Introduction to Astronomy
AA 201
Fall Semester 2019

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Course webpage:
http://www.iiti.ac.in/people/~manoneeta/courses/AA201_2019/

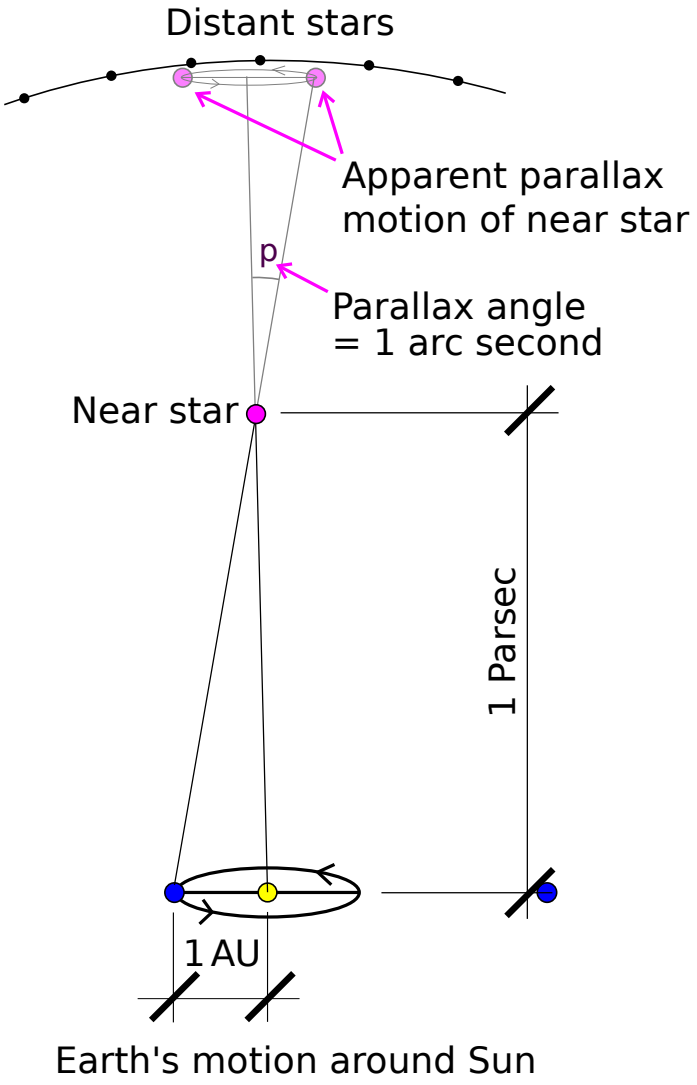
Distance

- Inside solar system: radio and laser imaging
- Nearby stars: Parallax

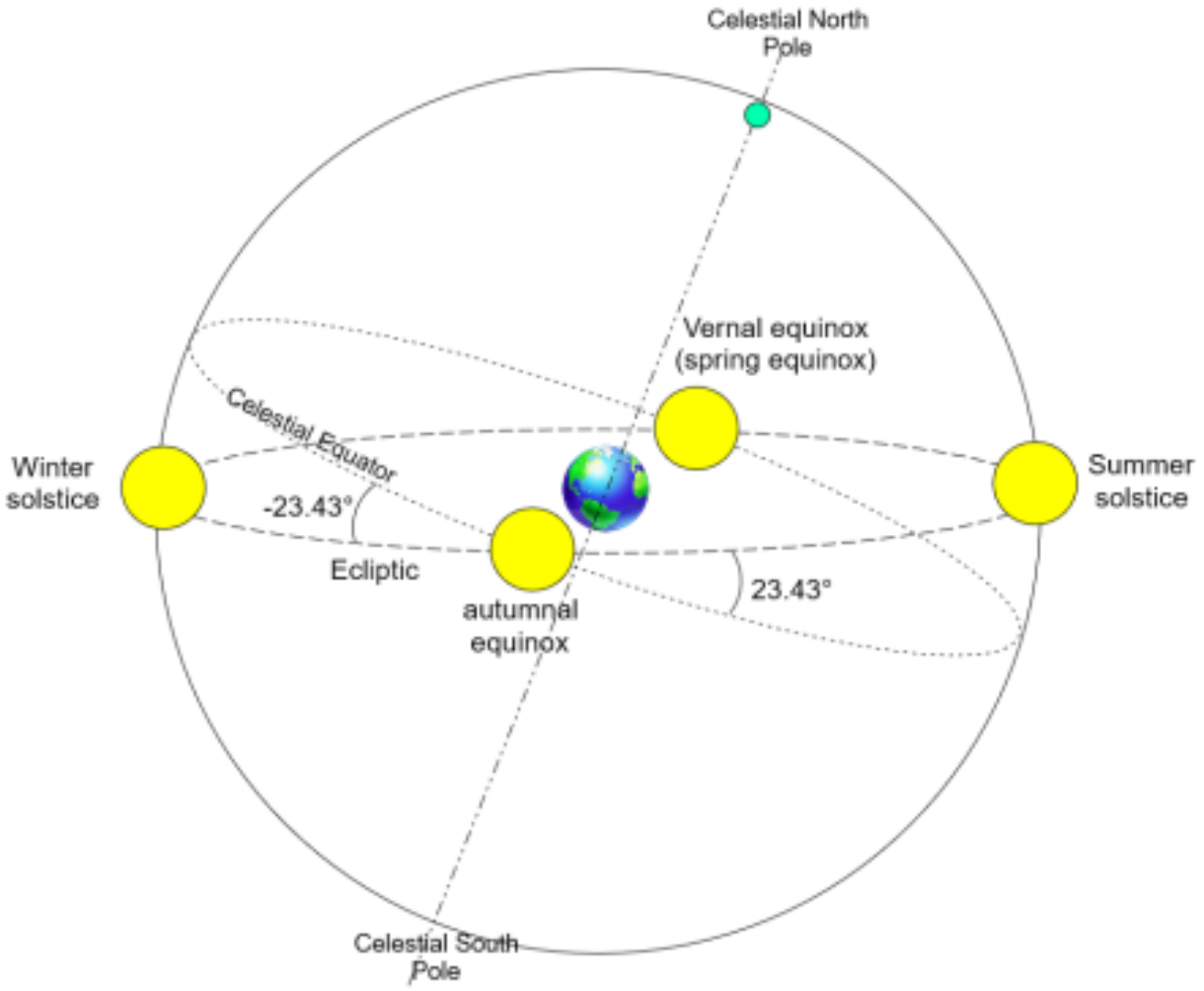
  parsec (pc) = 3.26 light year

