Potsdam
THE STATE UNIVERSITY OF NEW YORK

SOAR: The Sky in Motion

Life on the Tilted Teacup Ride

Celestial Coordinates and the Day

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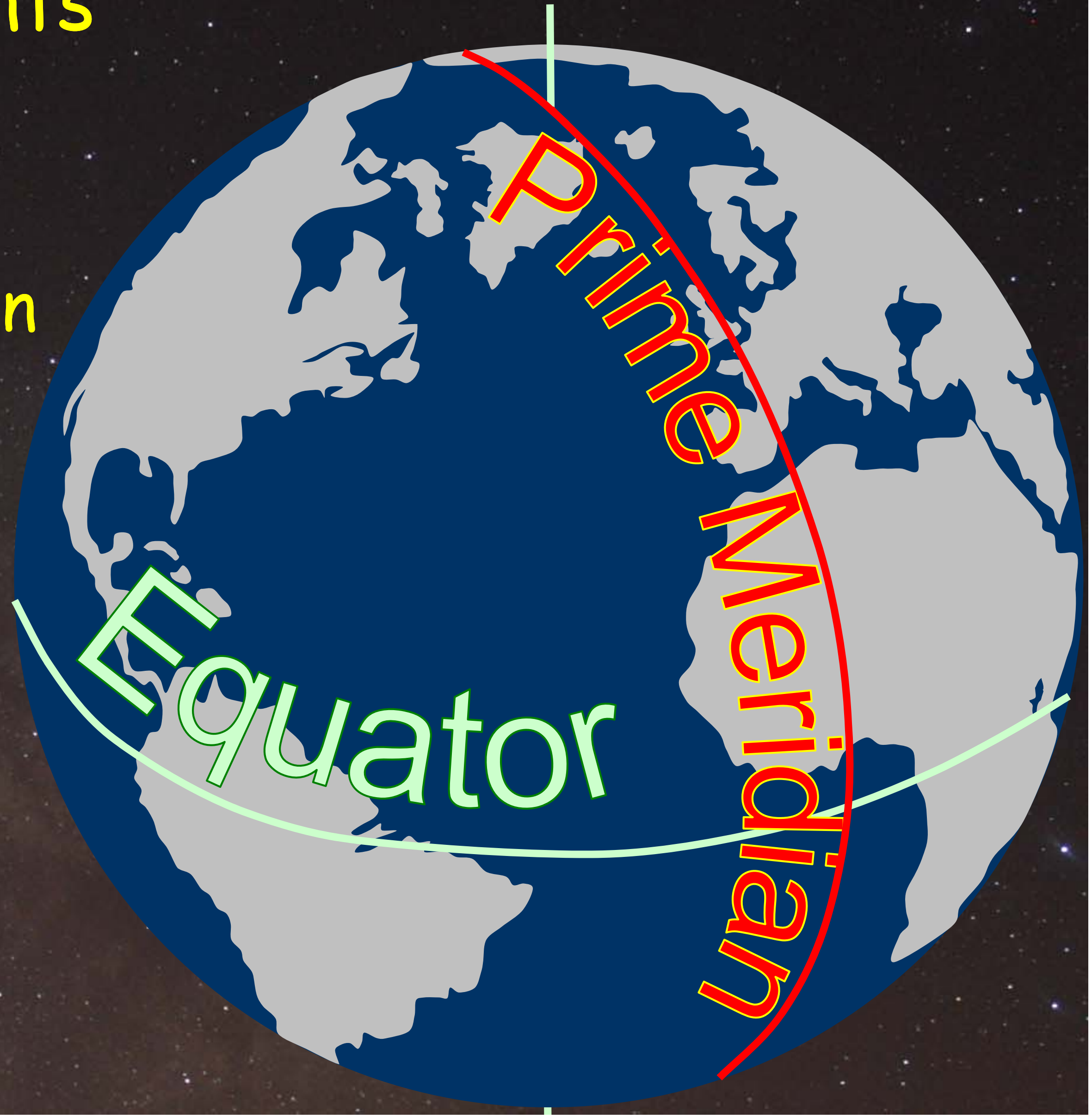
ST. LAWRENCE UNIVERSITY

Photo by Marc Staves 2011

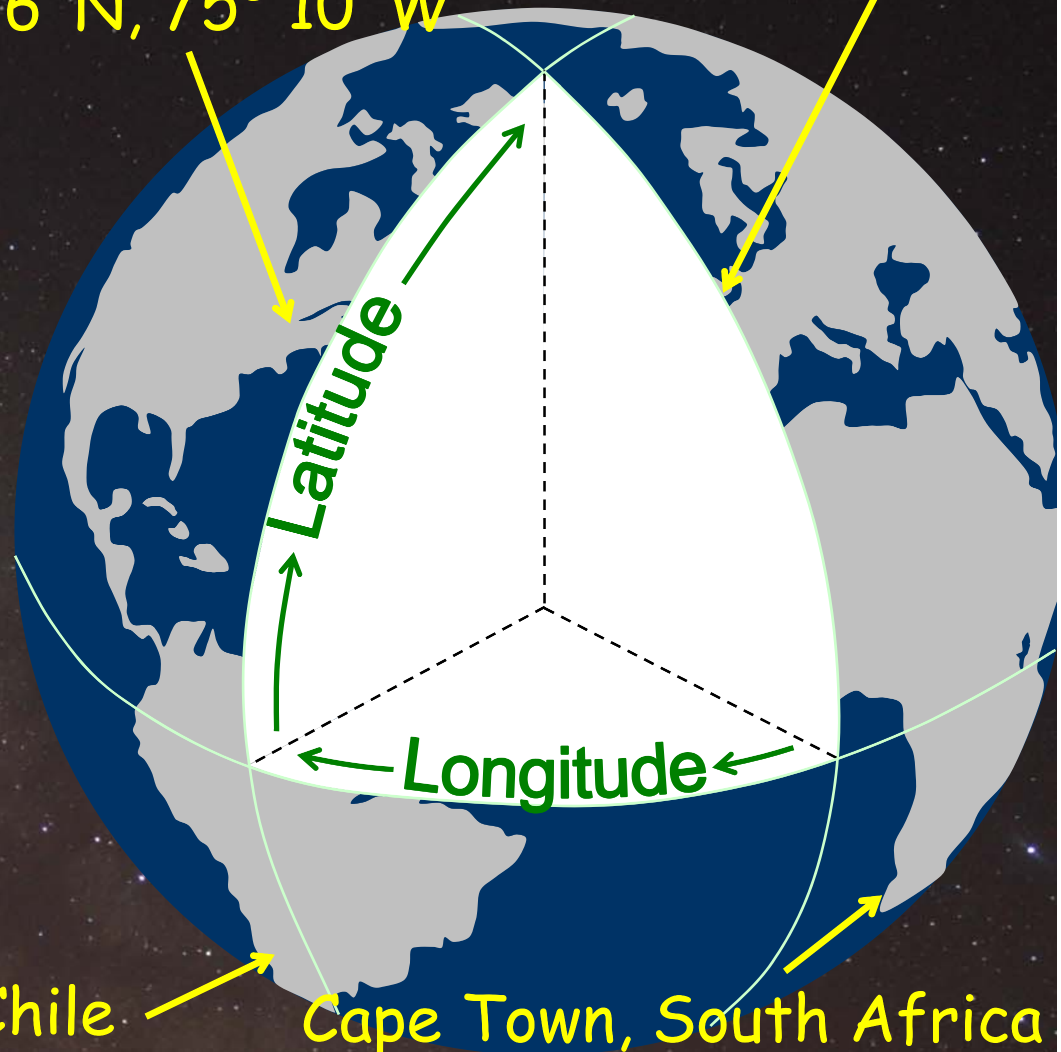
Where on Earth?

- ☆ Reference Points
  - Poles
  - Equator
  - Prime Meridian
    - Greenwich, England
- ☆ Coordinates
  - Latitude
  - Longitude



Where on Earth?

- ☆ Coordinates
  - Latitude
    - Measured N & S
    - From Equator to Poles
    - 0° to 90° N & S
  - Longitude
    - Measure E & W
    - From Prime Meridian (0°) to 180° E & W



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The Celestial Sphere

The view from a small planet on the edge of the Orion arm of the Milky Way galaxy …

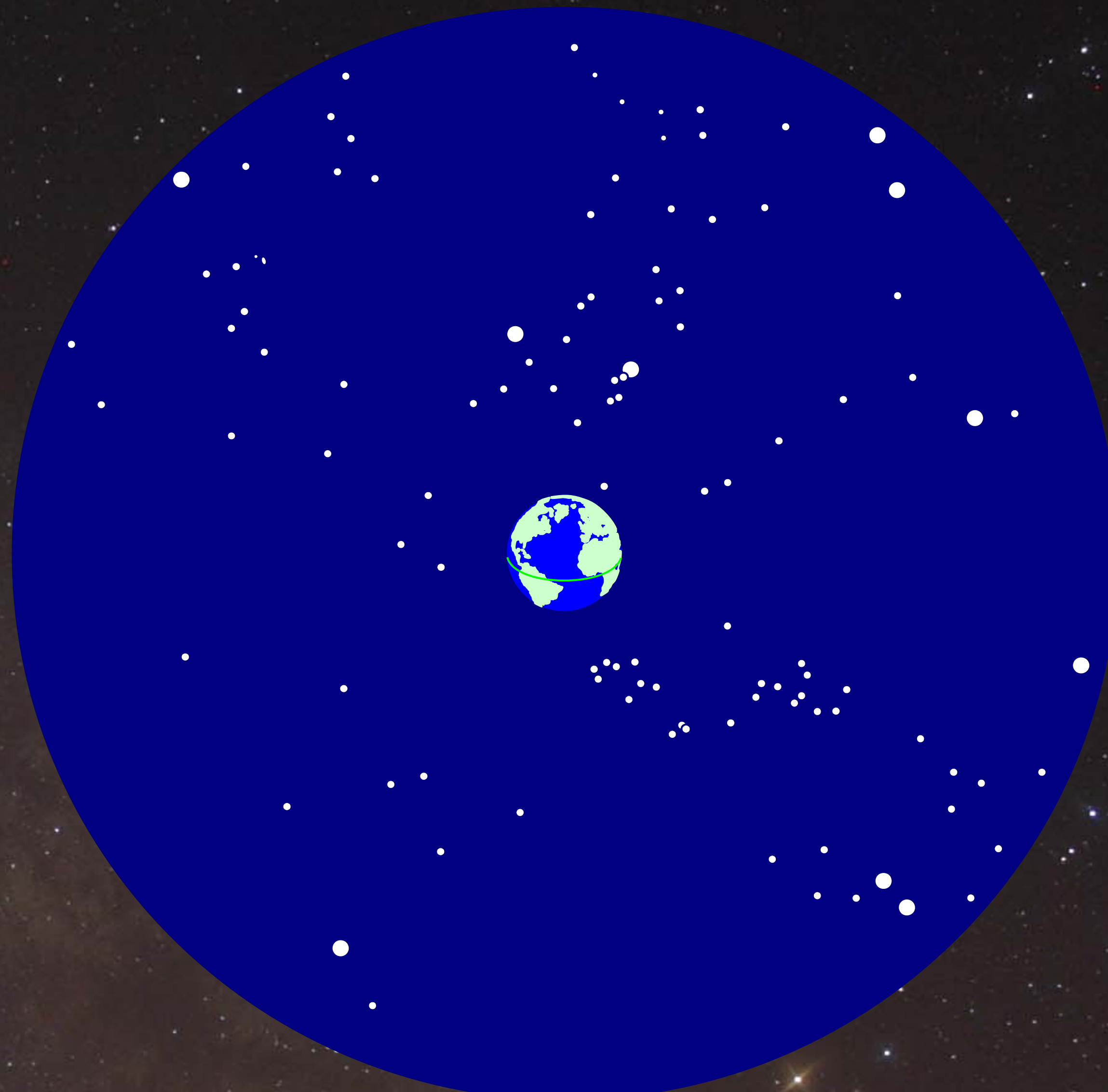


Photo by Marc Staves 2011

Reference Points

- ☆ Celestial Equator
  - Projection of Earth's equator
- ☆ Celestial Poles
  - Projections of Earth's poles
- ☆ Point of Aries
  - Vernal Equinox
  - Defines prime meridian (Celestial Greenwich)

