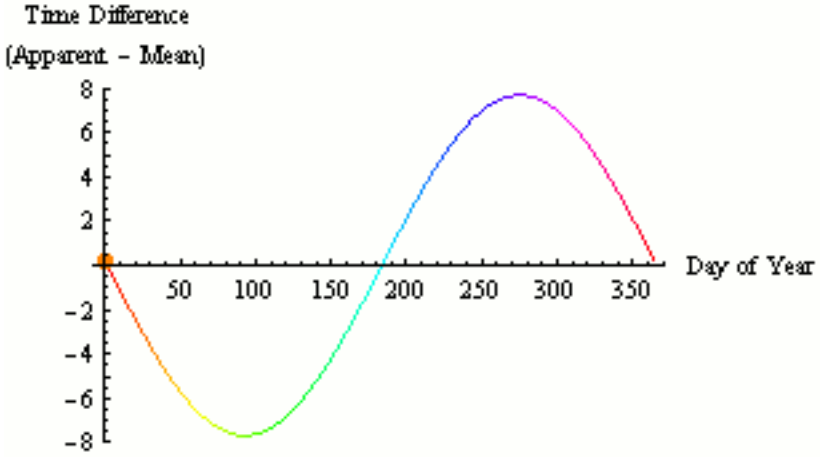
True Sun vs Mean Sun: The analemma



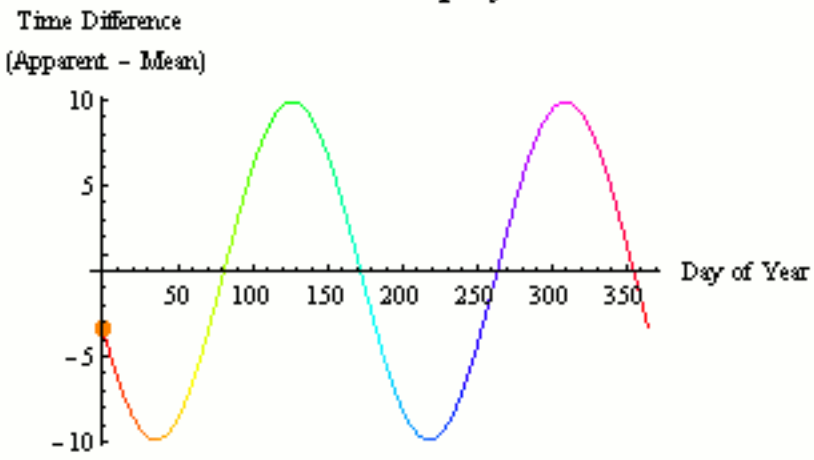
True Sun vs Mean Sun



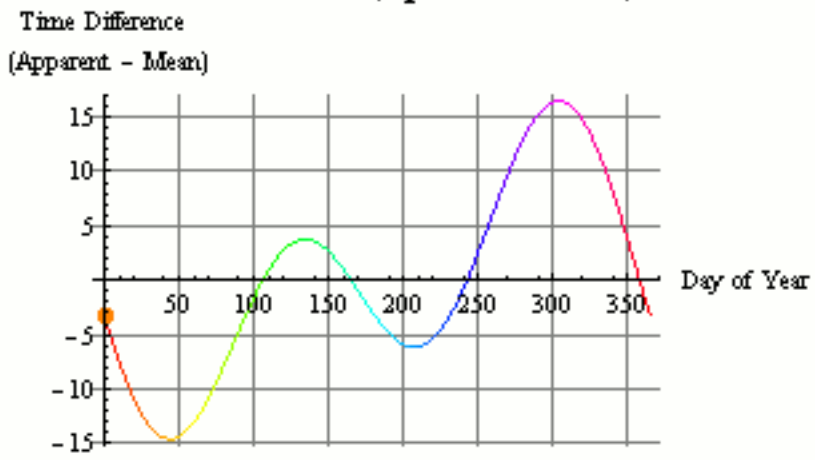
Effect of Orbit Eccentricity



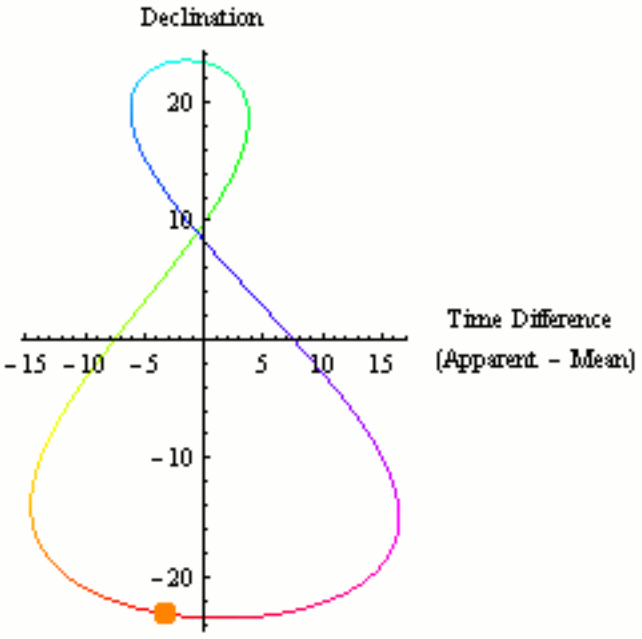
Effect of Obliquity



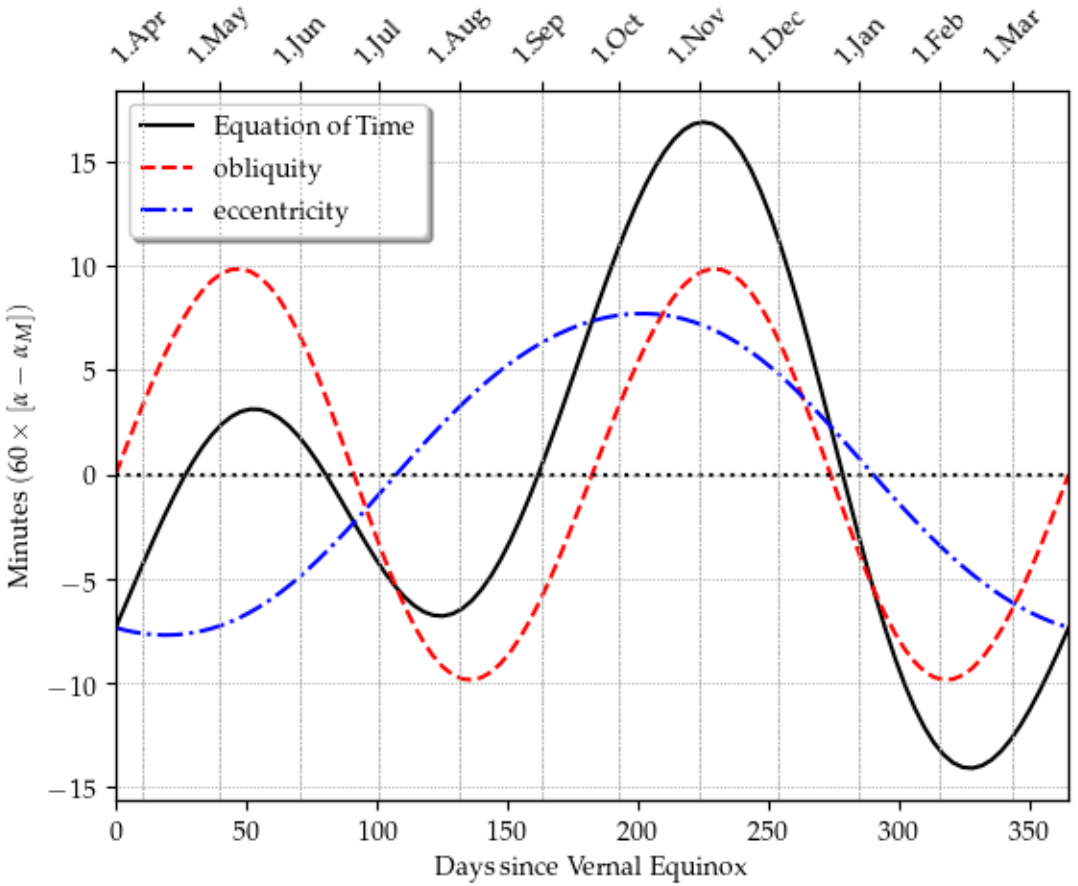
Combined Effects (Equation of Time)

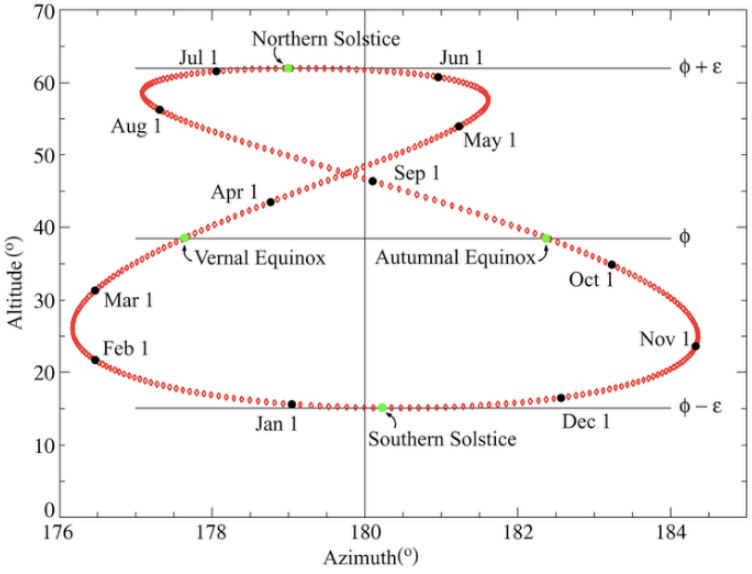


Sun Position Trace (Analemma)

