



Potsdam
THE STATE UNIVERSITY OF NEW YORK

SOAR: The Sky in Motion Life on the Tilted Teacup Ride

Phases of the Moon

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Kiva

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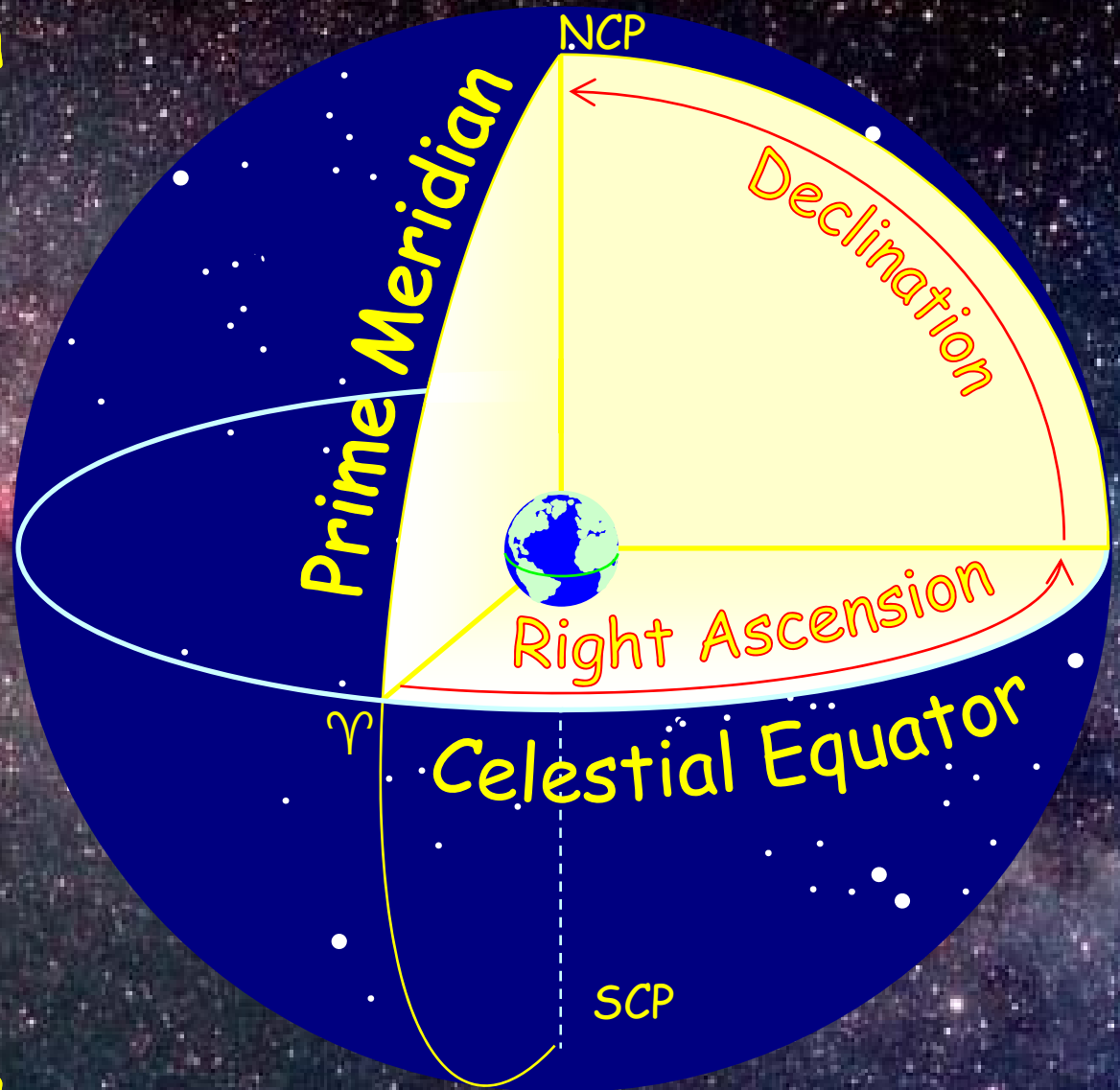
Celestial Coordinates

☆ Right Ascension

- 🌐 RA or α
- 🌐 From prime meridian (0^h) to $23^h59^m59^s$ Eastward

☆ Declination

- 🌐 Dec or δ
- 🌐 From celestial equator (0°) to poles N & S 90°

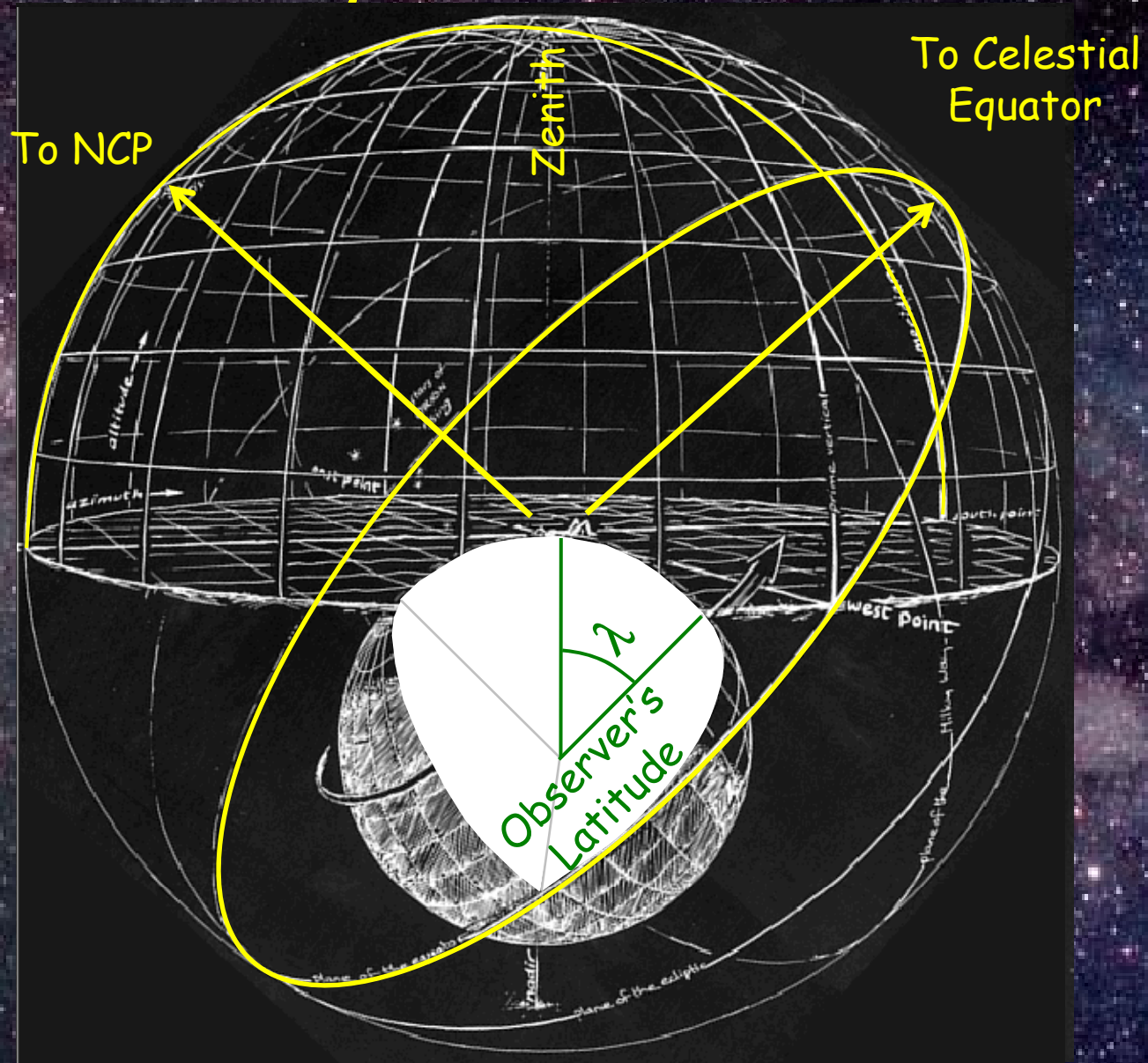


Tilted Sky

☆ Observers see sky "tilted" due to latitude

We see ourselves "on top" of the Earth, beneath the sky.

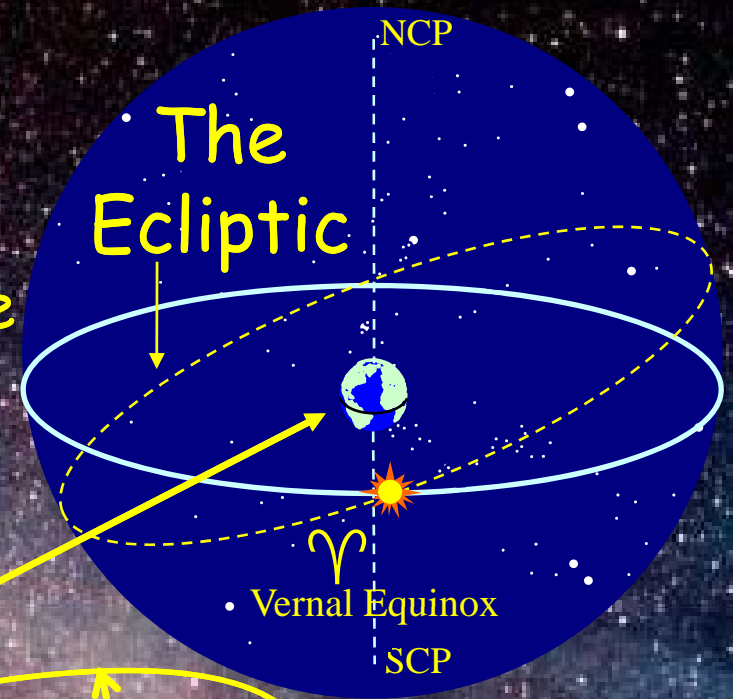
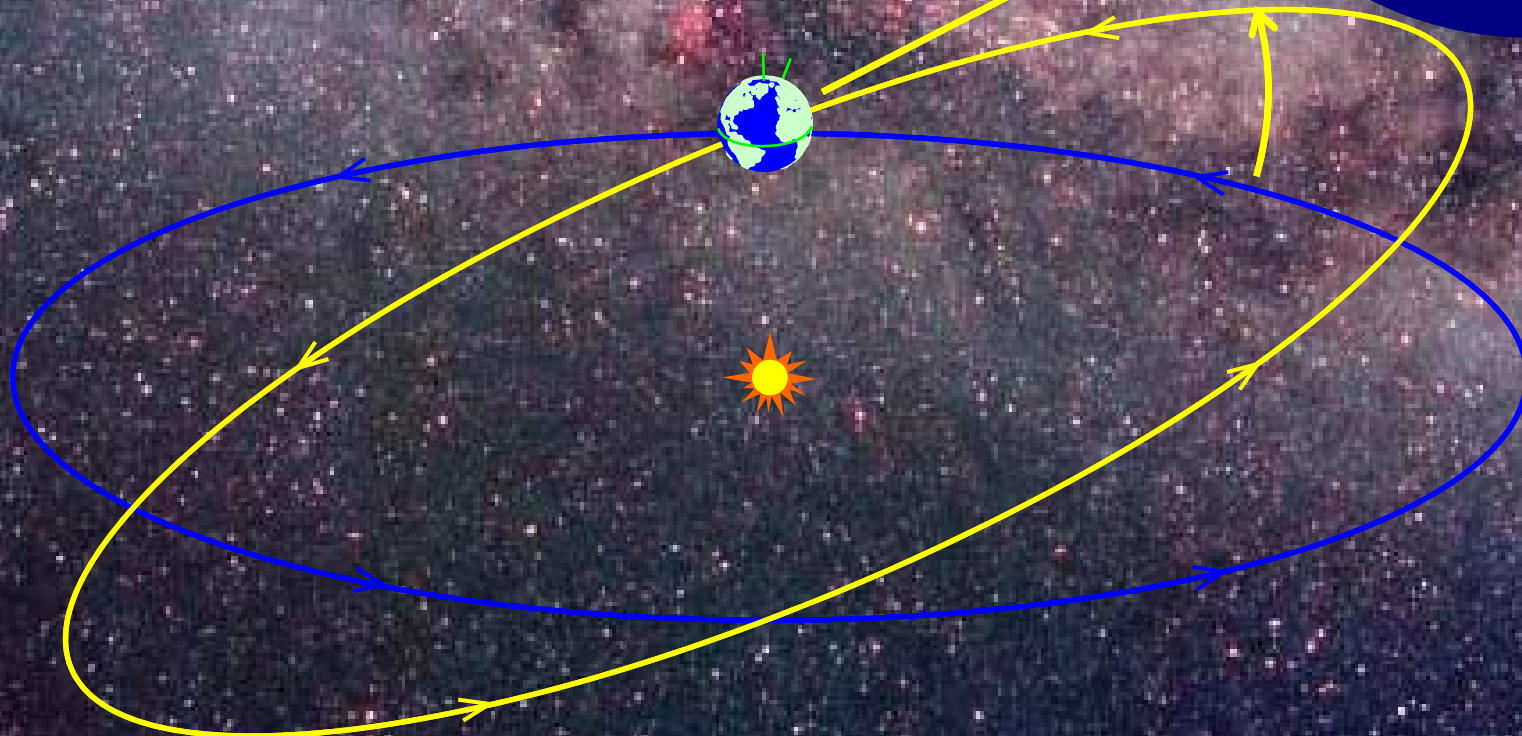
So we see sky motions tilted