  distance at which 1 AU subtends 1 arc sec
- Distant Objects: Standard Candles

  type Ia supernova, cepheids
- Cosmological distances: redshift



Celestial sphere



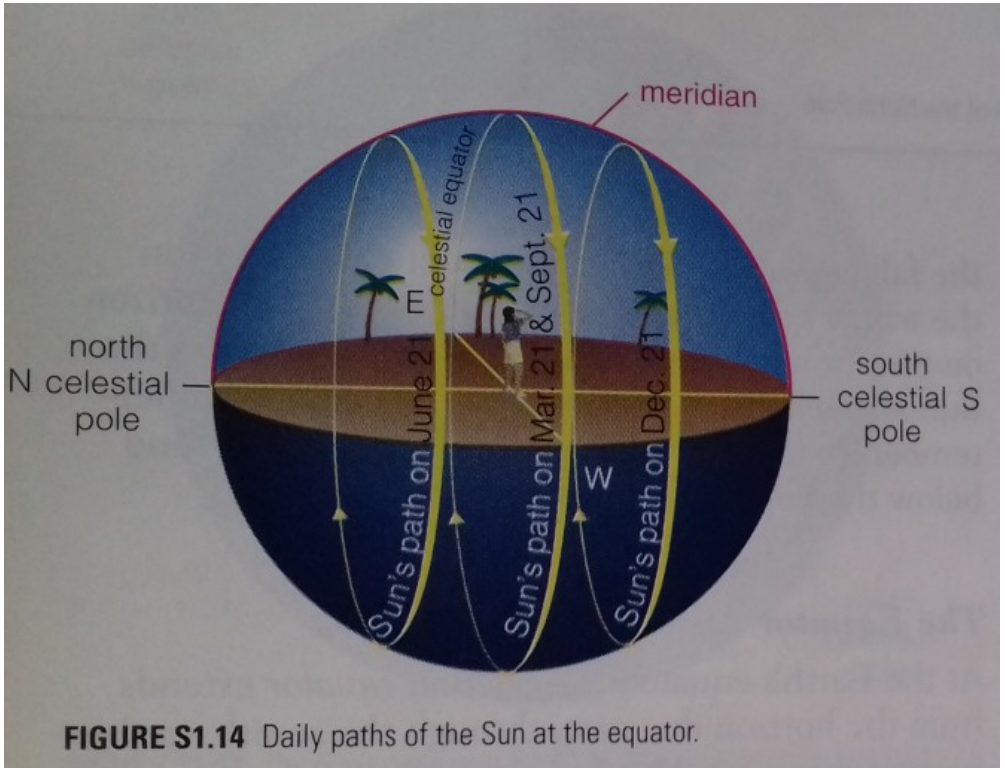
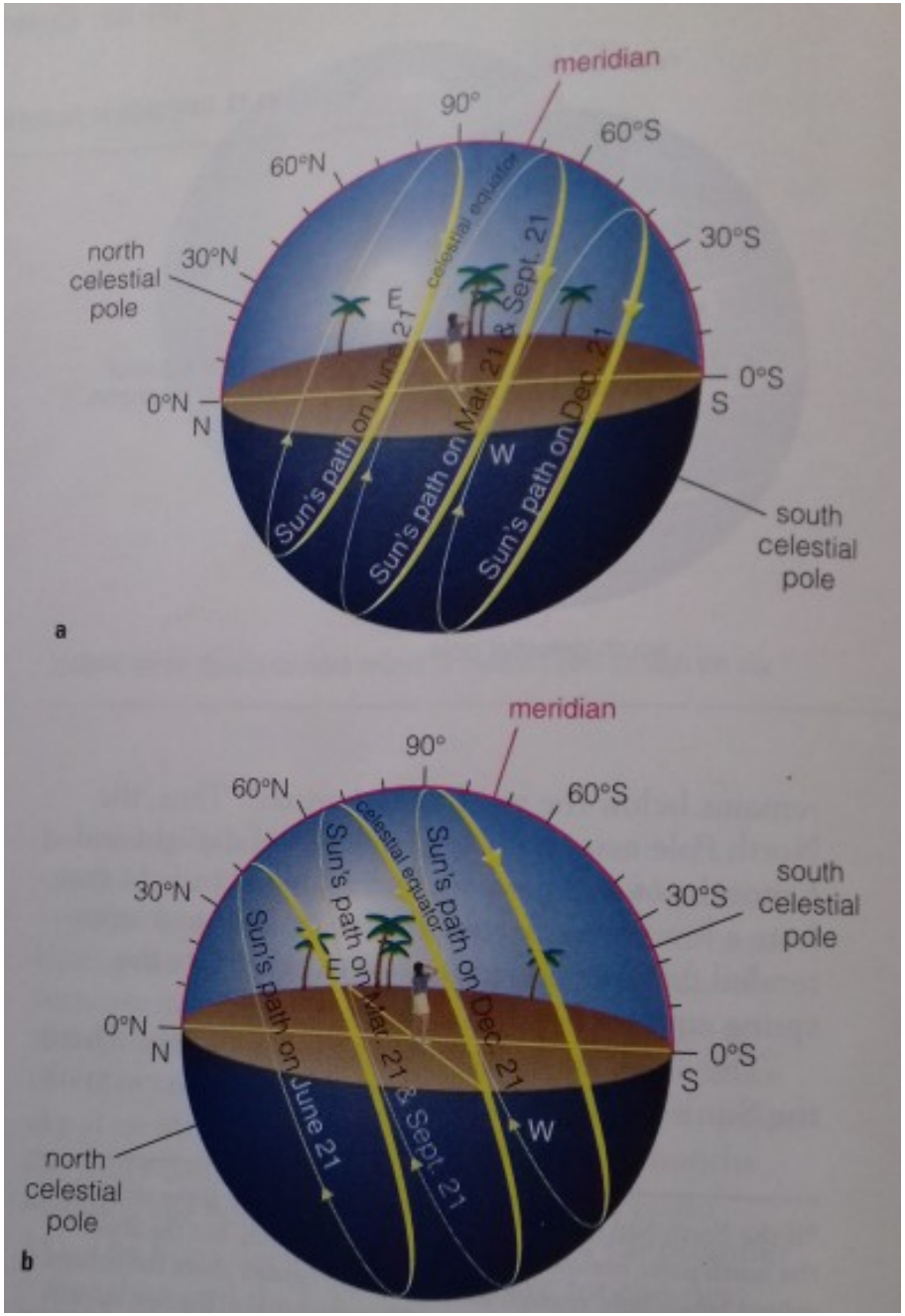
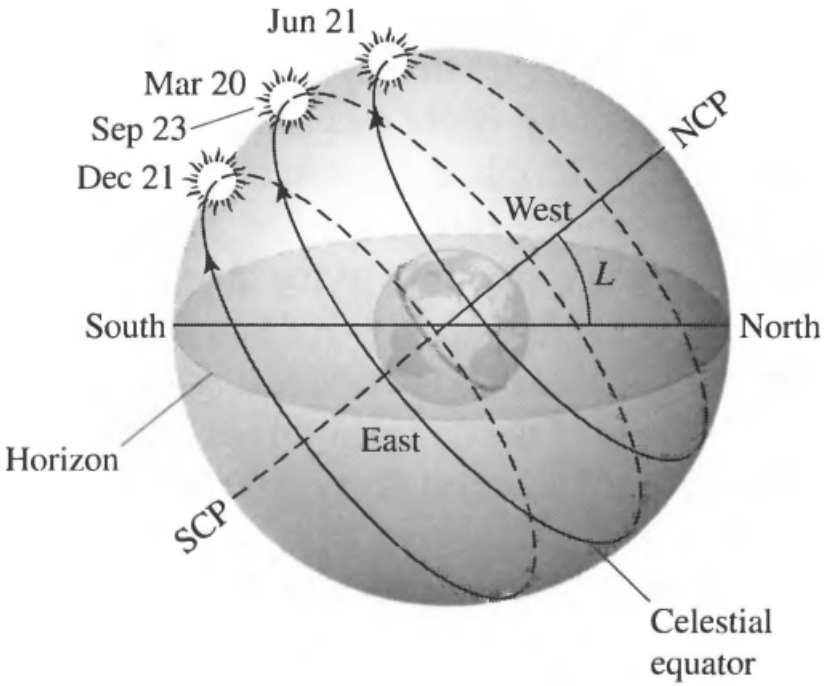
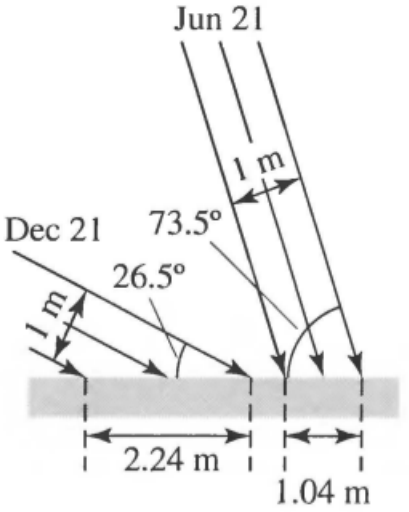


FIGURE S1.14 Daily paths of the Sun at the equator.