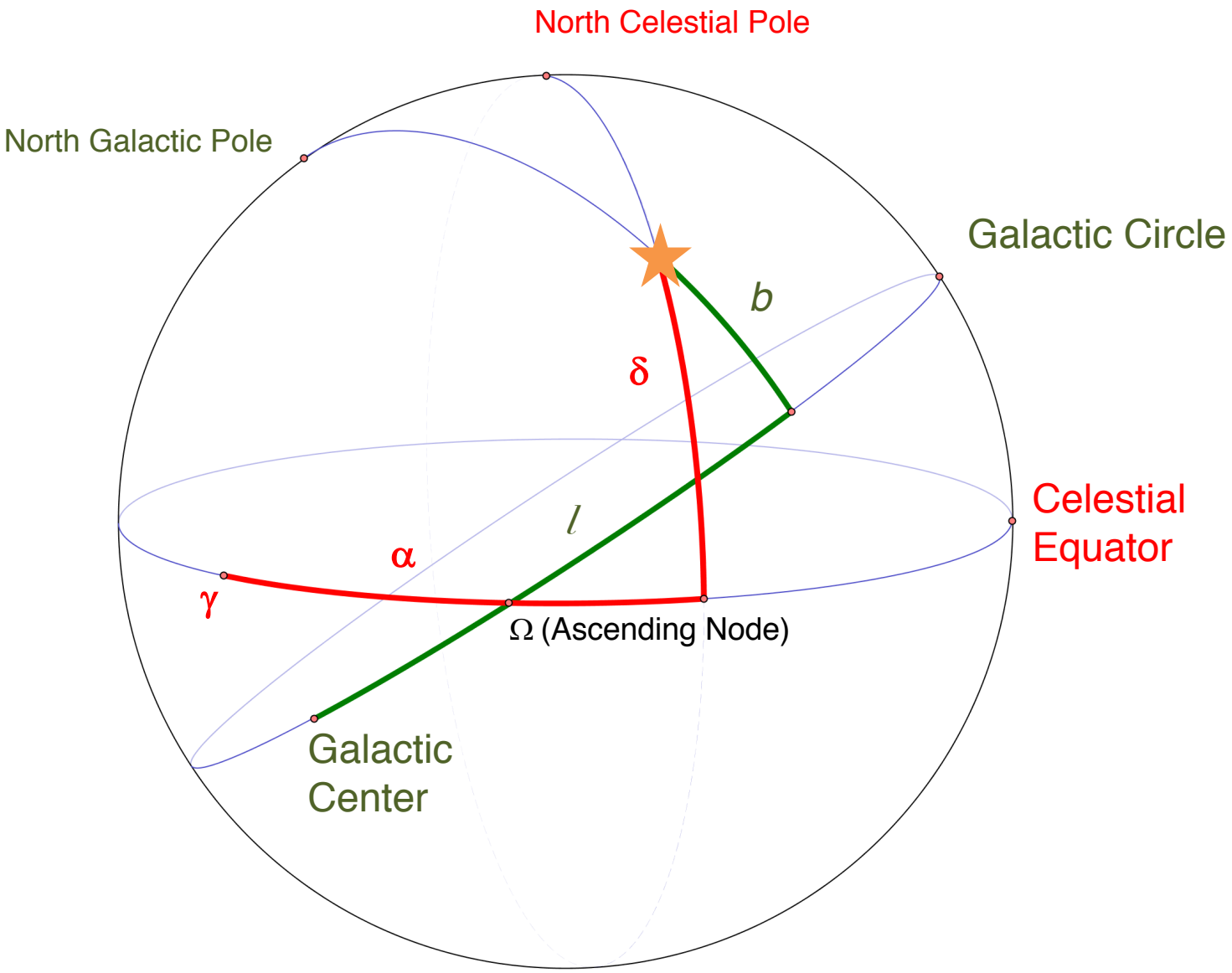


Equation of Time





Equatorial to Galactic



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