

# Lots and Lots and Lots of Stars

Imagine you are in a place far away from the city on a clear night, about how many stars can you see with the naked eye?

- a) A few million
- b) A few thousand
- c) A few hundred
- d) A few hundred thousand

As of July 2003 the total number of stars in the observable Universe was estimated at:

- 70 sextillion ( $7.0 \times 10^{22}$ )
- 10 times the number of grains of sand on all of the beaches and deserts on Earth.
- This is just an estimate!!!

# Constellations/Asterisms

## Constellations:

- A group of stars visibly related to each other that move in a fixed imaginary pattern across the sky.
- Today there are 88 “official” constellations
  - 50 ancient
  - 38 modern
- Each constellation divides the sky into smaller segments.

# Constellations/Asterisms

- Keyword patterns:
  - Stars within constellations can be very far away from one another.
  - From another solar system the sky would not contain these same patterns.

# Constellations: The Zodiac

- Most well-known of the ancient constellations
- First celestial coordinate system.
- Lie in a band 18 degrees wide centered on the area that the sun travels in the sky called the ecliptic.
- 12 constellations..why???

\*\*\* Actually there are 13 constellations that lie within the Zodiac.

# The Zodiac

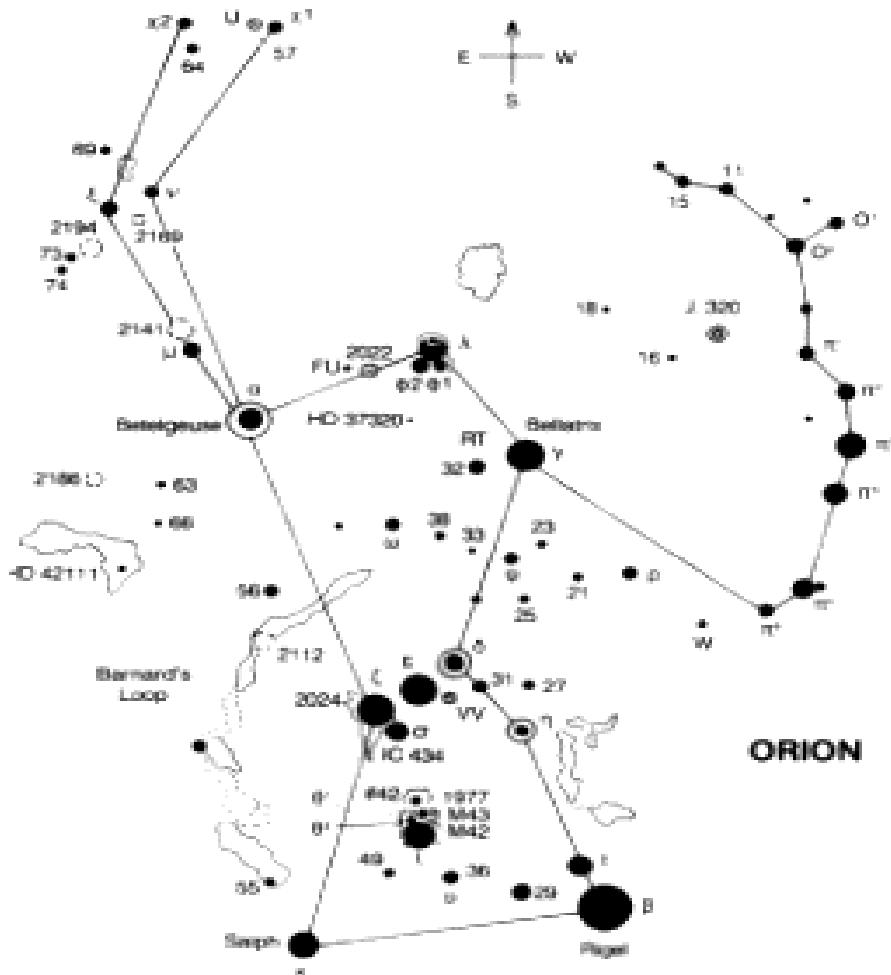
Constellation	Dates of Sun's Passage Through
Pisces	March 12 – April 18
Aries	April 19 – May 13
Taurus	May 14 – June 19
Gemini	June 20 – July 20
Cancer	July 21 – August 9
Leo	August 10 – September 15
Virgo	September 16 – October 30
Libra	October 31 – November 22
Scorpius	November 23 – November 29
Ophiuchus	November 30 – December 17
Sagittarius	December 18 – January 18
Capricorn	January 19 – February 15
Aquarius	February 16 – March 11

# Asterisms

An asterism is a star pattern that may be contained in a constellation or consist of stars belonging to different constellations.

# Naming Conventions

- Many of the Bright Stars within Constellations and Asterisms have proper names usually of Arabic and Greek origin.



Betelgeuse:

Misread word “yad al-jawza” which means hand of the central one. Thought it read “Bait al-Juaza” which means Armpit.

Rigel:

Contraction of the word “Rijl Jauza al-Yusra” which means left foot of the central one or the foot of the great one.

# Observing Methods and Tools

- Many tools with mapped celestial sphere coordinates.

- planisphere

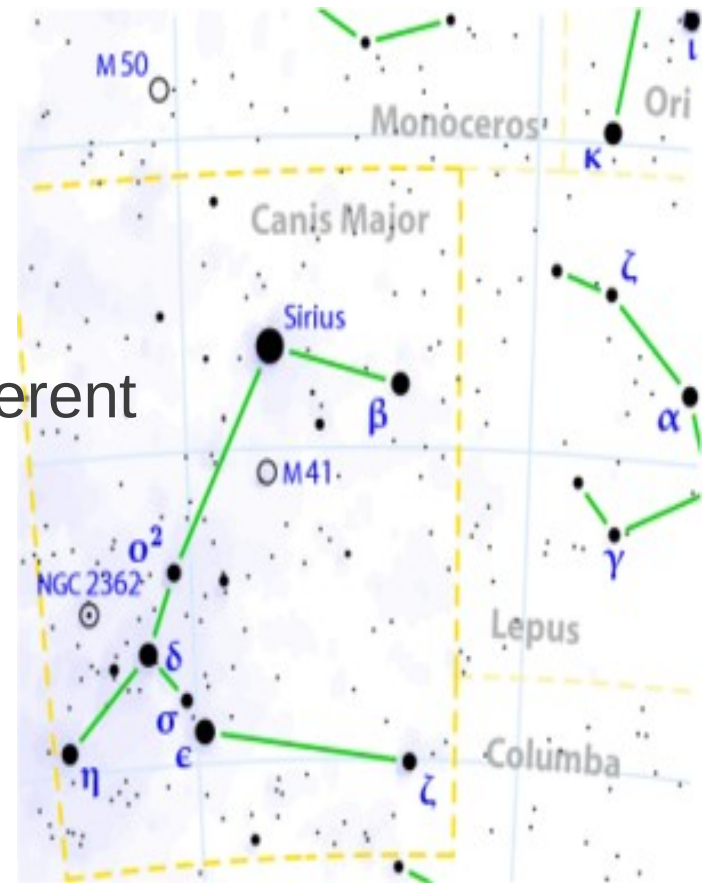
- software:

[www.stellarium.org](http://www.stellarium.org)

- sky chart

- books/magazines

- Stars represented on the above tools as different size dots refer to the apparent brightness of the star in the sky, which is called the magnitude of the star.



# Approximating Sizes on the Sky

1°



5°



10°



15°



25°



*Duane H.*

# Motions of the Stars in the Sky

- Earth rotates counter-clockwise tilted  $23.5^\circ$  on its axis.
- Terminator is the line defined between day and night.
- Earth's rotation creates daily (diurnal) motion of the stars, Sun, Moon, and Planets.

Diurnal Motion creates an apparent East to West motion of the Stars in the sky.

## Two Types of Day

### Solar Day:

24 hour day measured from apparent noon to apparent noon.

### Sidereal Day:

23 hours 56 minutes 4.099 seconds long and is measured with respect to the stars.

# Precession of the Earth

Due to precession:

The north star will be Vega in  
14000 AD

Orion will be seen in the summer  
sky in 13,000 years.

# Movement of the Stars in the Sky

The Celestial Sphere: an imaginary sphere of gigantic radius with the earth located at its center.