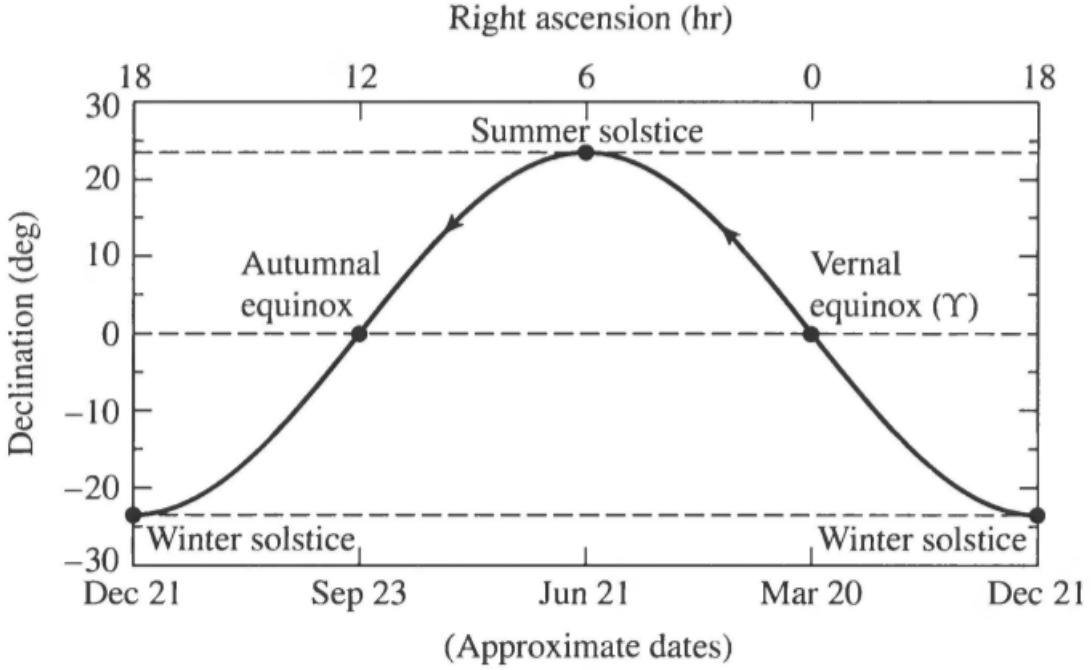



Jun 21
Mar 20
Sep 23
Dec 21
NCP
West
L
South
North
Horizon
East
SCP
Celestial
equator

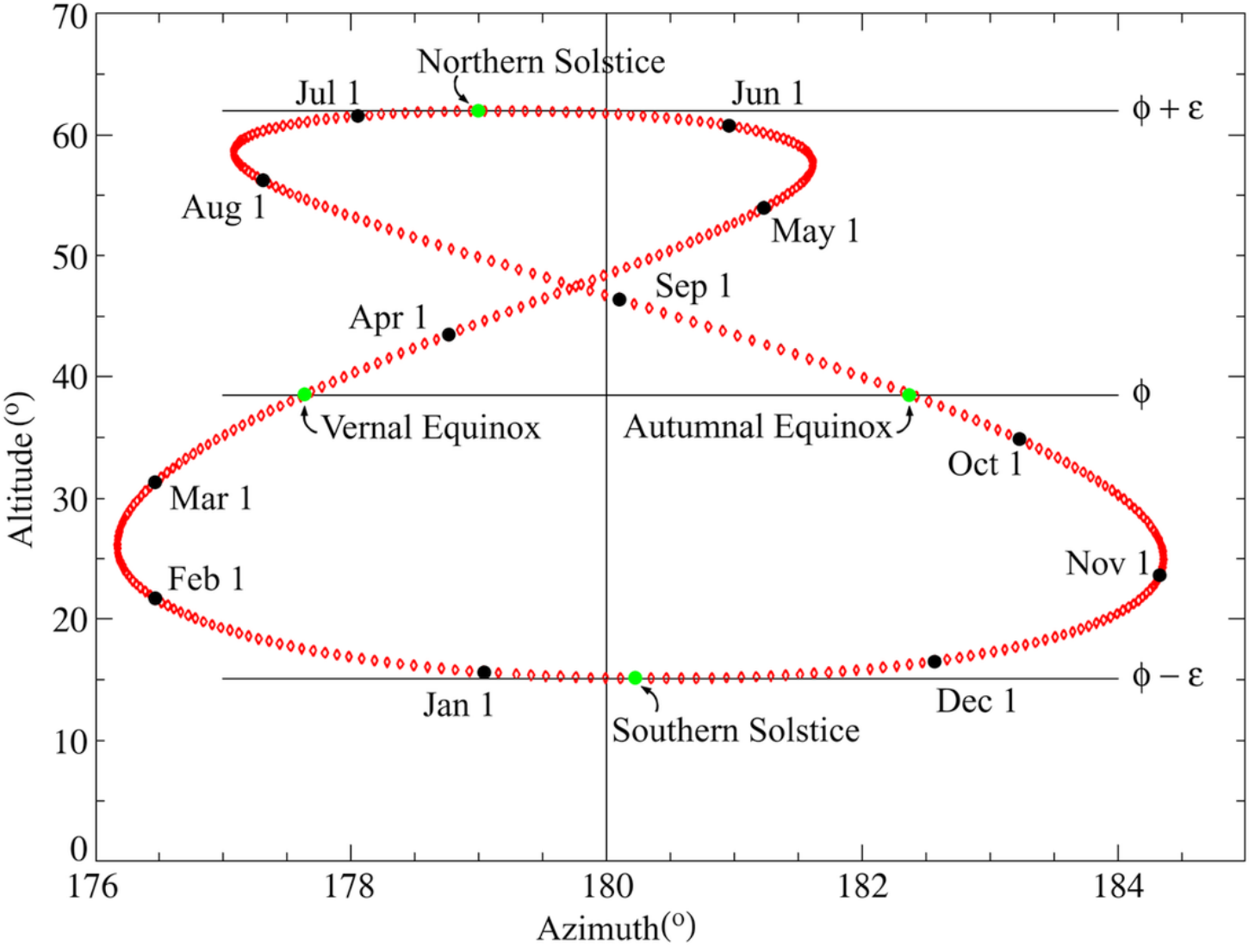
(a)


Jun 21
1 m
Dec 21
73.5°
26.5°
1 m
2.24 m
1.04 m

(b)