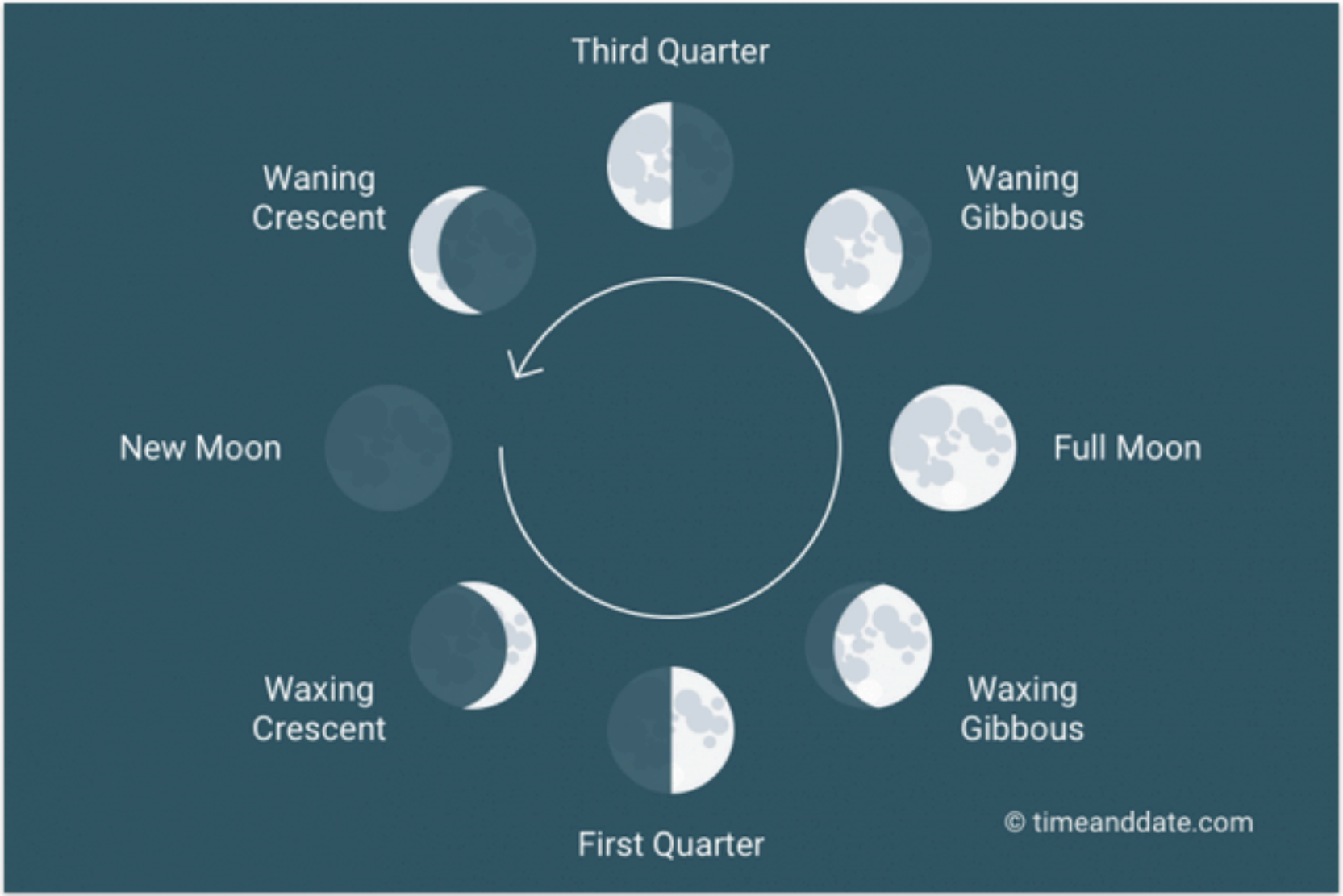
Third Quarter
Waning Crescent
Waning Gibbous
New Moon
Full Moon
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