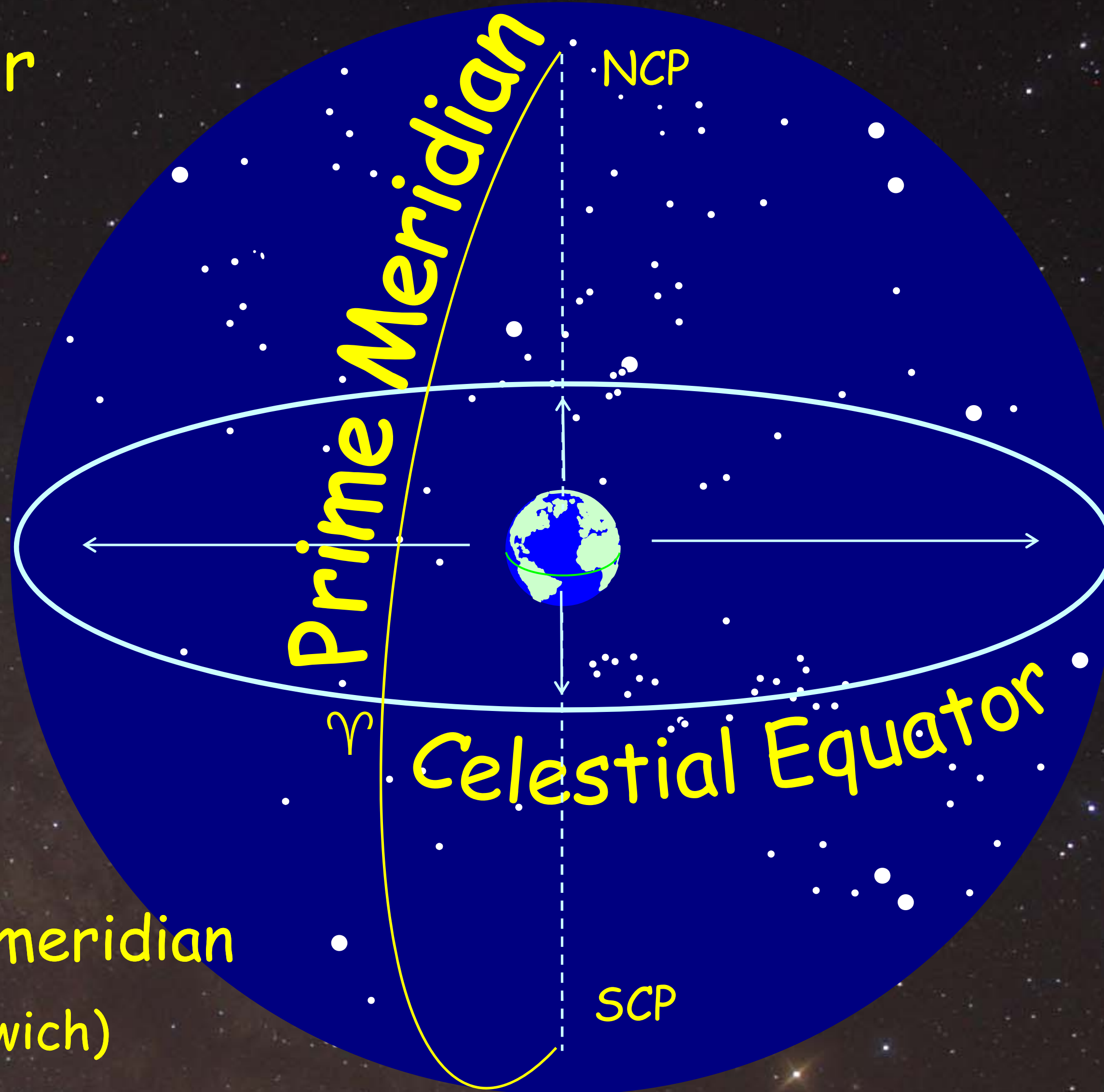


Photo by Marc Staves 2011

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°

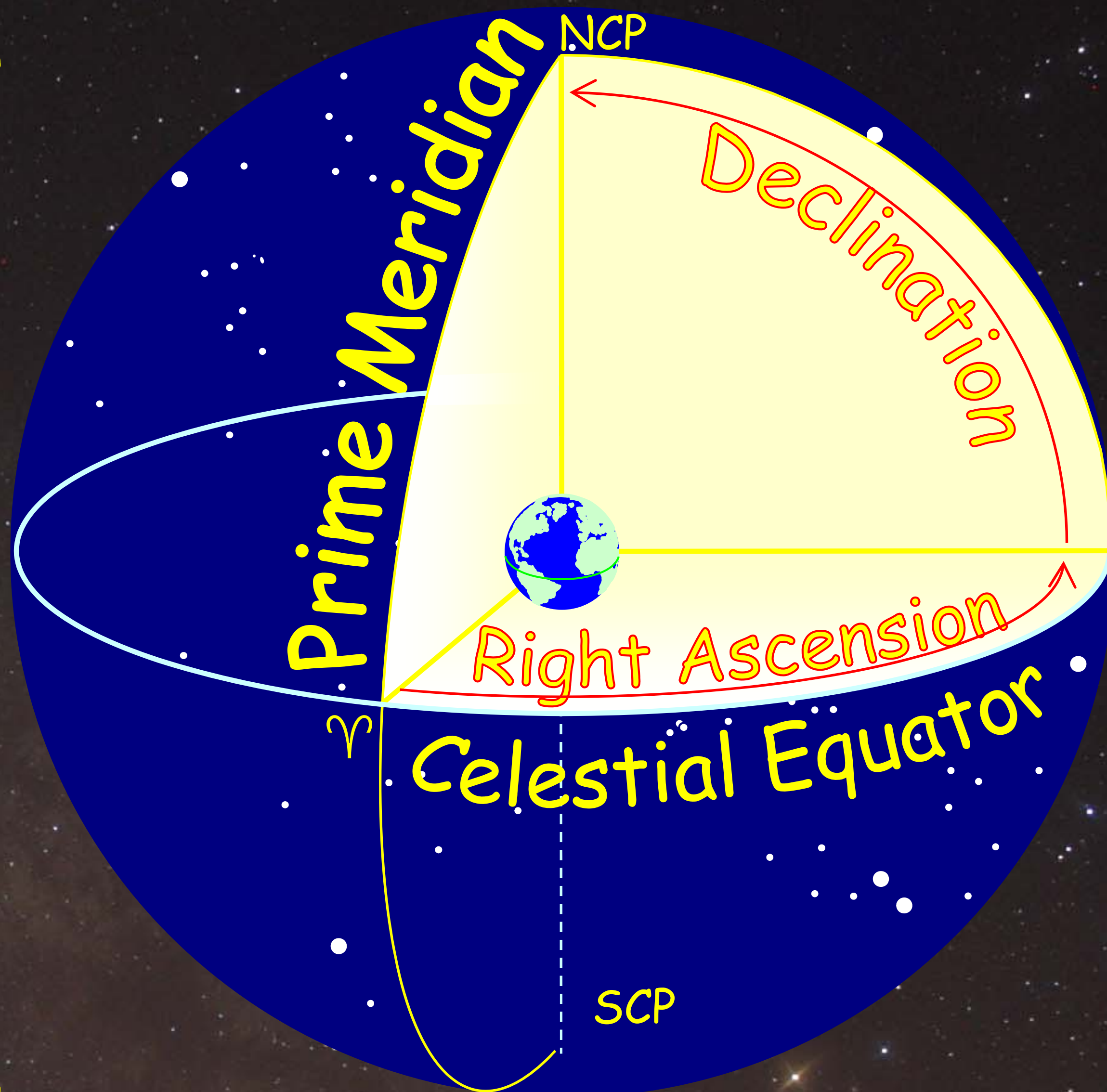
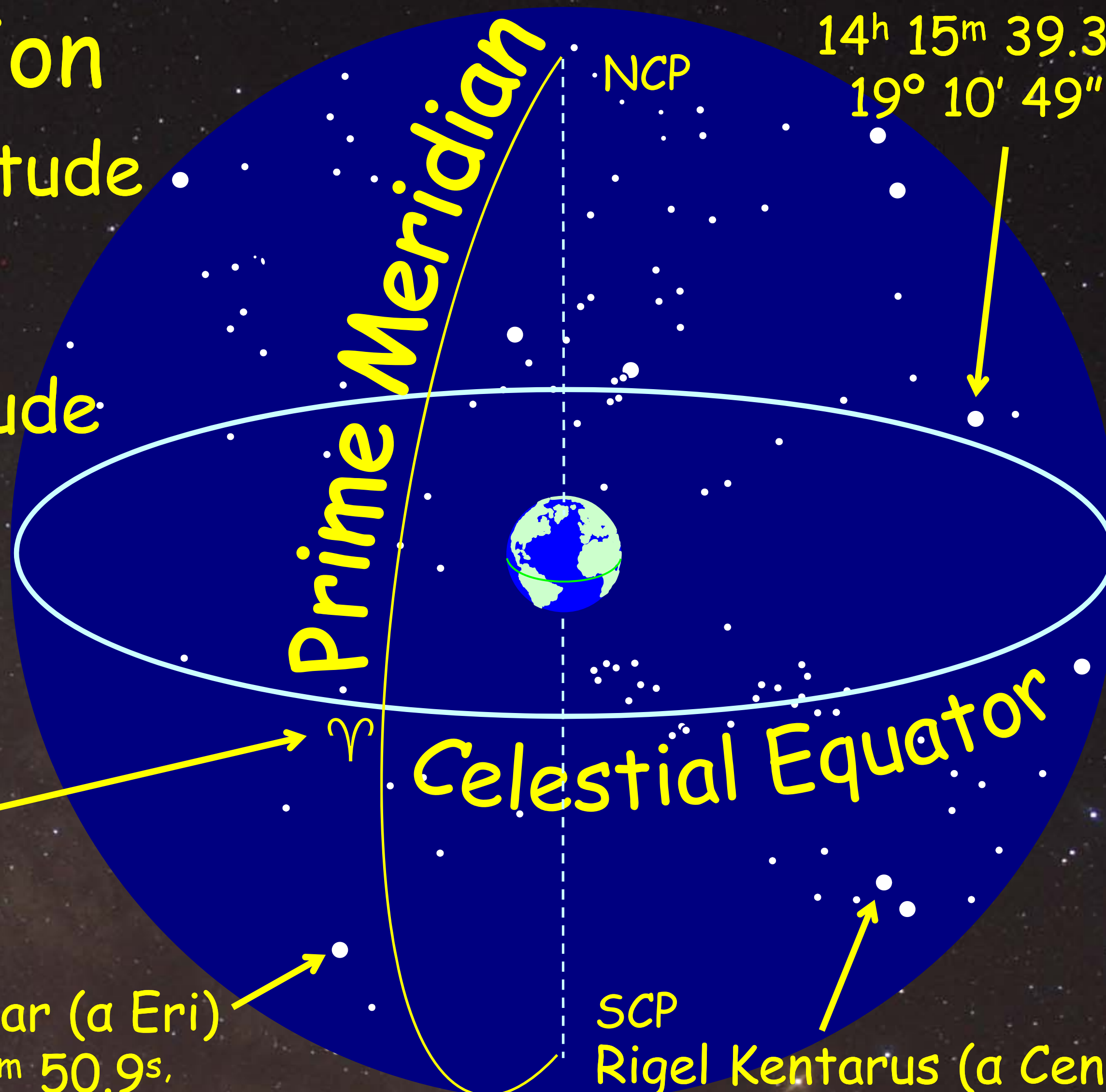


Photo by Marc Staves 2011

Celestial Coordinates

- ☆ Right Ascension
  - Celestial Longitude
- ☆ Declination
  - Celestial Latitude



Celestial Coordinates

☆ Chet Raymo: 365 Starry Nights: October

Earth observer in North America looking up at Great Square of Pegasus (an asterism)

Degrees of Declination:
Positive (N) 0° to +90°
Negative (S) 0° to -90°

Hours of Right Ascension
0^h to 24^h

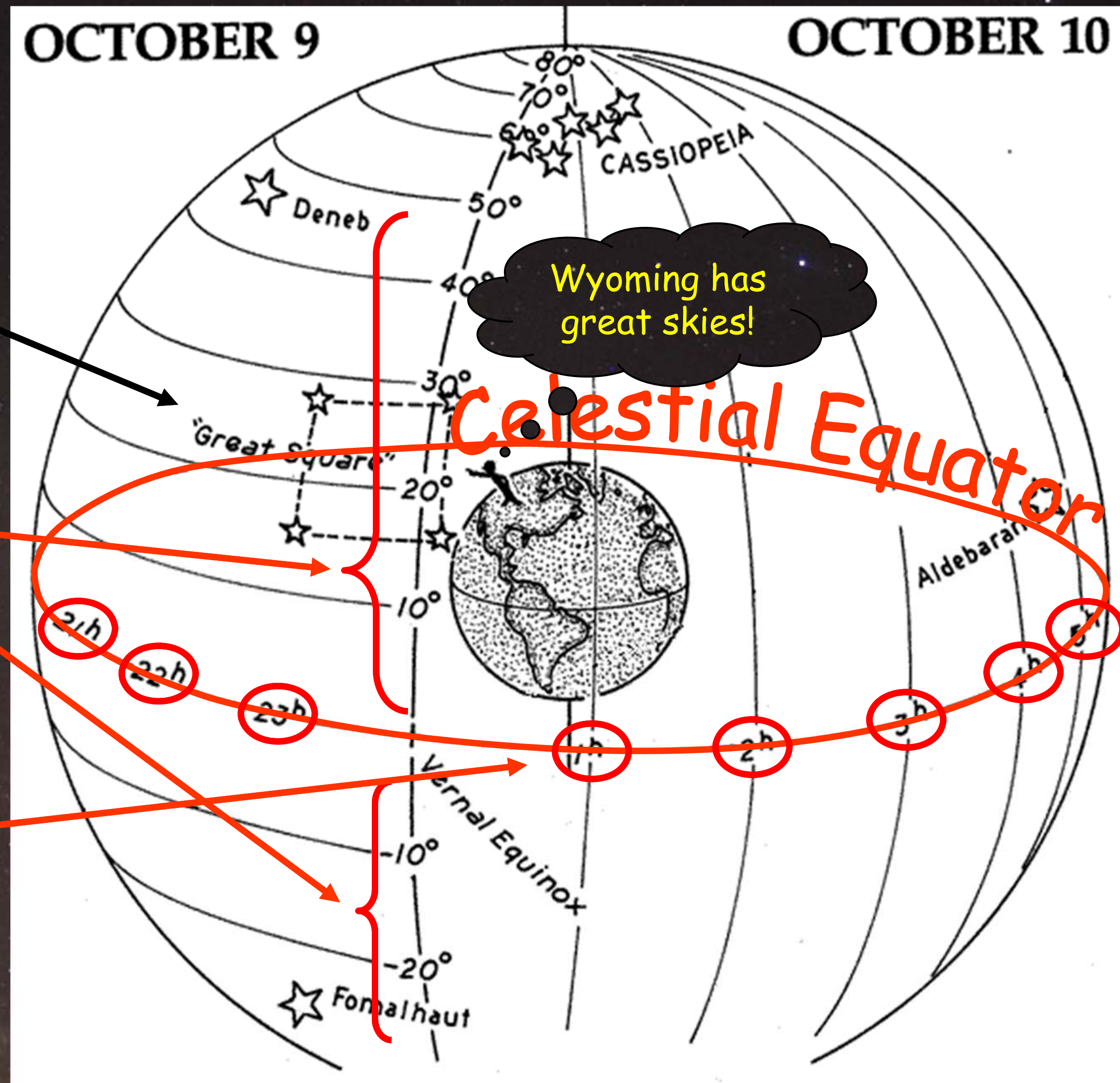
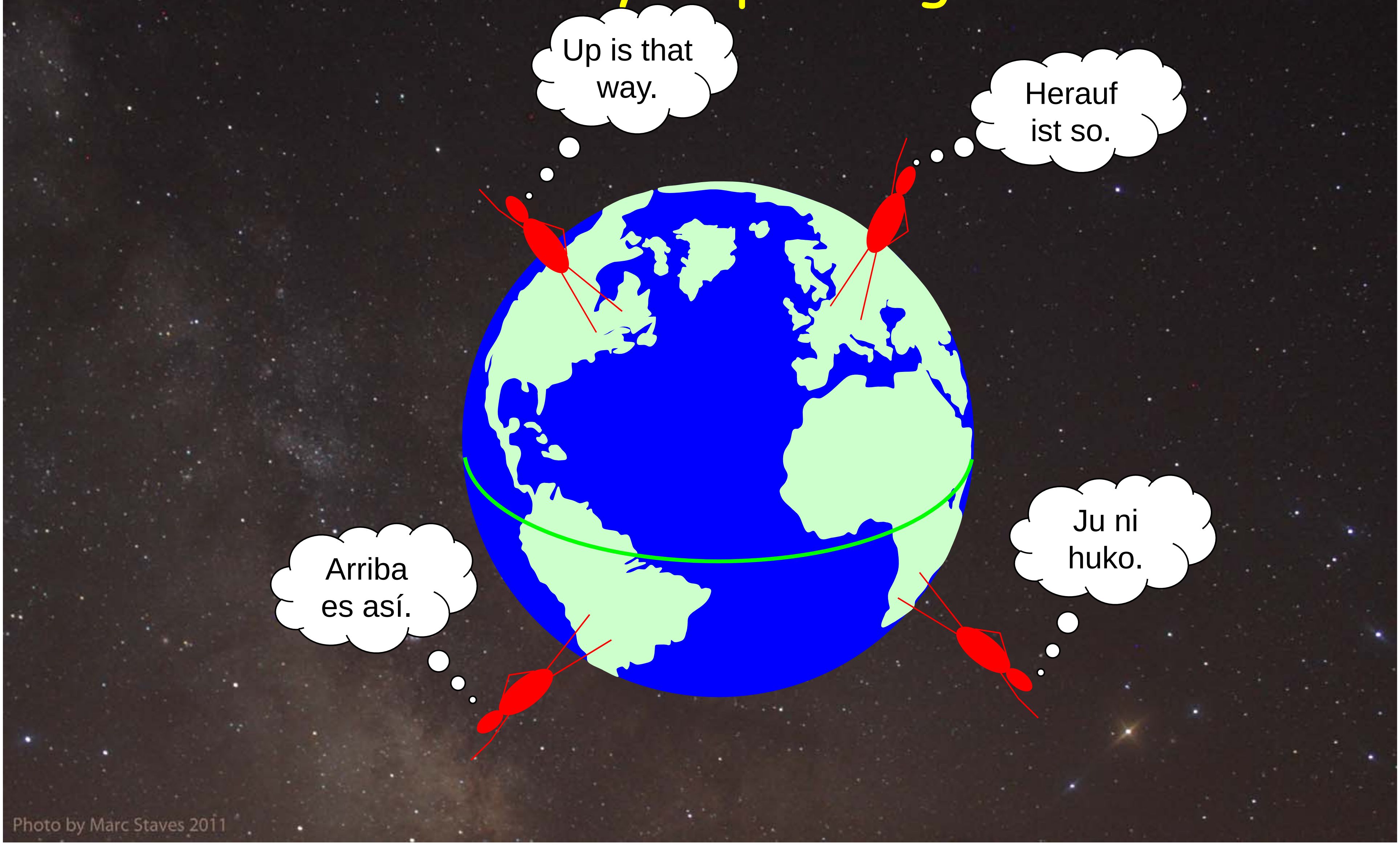