Right ascension (hr)
18
12
6
0
18
30
20
10
0
−10
−20
−30
Summer solstice
Autumnal
equinox
Vernal
equinox (ϒ)
Winter solstice
Winter solstice
Declination (deg)
Dec 21
Sep 23
Jun 21
Mar 20
Dec 21
(Approximate dates)

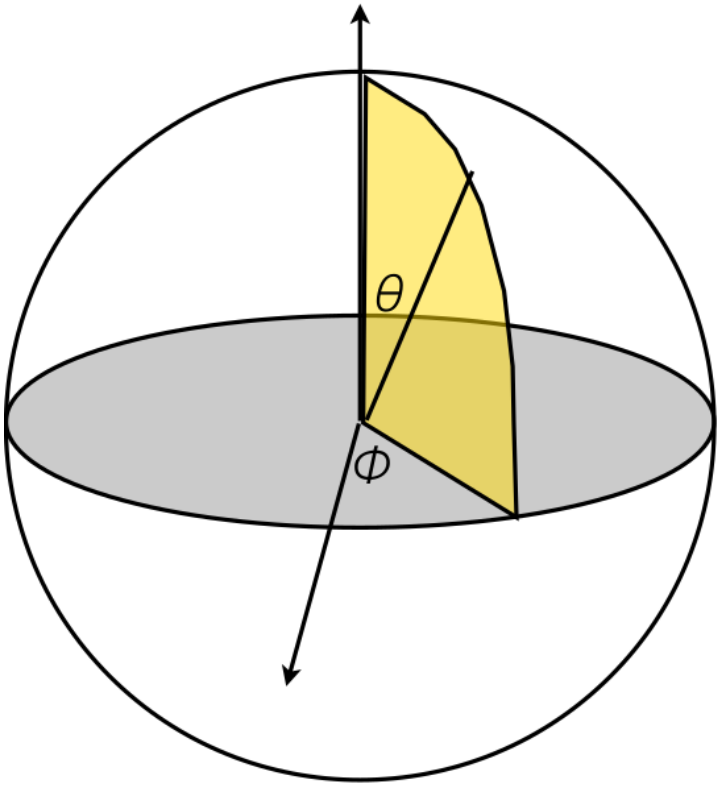
Analemma


Northern Solstice
Jul 1
Jun 1
ϕ + ε
Aug 1
May 1
Sep 1
Apr 1
ϕ
Vernal Equinox
Autumnal Equinox
Oct 1
Mar 1
Nov 1
Feb 1
ϕ − ε
Jan 1
Dec 1
Southern Solstice
Altitude (°)
Azimuth(°)
70
60
50
40
30
20
10
0
176
178
180
182
184

Different coordinate systems

Convention: Latitude: ($\pi/2 - \theta$) ; Longitude: Φ

- Horizontal: Poles: Normal the plane of observer's location
- Equatorial: Poles: extension of the earth's spin axis
- Ecliptic: Poles: Normal to the earth's orbit around the sun
- Galactic: Poles: Normal to the plane of the Galaxy



- For Horizontal: longitude reference is clockwise from direction of the north poles
- For Equatorial and Ecliptic: same longitude reference (ascending node - vernal equinox)
- For Galactic coordinates: longitude reference is the direction to the Galactic Centre

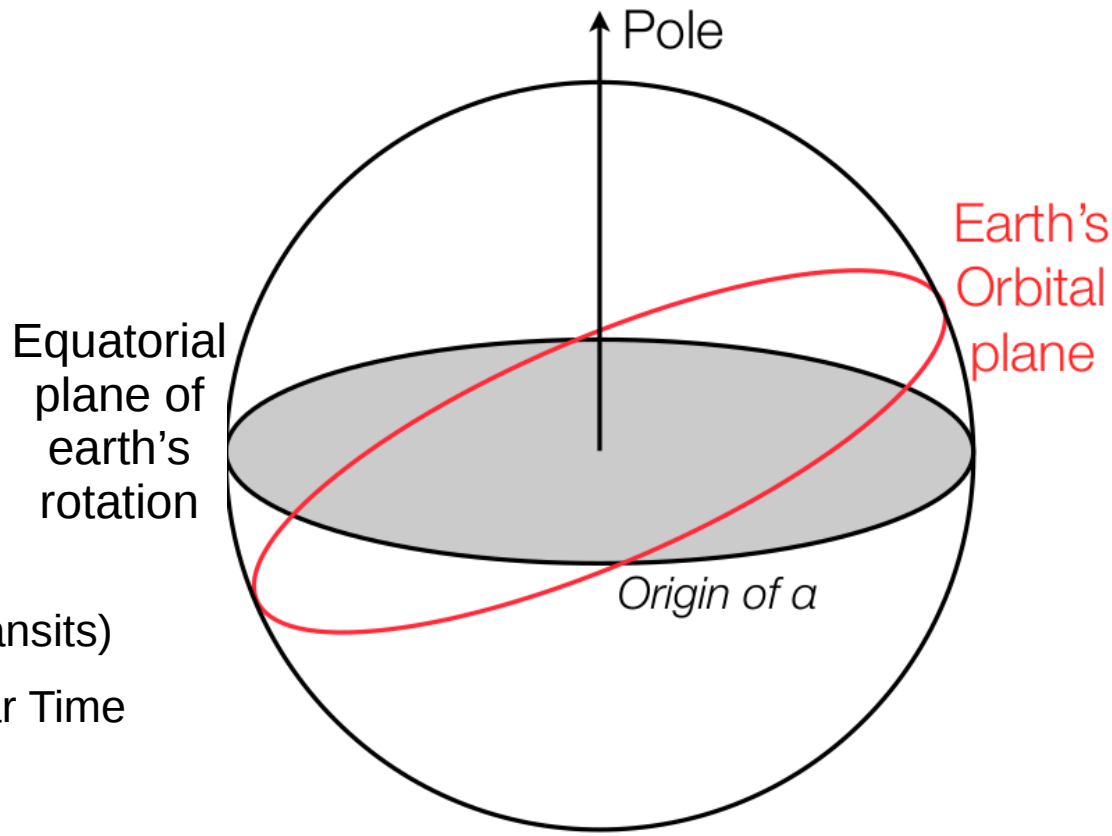
Locating an object

- Angular position can be measured accurately; distance difficult
- Spherical Polar Coordinate System:

  latitude = Declination (δ)

  longitude = Right Ascension (α)

- Time
  - Solar day = 24 hours (time between successive solar transits)
  - Earth's Spin Period: 23h56m (time between successive stellar transits)
  - 24h "Sidereal Time" = 23h56m Solar Time