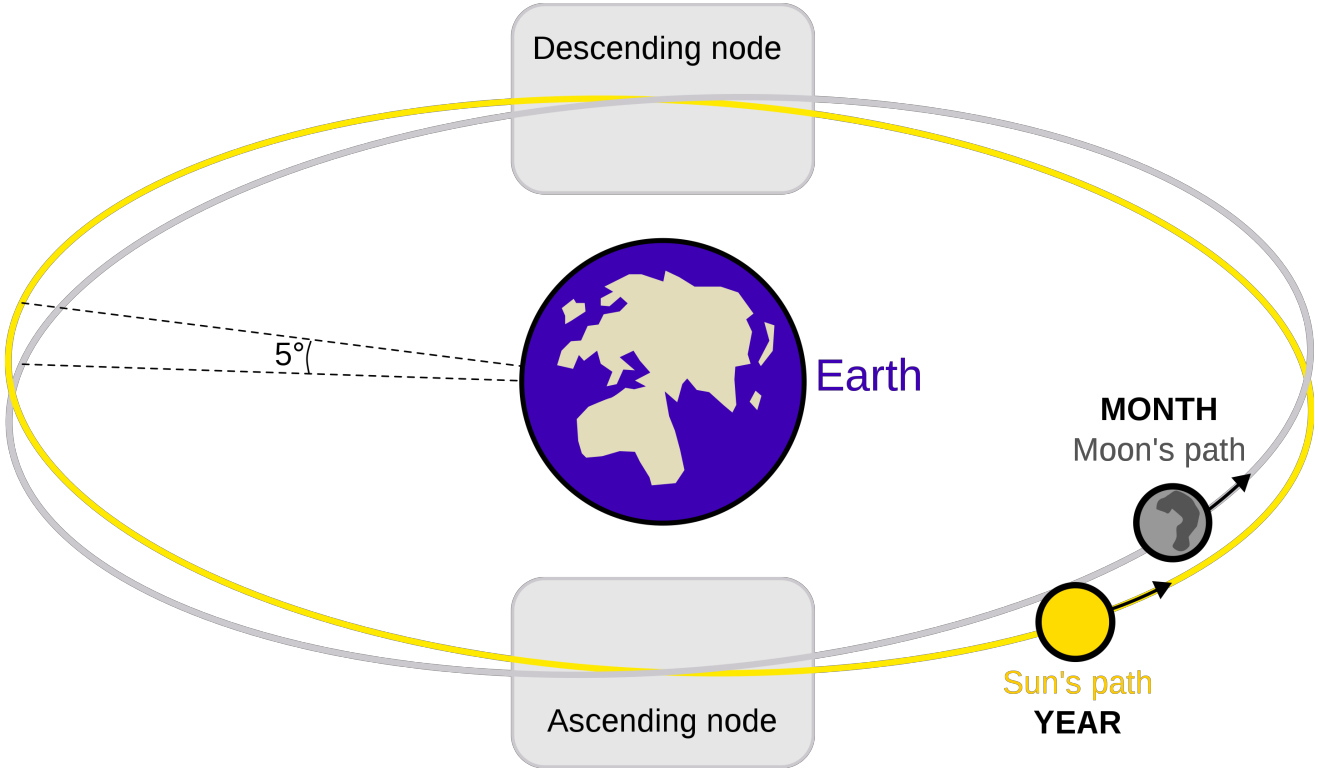
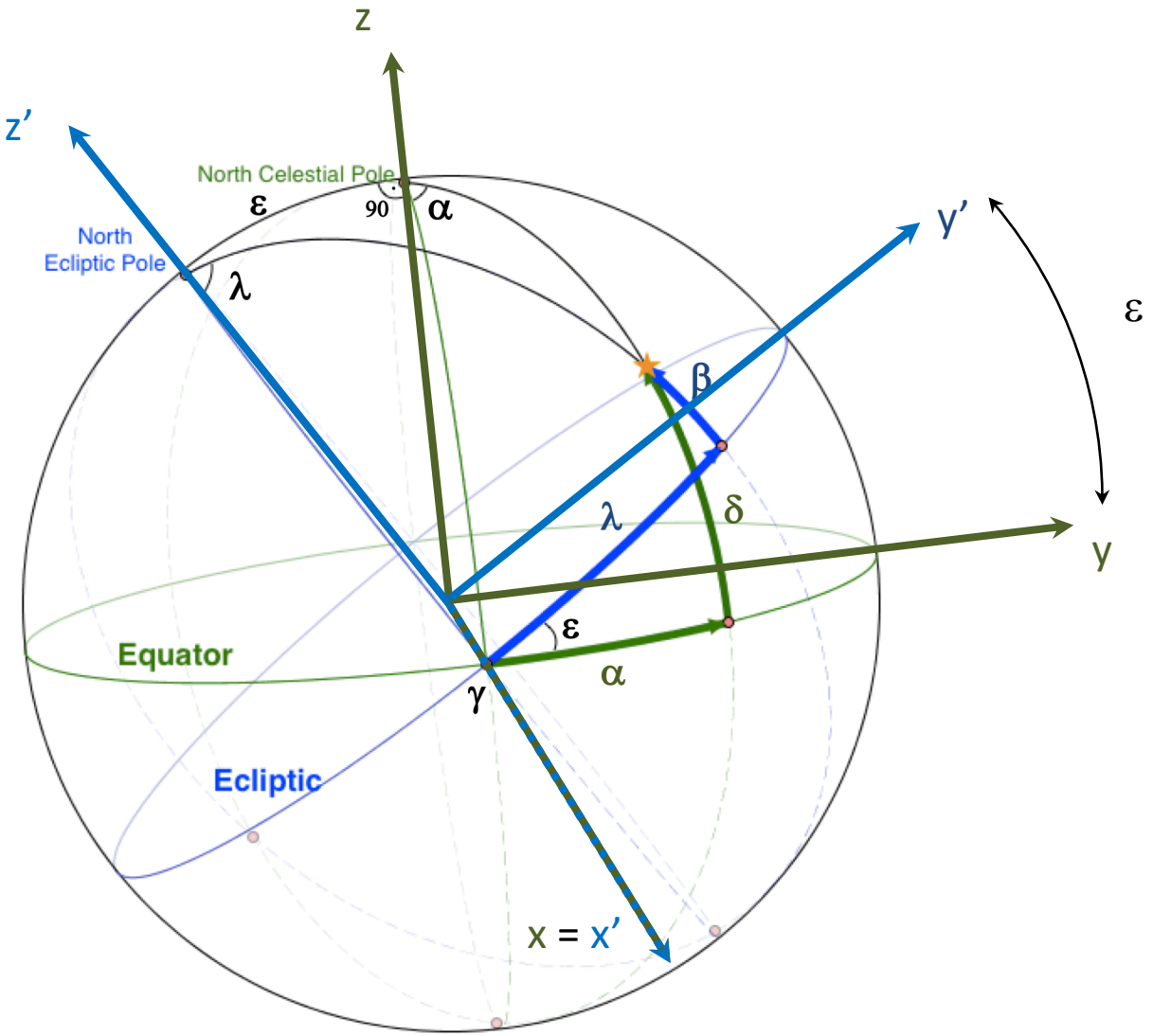
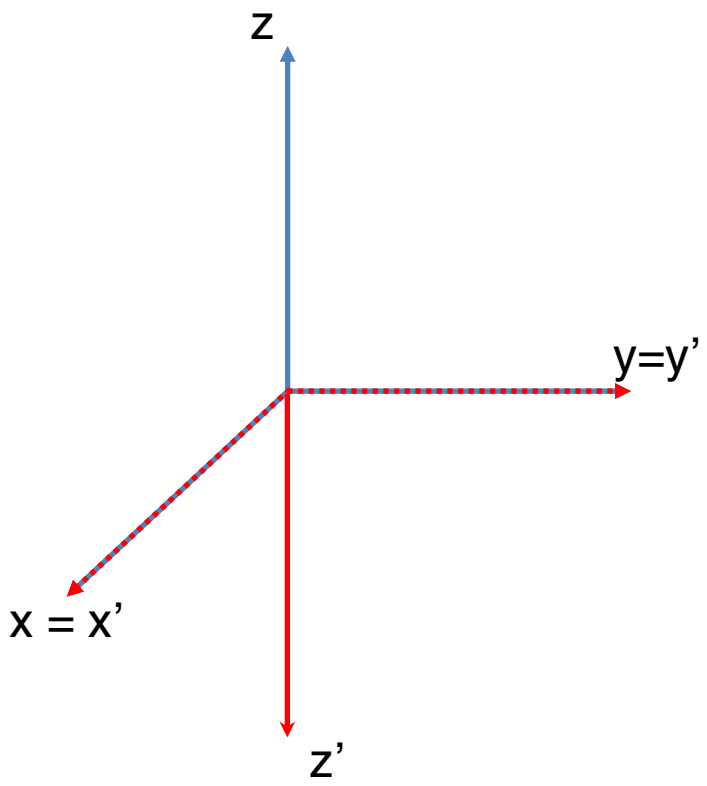
Waxing Gibbous
First Quarter
© timeanddate.com