Sun in the sky

☆ View from Earth

- 🌍 Rotate to Earth's equatorial plane
- 🌍 Center on Earth
- 🌍 Project sun onto sky



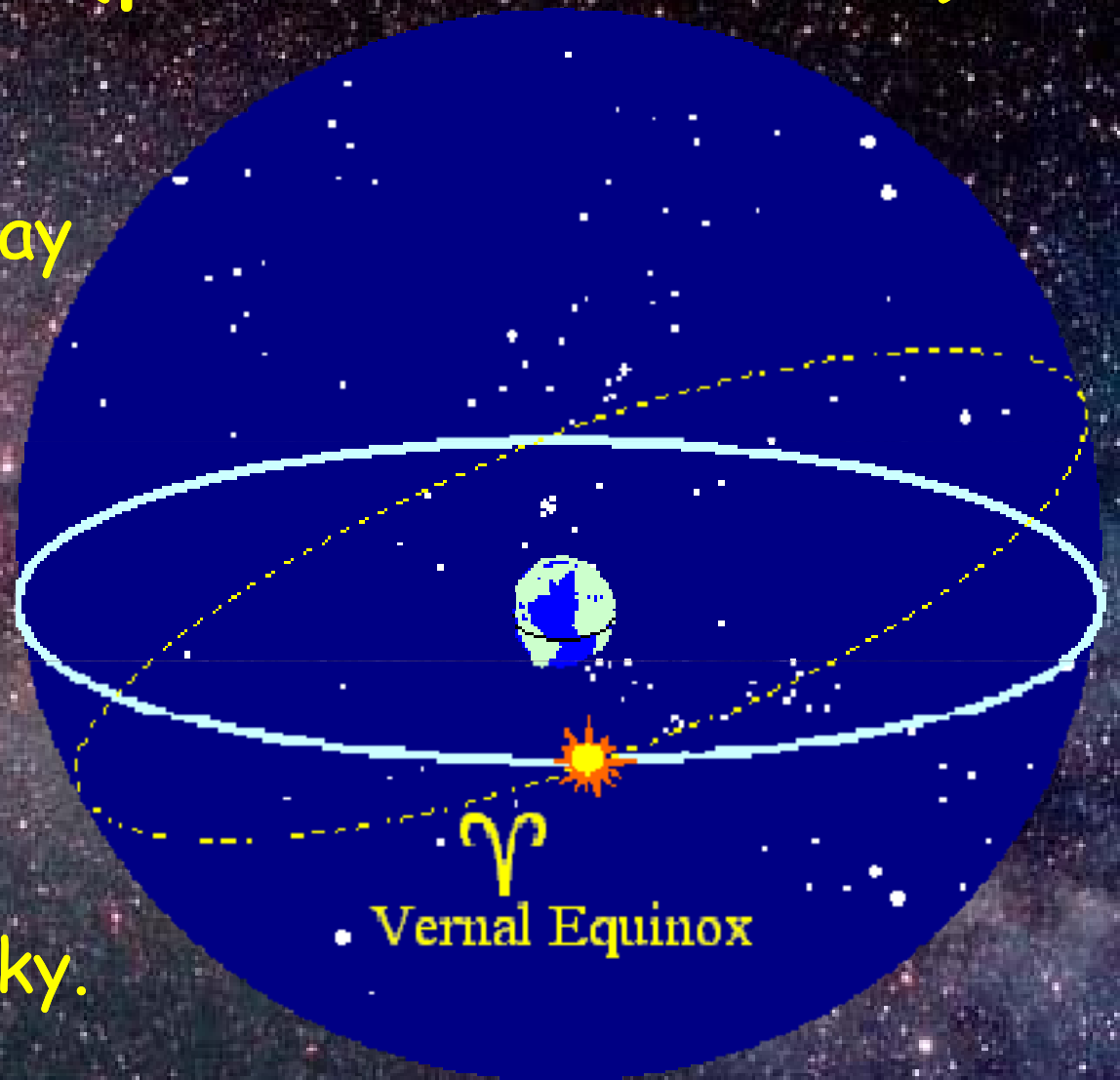
The Ecliptic (path of the sun)

☆ View from Earth

🌍 Sun moves $\sim 1^\circ$ /day eastward across stars

🌍 Sun moves north and south in declination

🌍 Solstices & Equinoxes are positions in the sky.



This motion is through the YEAR!

Position of Sunrise & Sunset

☆ Azimuth of rising depends on δ

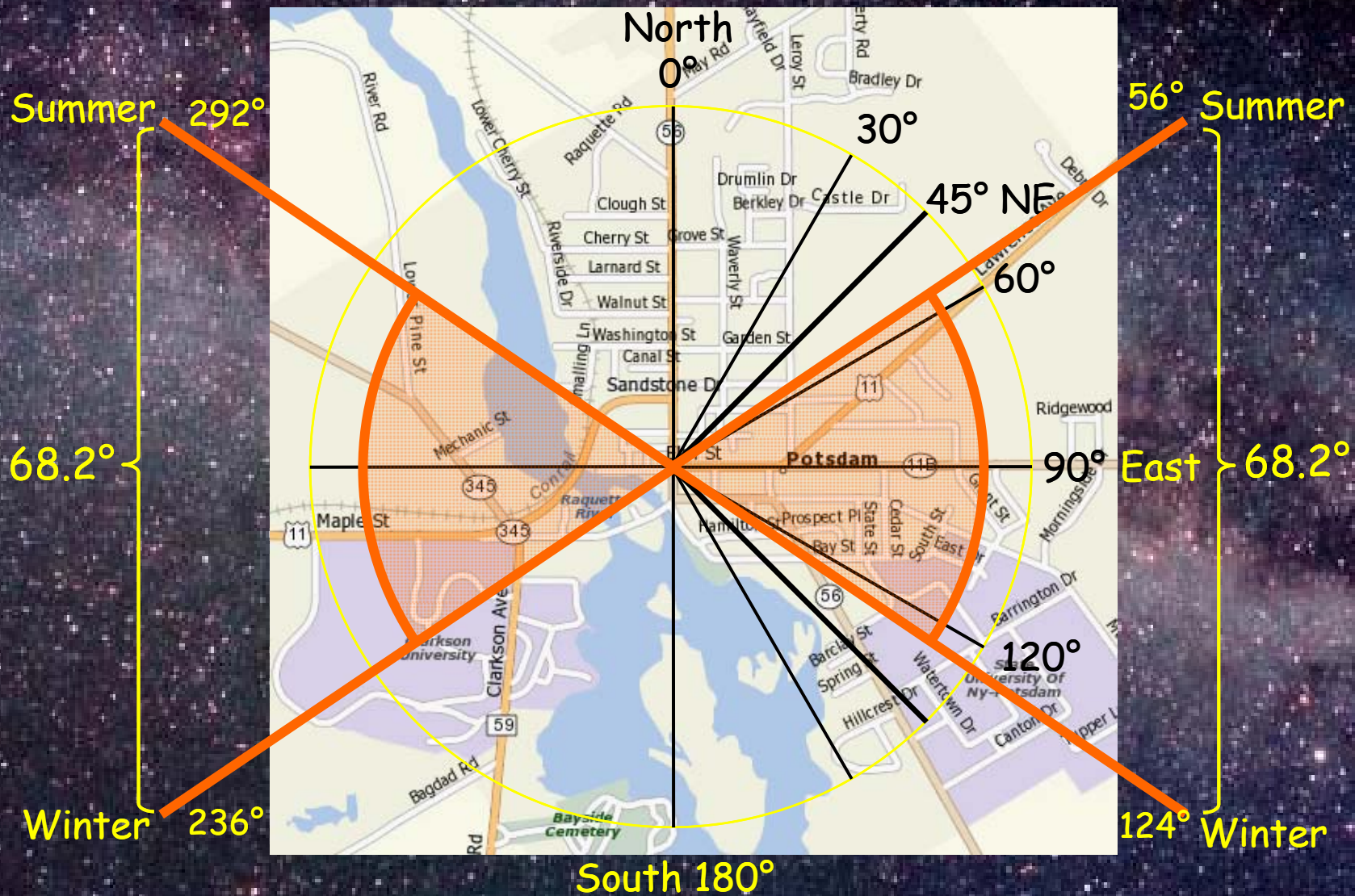
$$A_{\text{rise}} = \cos^{-1} \left(\frac{\sin \delta}{\cos \lambda} \right) \text{ degrees}$$

☆ In Potsdam ($44^{\circ}40' \text{ N } 75^{\circ}59' \text{ W}$)

$$\begin{array}{l} \text{Summer: } A_{\text{rise}} = \cos^{-1} \left(\frac{\sin 23.5}{\cos 44.67} \right) = 55.9 \text{ degrees} \\ \text{Winter: } A_{\text{rise}} = \cos^{-1} \left(\frac{\sin -23.5}{\cos 44.67} \right) = 124.1 \text{ degrees} \end{array} \left. \vphantom{\begin{array}{l} \text{Summer: } \\ \text{Winter: } \end{array}} \right\} 68.2^{\circ}$$

Position of Sunrise & Sunset

☆ Sun rises at 56° in Summer, 124° in Winter



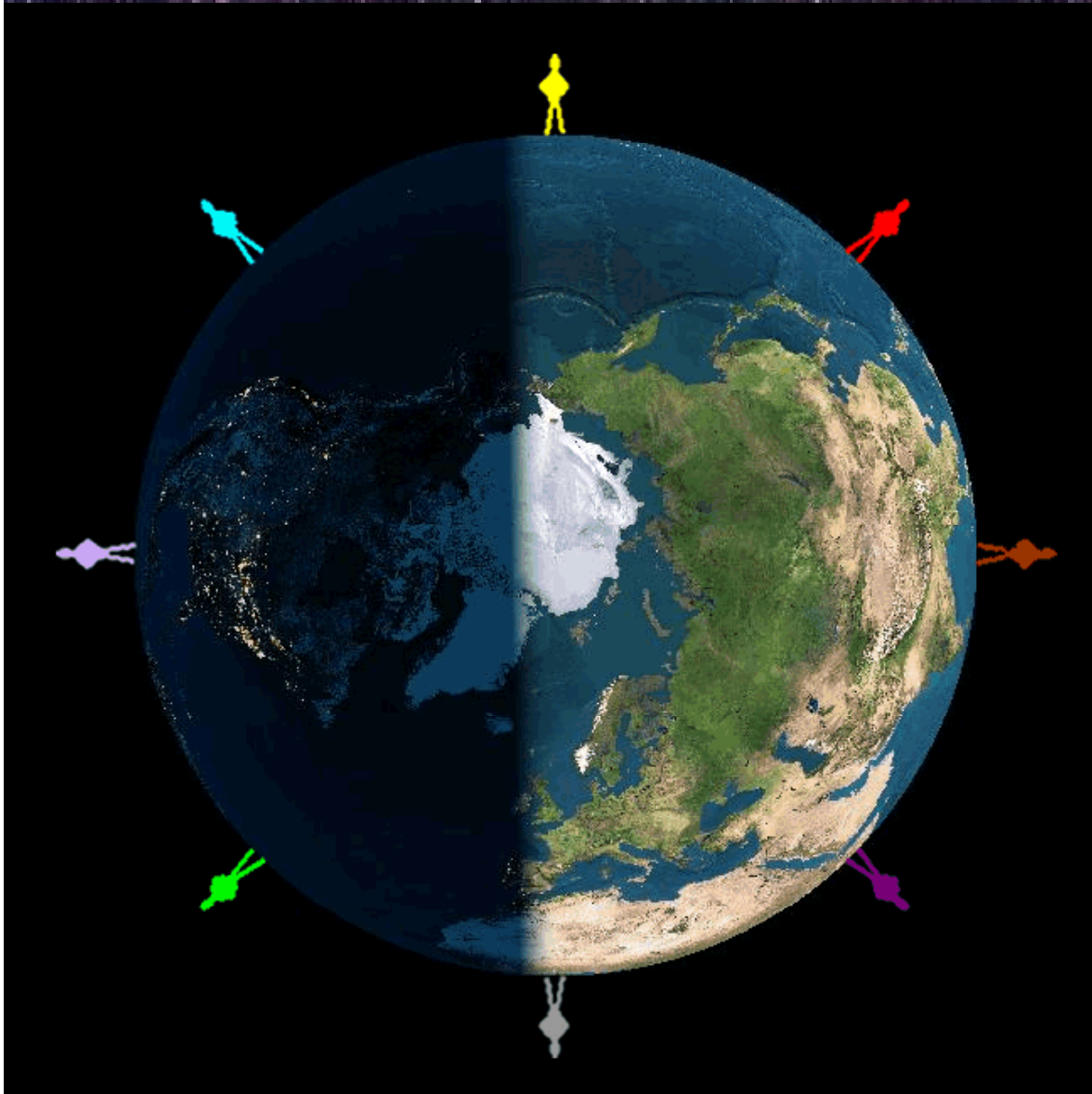
When on Earth?