Horizontal coordinate system

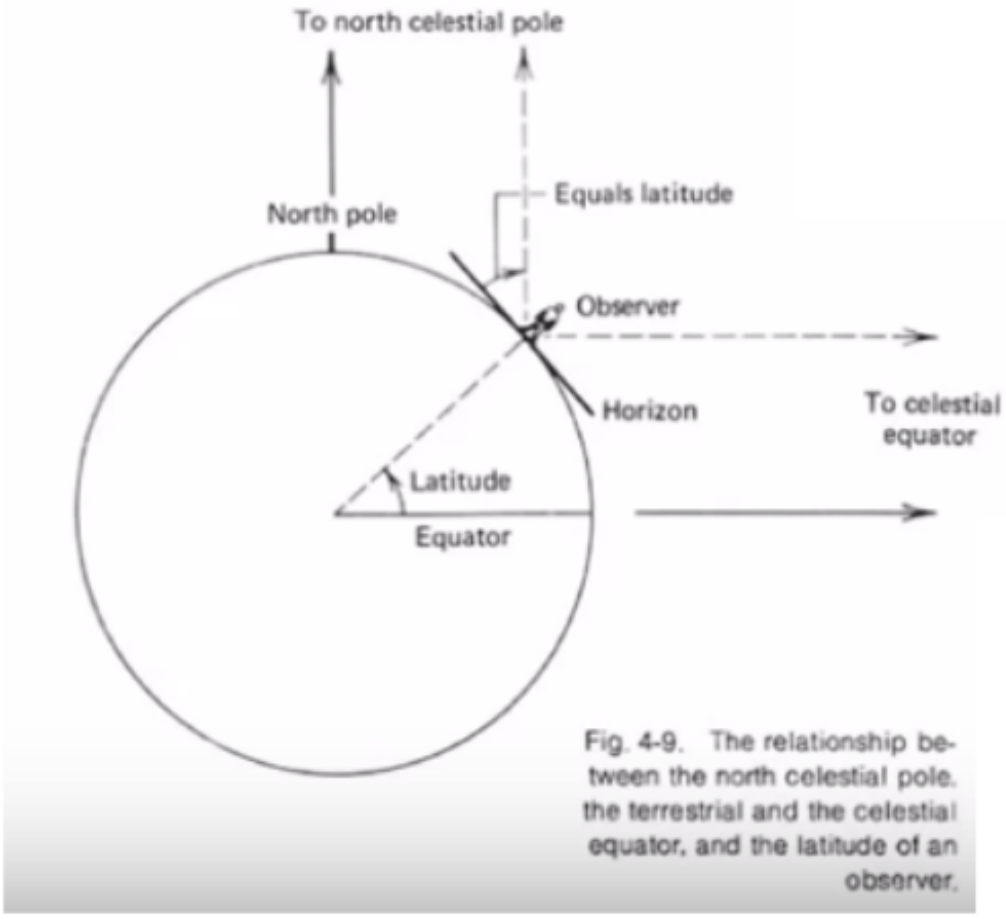


Fig. 4-9. The relationship between the north celestial pole, the terrestrial and the celestial equator, and the latitude of an observer.

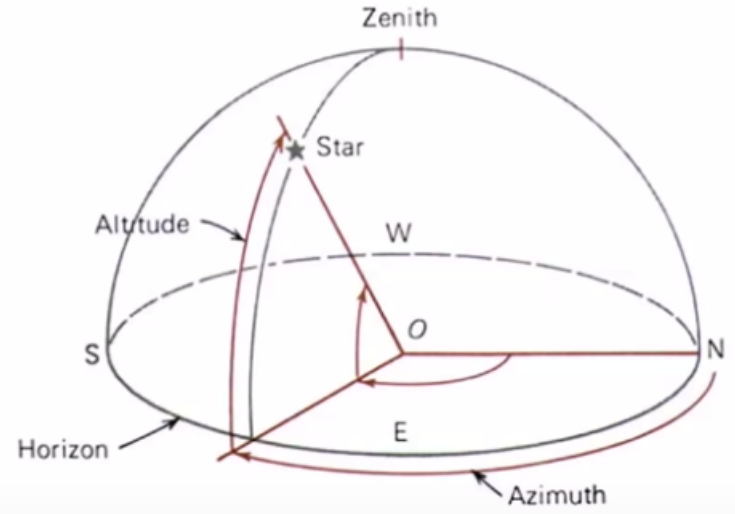
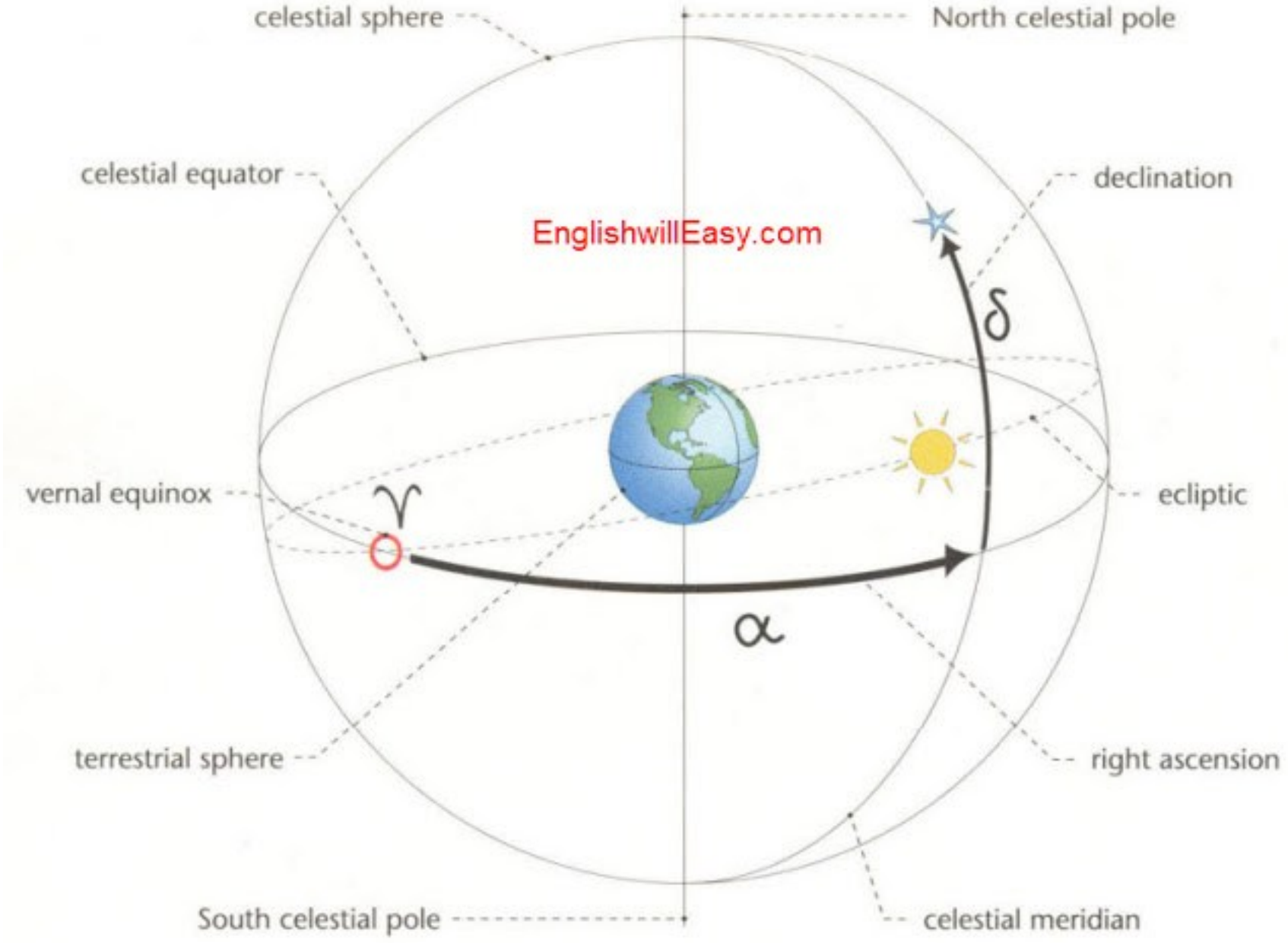


FIG. 5-3 Altitude and azimuth.