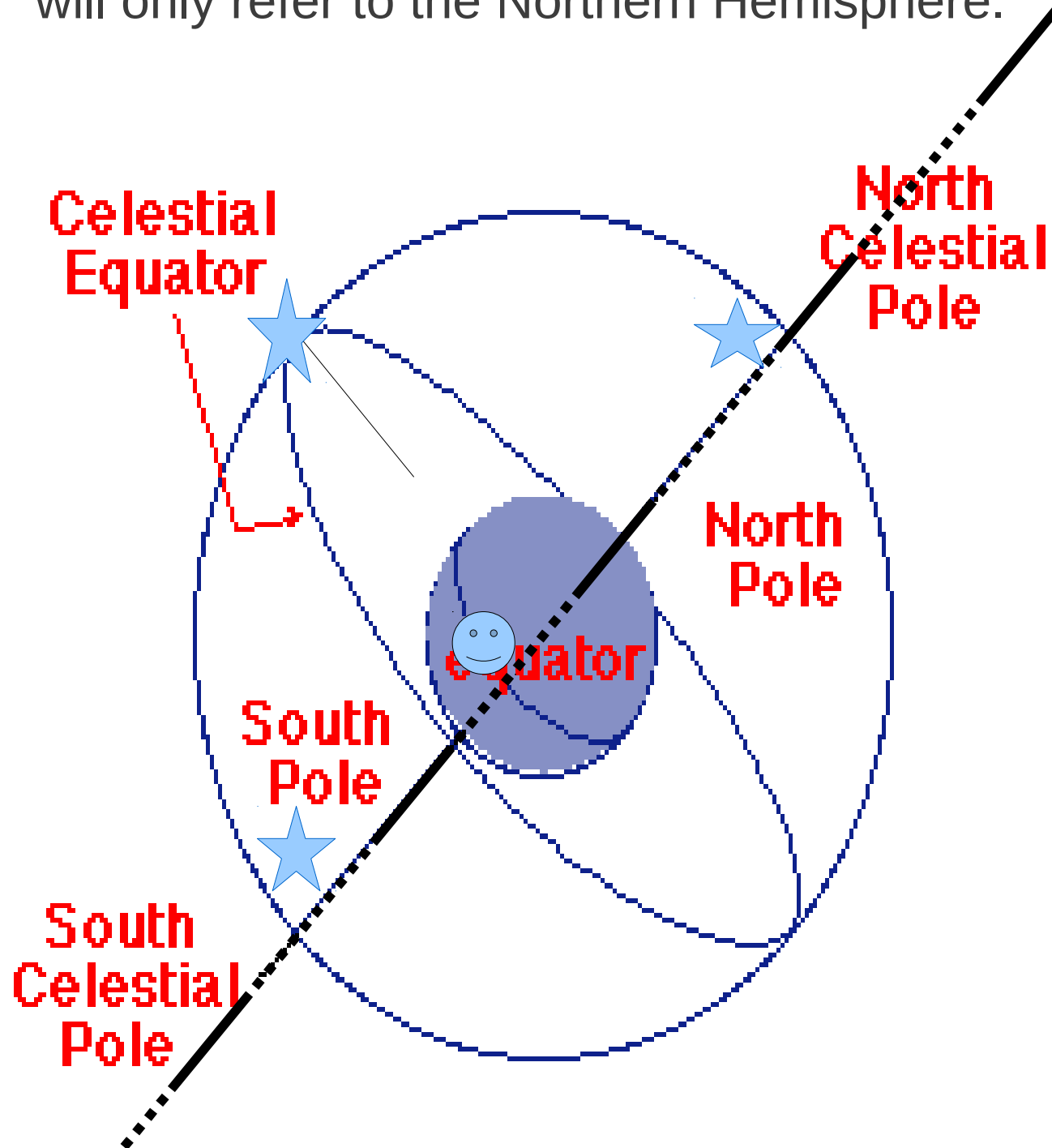
Stars are fixed to celestial Sphere.

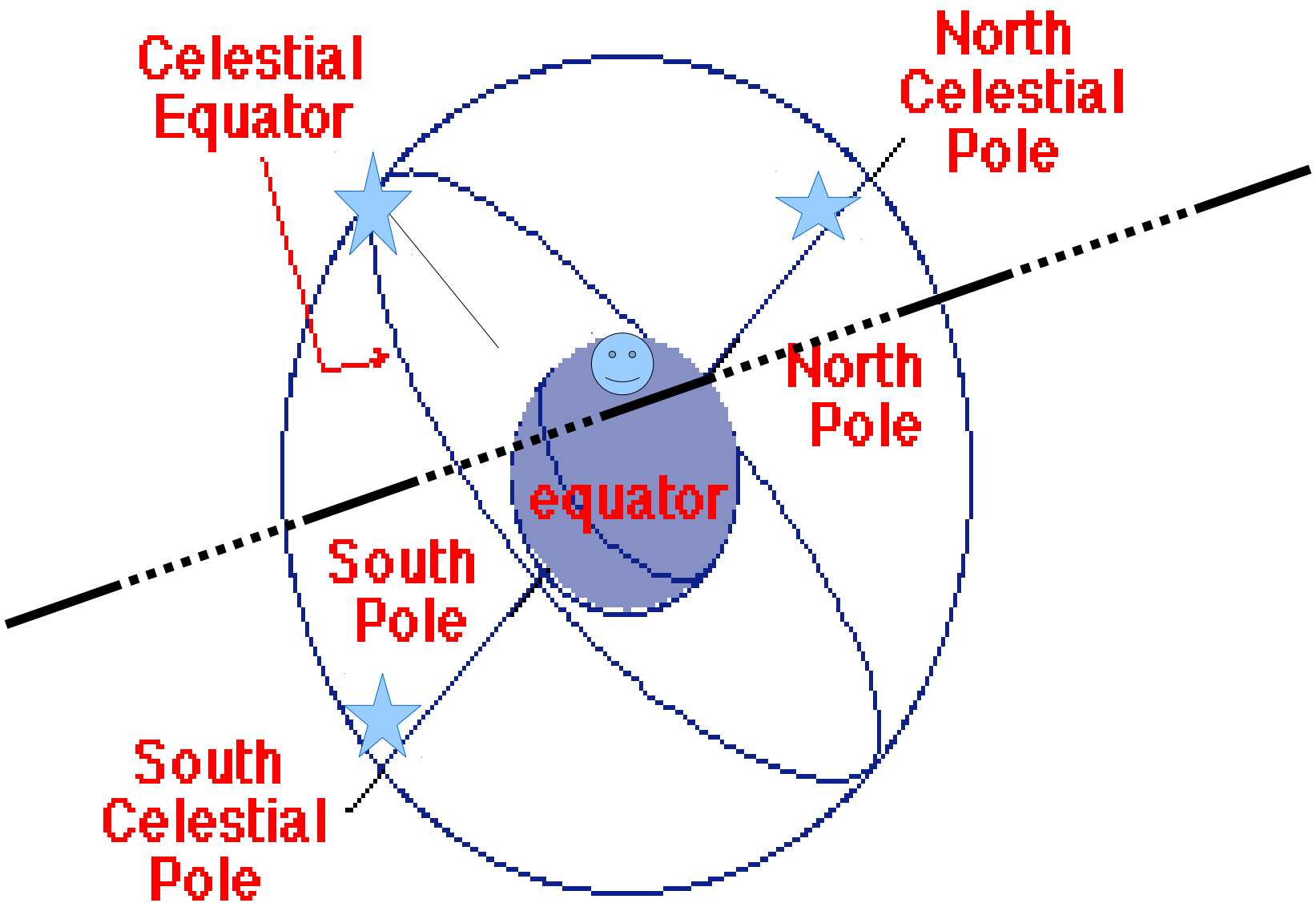
Stars move around the NCP and SCP parallel to the celestial equator.

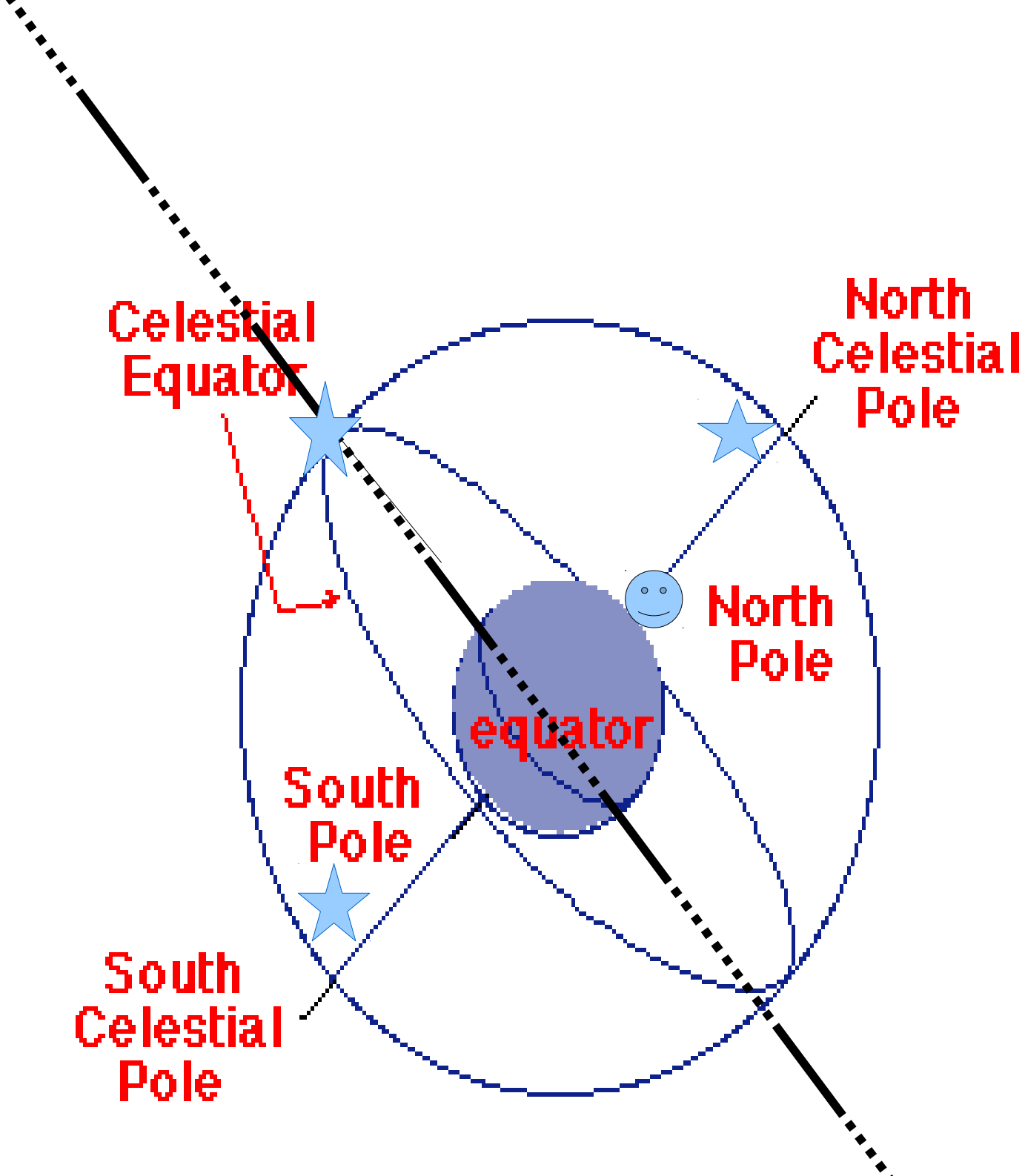
Stars rise and set four minutes earlier each day.