Descending node
5°
Earth
MONTH
Moon's path
Sun's path
YEAR
Ascending node

Equatorial and Ecliptic



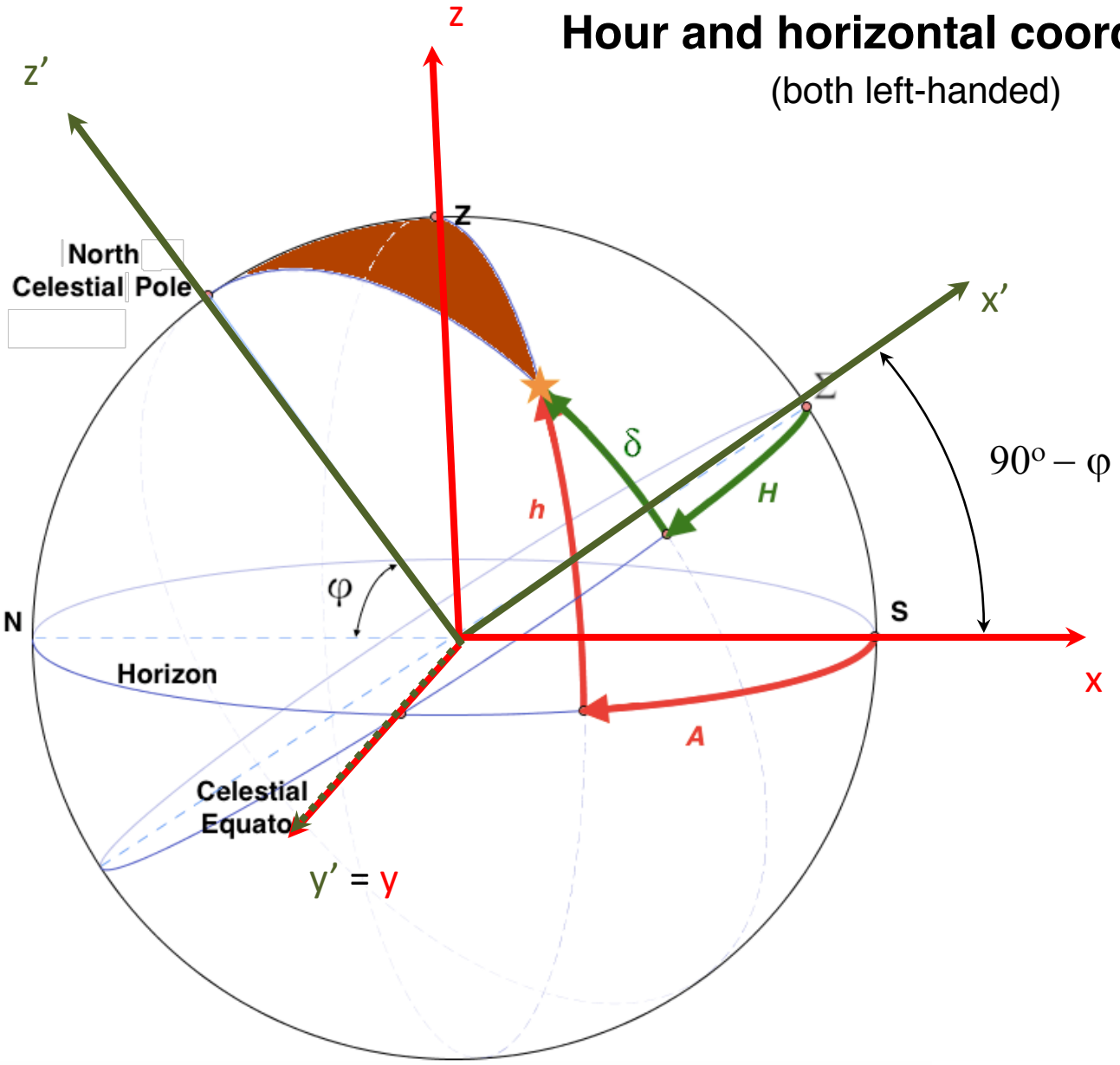
Right-handed coordinates (x *x* y = z)



Left-handed coordinates (y *x* x = z)