Equatorial coordinate system



Equatorial

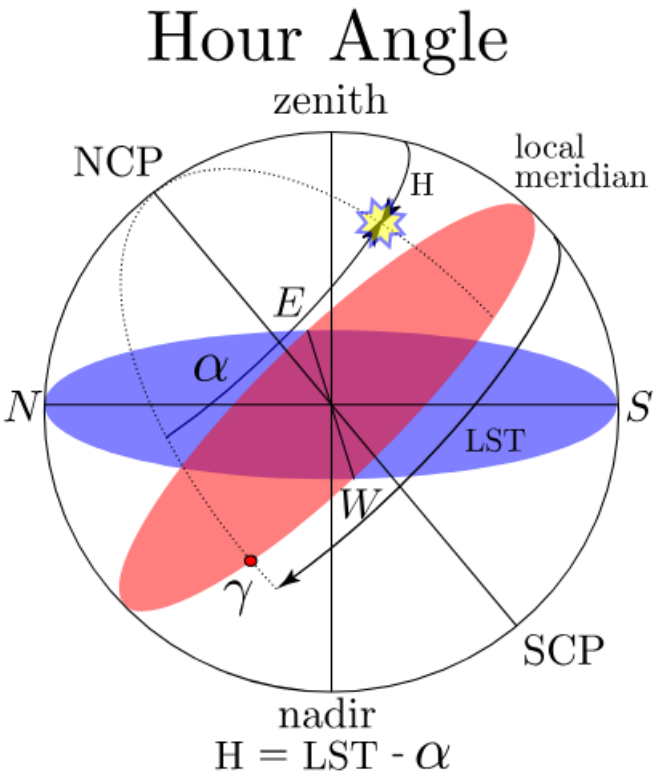
- Hour circle: great circle passing through object and celestial poles measured in hours
- RA: angular distance measured eastward from Vernal equinox to intersection of objects meridian (hour circle)
- DEC: Angular distance of object along hour circle from celestial equator

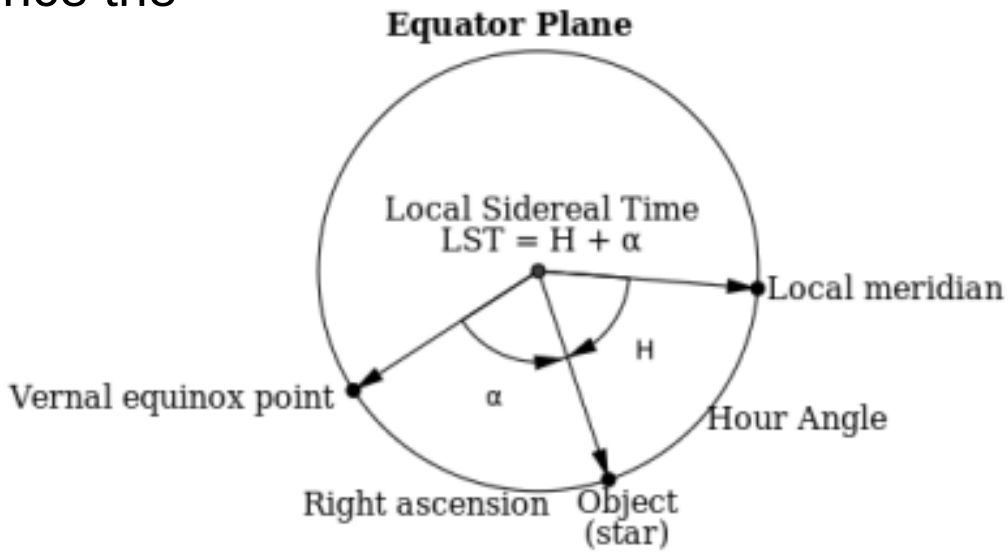
It’s time!

- Solar time is measured with respect to the position of the Sun
- Whenever sun crosses meridian it is 12 noon
- The apparent motion of the Sun across the sky, actually caused by the rotation of the Earth, affects this
- In one solar day the Earth has to spin 360° plus 1° to make the Sun return to the same position in the sky
- The sidereal time is measured by the rotation of the Earth, with respect to the stars (rather than relative to the Sun)
- The time period for Earth to rotate 360°, relative to the distant stars, is called the sidereal day and is 23h 56m 04s of a solar day
- **LOCAL SIDEREAL TIME**
  - It is same as the RA of a star on observer’s meridian
  - RA coordinate measures positions around the equator of the celestial sphereRA coordinate measures positions around the equator of the celestial sphere

More time..

- Hour angle
  - The hour angle of a point is the angle between two planes: one containing the earth's axis and the zenith (the meridian plane), and the other containing the earth's axis and the given point
  - the object's hour angle indicates how much sidereal time has passed since the object was on the local meridian
  - $HA_{object} = LST - RA_{object}$





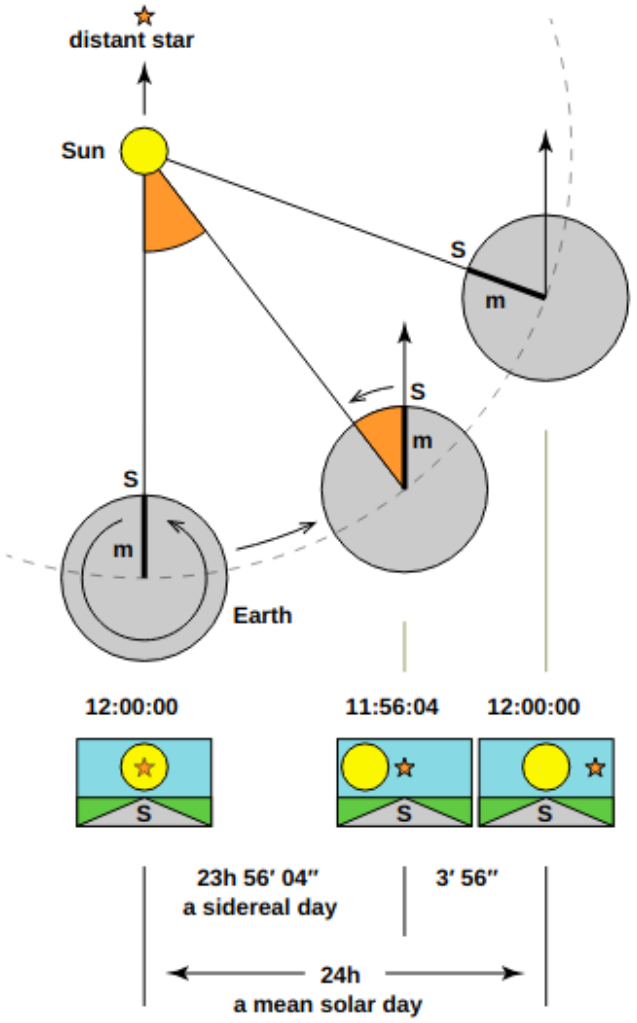
$$\sin(a) = \sin(\phi_o)\sin(\delta) + \cos(\phi_o)\cos(\delta)\cos(h)$$

$$\cos(a)\sin(A) = \cos(\delta)\sin(h)$$

a → altitude
A → Azimuth

$$\cos(\gamma) = \cos(90^\circ - \delta_1)\cos(90^\circ - \delta_2) + \sin(90^\circ - \delta_1)\sin(90^\circ - \delta_2)\cos(\alpha_1 - \alpha_2)$$