Photo by Marc Staves 2011

Observers On Earth

- ☆ See different sky depending on Latitude



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

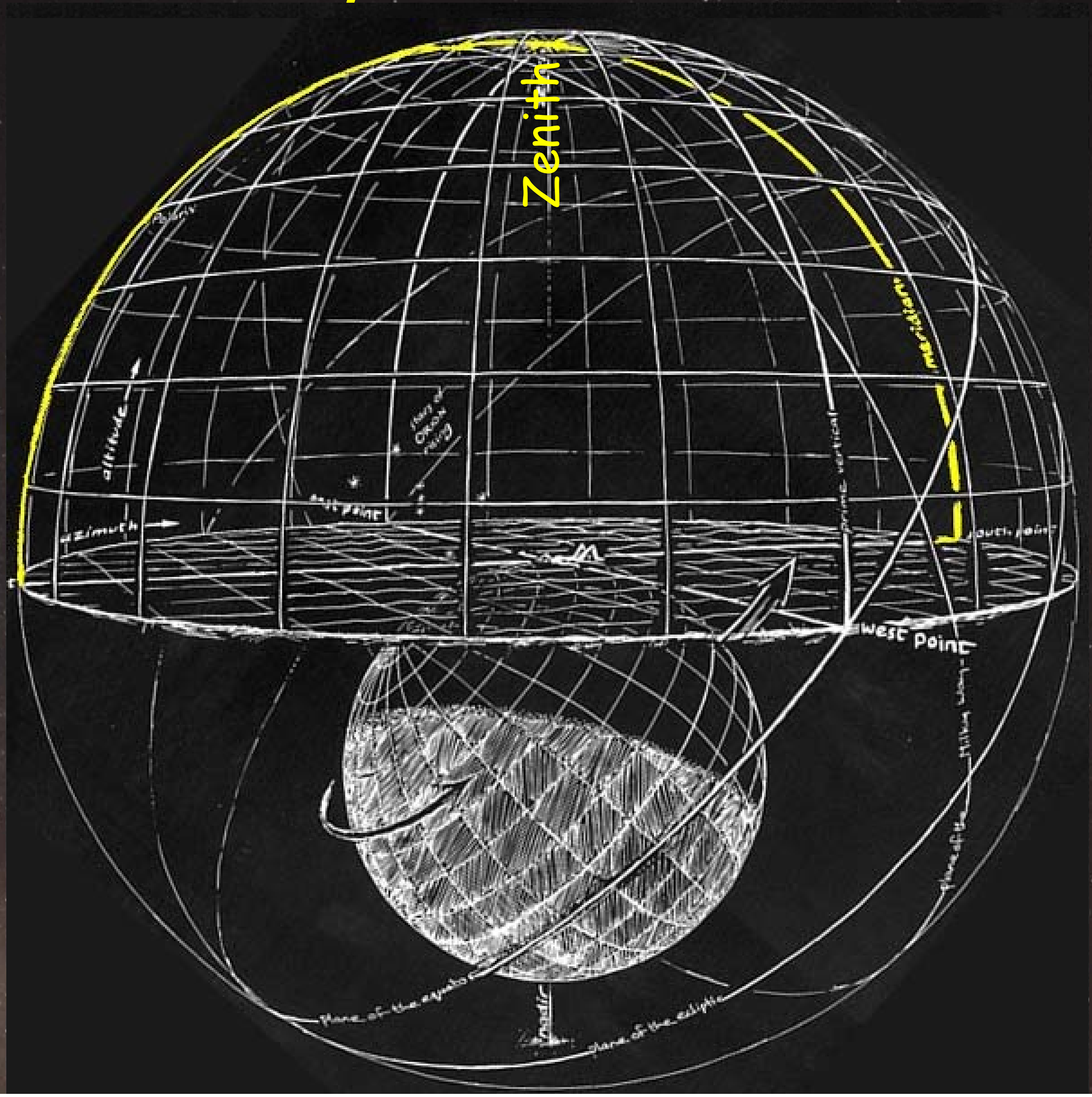
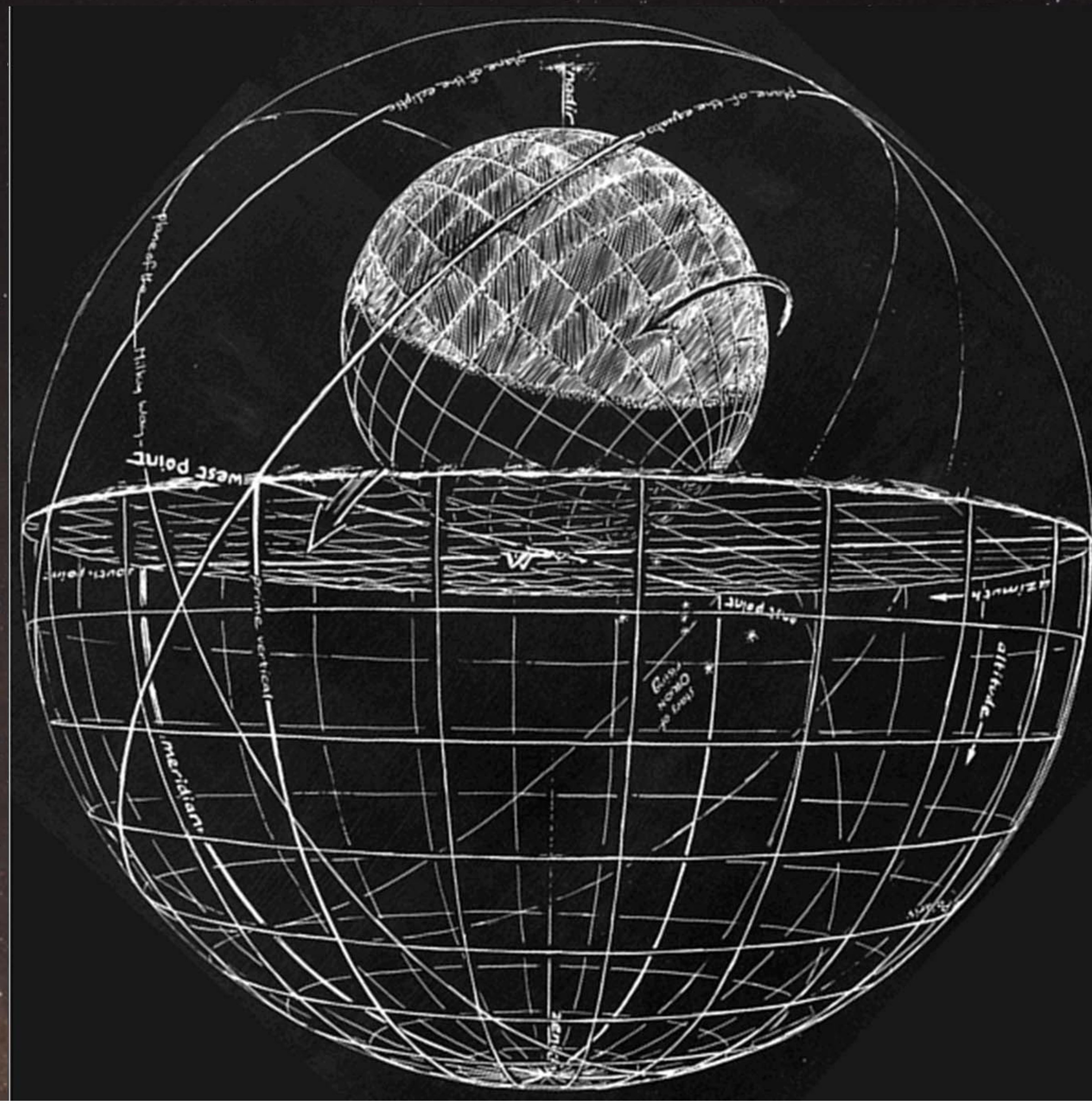


Photo by Marc Staves 2011

Tilted Sky

- ☆ Fun with your mind …

Try to see yourself held to the bottom of Earth by gravity looking "down" at the sky!



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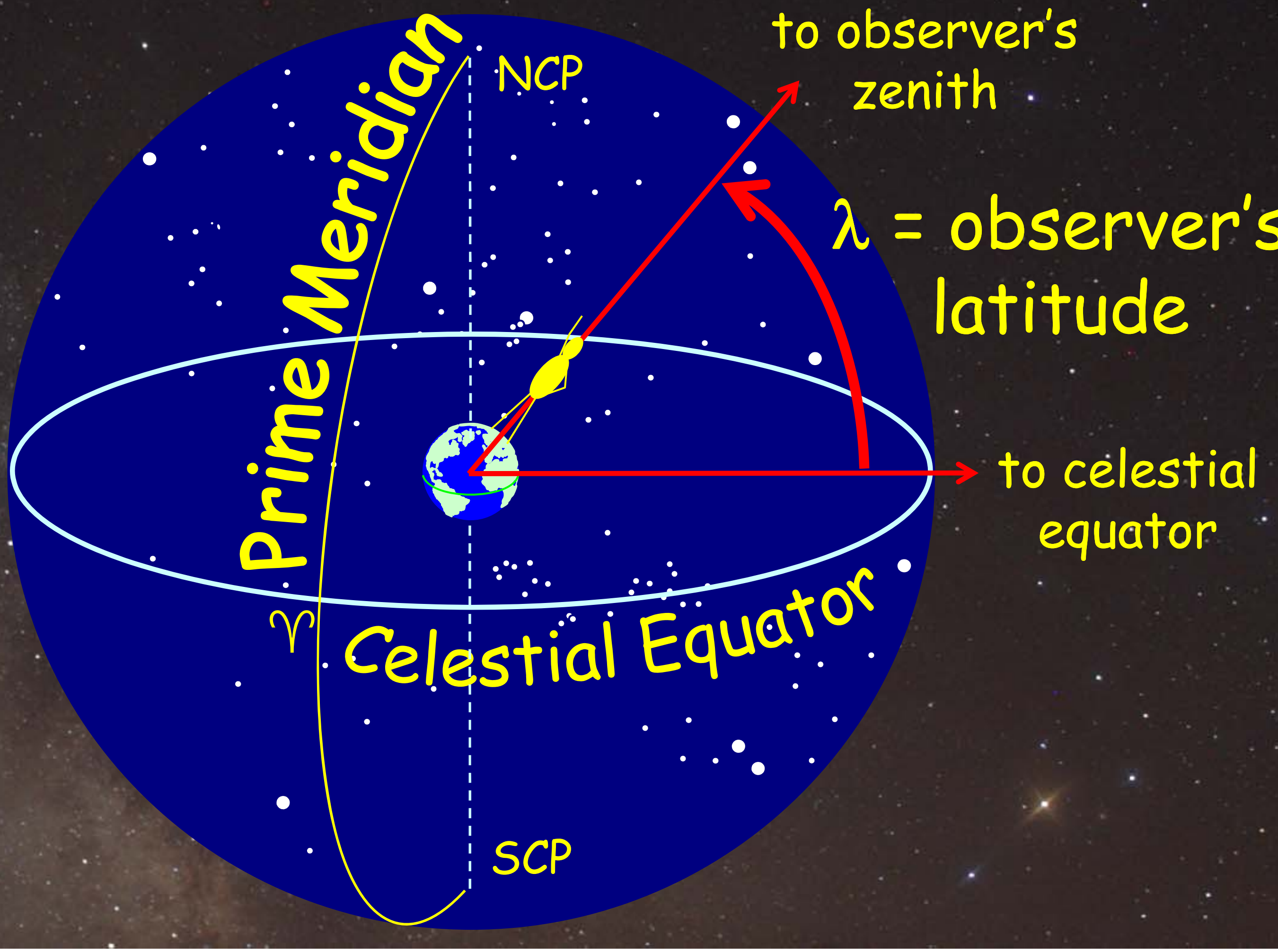
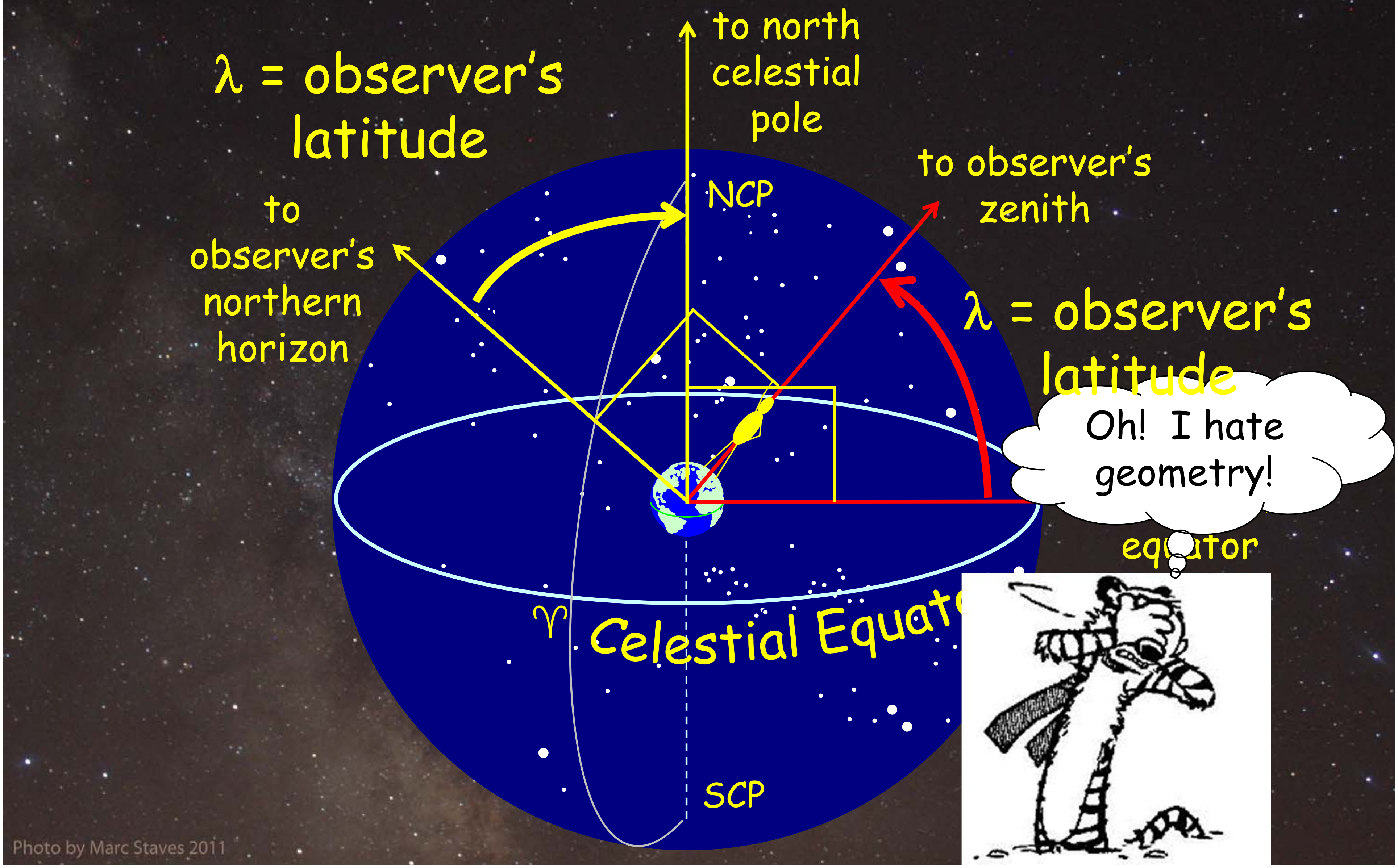
Viewing the Sky