☆ Earth Rotates Once Each Day

🌍 360° with respect to Earth-Sun line

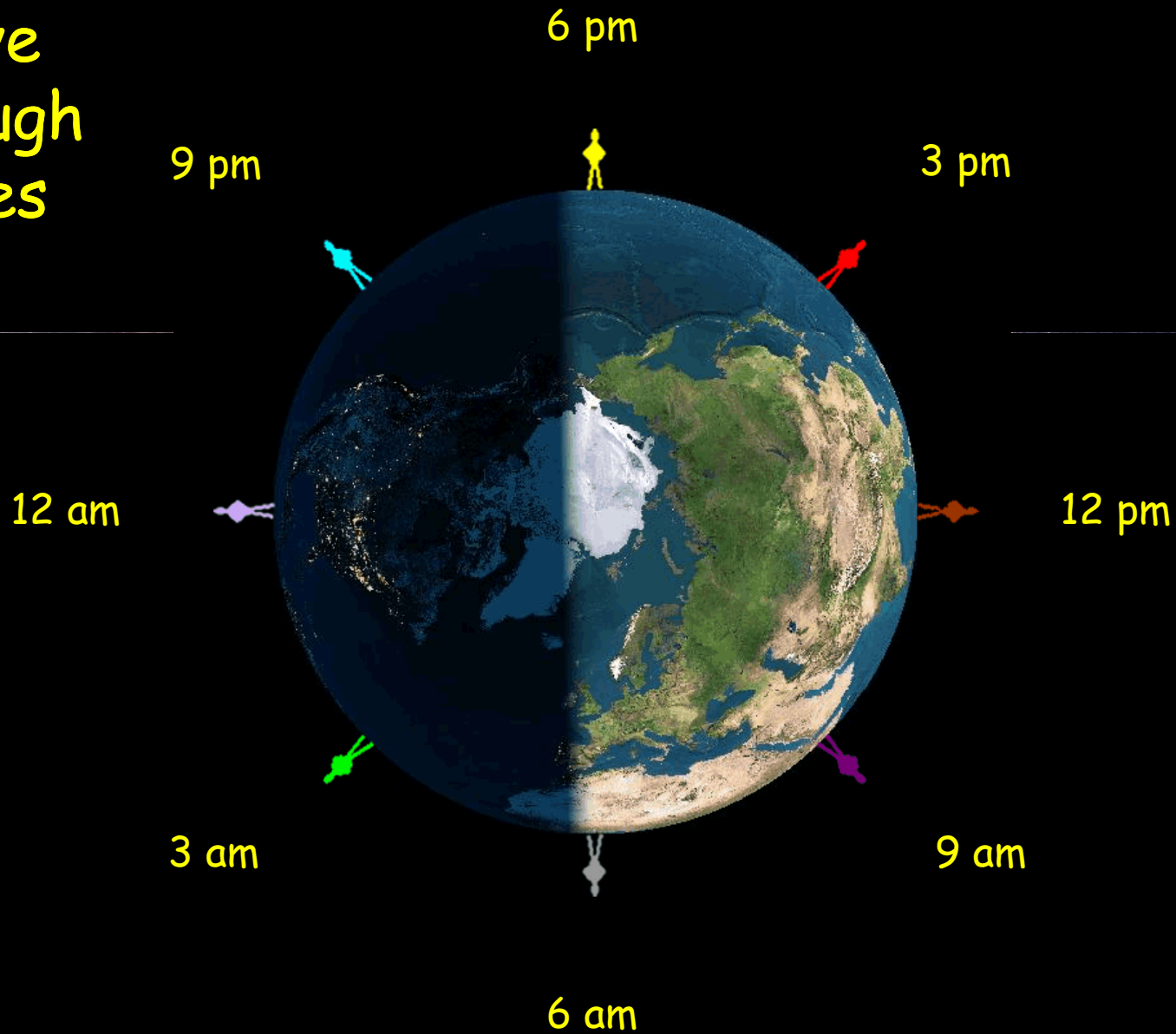
🌍 All Earthlings ride along

→ To Sol



Clock Time

Observers
move
through
times



Moon orbits Earth

☆ Solar Month

🌍 New Moon to
New Moon

🌍 29d 12h 44m ~ 29.5d

☆ Sidereal Month

🌍 Moon moves 360°

🌍 27d 7h 43m

☆ Moon rotates on its axis once/month

🌍 Keeps same face toward Earth

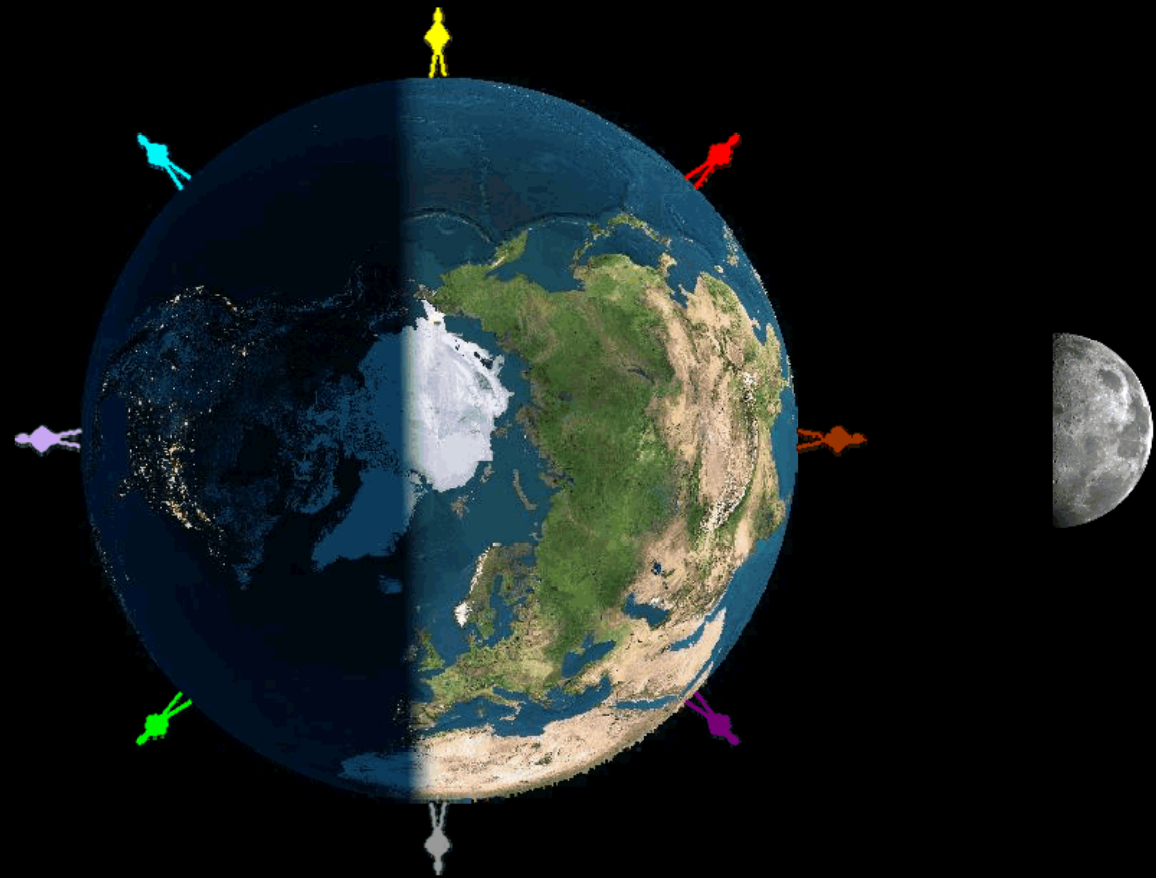
) hangs "heavy side down"

🌍 Appears larger at perigee than apogee

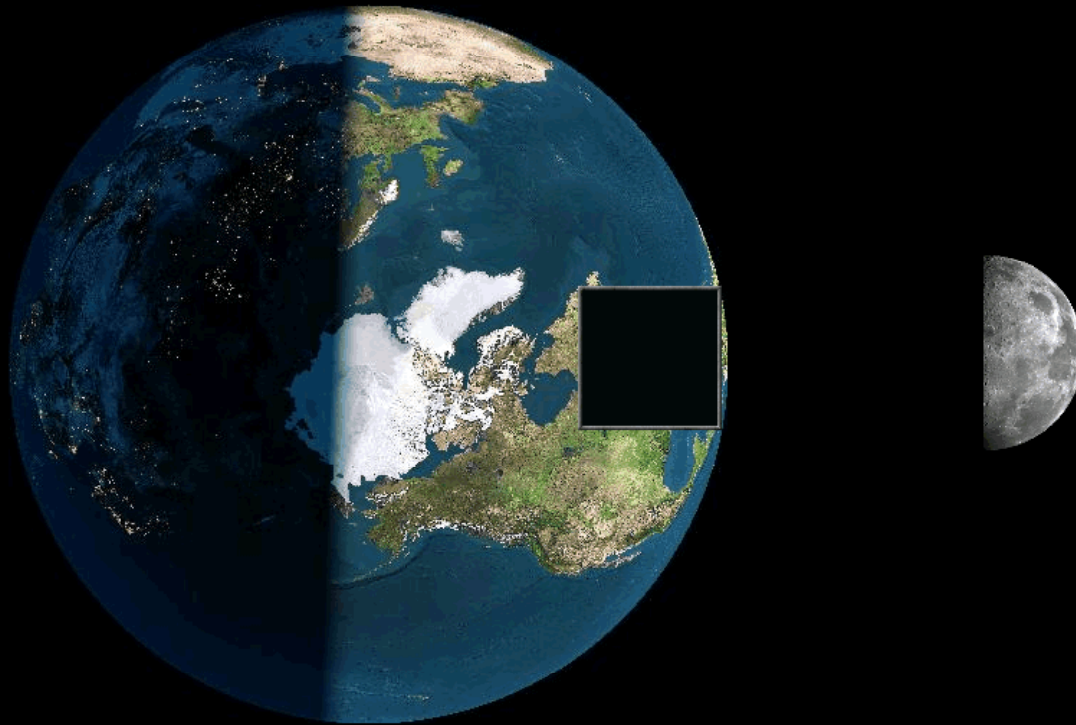
Moon orbits Earth

Lunar
Month

New Moon to
New Moon
29d 12h 44m
~ 29.5d



Moon
Phase is
lit moon
visible



Insert is
moon as
see from
Earth

Moon Phases

☆ **New Moon: Elongation = 0°** (angle from sun to moon)

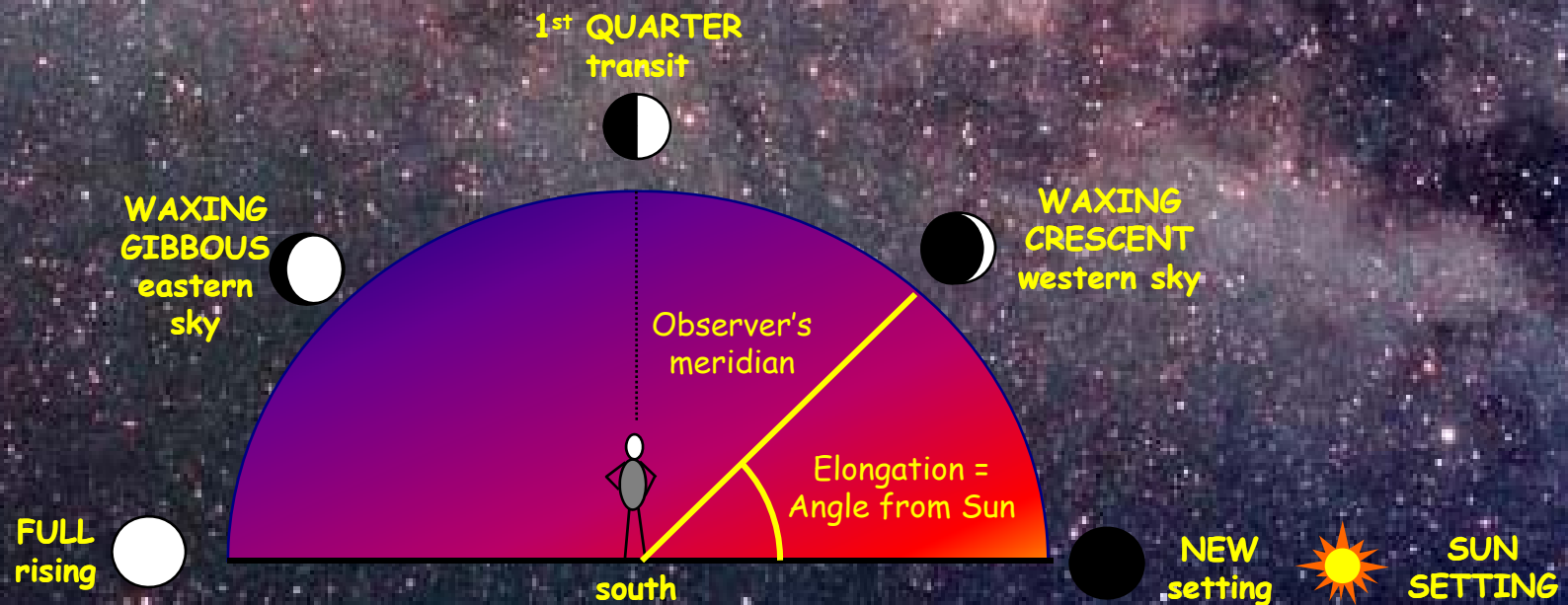
🌍 **Waxing Phases: visible after sunset**

› Waxing Crescent: $0^\circ < \text{Elongation} < 90^\circ \text{ E}$

› First Quarter: Elongation = 90° E

› Waxing Gibbous: $90^\circ \text{ E} < \text{Elongation} < 180^\circ$

☆ **Full Moon: Elongation = 180°**



Evening Moon Phases

☆ Look south at sunset

9/28/6 6:47:00 pm
Waxing Gibbous

12/01/9 4:21:53 pm
Almost Full



Evening Moon Phases

☆ Look south at sunset

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12/01/9 4:21:53 pm
Almost Full