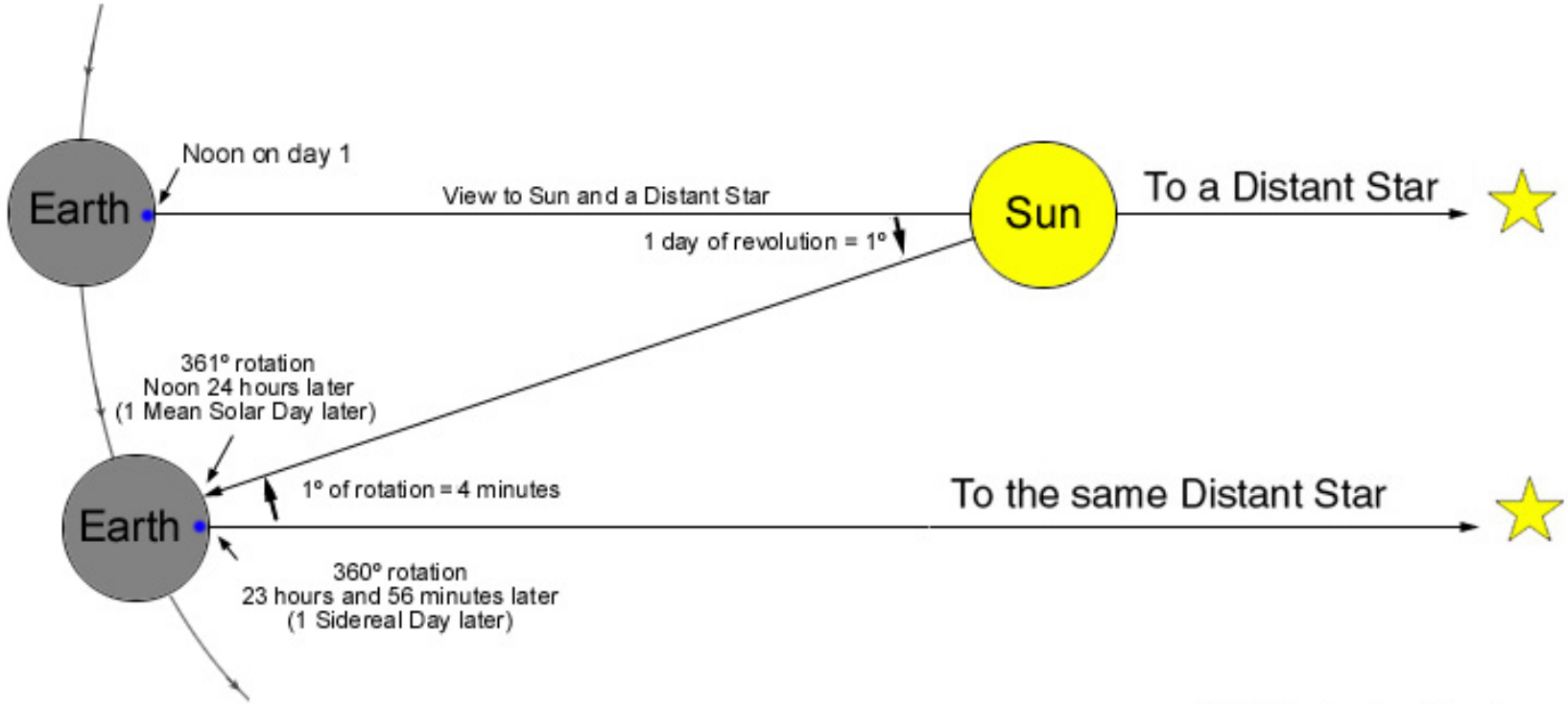
Sidereal time

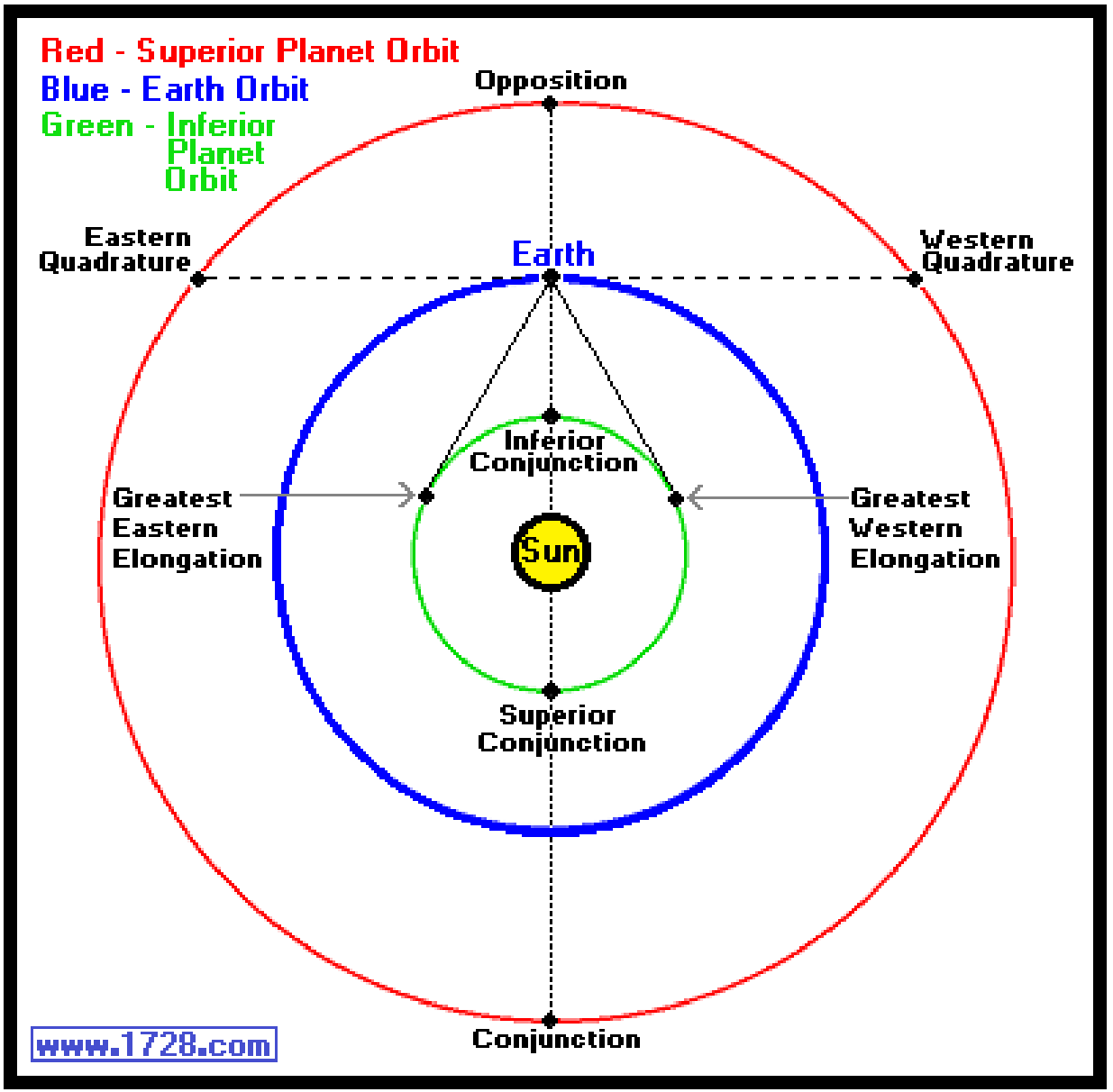


local sidereal time (LST) = the RA on the observer's meridian

$LST = HA_{obj} + RA_{obj}$

The Sidereal and Mean Solar Day




Red - Superior Planet Orbit
Blue - Earth Orbit
Green - Inferior Planet Orbit
Opposition