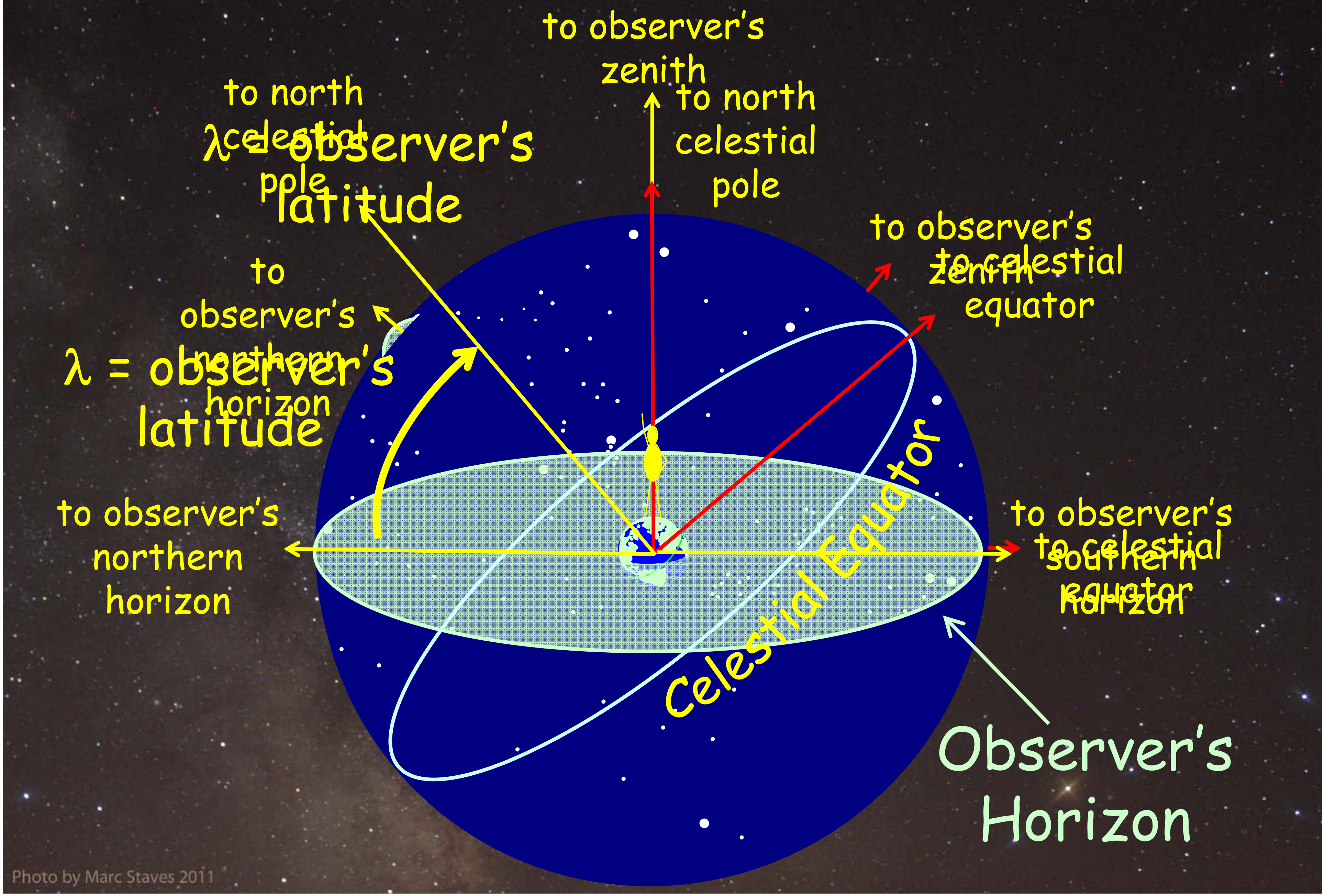
☆ Observers see celestial reference points at angles related to their latitude



Sky Angles

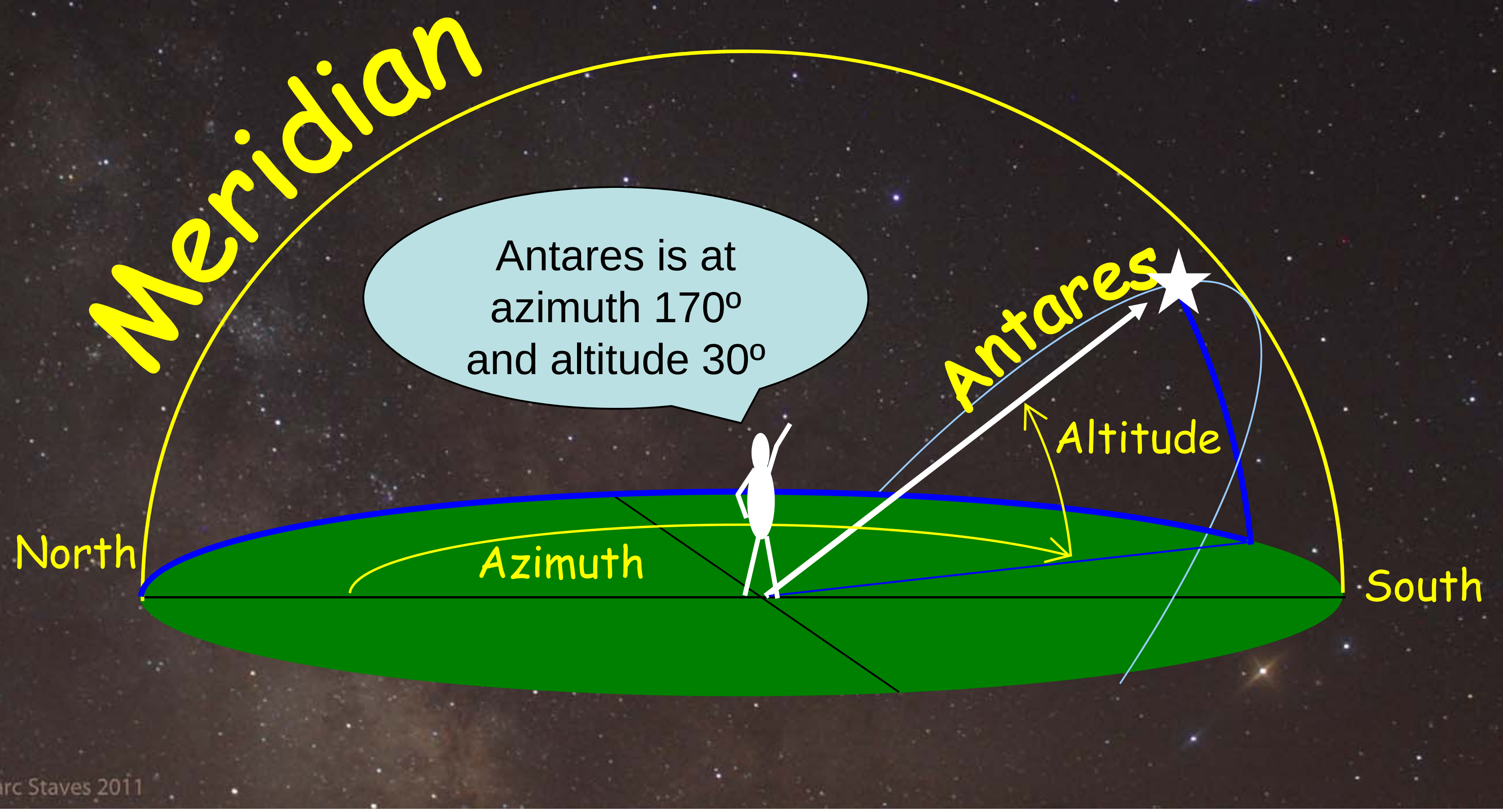

λ = observer's latitude
to north celestial pole
NCP
to observer's zenith
to observer's northern horizon
λ = observer's latitude
Oh! I hate geometry!
♈
Celestial
SCP
Photo by Marc Staves 2011

Earth Observer's View



Altitude & Azimuth

- Position of an object in the sky
  - Azimuth = Angle from north through east
  - Altitude = Angle from horizon to object



Azimuth

- ☆ Angle from North through East

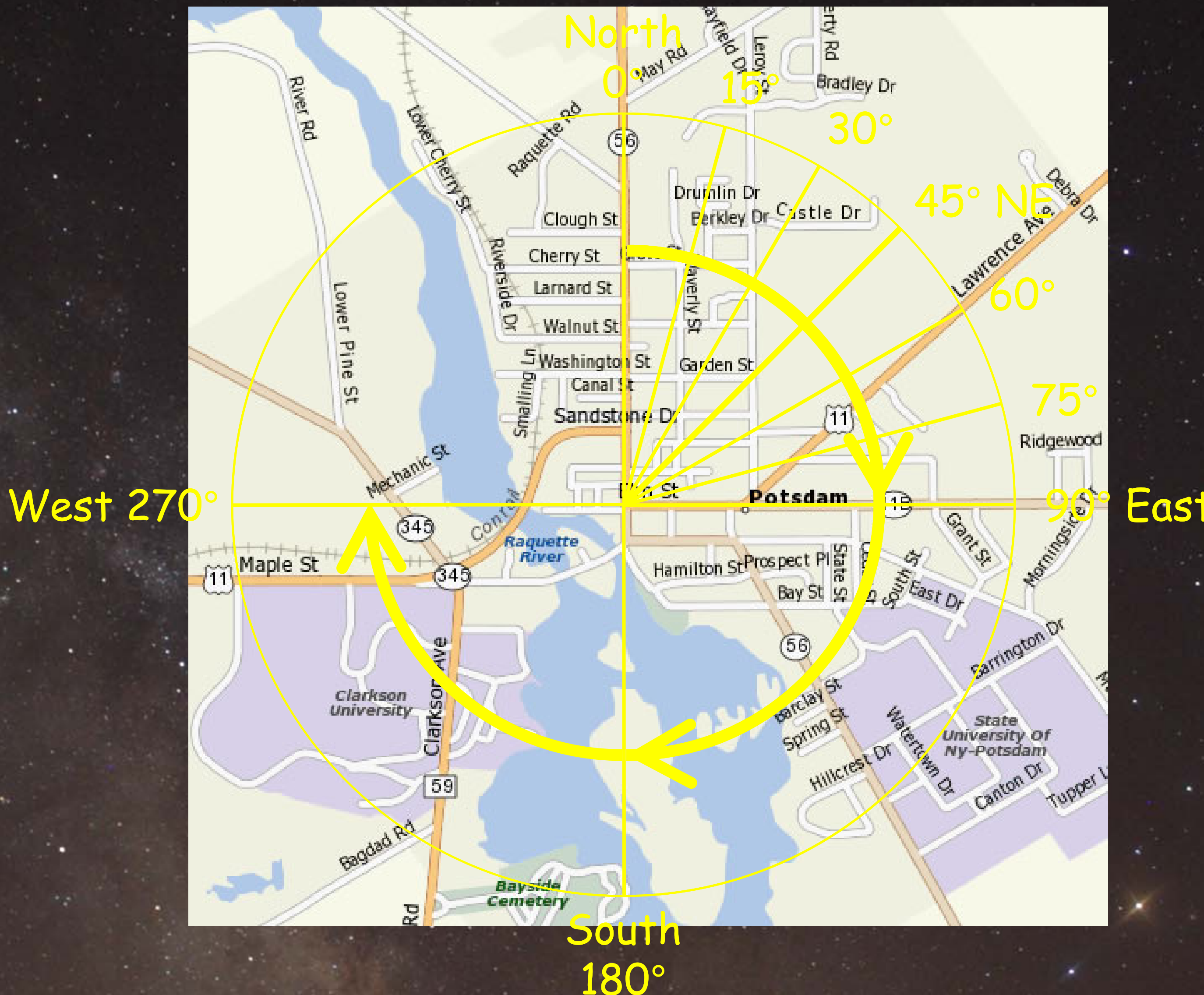
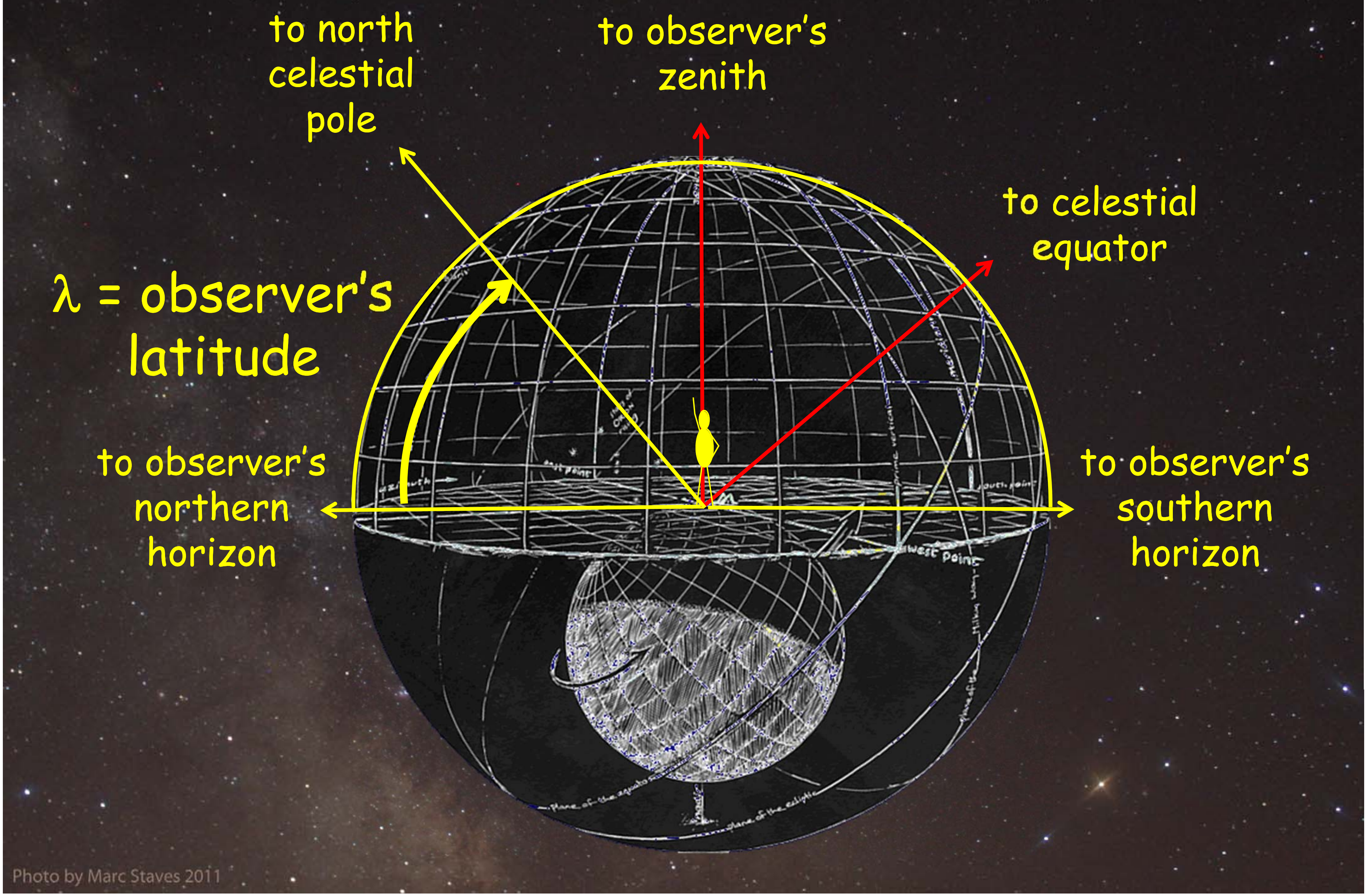
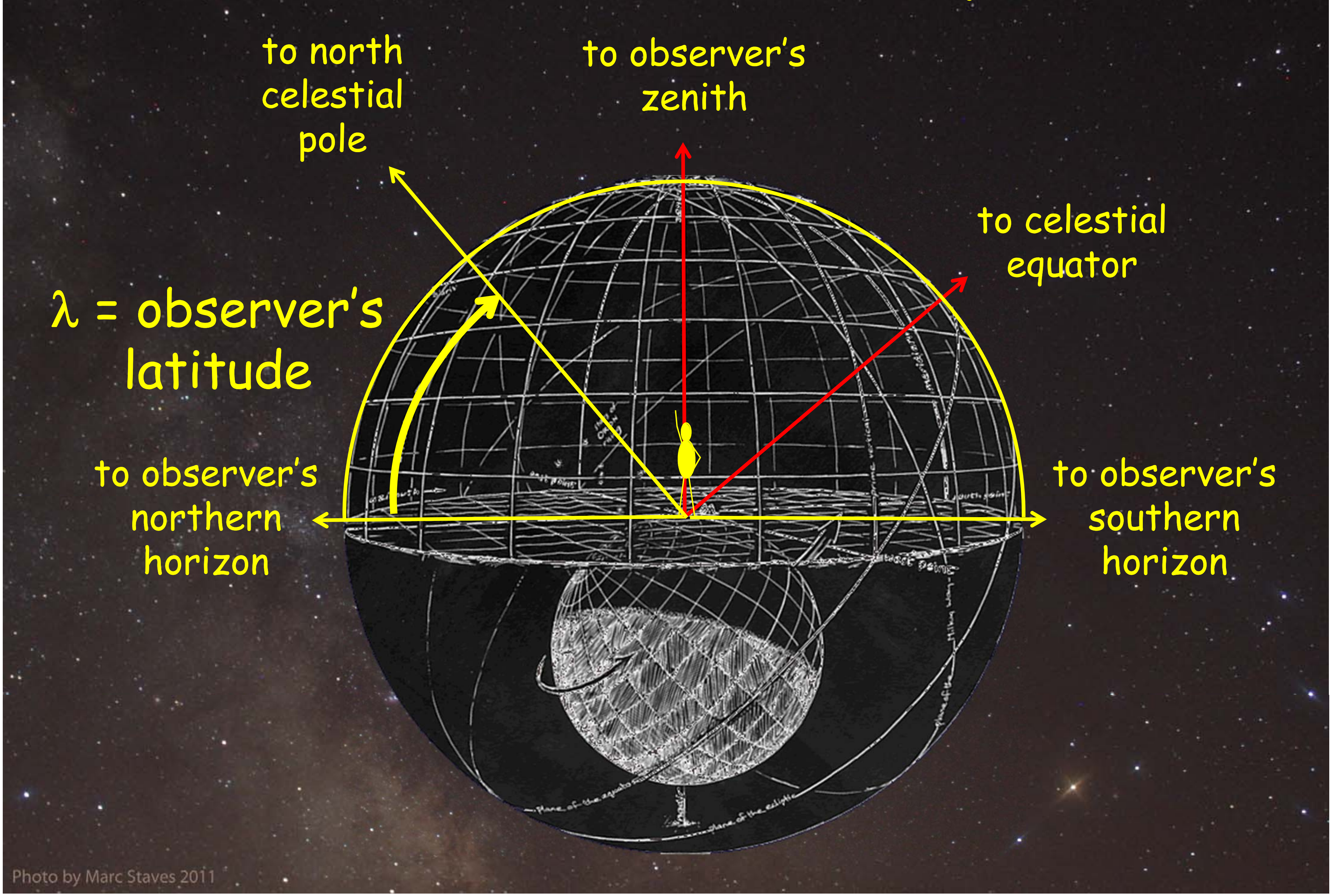