Polaris, the North Star, is located within a few degrees of the North Celestial Pole.

- Only see half of the Celestial Sphere therefore, we will only refer to the Northern Hemisphere.





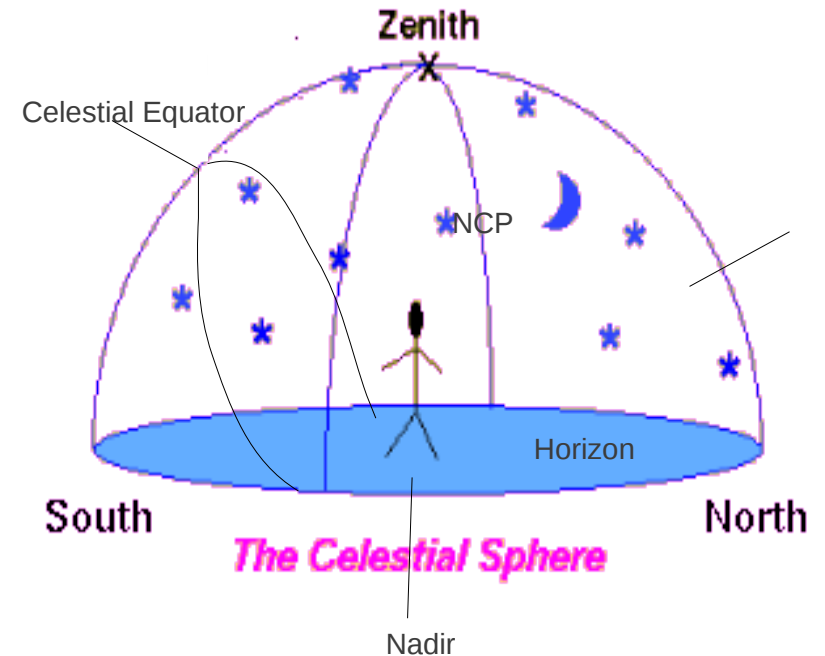


# Local Celestial Sphere or your local sky!

Zenith: The point directly above an observers head at  $90^\circ$  altitude.

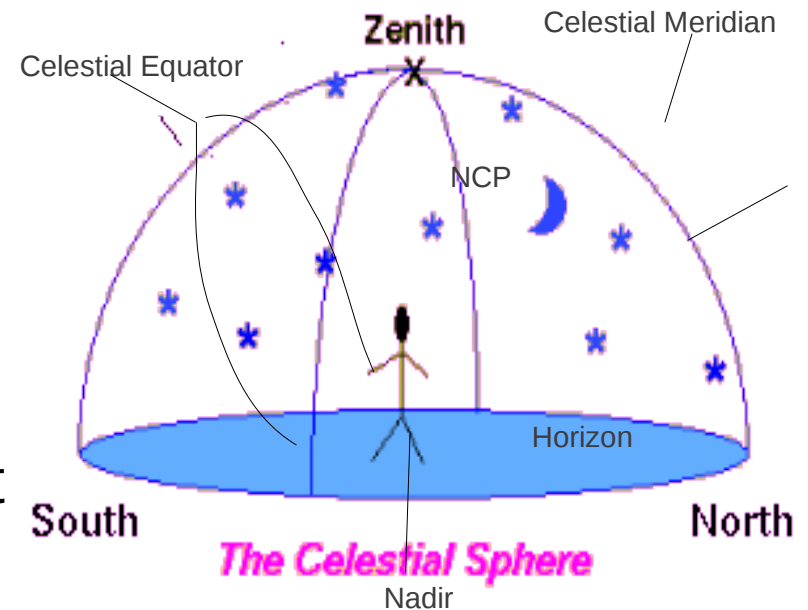
Nadir: The point directly opposite the Zenith.

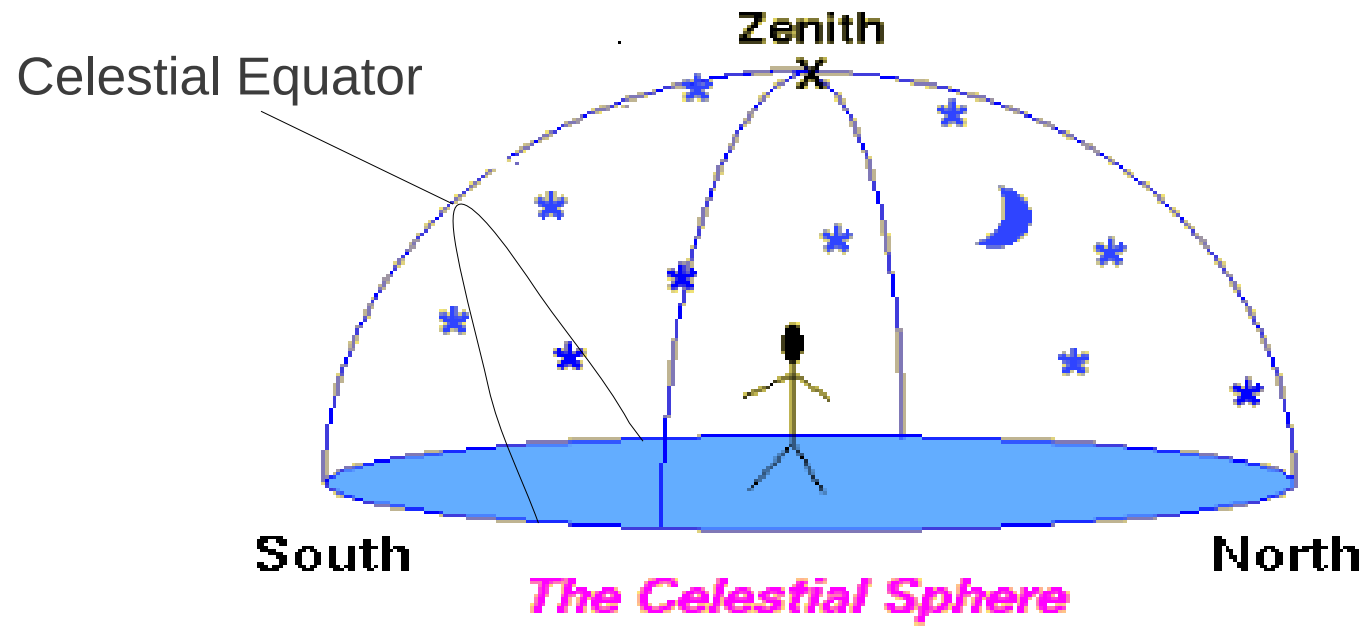
Horizon: Line where the sky meets the ground and your view of the celestial sphere is blocked.



Celestial Meridian: The imaginary circle passing through the North and South points on our horizon and through the zenith.

Any celestial object crossing the meridian is at its highest altitude (distance from the horizon) during that night (or day).





Stars North of the Celestial Equator are above the horizon for more than 12 hours.

Stars that are on the Celestial Equator are above the horizon for 12 hours.

Stars that are below the Celestial Equator are above the horizon less than 12 hours.

## Circumpolar Stars

- Constellations that never set (always above horizon) during diurnal motion.
- These constellations are found near the NCP and are slightly different for different latitudes.

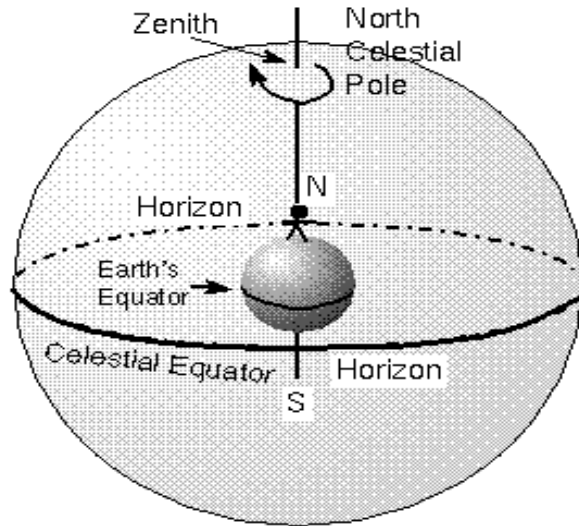
Most of the United States see the following constellations as circumpolar:

Ursa Major  
Ursa Minor  
Camelopardalis  
Cassiopeia  
Cephus  
Draco

- A few stars within Perseus do not set but we are not going to call the whole constellation circumpolar.

- Also Lynx and Auriga are not circumpolar

# Latitude = 90° N



Altitude of North Celestial pole = observer's latitude

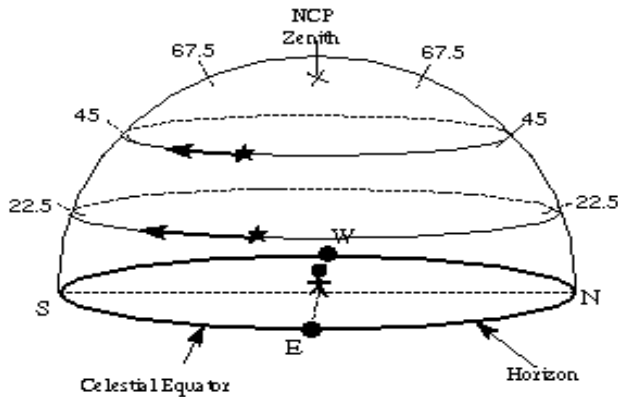
$$90 \text{ degrees N} = 90 \text{ degrees N}$$

Altitude of celestial equator with the horizon:

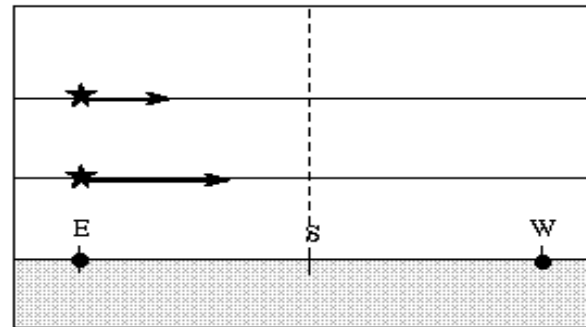
$$\text{C.E.} = 90 - \text{observer's latitude.}$$

$$90 - 90 \text{ degrees} = 0 \text{ S}$$

The celestial sphere for an observer at the North Pole.  
The NCP is straight overhead at the zenith and the celestial equator is on the horizon.