Moon Phases

☆ Full Moon: Elongation = 180°

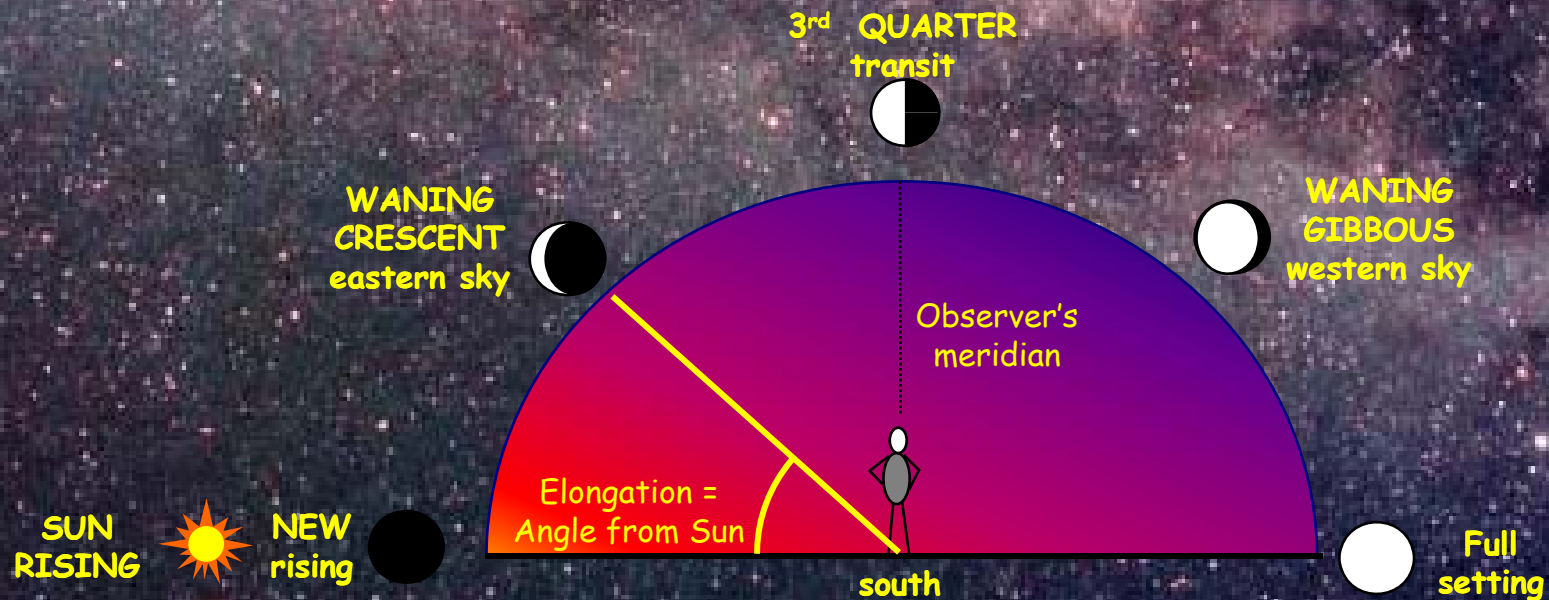
🌍 Waning Phases: visible before sunrise

› Waning Gibbous: $90^\circ \text{ W} < \text{Elongation} < 180^\circ$

› Third Quarter: Elongation = 90° W

› Waning Crescent: $0^\circ < \text{Elongation} < 90^\circ \text{ W}$

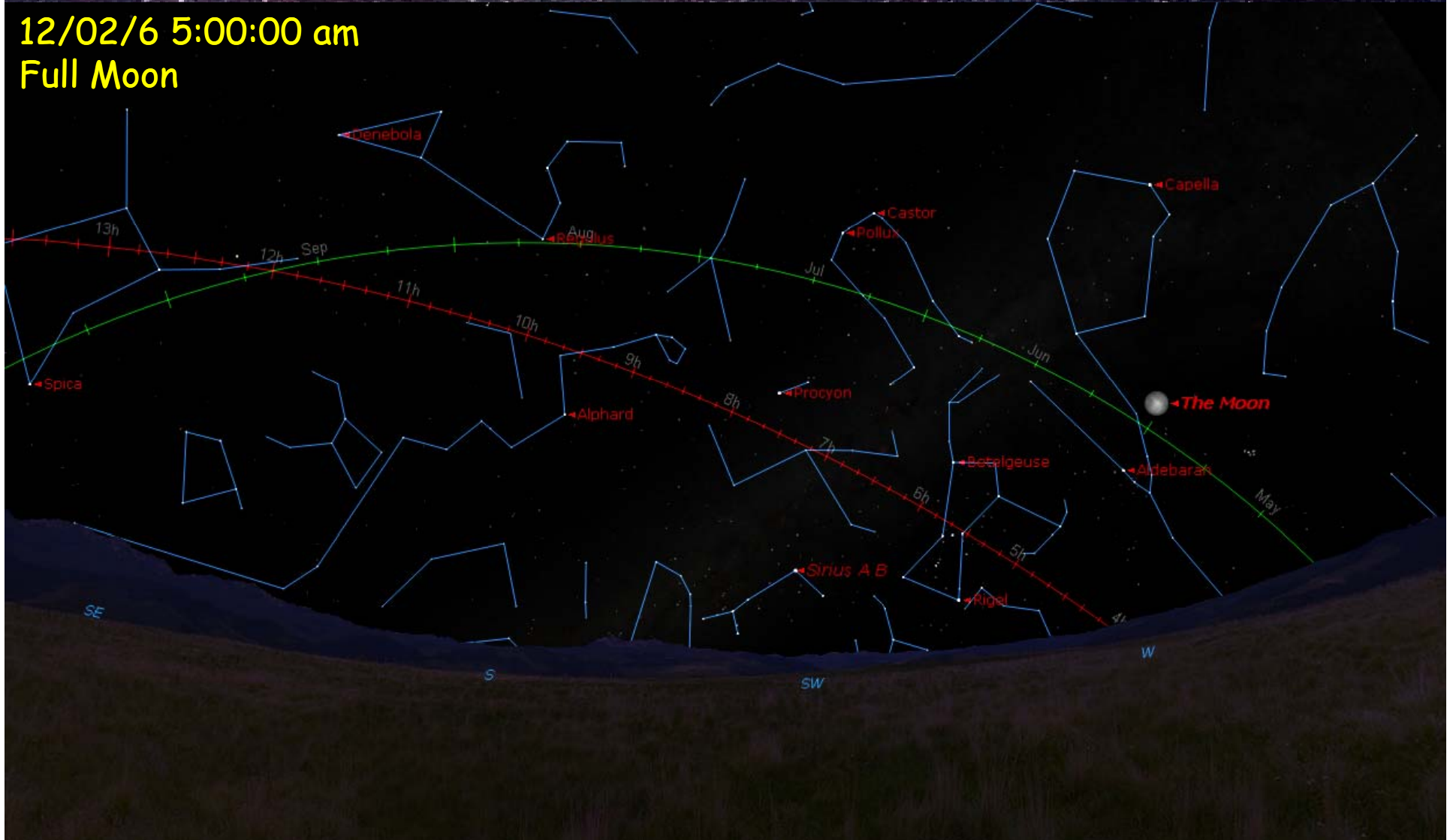
☆ New Moon: Elongation = 0°



Morning Moon Phases

☆ Look south at sunrise ... the cold moon

12/02/6 5:00:00 am
Full Moon



Morning Moon Phases

☆ Look south at sunrise

12/15/9 7:30:46 am

Waning Crescent



Morning Moon Phases

☆ Look south at sunrise

12/15/9 7:30:46 am

Waning Crescent



Moon Phases & Time of Day

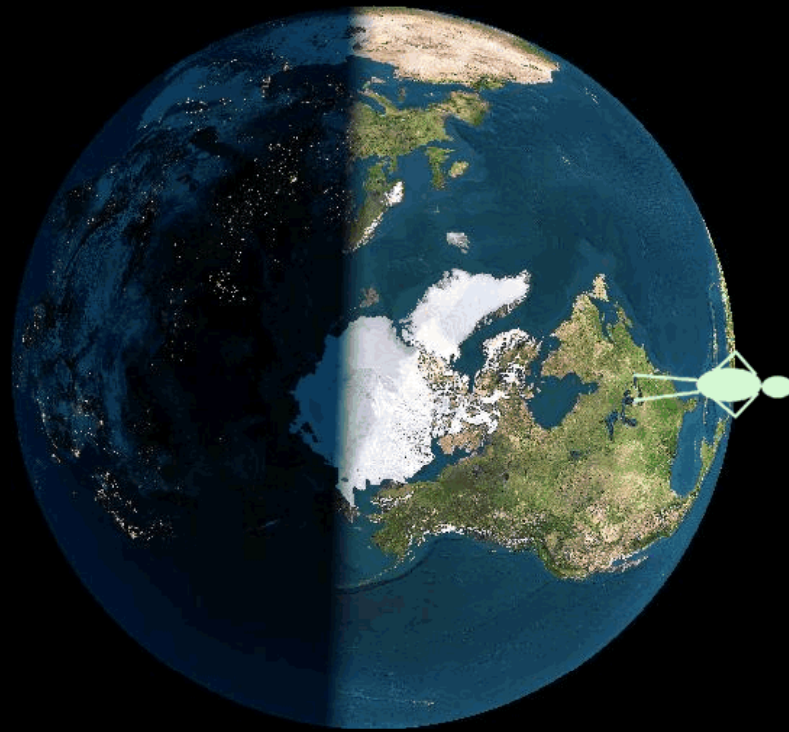
☆ Moon phase

🌍 Due to positions of Earth, Sun & Moon

☆ Time of Day

🌍 Due to positions of Earth, Sun & Observer

Position & Phase of Moon
Gives Time of Day

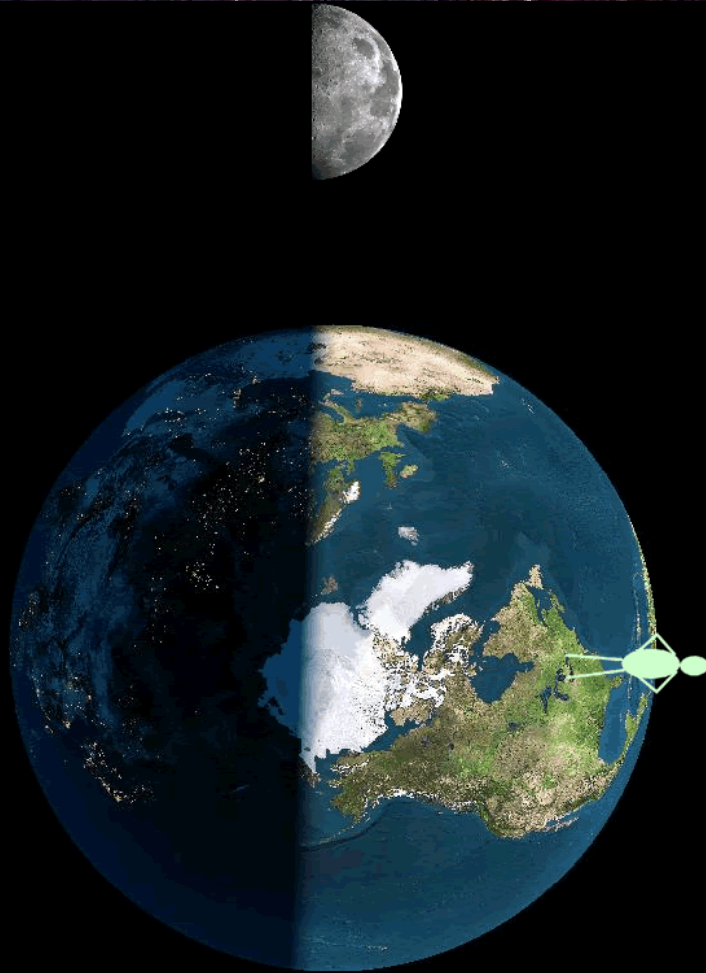


Earth
rotates
beneath
each
phase

Example:
First