Photo by Marc Staves 2011

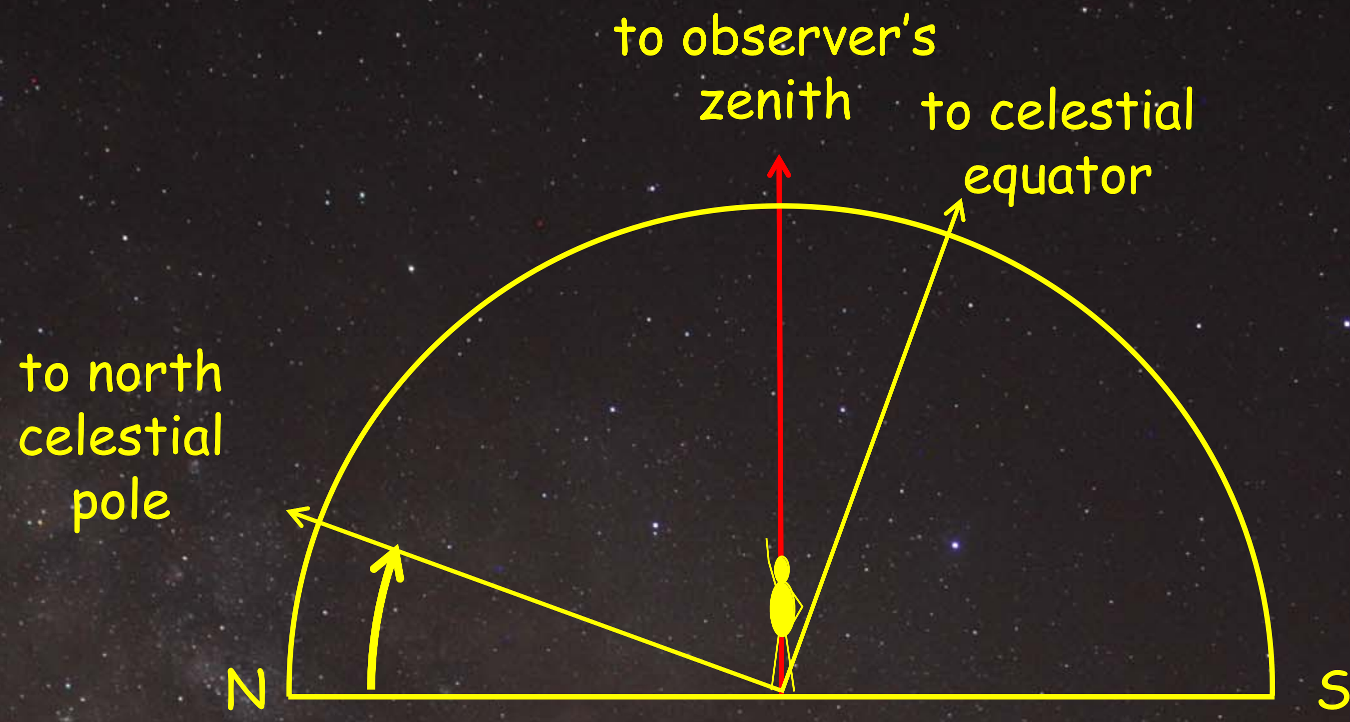
Horizon Coordinate System



Horizon Coordinate System



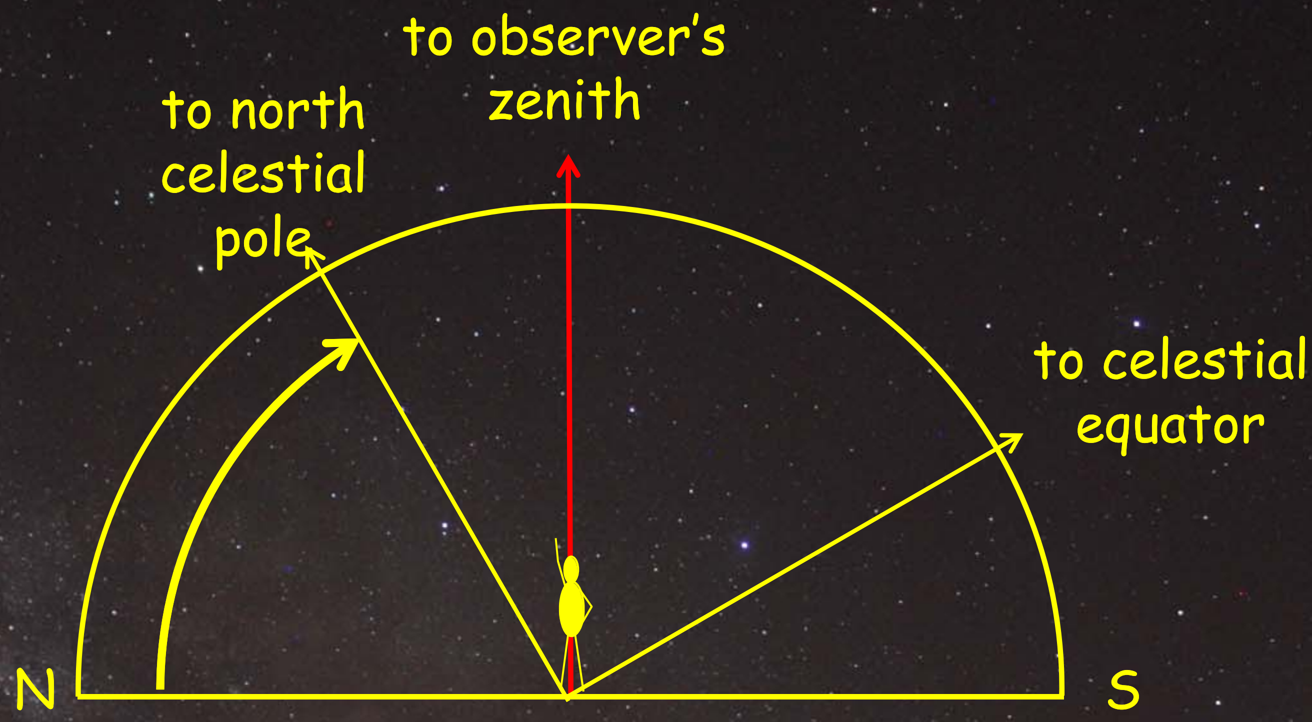
Question



What's the observer's latitude?

a) 70° N b) 20° N

Question



What's the observer's latitude?

a) 60° N   b) 30° N

Diurnal Circles

- ☆ Each celestial object circles the observer each day
- ☆ Observer sees part of each circle

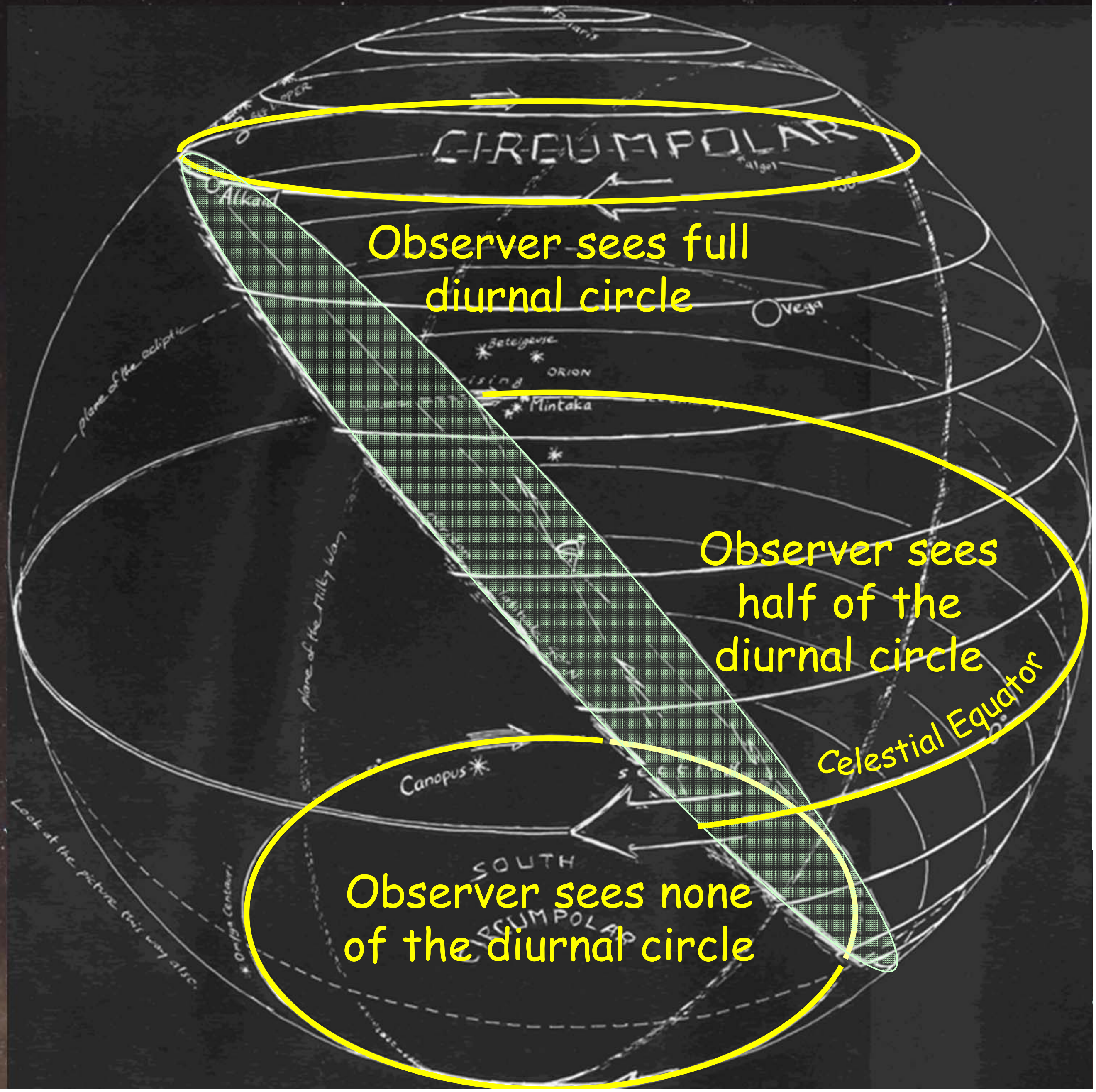
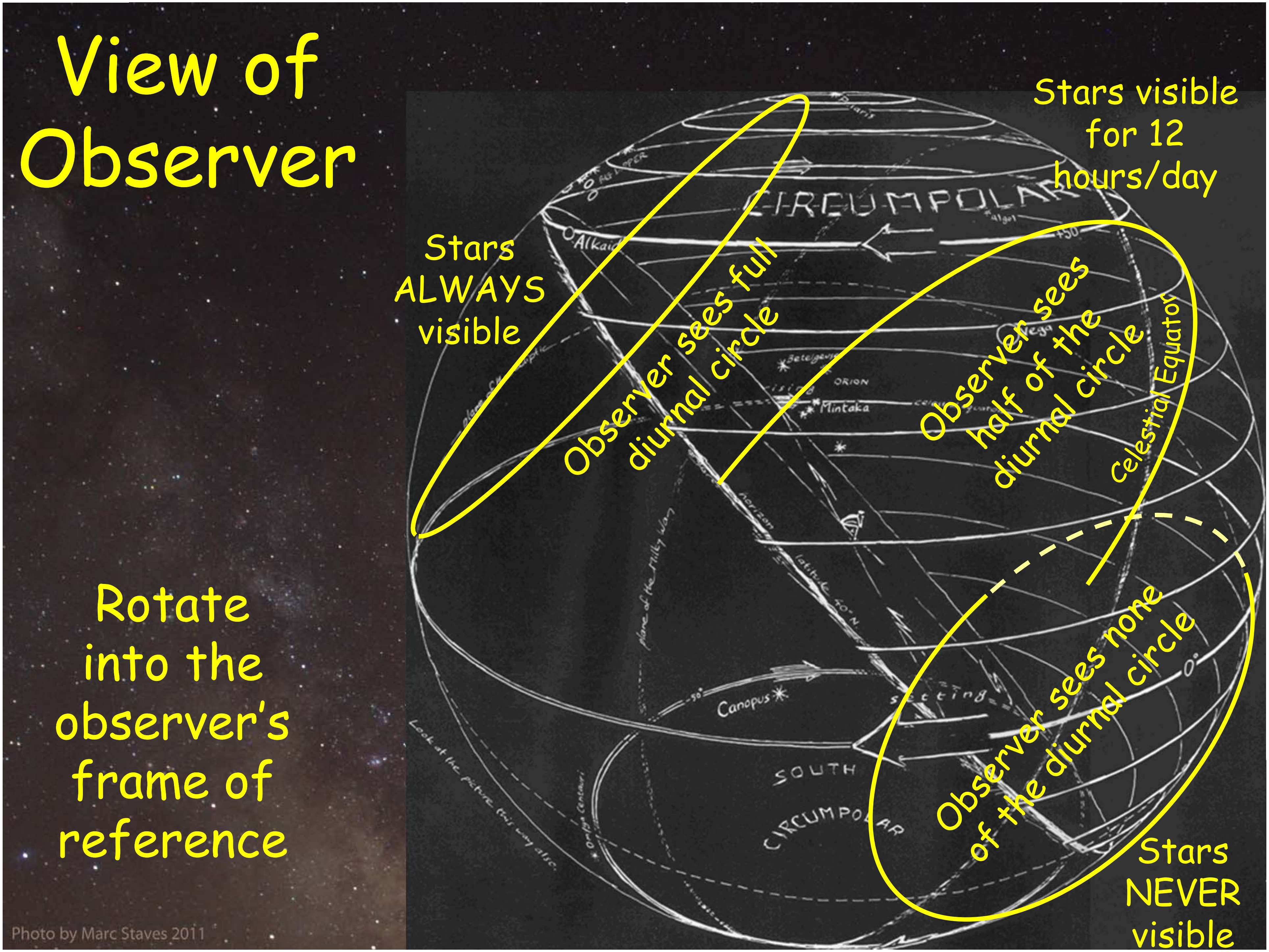