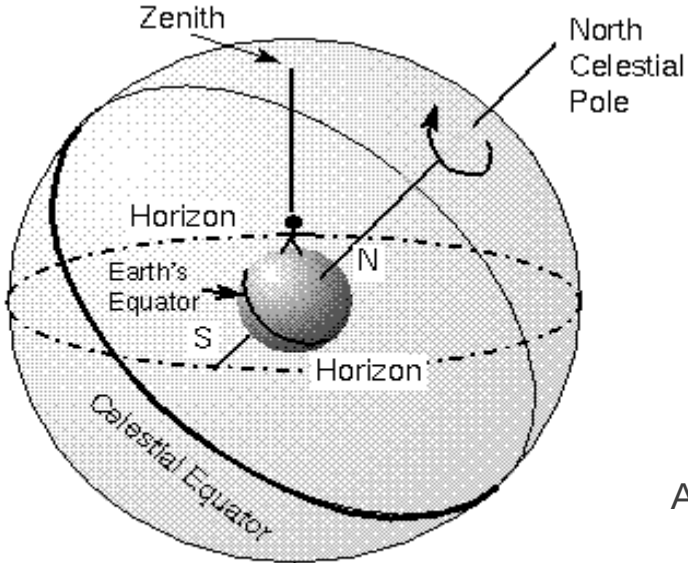
Stars motion at North Pole. Stars rotate parallel to the Celestial Equator, so they move parallel to the horizon here--they never set! Altitudes of 1/4, 1/2, and 3/4 the way to zenith are marked.



Your view from the North Pole. Stars move parallel to the horizon. The Celestial Equator is on the horizon.



# Latitude = 47 ° N



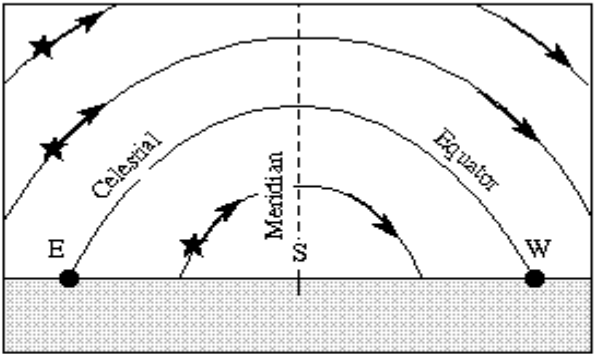
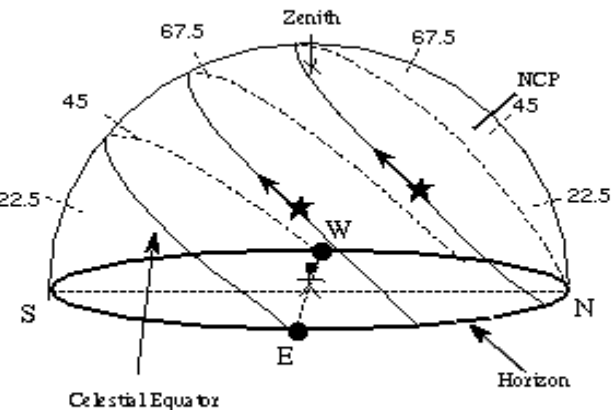
Altitude of North Celestial pole = observer's latitude

47 degrees N = 47 degrees N

Angle celestial equator makes with horizon =:

C.E. = 90 - observer's latitude.

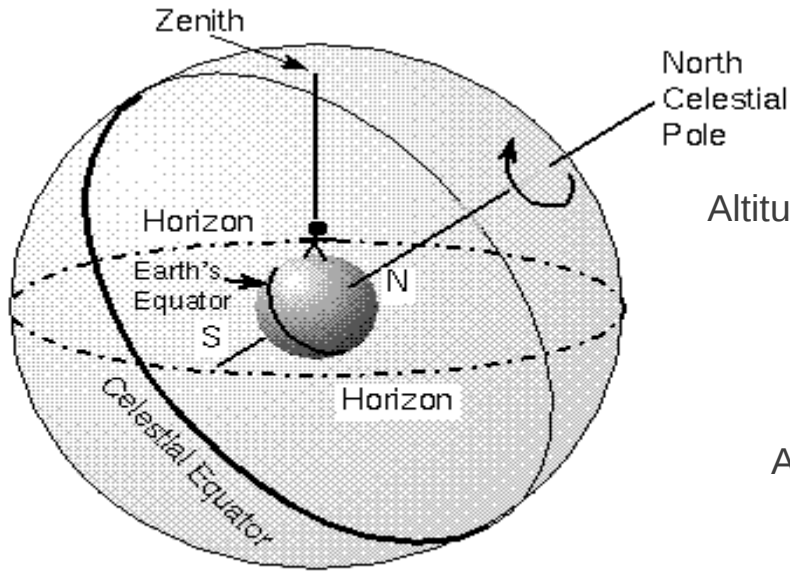
90 - 47 degrees = 43 S



Stars motion at Seattle. Stars rotate parallel to the Celestial Equator, so they move at an angle with respect to the horizon here. Altitudes of 1/4, 1/2, and 3/4 the way up to the zenith are marked.

Your view from Seattle. Stars rise in the East half of the sky, reach maximum altitude when crossing the meridian (due South) and set in the West half of the sky. The Celestial Equator goes through due East and due West.

# Latitude = 37° N



Altitude of North Celestial pole = observer's latitude

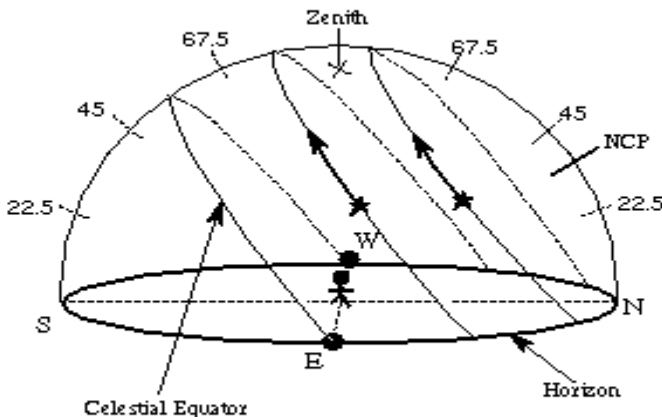
37 degrees N = 37 degrees N

Angle celestial equator makes with horizon :

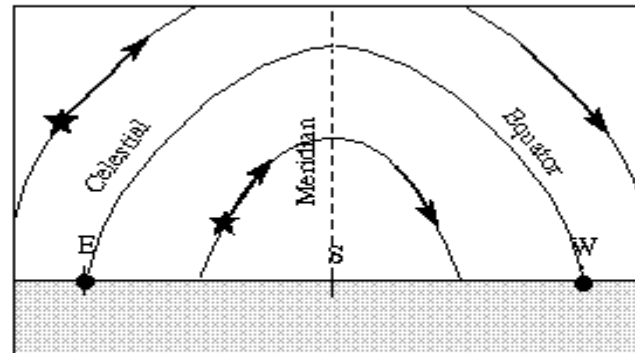
C.E. = 90 - observer's latitude.

90- 37 degrees = 53 degrees S

The celestial sphere for an observer in Los Angeles. The Earth's rotation axis pierces the celestial sphere at the north and south celestial poles.

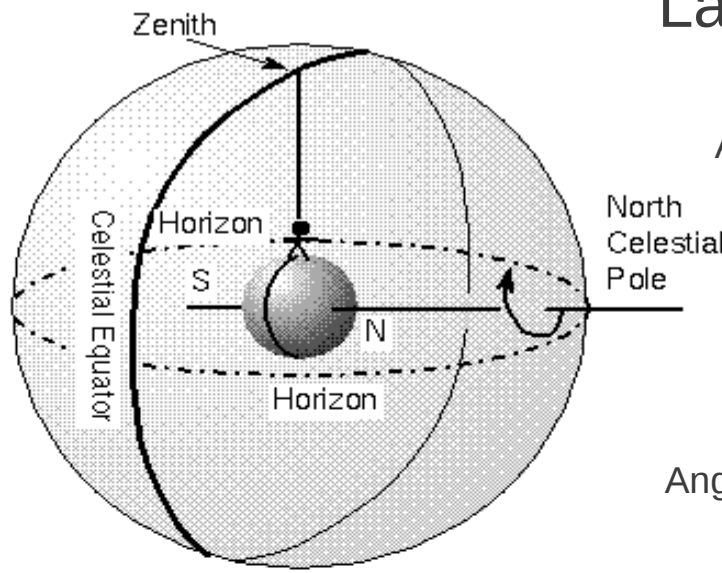


Stars motion at Los Angeles Stars rotate parallel to the Celestial Equator, so they move at angle with respect to the horizon here. Altitudes of 1/4, 1/2, and 3/4 the way up to zenith are marked.