Quarter

Observer's time is 12:00

Single observer sees moon in sky



Observer
sees moon
rising

Observer's time is 12:00

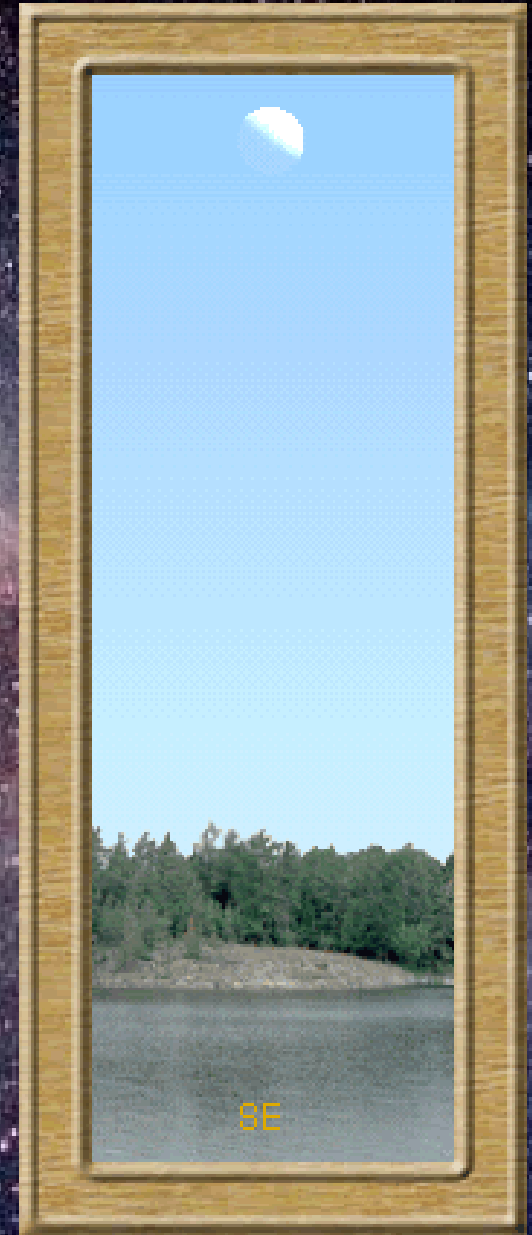


Single observer sees moon in sky



Observer
sees moon in
eastern sky

Observer's time is 15:00

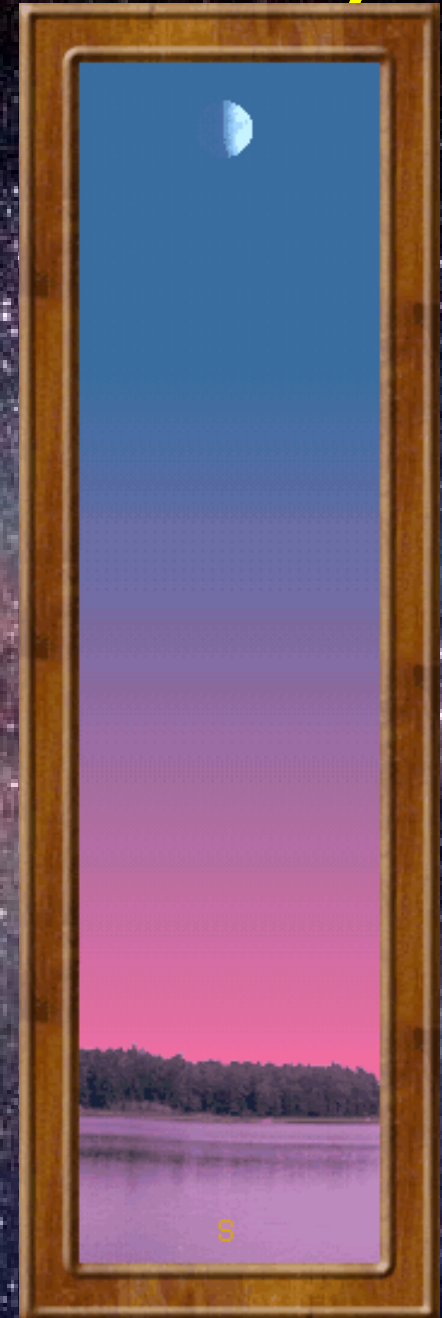


Single observer sees moon in sky

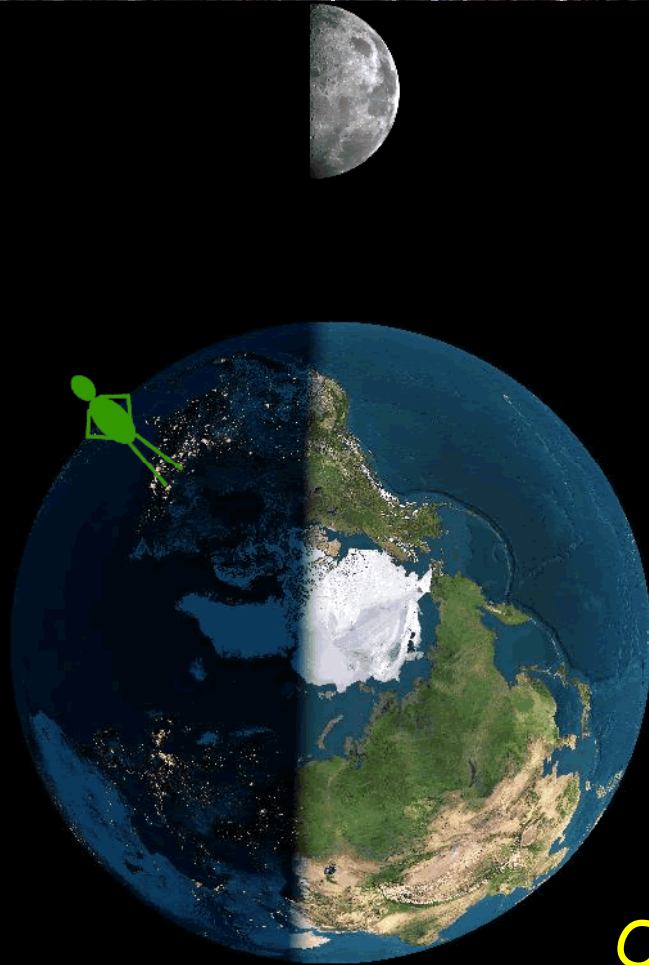


Observer
sees moon
transiting as
sun sets

Observer's time is 18:00

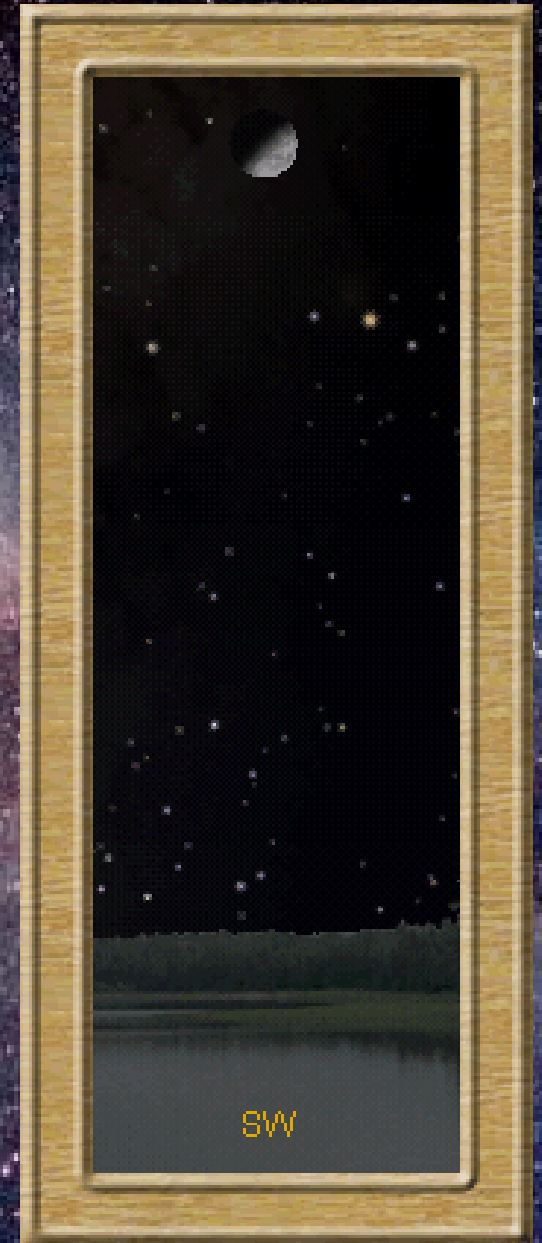


Single observer sees moon in sky



Observer
sees moon in
western sky

Observer's time is 21:00



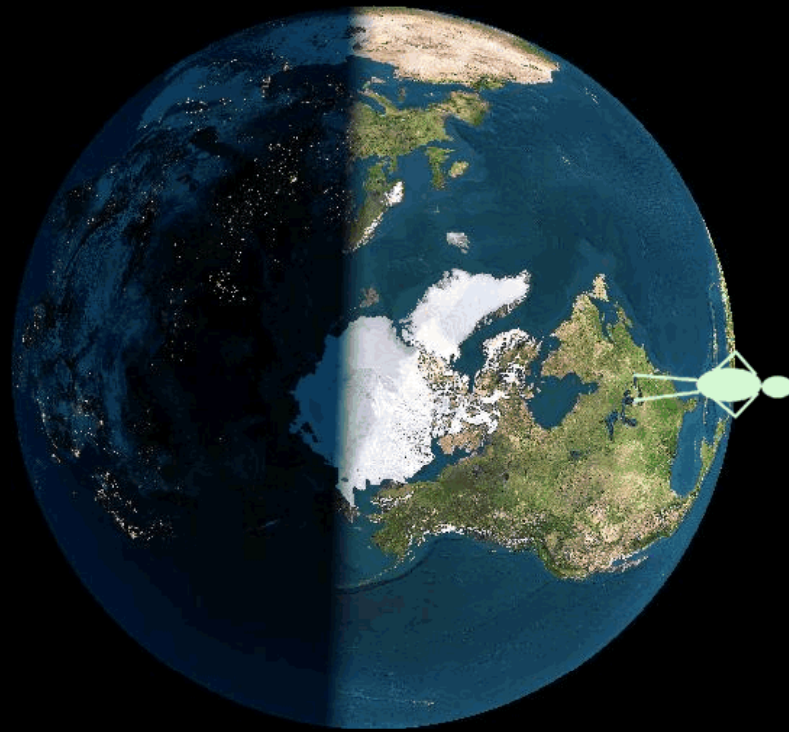
Single observer sees moon in sky



Observer
sees moon
setting

Observer's time is 00:00





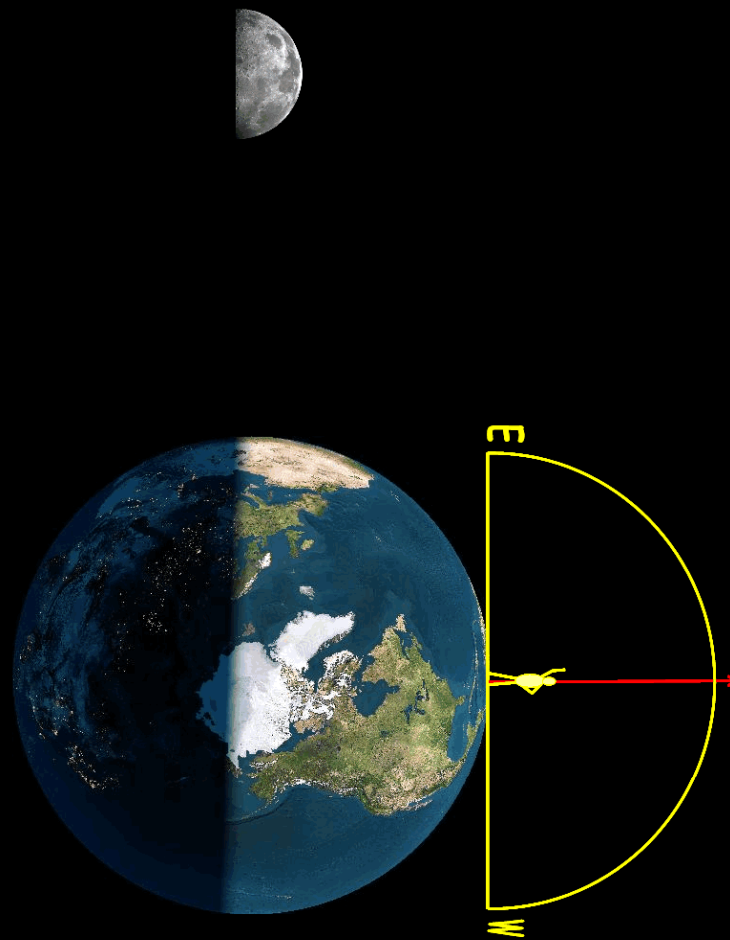
Earth
rotates
beneath
each
phase

Example:
First
Quarter

Observer's time is 12:00

Earth Observer

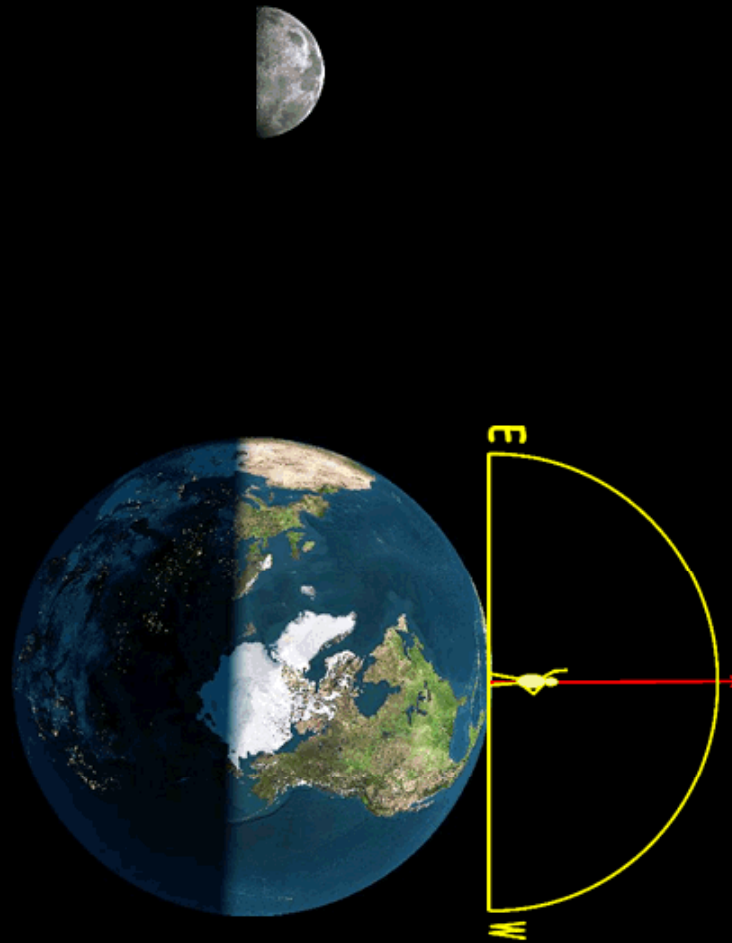
Observer
views moon
from own
horizon
system