Hour and horizontal coordinates

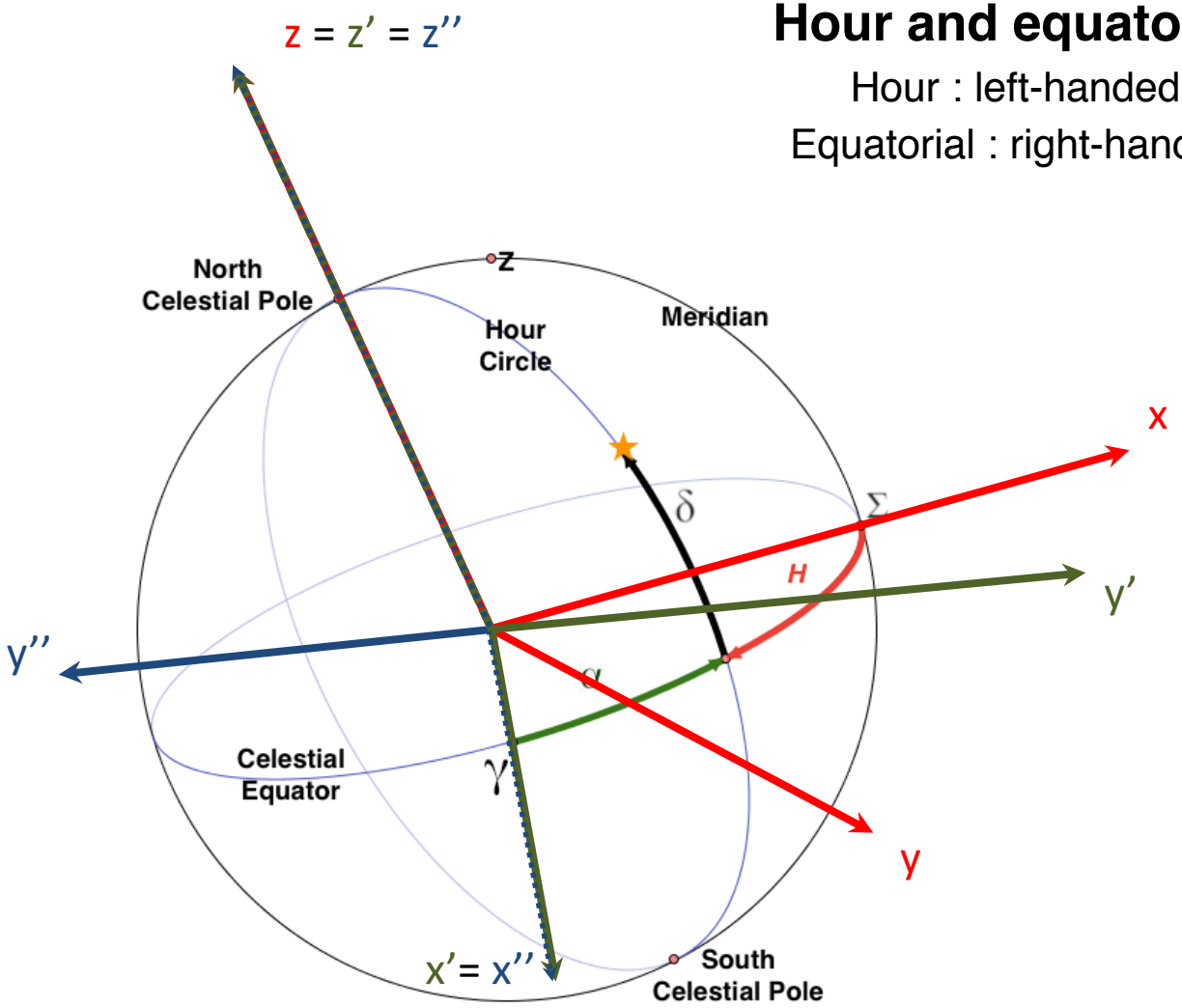
(both left-handed)