Eastern Quadrature
Earth
Western Quadrature
Inferior Conjunction
Greatest Eastern Elongation
Sun
Greatest Western Elongation
Superior Conjunction
Conjunction
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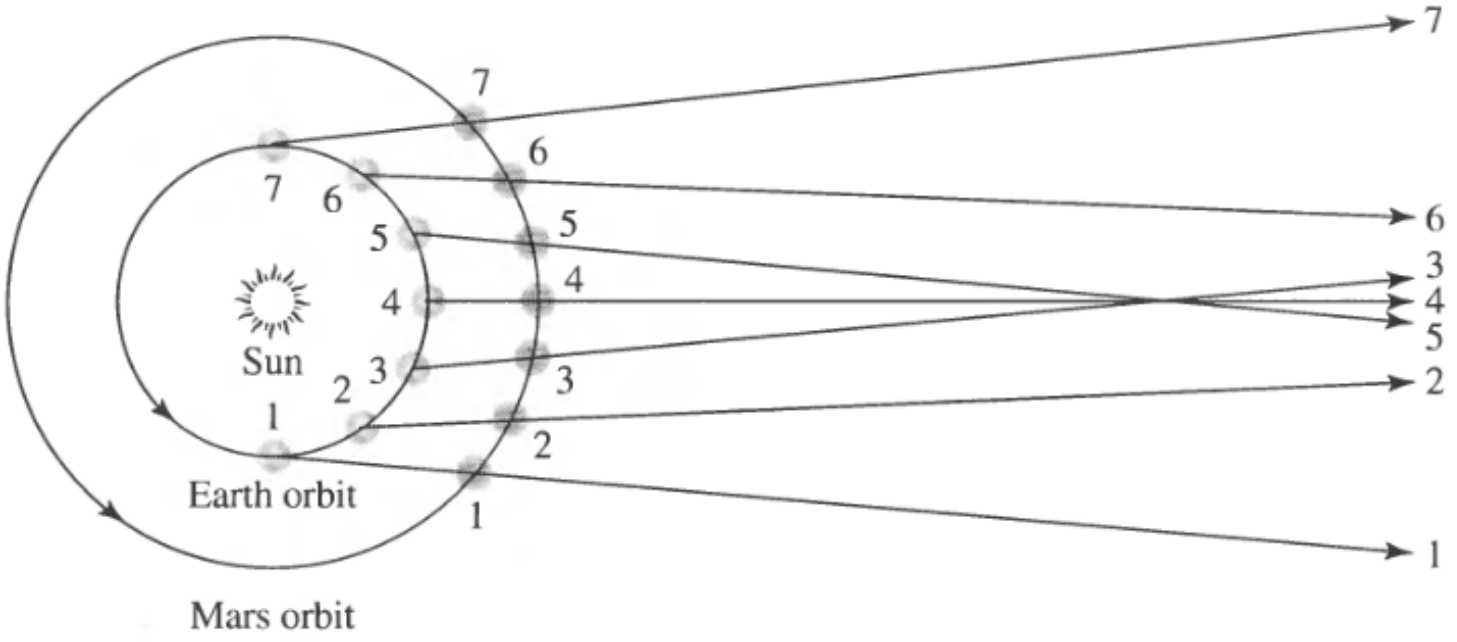
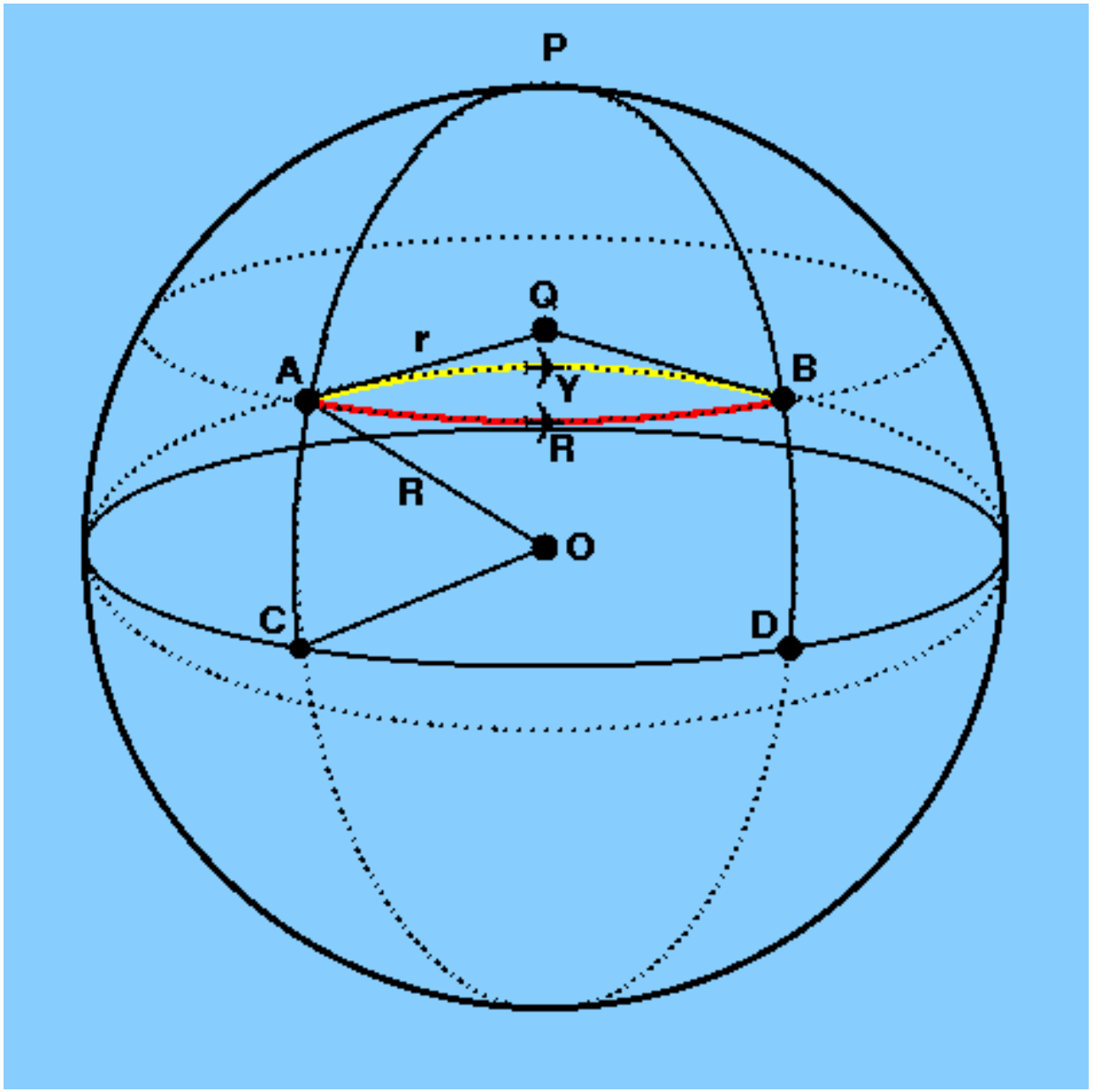
Retrograde




P
Q
r
A
B
Y
R
R
O
C
D