Observer's time is 12:00

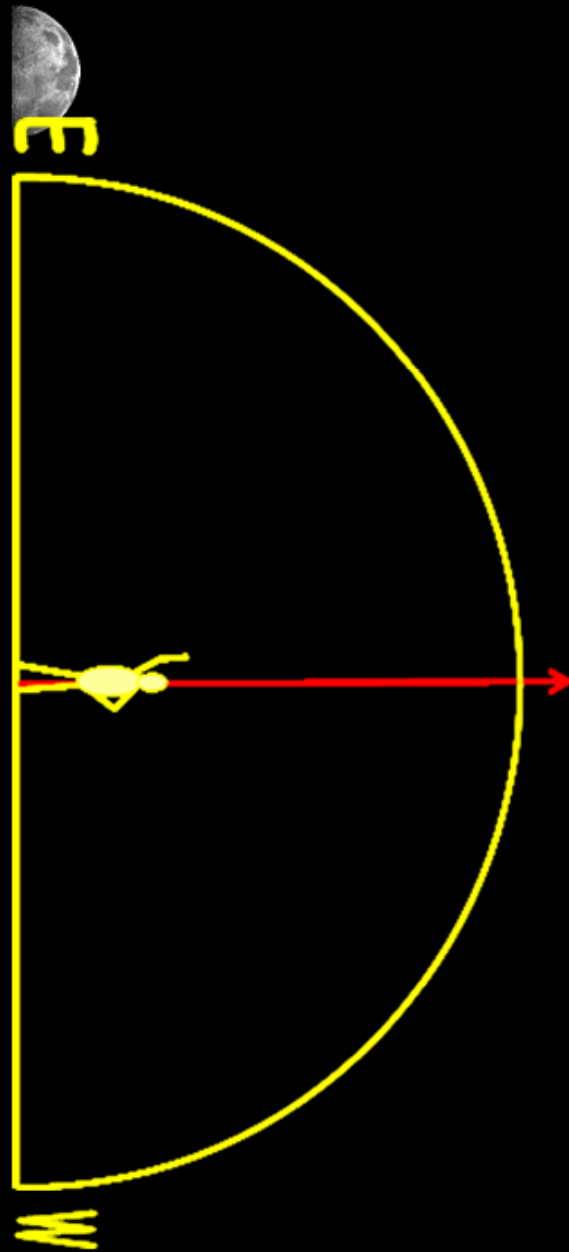
Earth Observer

Observer
only aware
of own
horizon
system



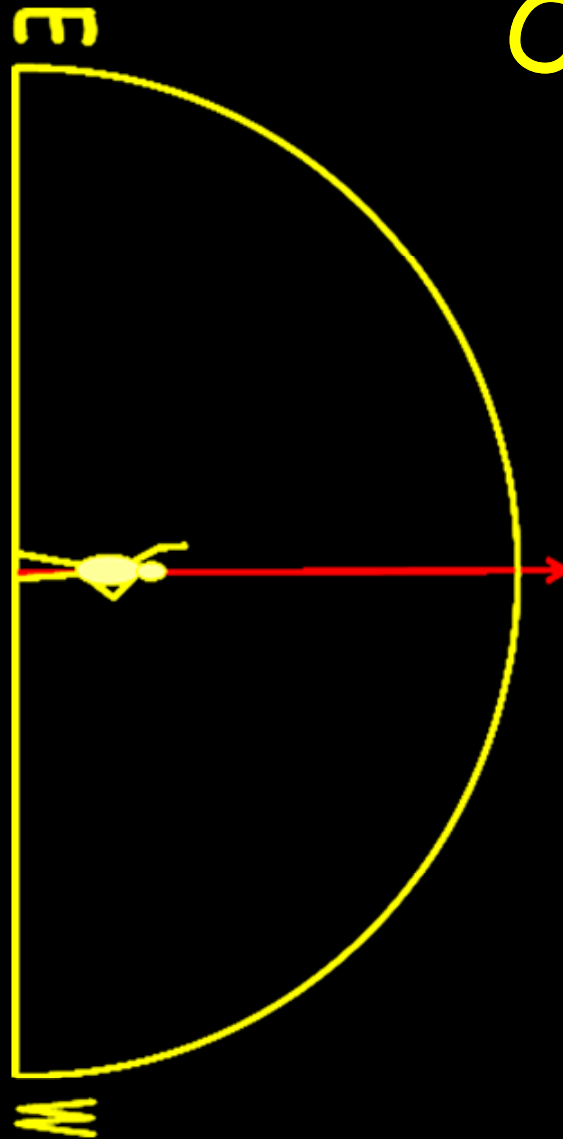
Observer's time is 12:00

1st Quarter Observer



Observer's time is 12:00 1st Quarter moon is rising

Waning Gibbous Observer



Observer's time is 12:00 waning gibbous moon is invisible

Phases Rising & Setting

1st Quarter

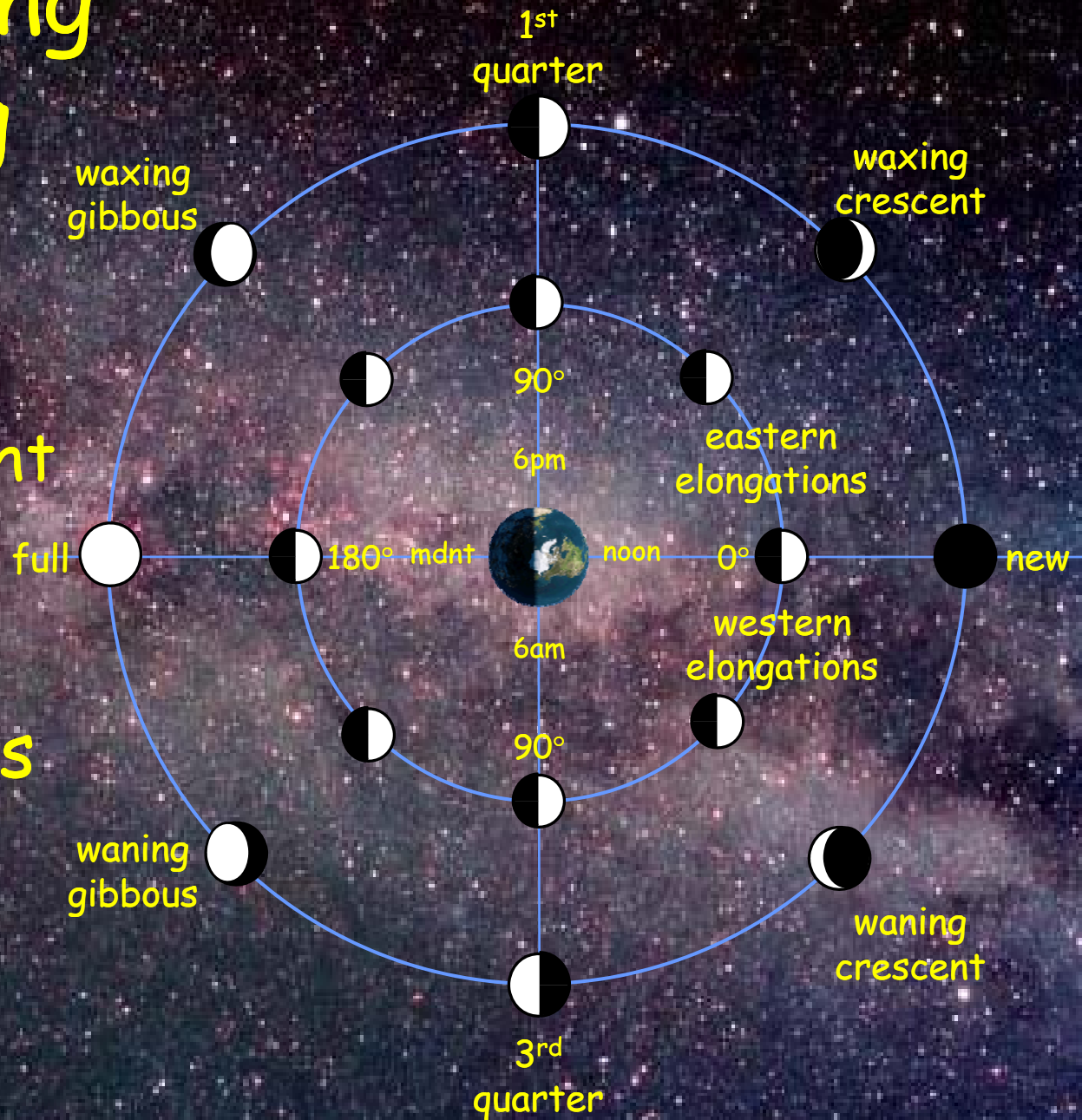
Rises at noon

Sets at midnight

Waning Gibbous

Rises at 9 pm

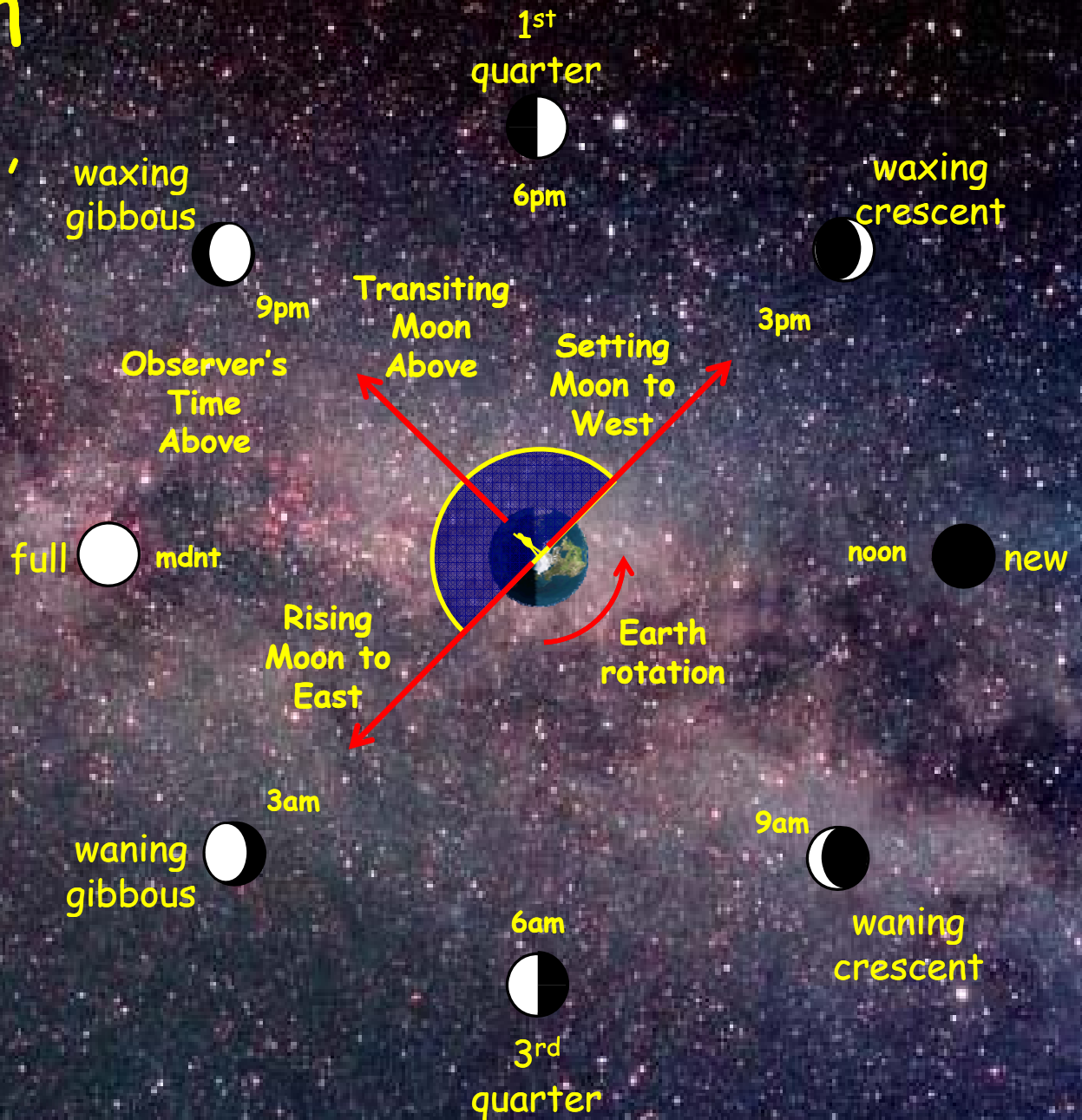
Sets at 9 am



Today's Fun

Determine rising, transit and setting times of each phase

Time is the one above the observer's head!