Hour and equatorial

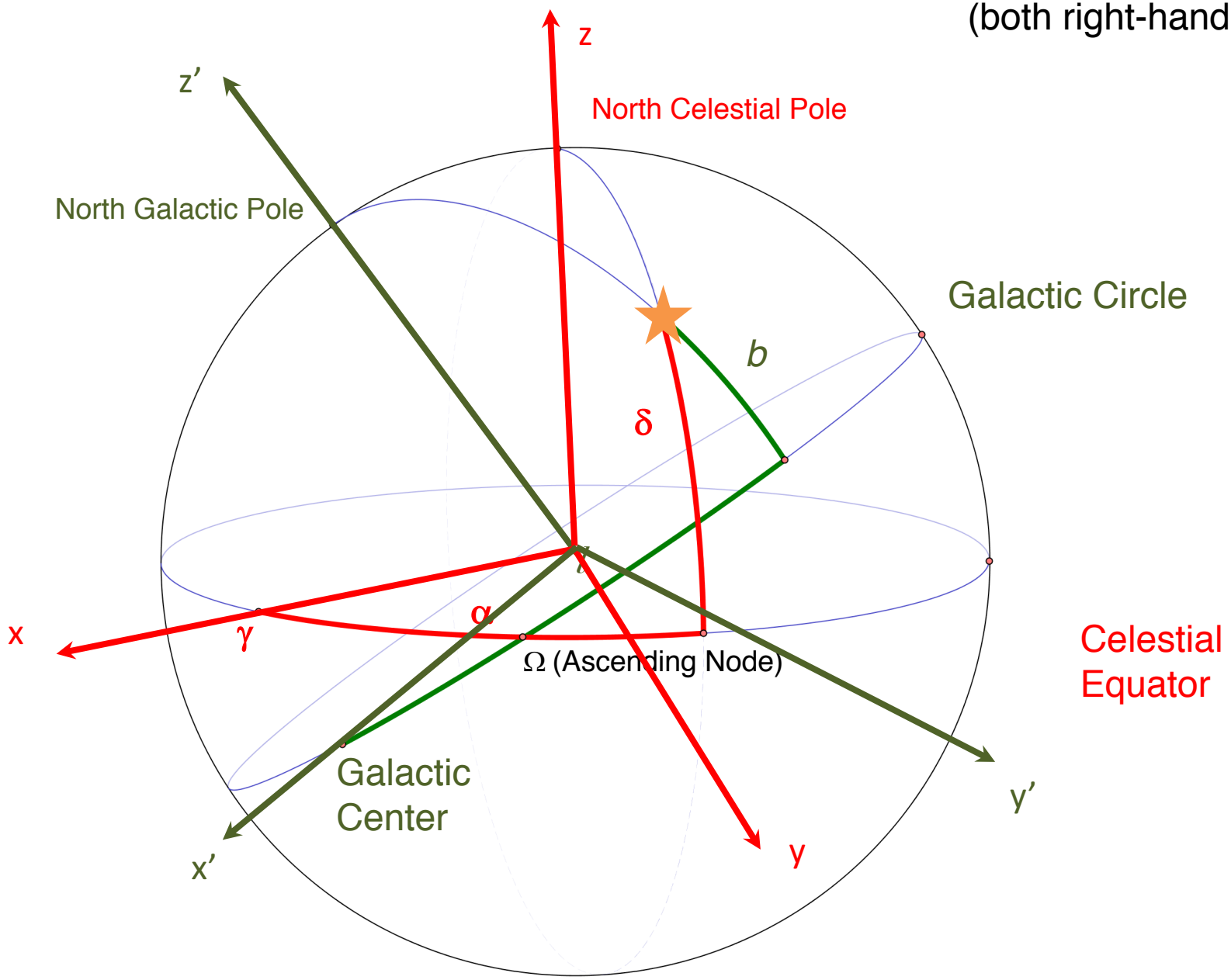
Hour : left-handed

Equatorial : right-handed



Equatorial to Galactic

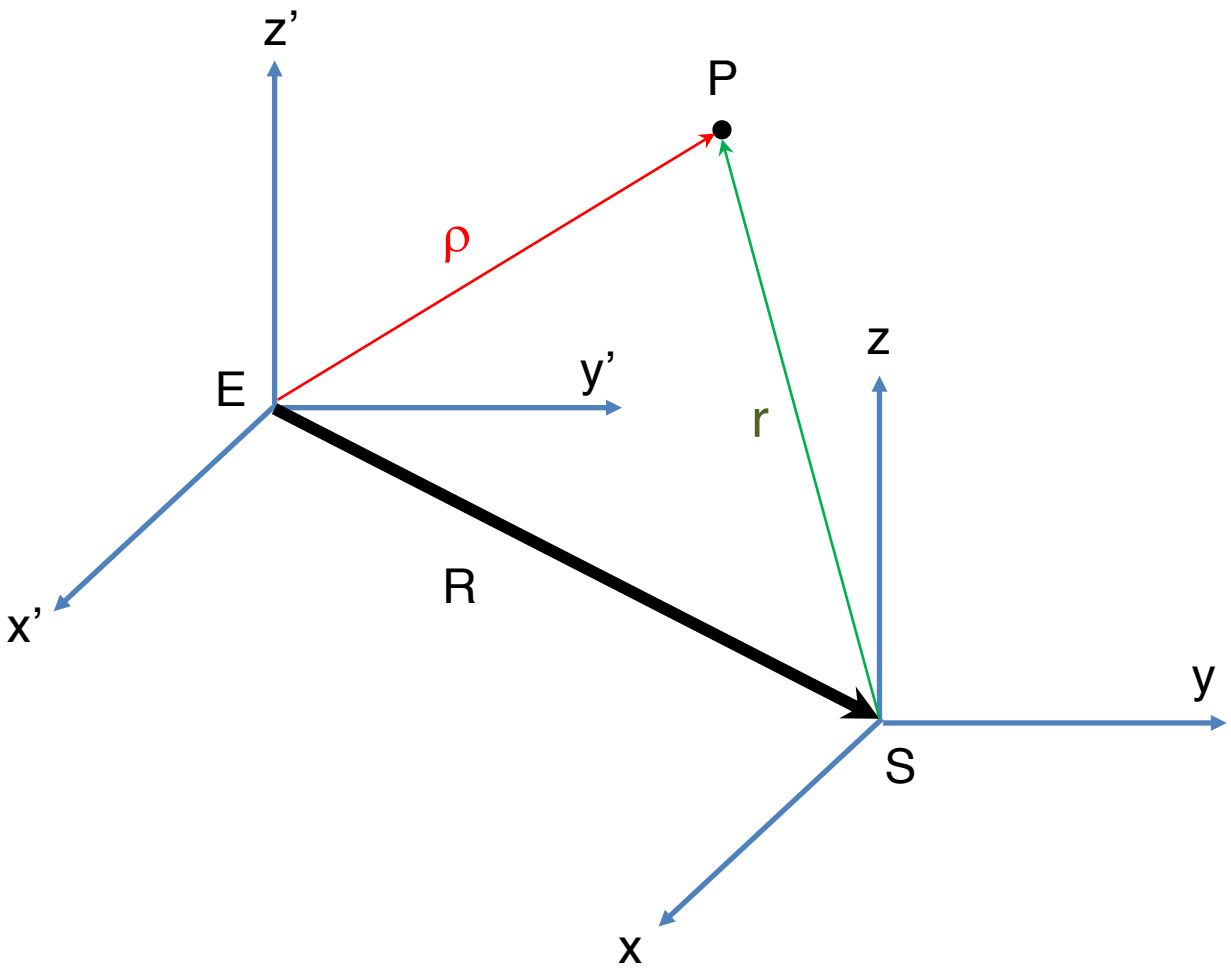
(both right-handed)