Photo by Marc Staves 2011


View of Observer
Rotate into the observer's frame of reference
Stars visible for 12 hours/day
Stars ALWAYS visible
Observer sees full diurnal circle
Observer sees half of the diurnal circle
Celestial Equator
Observer sees none of the diurnal circle
Stars NEVER visible
CIRCUMPOLAR
Alkaid
Betelgeuse
ORION
Mintaka
horizon
latitude 40°N
plane of the Milky Way
Canopus
setting
SOUTH
CIRCUMPOLAR
Look at the picture this way also
Photo by Marc Staves 2011

View of Observers

- ☆ Diurnal circles are parallel to CE
  - Stars rise and set at CE's angle from horizon

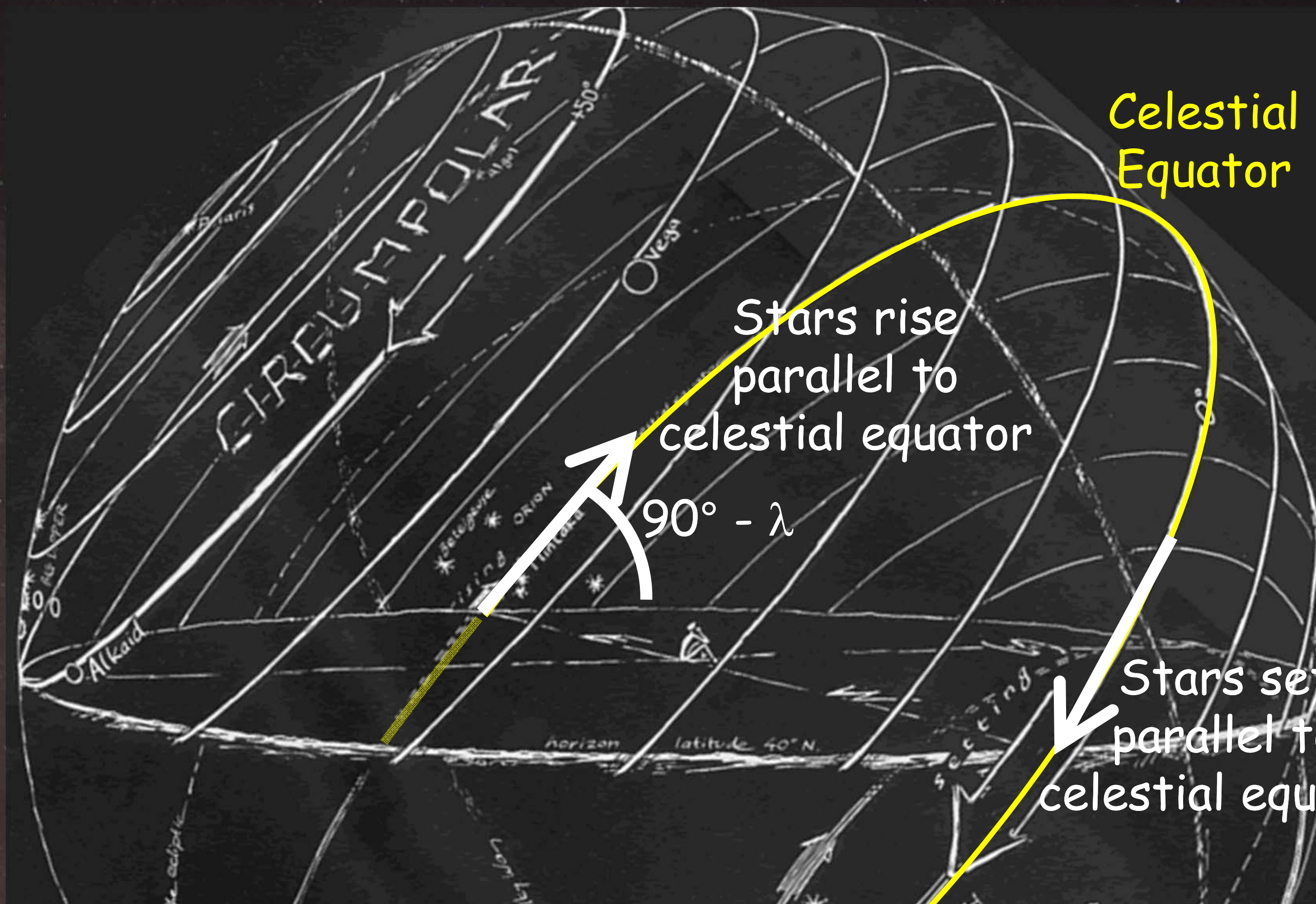
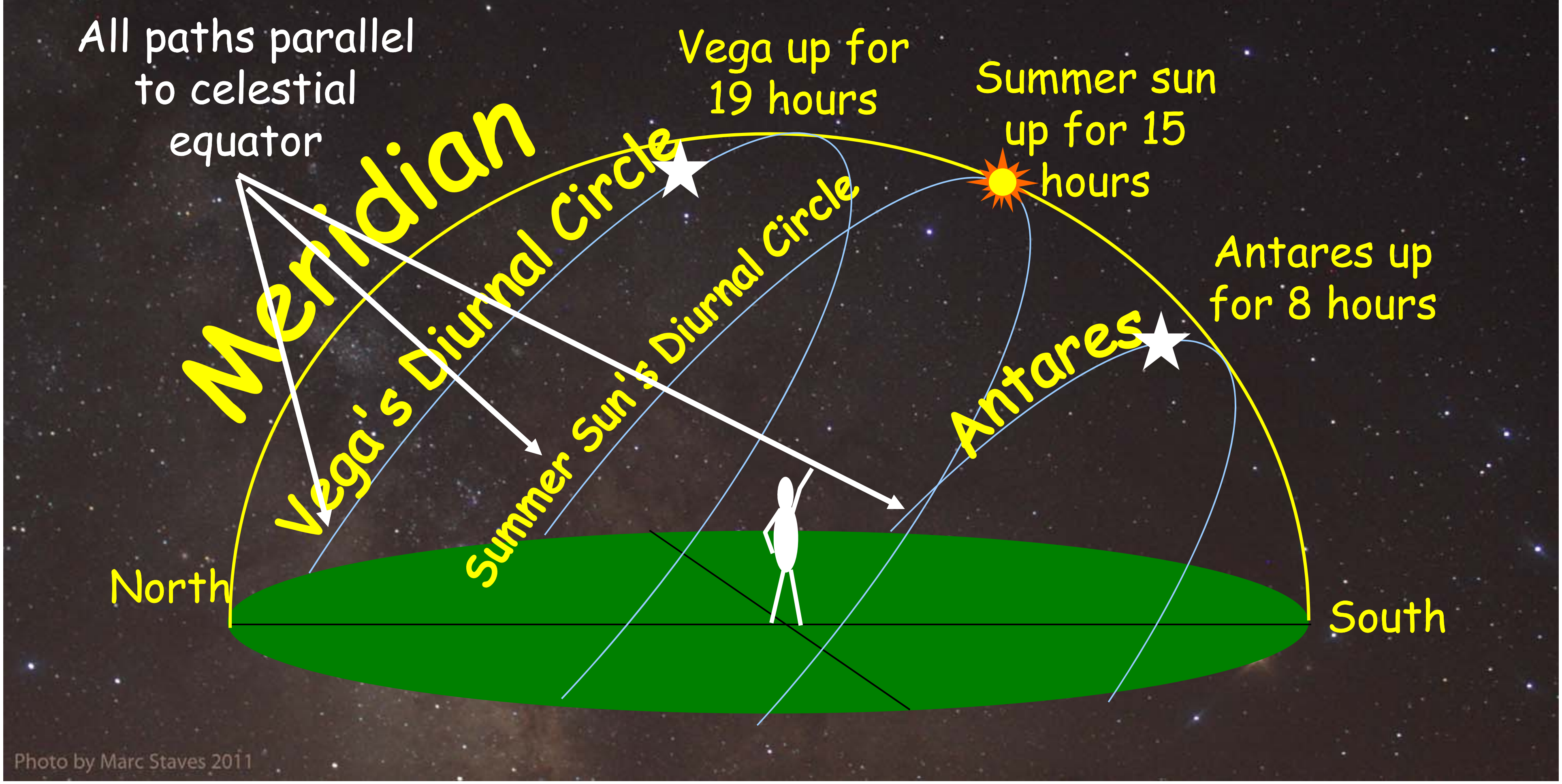


Photo by Marc Staves 2011

Star Paths

- ☆ Each travels a diurnal circle
  - Portion of diurnal circle above horizon determines time object is "up"



Question

Which observer(s) would see the star travel on the diurnal circle shown?

a) 

b) 

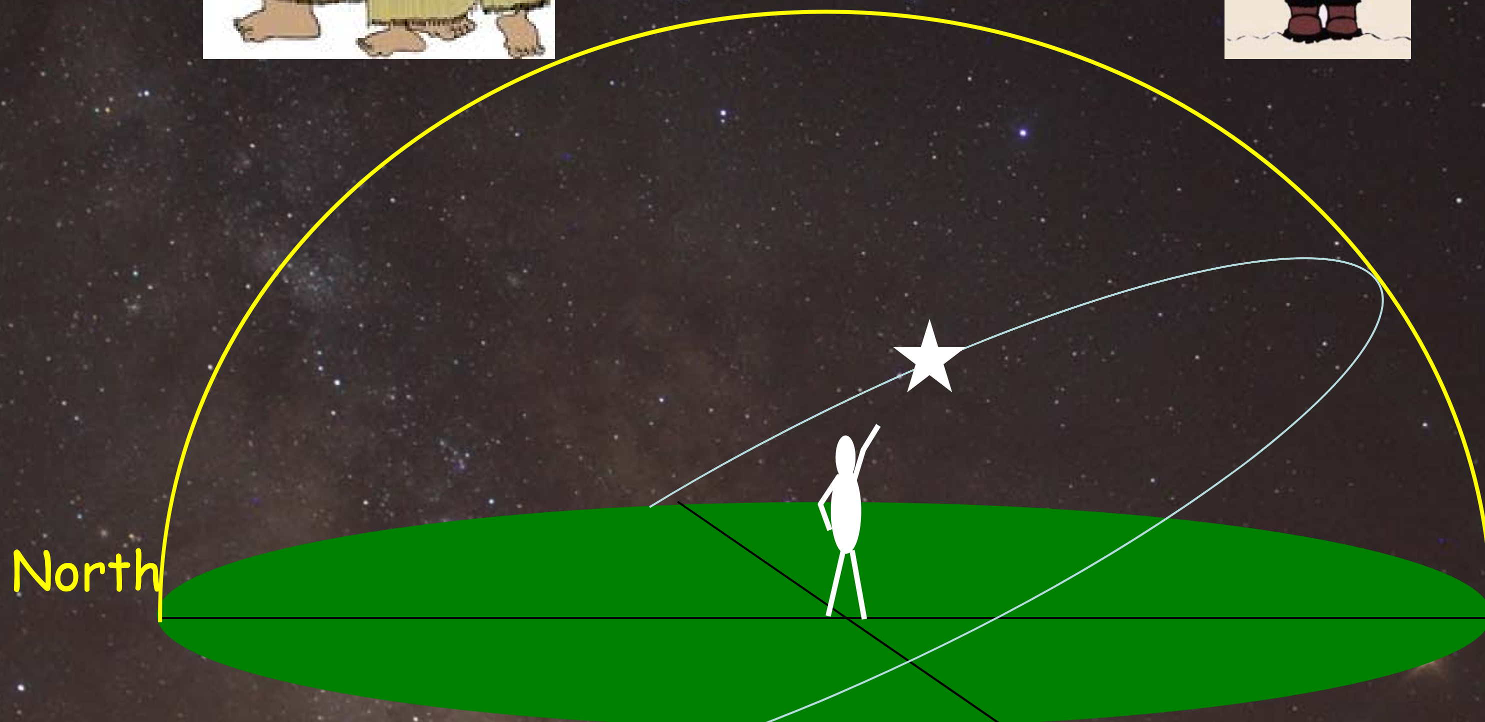


Photo by Marc Staves 2011

Question

Which observer(s) would see the star travel on the diurnal circle shown?

a) 

b) 