Phases & Times

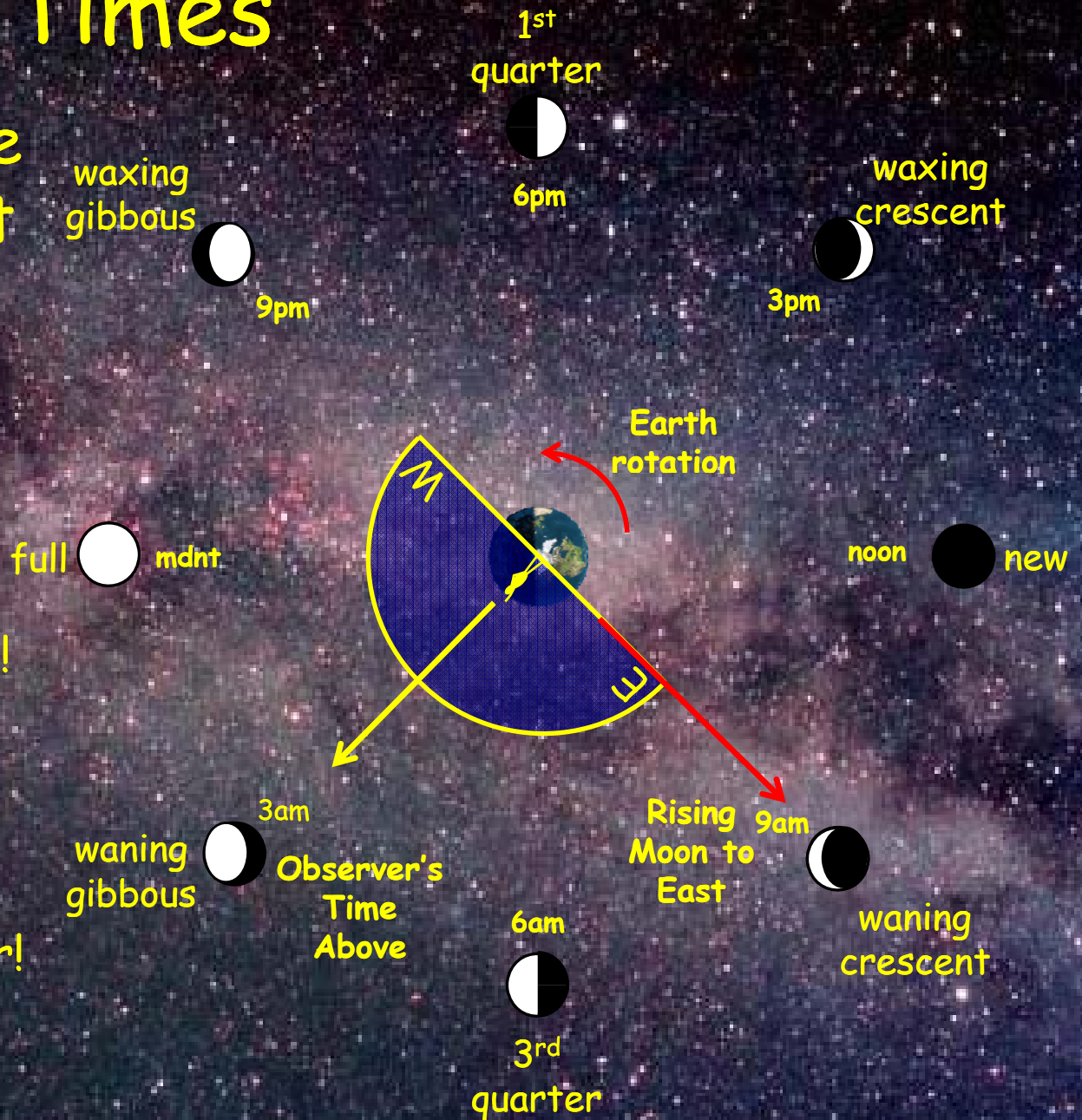
What's the phase of the moon that rises at 3 am?

3 am is the
**OBSERVER'S
TIME!**

No other times matter!

Rising moon on
eastern horizon

No other phases matter!