Your view from Los Angeles Stars rise in the East half of the sky, reach maximum altitude when crossing the meridian (due South) and set in the West half of the sky. The Celestial Equator goes through due East and due West

# Latitude = 0° N



Altitude of North Celestial pole = observer's latitude

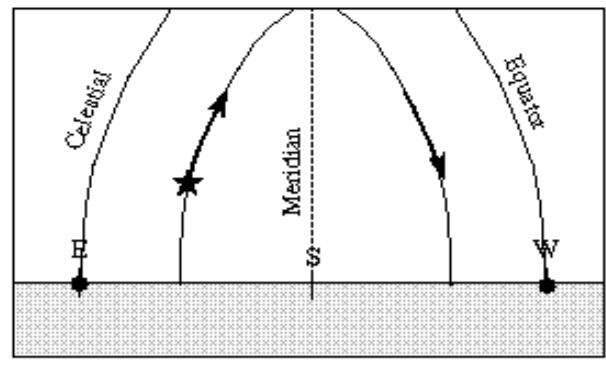
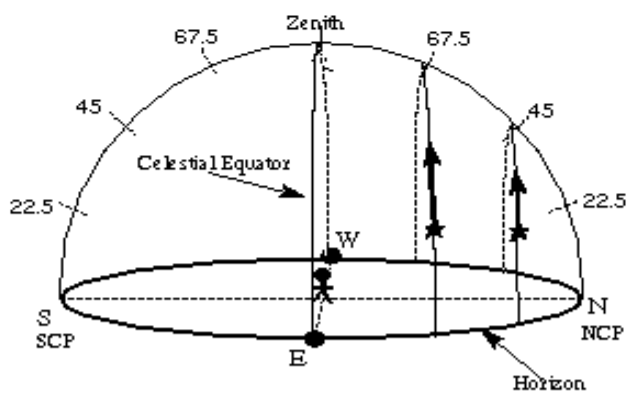
$$0 \text{ degrees N} = 0 \text{ degrees N}$$

Angle celestial equator makes with horizon :

$$\text{C.E.} = 90 - \text{observer's latitude.}$$

$$90 - 0 \text{ degrees} = 90 \text{ degrees S}$$

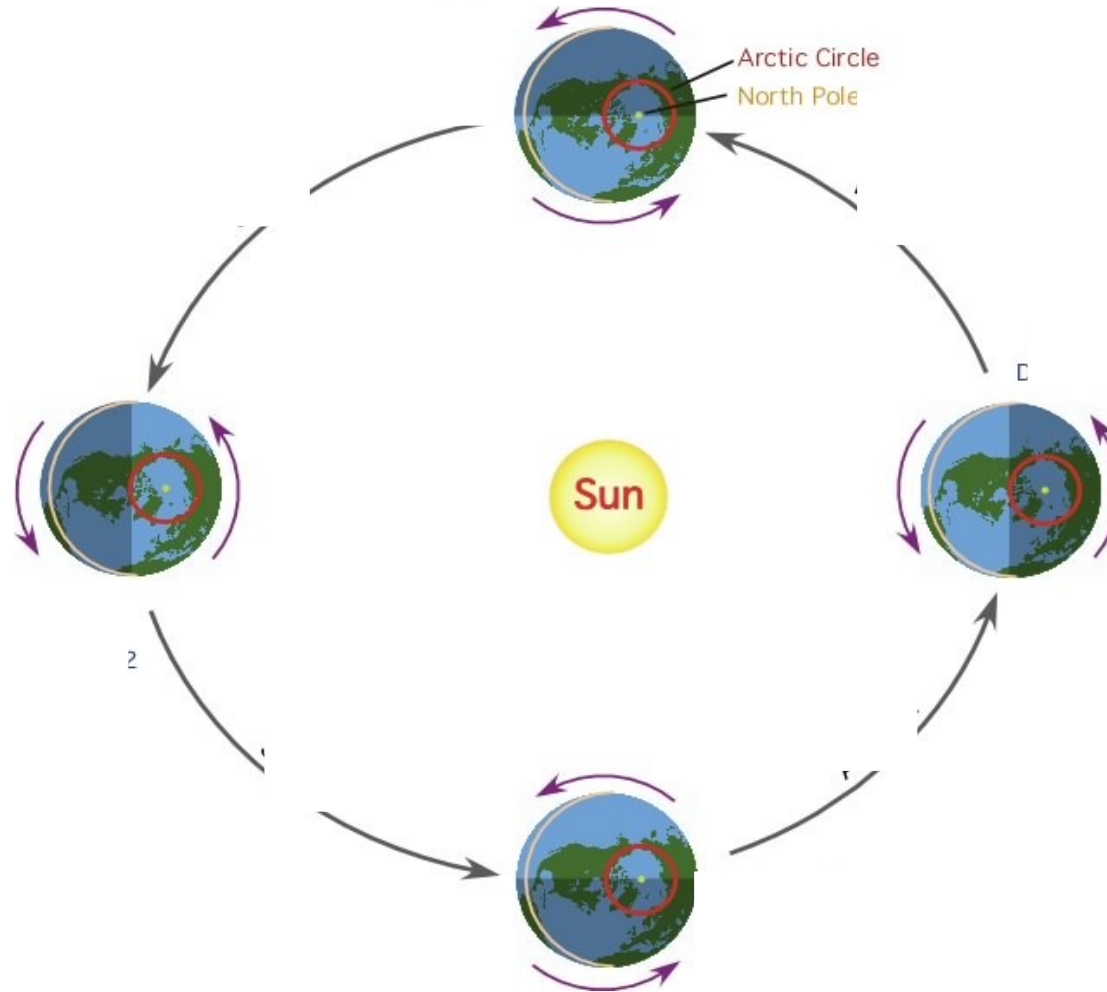
The celestial sphere for an observer on the Equator. The angle between the NCP and the horizon = observer's latitude. The Celestial Equator goes through the zenith.



Stars motion at the Equator. Stars rotate parallel to the Celestial Equator, so they move perpendicular to the horizon here. All stars are visible for 12 hours. Both celestial poles are visible on the horizon.

Your view from the Equator. Stars rise and set perpendicular to the horizon (a star south of the Celestial Equator is shown here). The Celestial Equator reaches zenith and goes through due East and due West on the horizon.

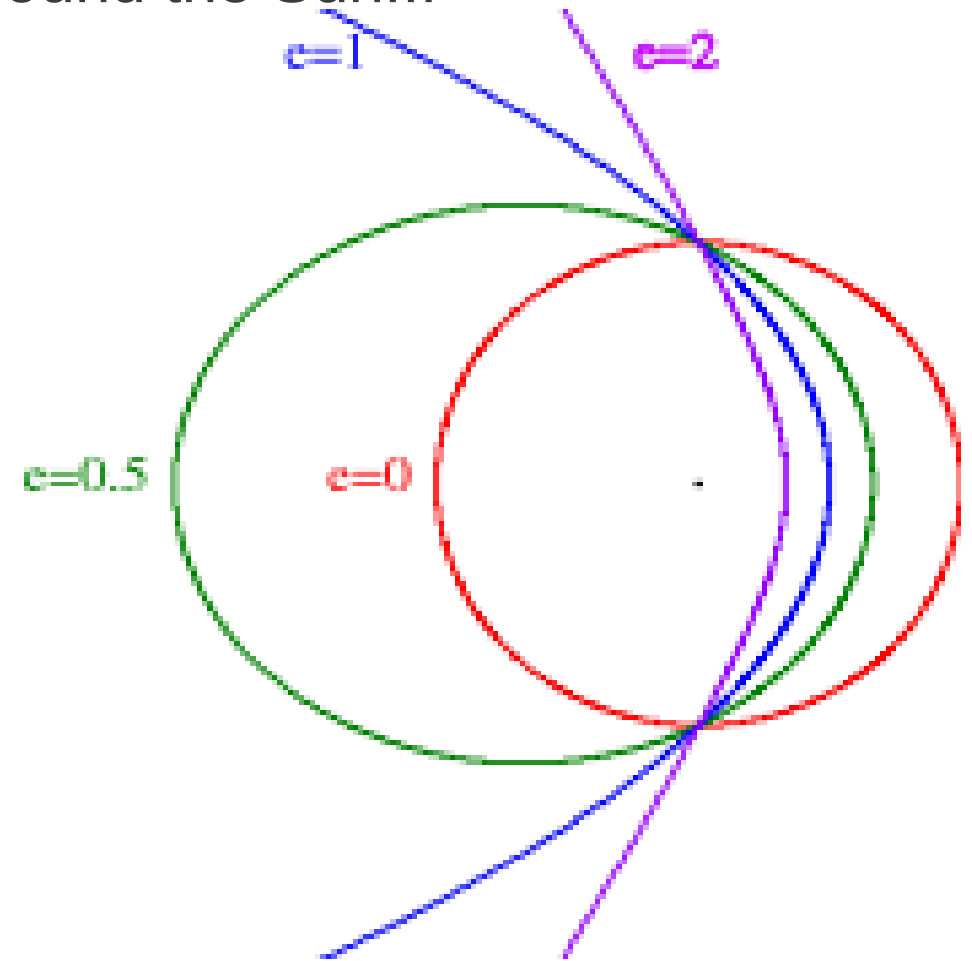
# The Seasons



As the Earth revolves around the sun it wobbles with its axis tilted in the same direction by 23.5 degrees.

1 Earth Revolution  $\approx$  365.25 days

Earth's orbit is not a perfect circle around the Sun!!!



Eccentricity: How much an orbit deviates from a perfect circle.

Earth:  $e = 0.0167$

# Earth's Revolution around Sun

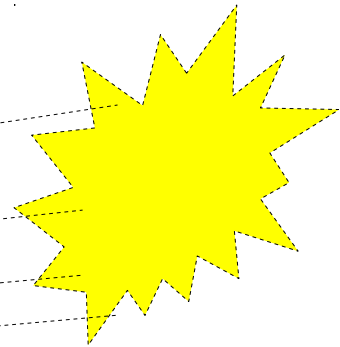
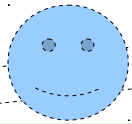
Perihelion: Point in Earth's revolution when closest to Sun  
91.7 million miles.