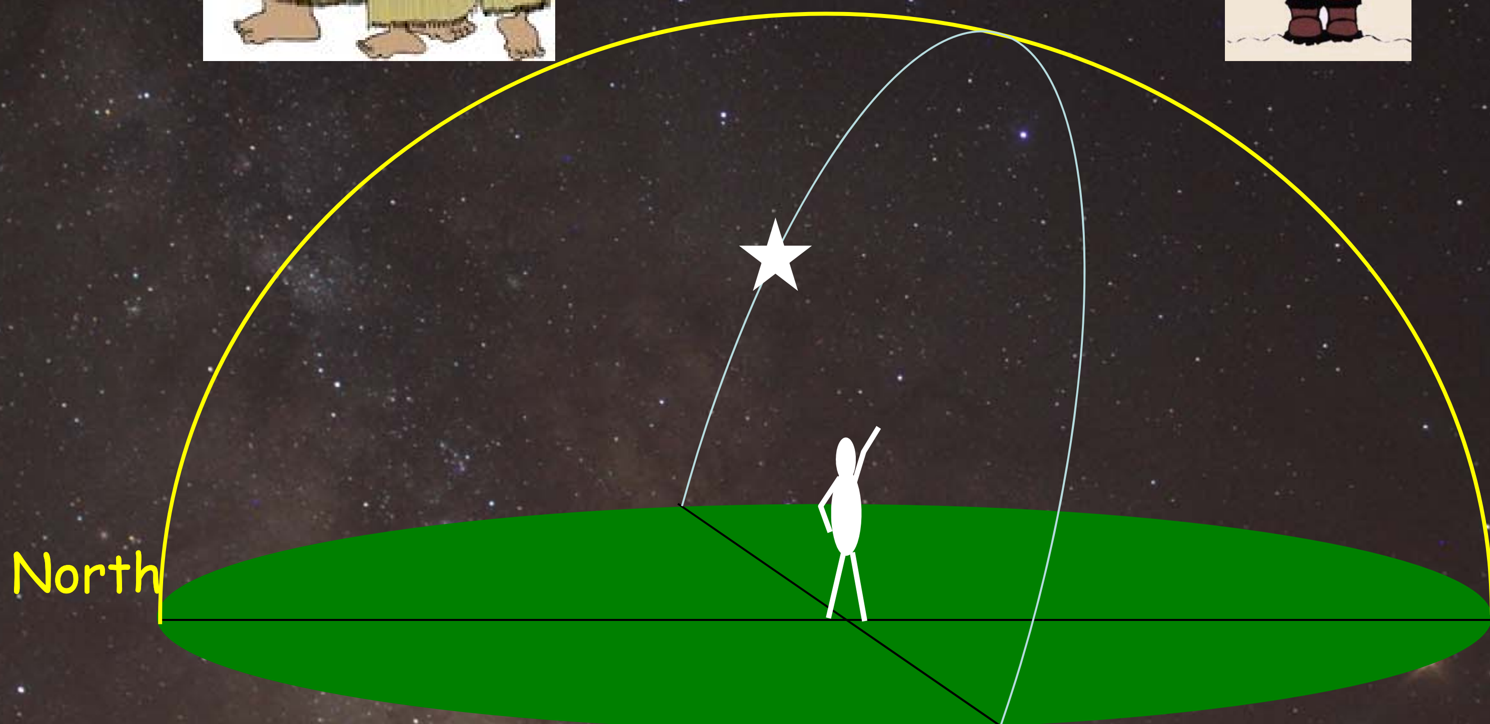
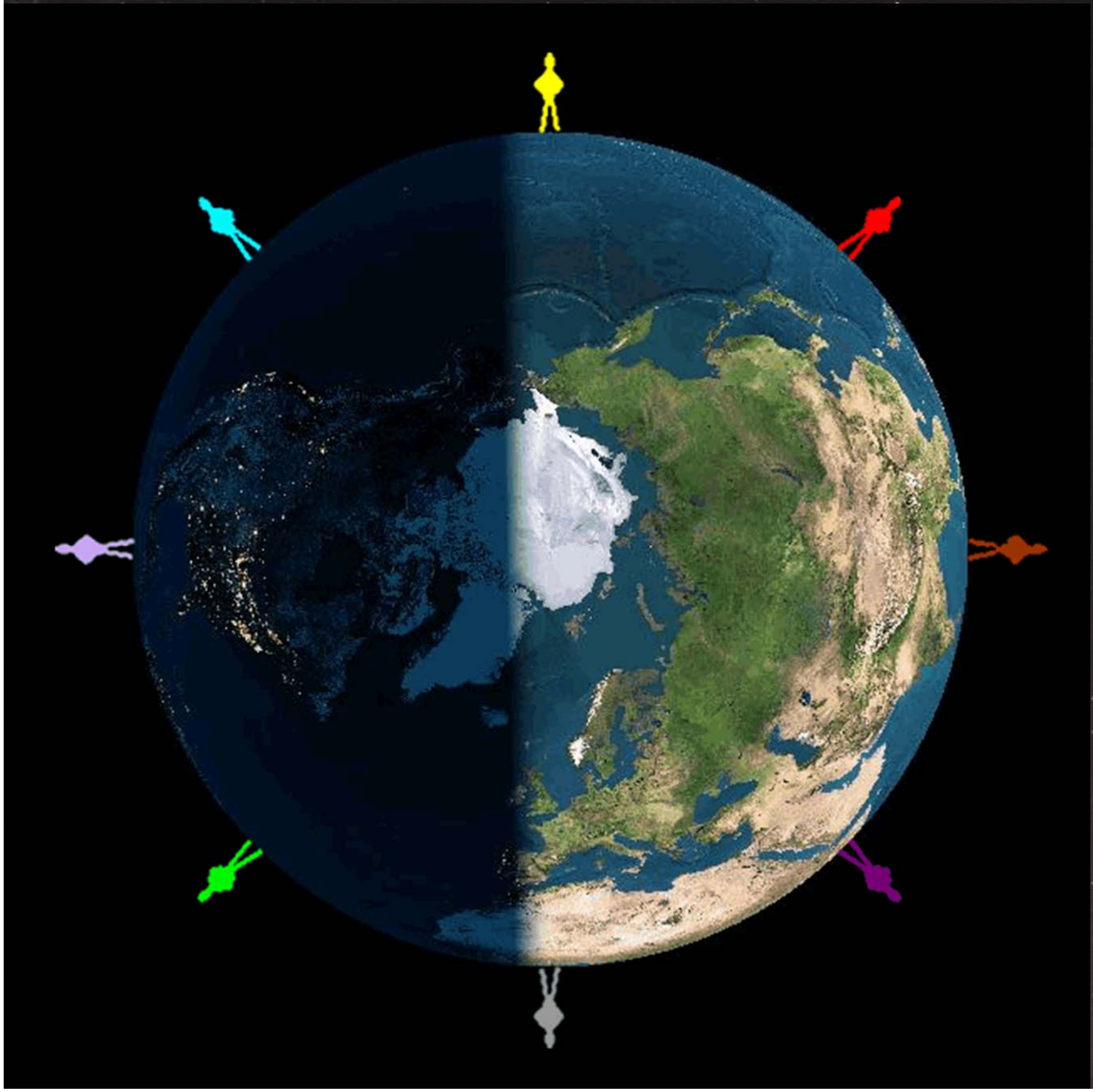


Photo by Marc Staves 2011

Time of day

☆ Earth Rotates Once Each Day



- 360° with respect to Earth-Sun line
- All Earthlings ride along

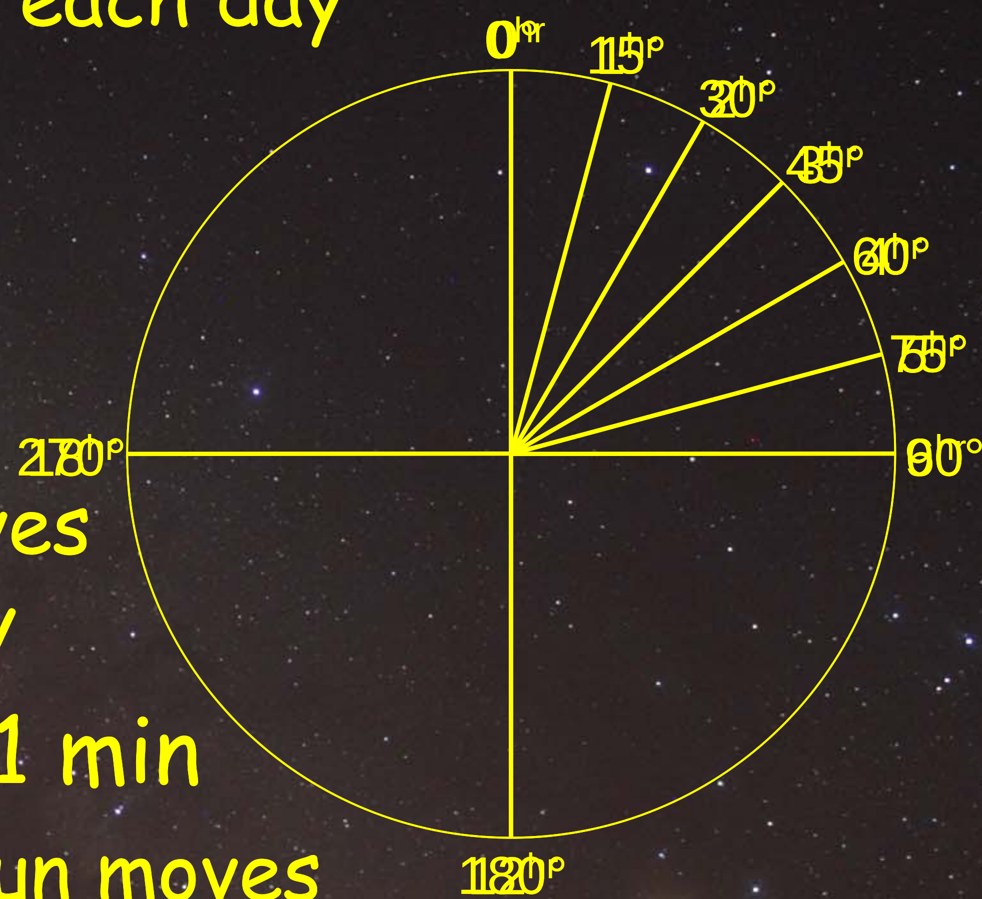
⟶ To Sol

Sunrise, Sunset …

☆ Everything in the sky (sun, moon, stars, etc.)

- Rises in the east
- Sets in the west

each day



Measuring Circles:

360° = 24 hr

15° = 1 hr

Each hour, the sun moves 15 degrees in the sky

1° = 4 min or 15′ = 1 min

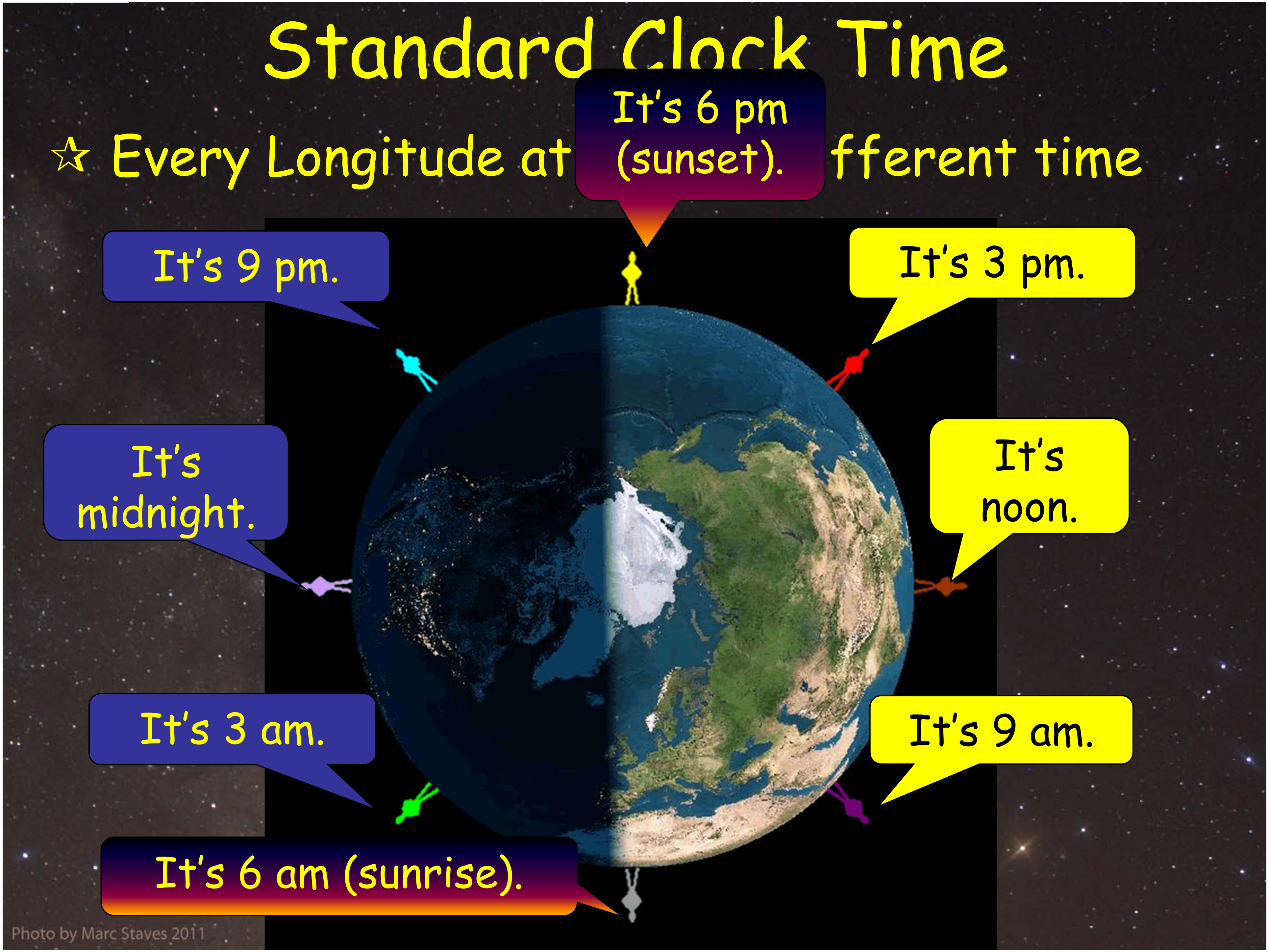
Every 4 minutes, the sun moves 1 degree = 60′ in the sky