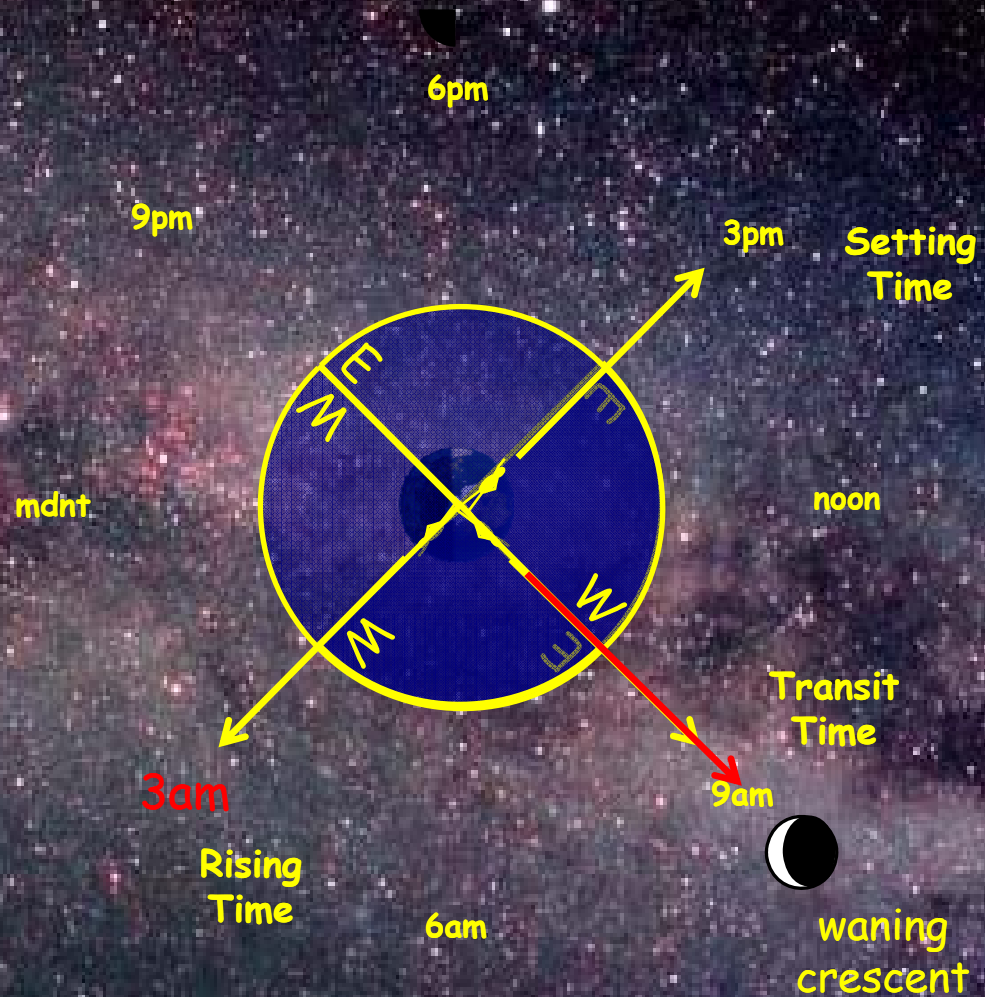
Phases & Times

What time does the phase rise & transit

Turn observer through day

Find time for transit

Find time for setting

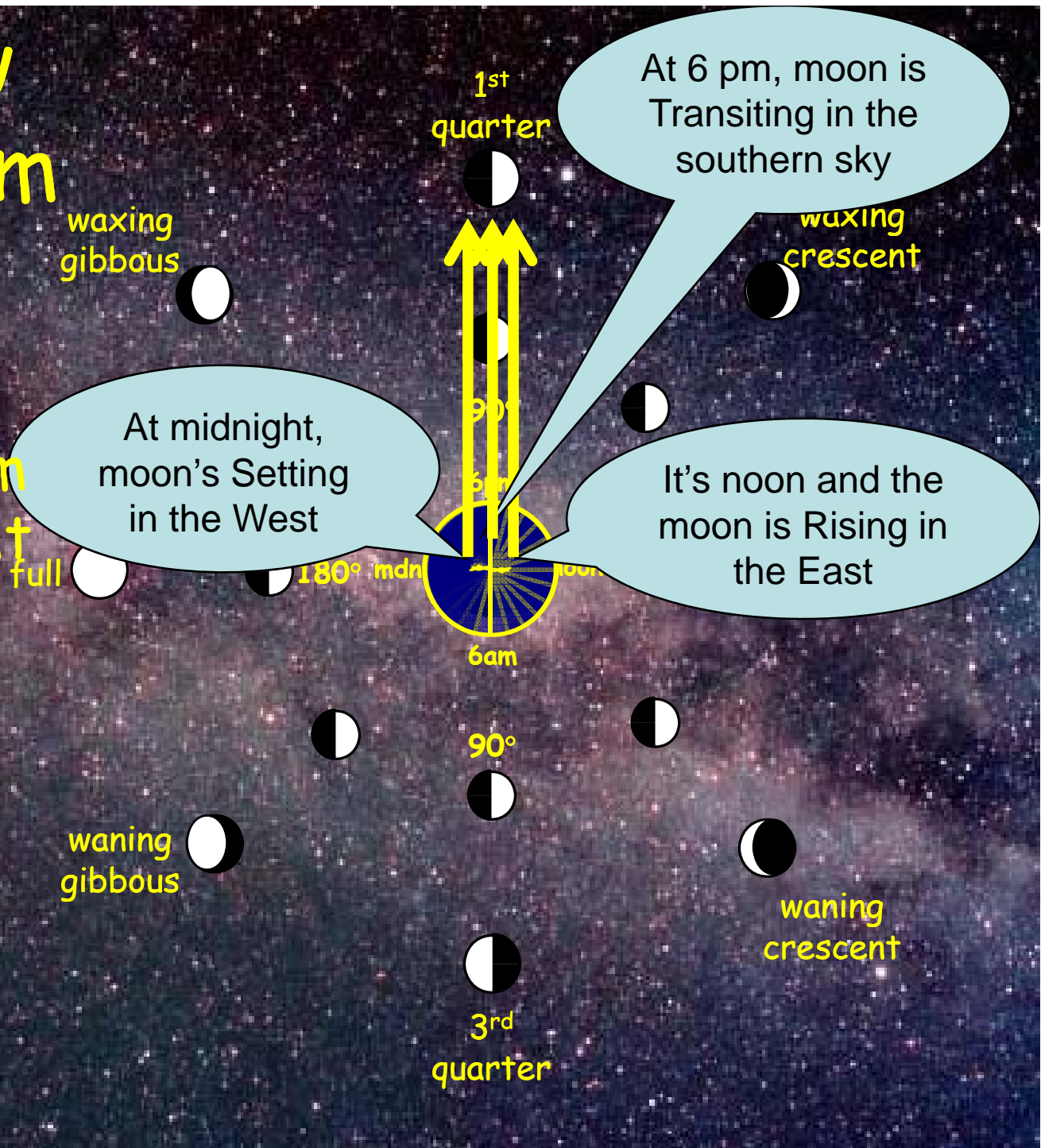


Waning Crescent rises at 3 am, transits at 9 am, sets at 3 pm

Now show the diagram

1st Quarter

Rises at noon
Transits at 6 pm
Sets at midnight



waxing gibbous

1st quarter

At 6 pm, moon is Transiting in the southern sky

waxing crescent

At midnight, moon's Setting in the West

It's noon and the moon is Rising in the East

full

180° midn

6am

90°

waning gibbous

waning crescent

3rd quarter

Now show the diagram

Waning Gibbous

Rises at 9 pm

Transits at 3 am

Sets at 9 am

waxing gibbous

1st quarter

waxing crescent

At 9 pm, moon's Rising in the East

90°

6pm

full

180° midnt

noon

0°

new

At 3 am, moon's transiting in the southern sky

It's 9 am, the moon's Setting in the West

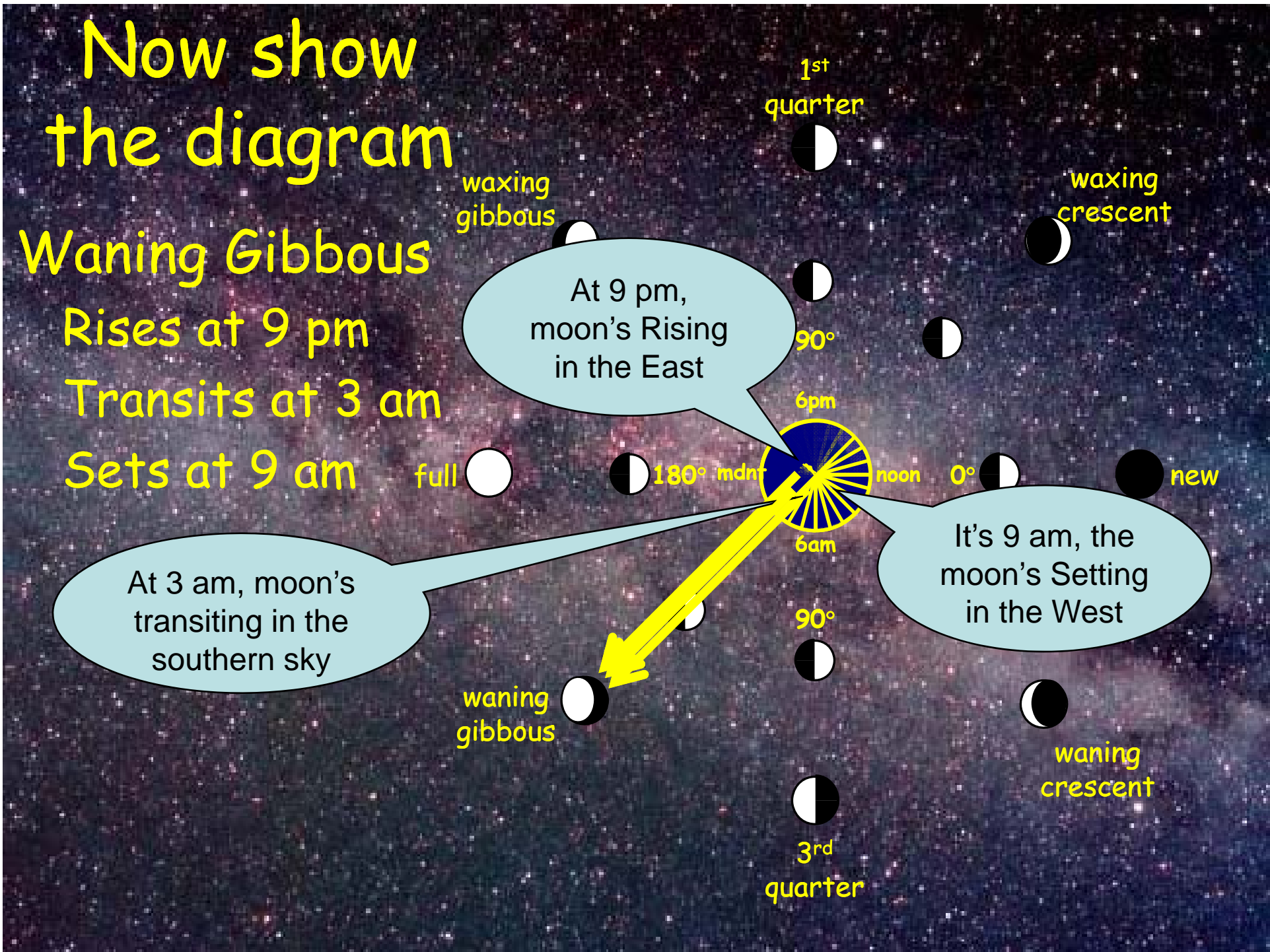
6am

90°

waning gibbous

waning crescent

3rd quarter

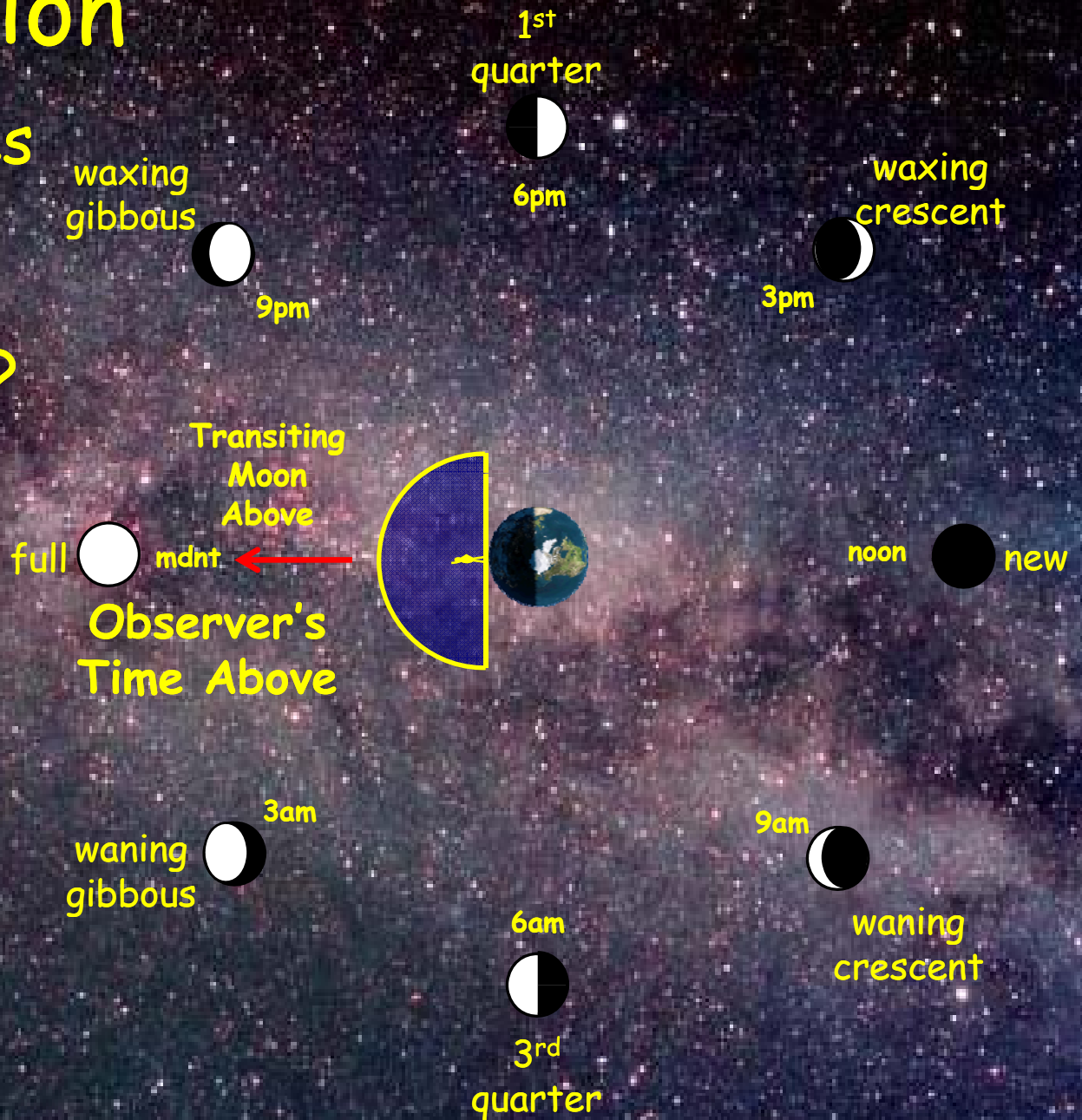


Question

An observer sees
the full moon
transit.

What time is it?

- a) 6 pm
- b) Midnight
- c) 6 am

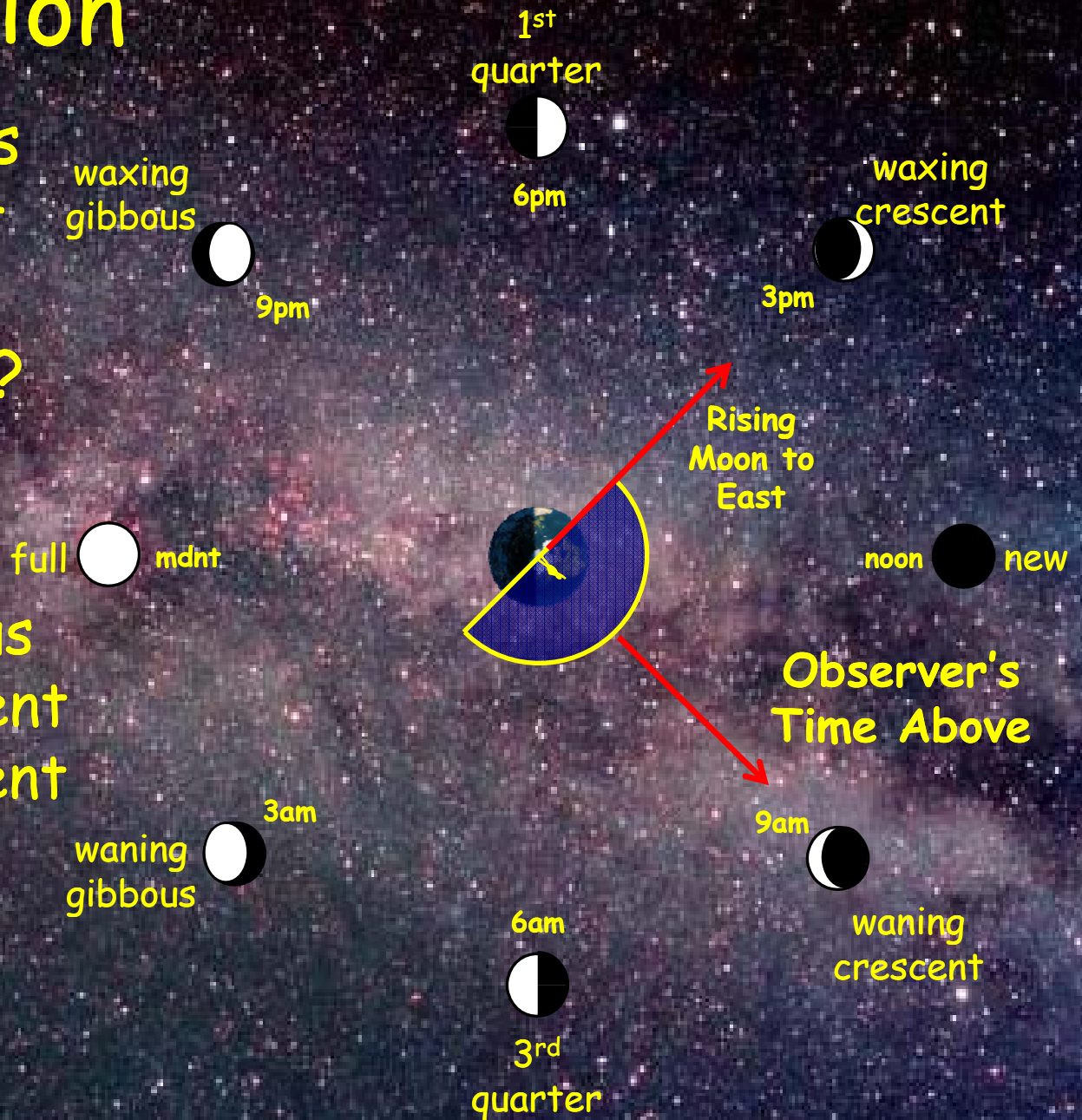


Question

An observer sees
the moon rise at
9 am.

What phase is it?

- a) Waning Gibbous
- b) Waning Crescent
- c) Waxing Crescent



Question

An observer sees
the moon set at
6 pm.
What phase is it?



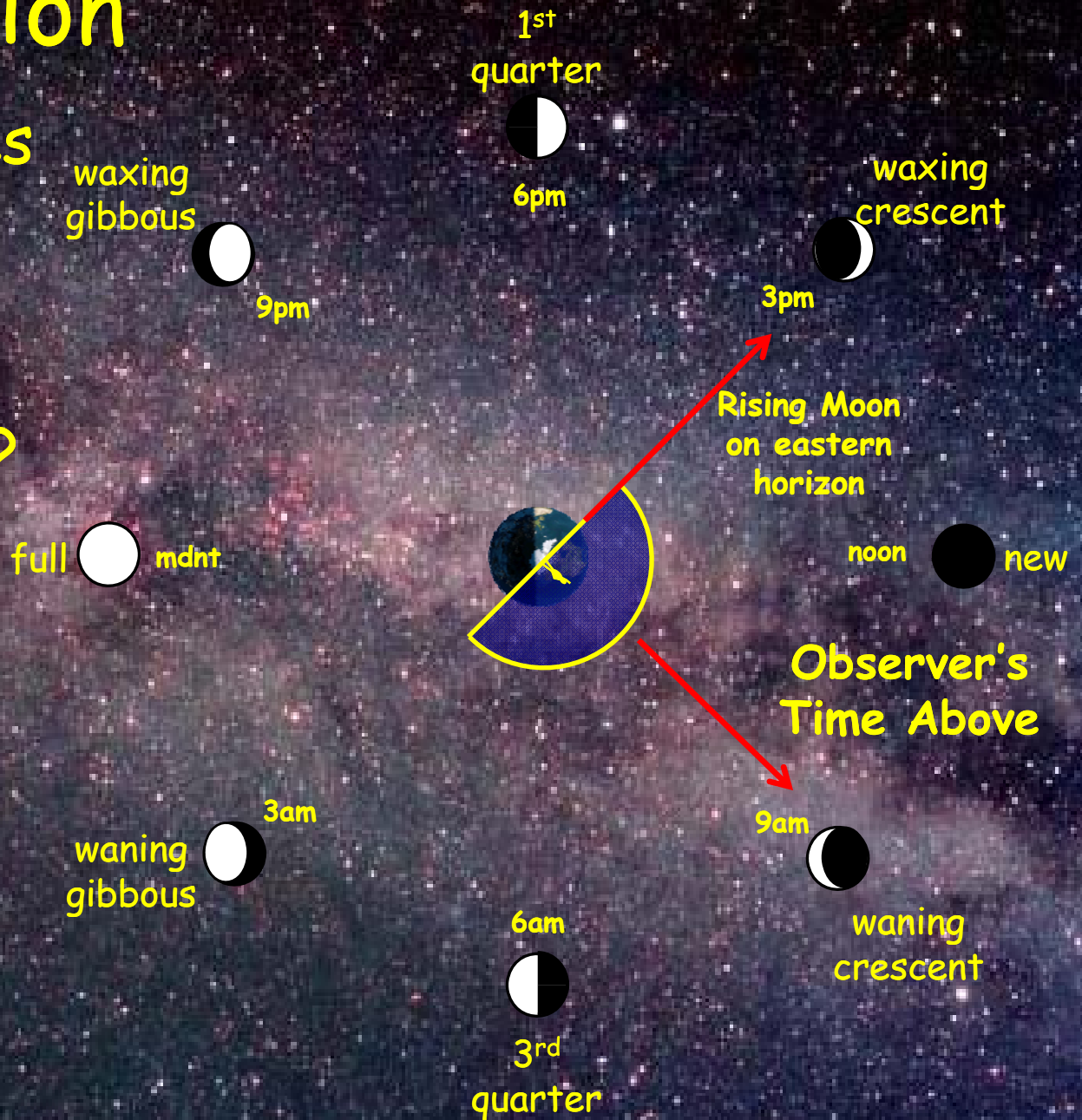
- a) New Moon
- b) First Quarter
- c) Full Moon

Question

An observer sees
the waxing
crescent moon
rise.

What time is it?

- a) 9am
- b) 3 pm
- c) 9 pm



Harvest Moon 2009

☆ Some full moons are named

🌍 harvest moon = full moon closest to equinox

› October 4, 2:11 am

› Moon bright at rising for days

› Allowed farmers to work into the night

🌍 hunter's moon = follows harvest moon

› November 2, 2:14 pm

Harvest Moon 2009

10/5/9