Aphelion: Point in Earth's revolution when it is the  
furthest from the Sun 94 million miles.

Winter-

Earth is tilted away: Sun rises lower in the sky causing the rays to hit the ground more spread out over more area.

Winter rays – lower angle

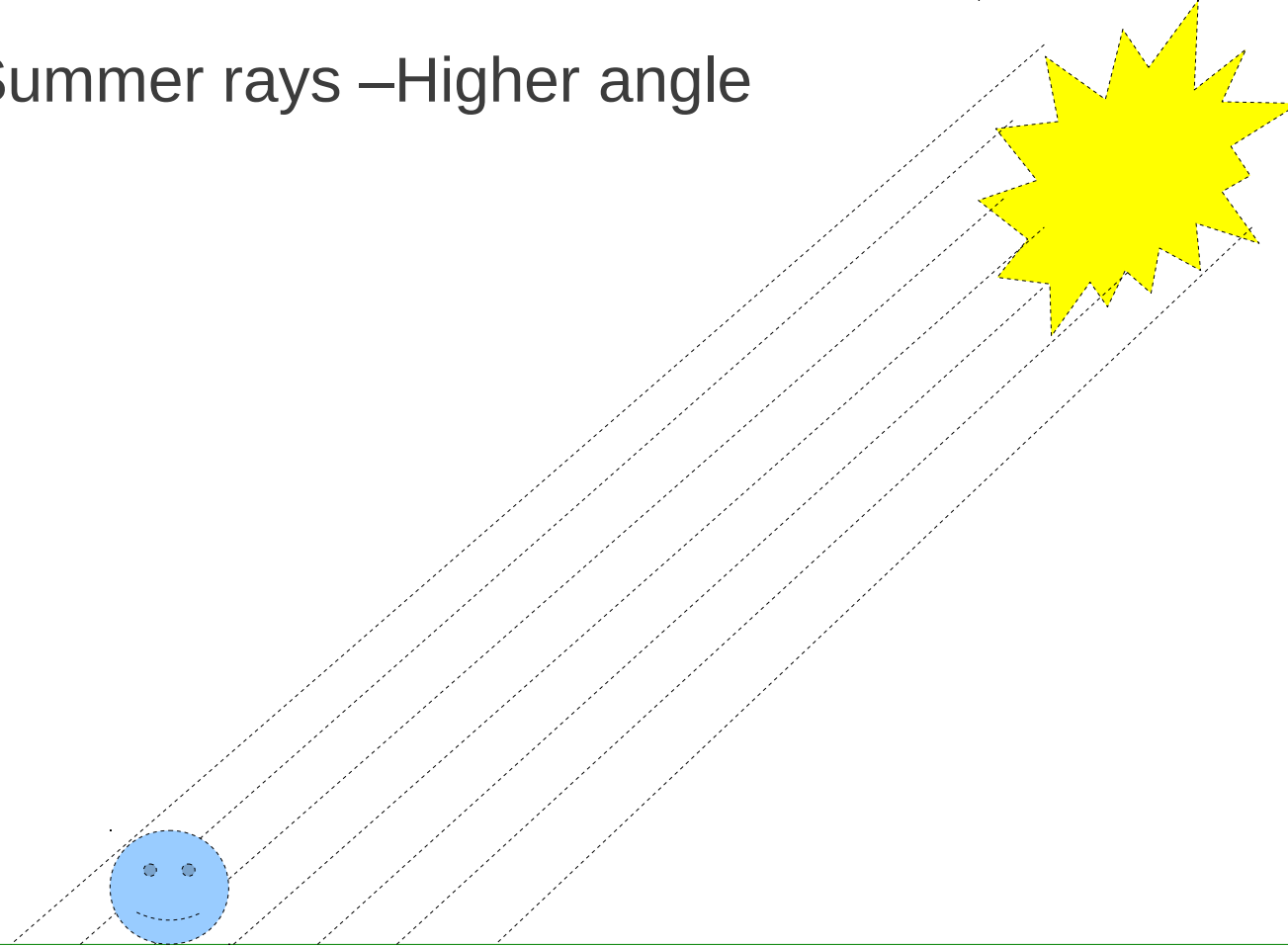


More spread out so less intense

Summer-

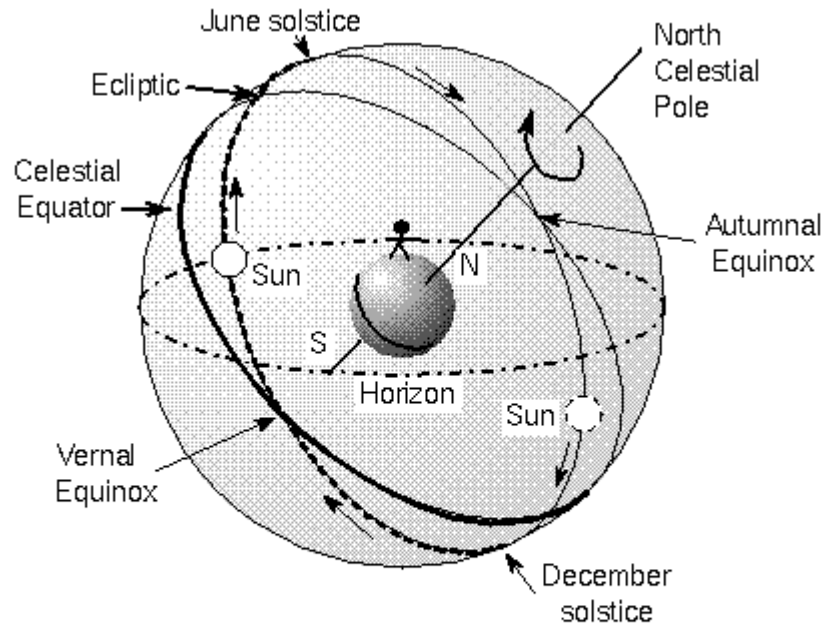
Earth is tilted toward : Sun rises higher in the sky causing the rays to hit the ground more directly.

Summer rays –Higher angle



Less spread out so more intense.

# Motion of the Sun



The Sun moves among the stars along the ecliptic, completing one 360° path in one year. The ecliptic is tilted by 23.5° with respect to the celestial equator. The Sun's position on the celestial sphere in April (full circle) and in October (dashed circle) is shown.

The apparent path of the Sun on the celestial sphere is called the ecliptic.

This circular path is tilted 23.5 degrees with respect to the celestial equator.

# Seasons

Vernal Equinox - March 20 2012

Sun is found on the Celestial Equator at apparent noon.

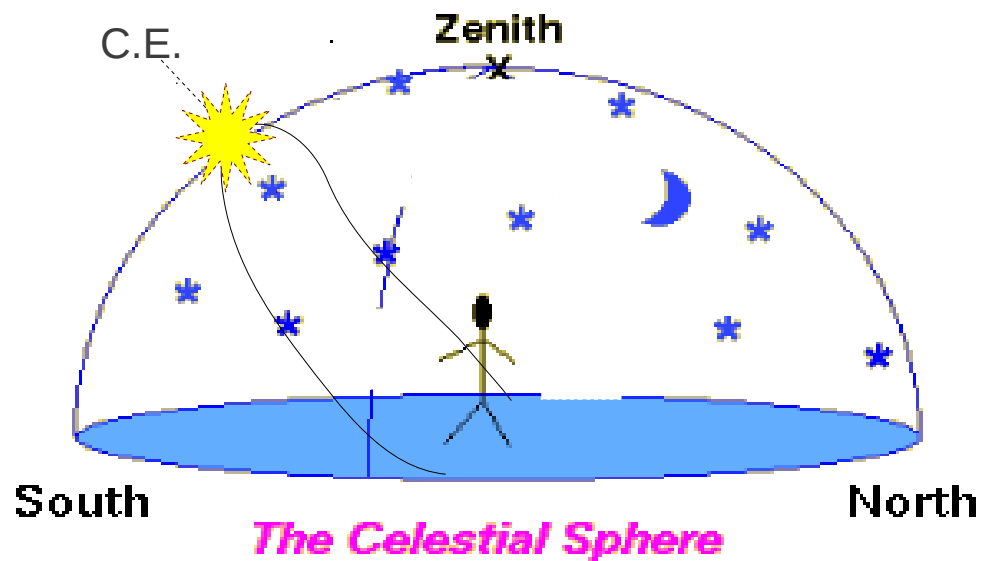
To find the altitude of the Sun at the Vernal Equinox for an observer's location:

**Altitude of Sun at Vernal Equinox = Altitude of Celestial Equator**

For OCC: Latitude = 42.68 N

Celestial Equator = 47.32 S

**Altitude of Sun at Vernal Equinox = 47.32 S**



## Seasons

Summer Solstice - June 20 2012

Sun is found at its highest altitude in the sky at apparent noon.