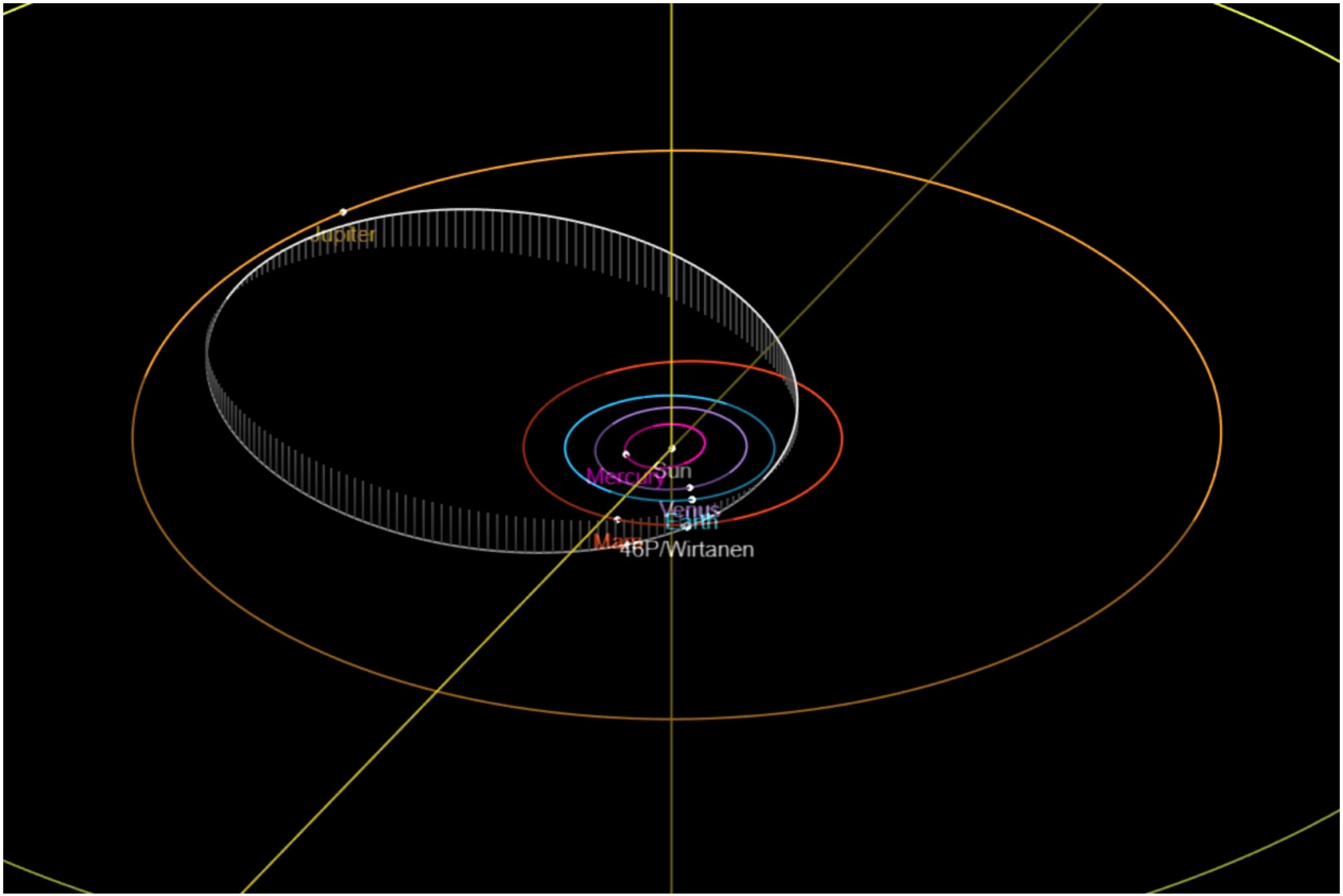
Lunar Parallax

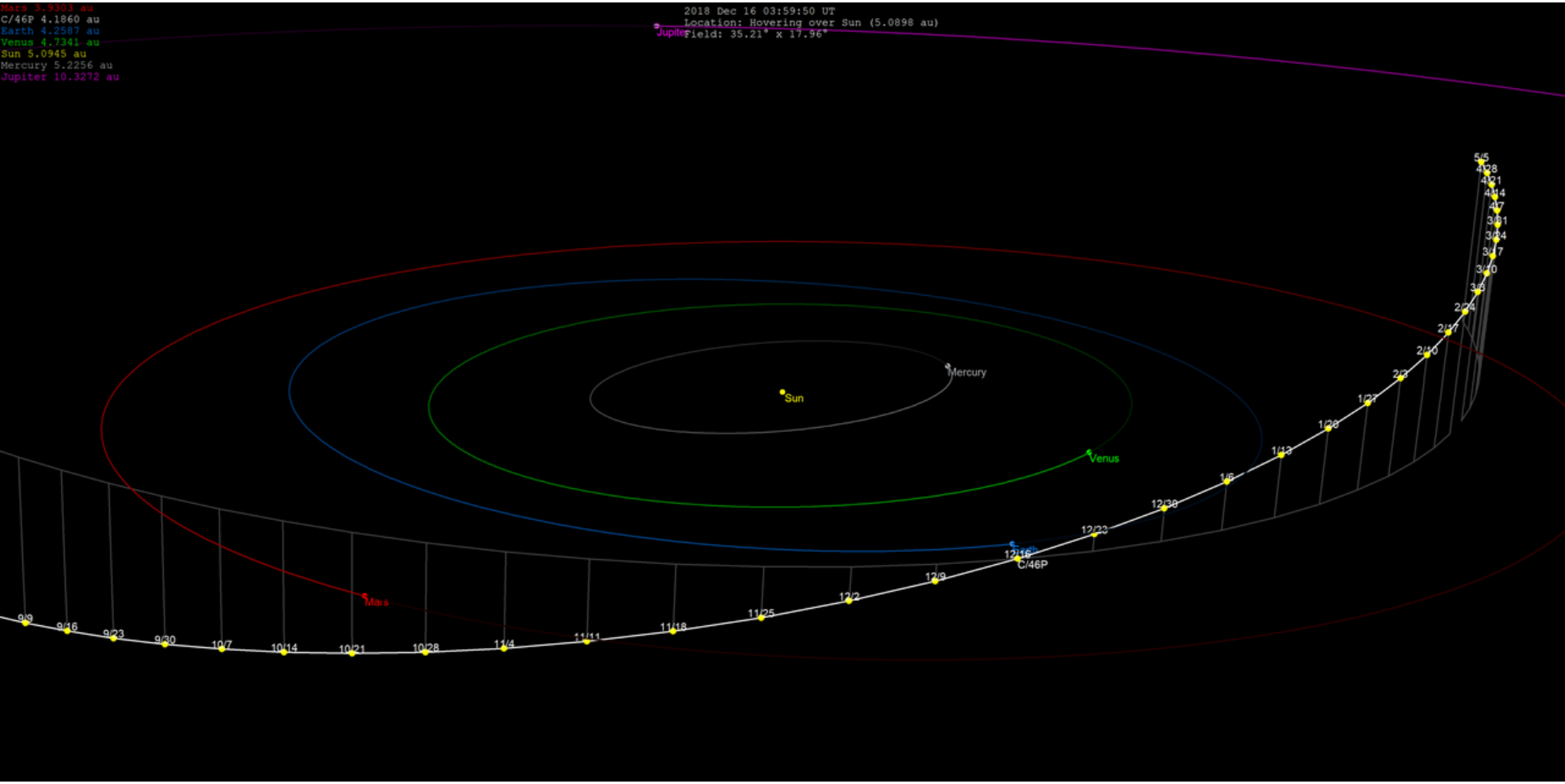
For very close objects, their position relative to the stars will change depending on the position of the observer.

Coordinate Translation



Convert from geocentric to “spacecraft” coordinates




Mars 3.9303 au
C/46P 4.1860 au
Earth 4.2587 au
Venus 4.7341 au
Sun 5.0945 au
Mercury 5.2256 au
Jupiter 10.3272 au
2018 Dec 16 03:59:50 UT
Location: Hovering over Sun (5.0898 au)
Field: 35.21° x 17.96°
Jupiter
Mercury
Sun
Venus
Mars
C/46P
9/9
9/16
9/23
9/30
10/7
10/14
10/21
10/28
11/4
11/11
11/18
11/25
12/2
12/9
12/16
12/23
12/30
1/6
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