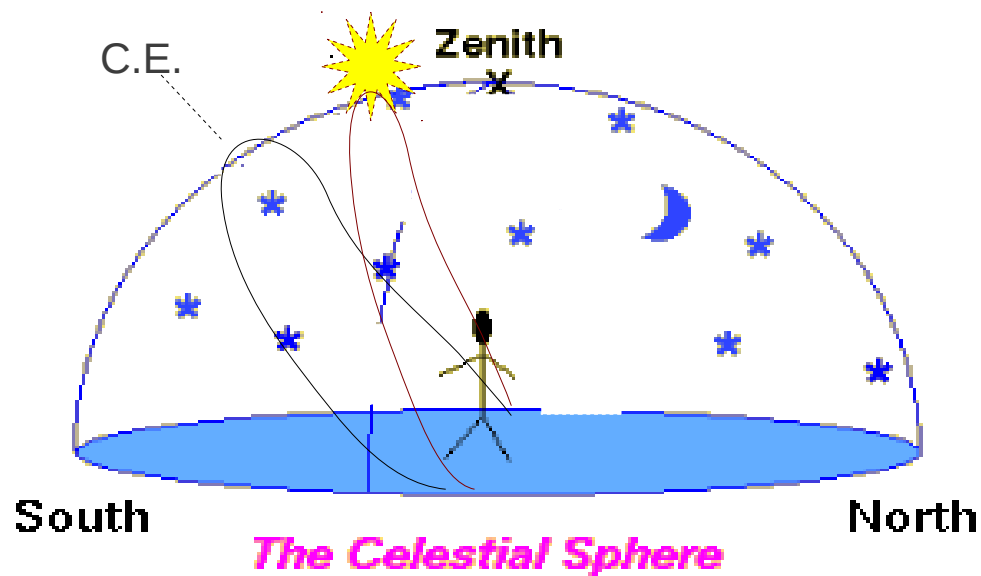
To find the altitude of the Sun at the Summer Solstice for an observer's location:

**Altitude of Sun at Summer Solstice = Altitude of Celestial Equator + 23.5**

For OCC: Latitude = 42.68 N

Celestial Equator = 47.32 S

**Altitude of Sun at Summer Solstice = 47.32 + 23.5 = 70.82 S**



# Seasons

Autumnal Equinox - September 23 2011

Sun is found on the Celestial Equator at apparent noon.

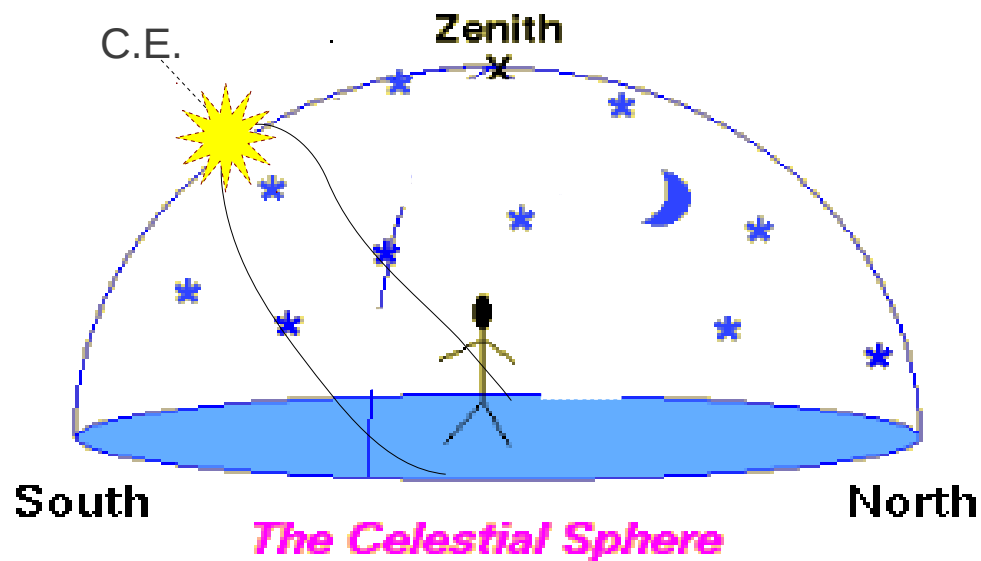
To find the altitude of the Sun at the Autumnal Equinox for an observer's location:

**Altitude of Sun at Autumnal Equinox = Altitude of Celestial Equator**

For OCC: Latitude = 42.68 N

Celestial Equator = 47.32 S

**Altitude of Sun at Autumnal Equinox = 47.32 S**



# Seasons

Winter Solstice - December 22 2011

Sun is found at its lowest altitude in the sky at apparent noon.

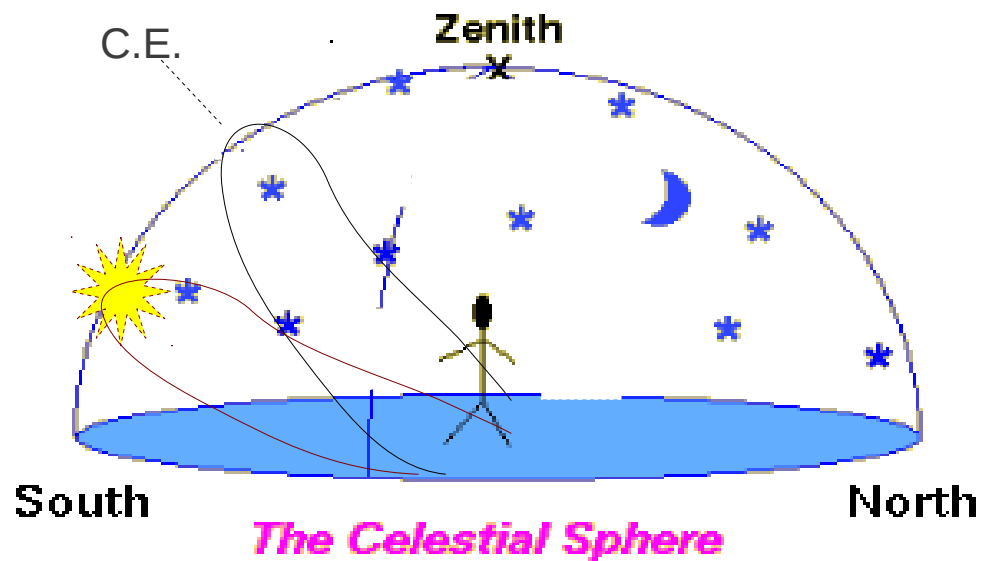
To find the altitude of the Sun at the Winter Solstice for an observer's location:

**Altitude of Sun at Winter Solstice = Altitude of Celestial Equator - 23.5**

For OCC: Latitude = 42.68 N

Celestial Equator = 47.32 S

**Altitude of Sun at Winter Solstice = 47.32 - 23.5 = 23.82 S**

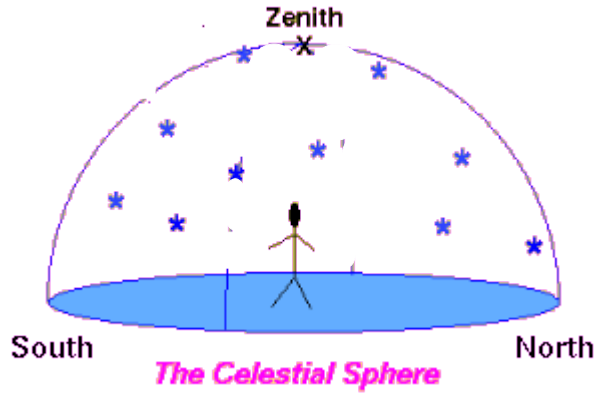


# Seasons

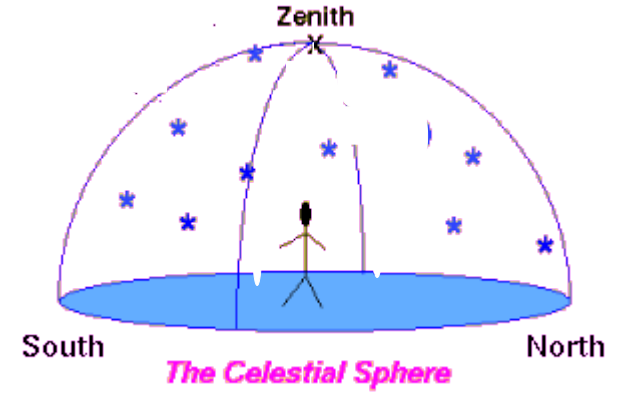
## Latitude = $90^\circ$

Celestial Equator =  $90 - 90 = ?$

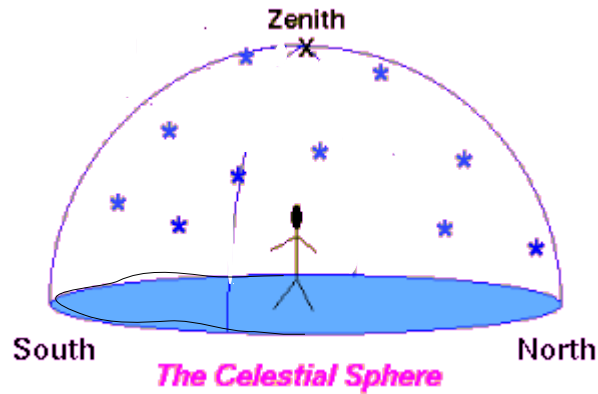
Summer Solstice = C.E. +  $23.5 = ?$



Winter Solstice = C.E. -  $23.5 = ?$



Autumnal/Vernal Equinox = C.E. = ?

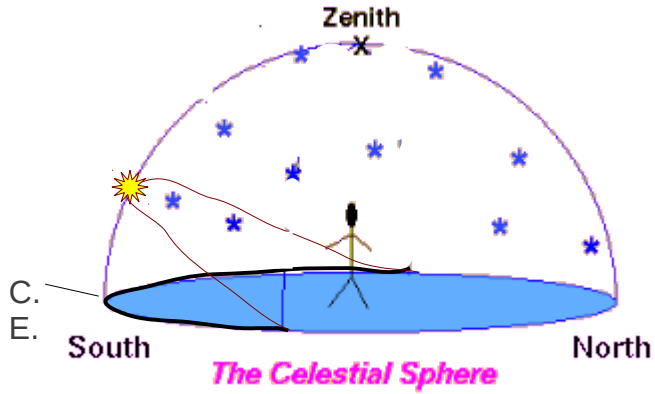


# Seasons

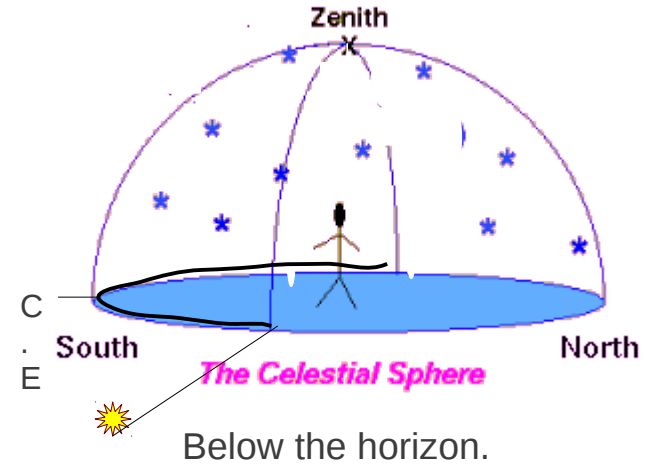
## Latitude = $90^\circ$ N

$$\text{Celestial Equator} = 90 - 90 = 0^\circ \text{ S}$$

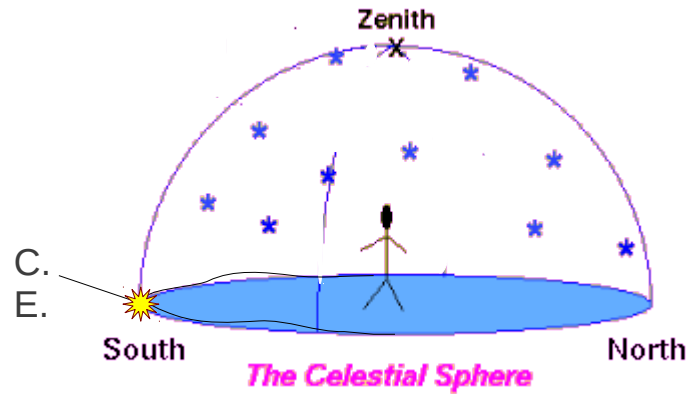
$$\text{Summer Solstice} = 0 + 23.5 = 23.5^\circ \text{ S}$$



$$\text{Winter Solstice} = 0 - 23.5 = -23.5^\circ \text{ S}$$



$$\text{Autumnal/Vernal Equinox} = 0^\circ \text{ S}$$

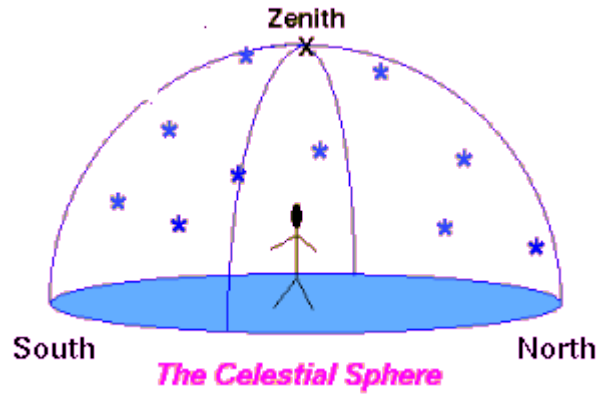


# Seasons

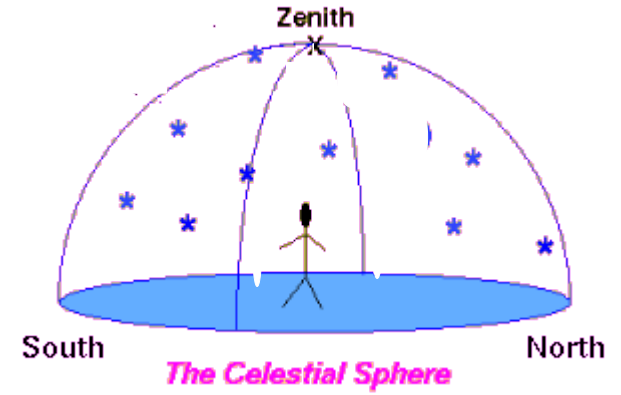
Latitude =  $0^\circ$  N

Celestial Equator = ?

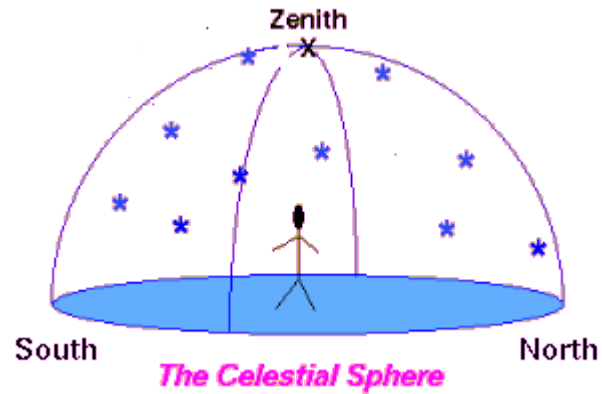
Summer Solstice = ?



Winter Solstice = ?



Autumnal/Vernal Equinox = ?

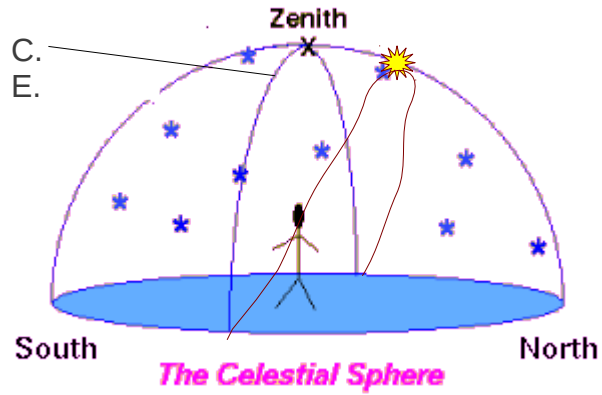


# Seasons

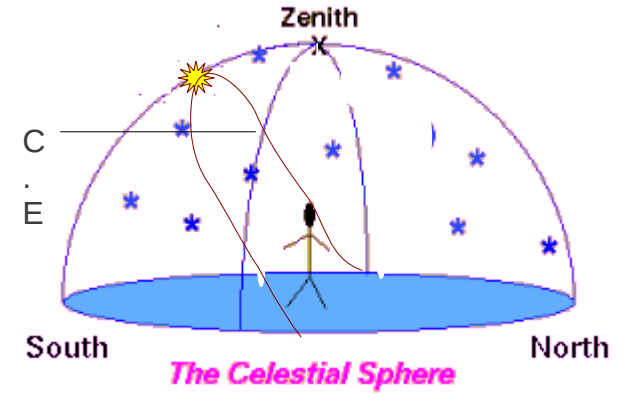
## Latitude = 0°N

$$\text{Celestial Equator} = 90 - 0 = 90^\circ$$

Summer Solstice =  $90 + 23.5 = 113.5^\circ$  past Zenith or  $66.5^\circ$  N

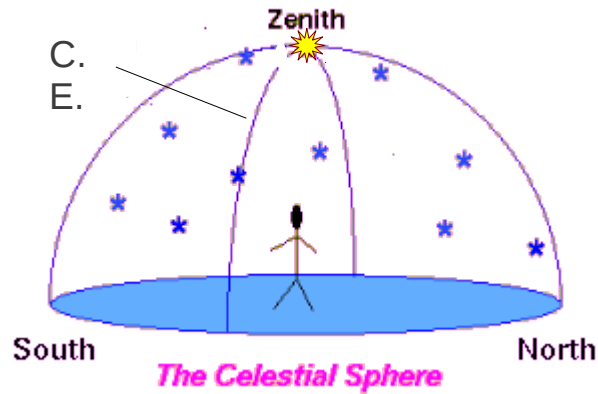


Winter Solstice =  $90 - 23.5 = 66.5^\circ$  S



Below the horizon.

Autumnal/Vernal Equinox =  $90^\circ$  N

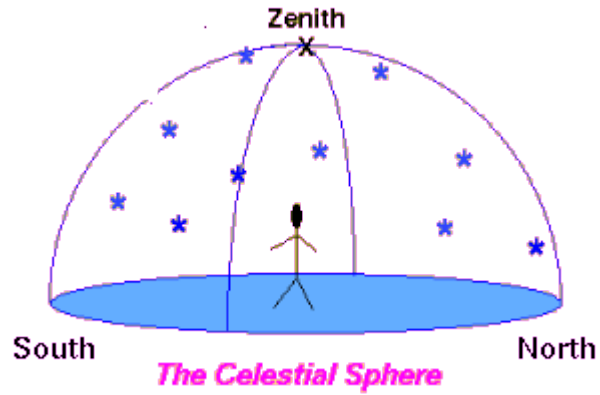


# Seasons

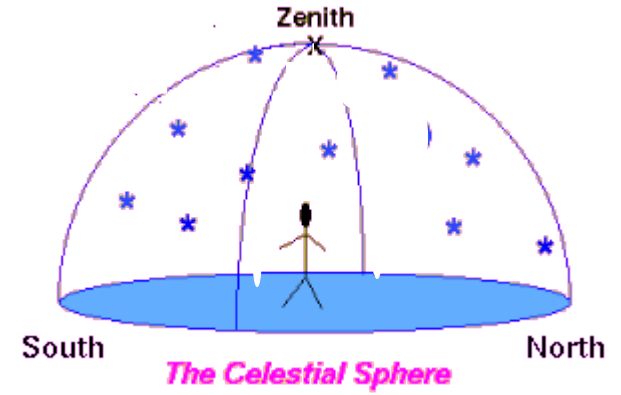
Latitude =  $45^{\circ}$  N

Celestial Equator = ?

Summer Solstice = ?



Winter Solstice = ?



Autumnal/Vernal Equinox = ?