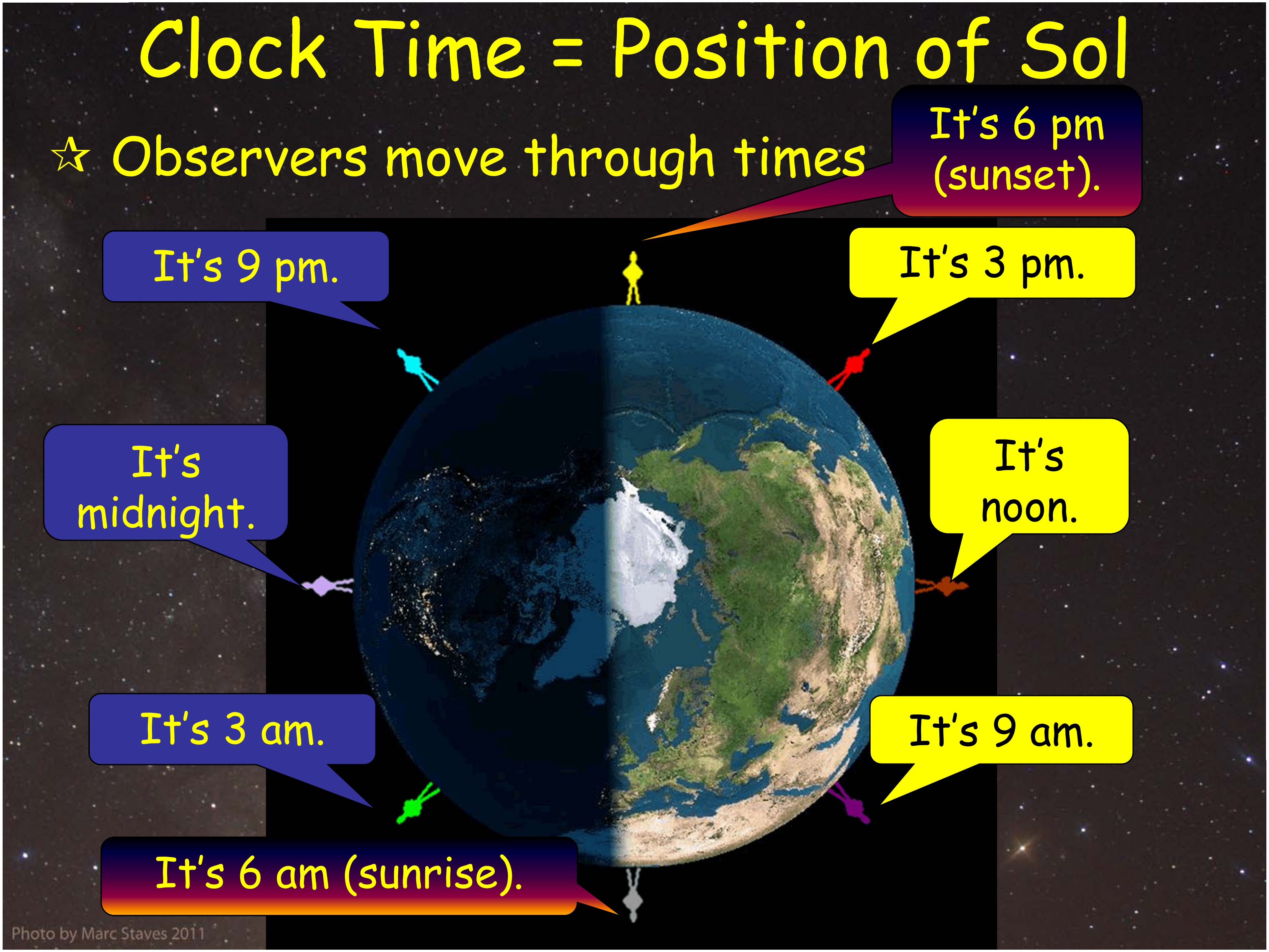
Photo by Marc Staves 2011

Observer's View of the Day

- ☆ Sun rises in east,
  moves 15°/hour from East to West
  transits at noon
  sets in west

Photo by Marc Staves 2011


Standard Clock Time
☆ Every Longitude at
fferent time
It's 6 pm (sunset).
It's 9 pm.
It's 3 pm.
It's midnight.
It's noon.
It's 3 am.
It's 9 am.
It's 6 am (sunrise).
Photo by Marc Staves 2011



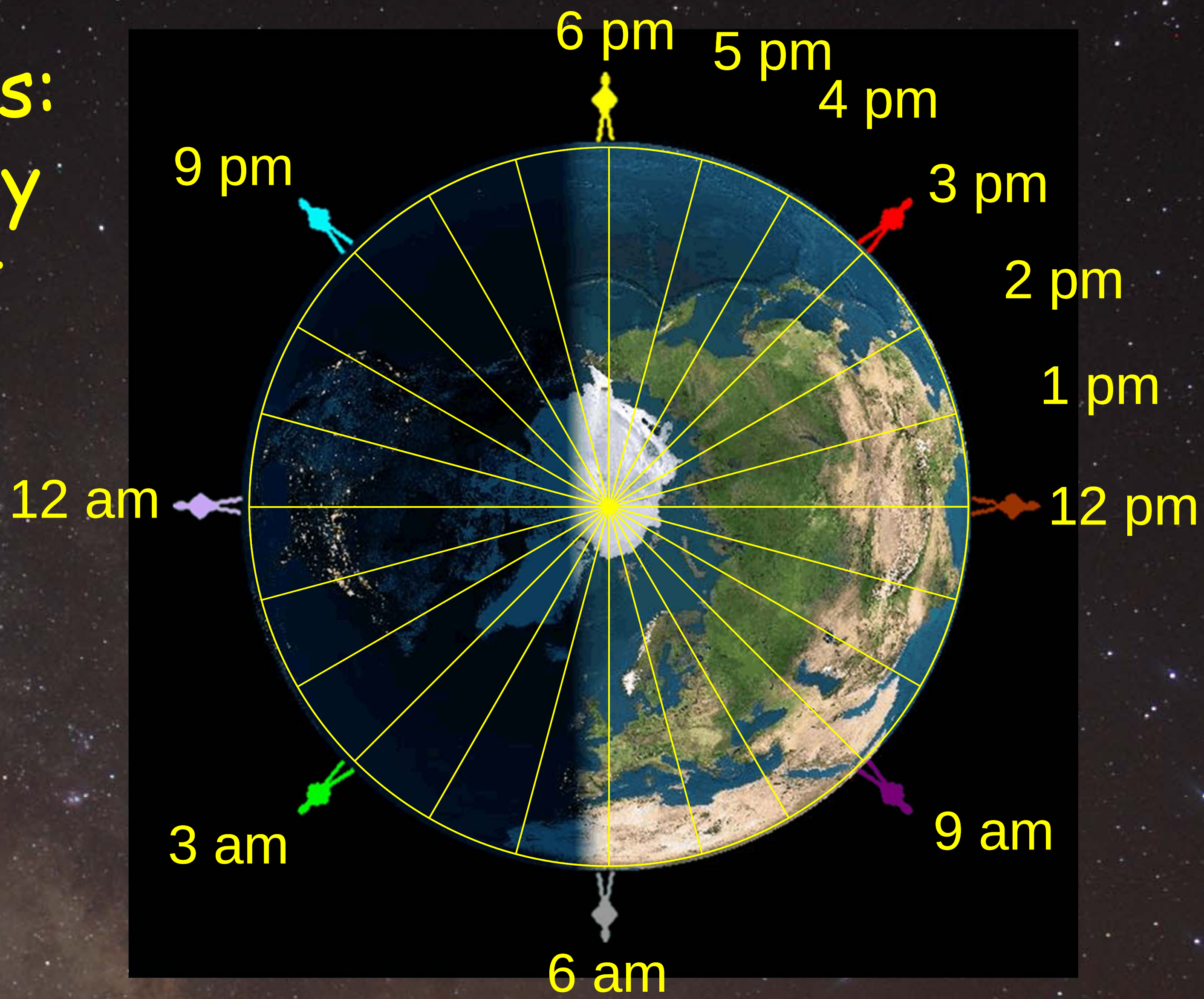
Clock Time = Position of Sol
☆ Observers move through times
It's 6 pm (sunset).
It's 9 pm.
It's 3 pm.
It's midnight.
It's noon.
It's 3 am.
It's 9 am.
It's 6 am (sunrise).
Photo by Marc Staves 2011

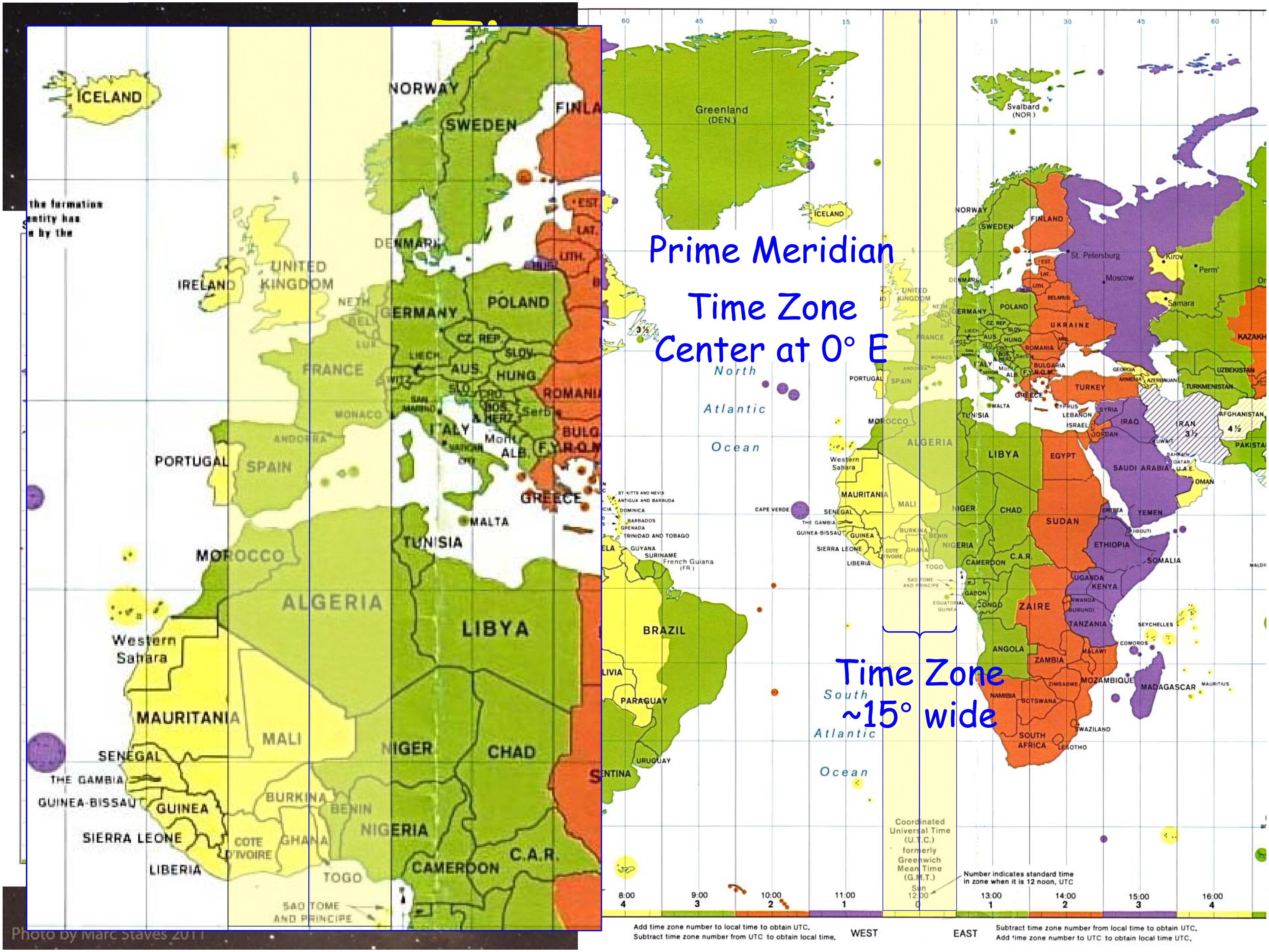
Daylight Saving Time

☆ Shifts times one h (USNO Explanation)

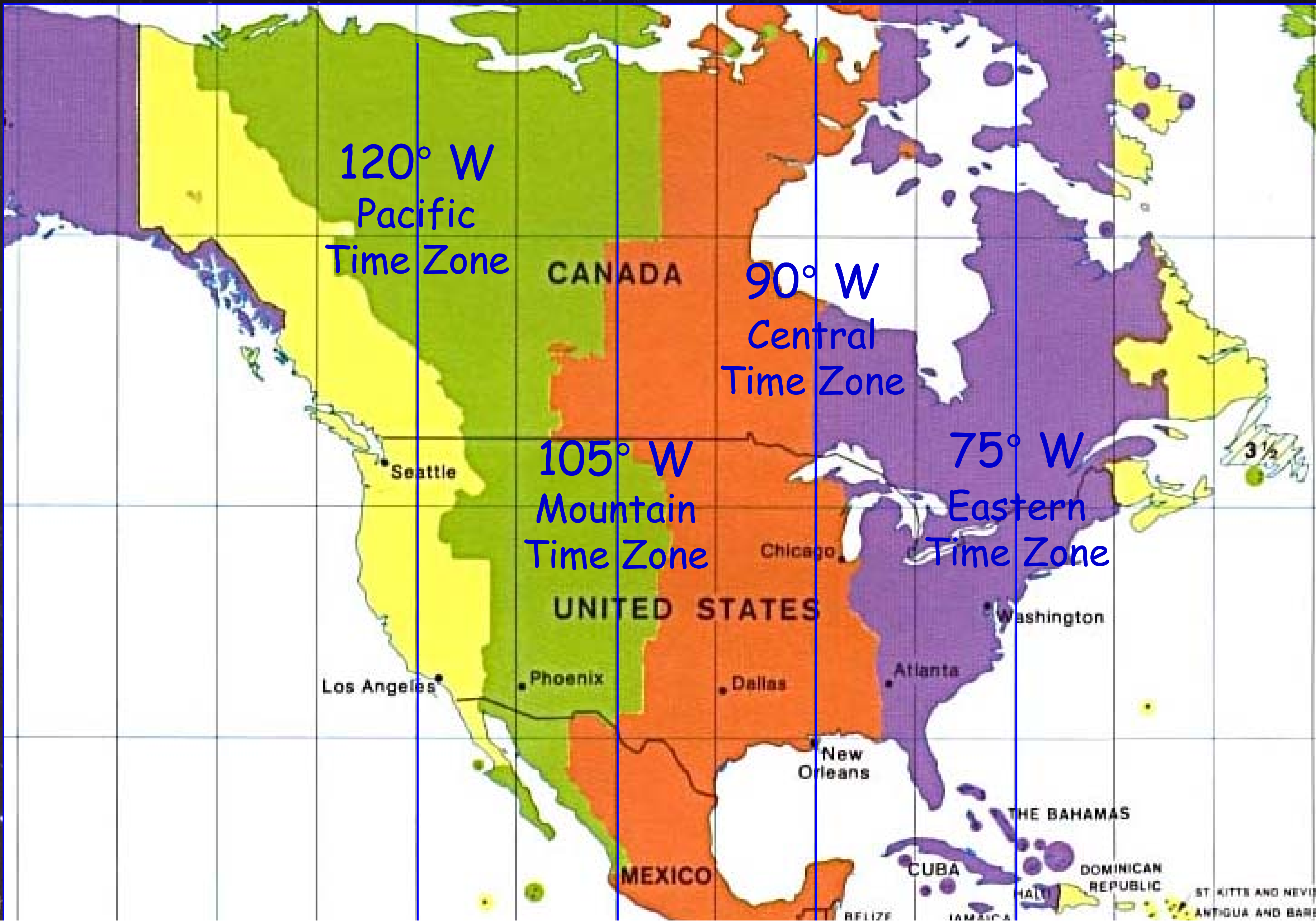
Clock Time

Time Zones:
24, roughly
15° apart




Prime Meridian
Time Zone
Center at 0° E
Time Zone
~15° wide
ICELAND
NORWAY
SWEDEN
UNITED KINGDOM
IRELAND
DENMARK
POLAND
GERMANY
FRANCE
SPAIN
PORTUGAL
ITALY
GREECE
MOROCCO
ALGERIA
LIBYA
TUNISIA
Western Sahara
MAURITANIA
MALI
NIGER
CHAD
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
SIERRA LEONE
LIBERIA
NIGERIA
CAMEROON
TOGO
SAO TOME AND PRINCIPE
Greenland (DEN.)
North Atlantic Ocean
South Atlantic Ocean
BRAZIL
Coordinated Universal Time (U.T.C.) formerly Greenwich Mean Time (G.M.T.)
Number indicates standard time in zone when it is 12 noon, UTC
Add time zone number to local time to obtain UTC.
Subtract time zone number from UTC to obtain local time.
WEST
EAST
Subtract time zone number from local time to obtain UTC.
Add time zone number to UTC to obtain local time.
Photo by Marc Staves 2011

North America Time Zones



Coordinated Universal Time

- ☆ UTC (UT or Zulu)
  - Time at Greenwich
    - no Daylight saving

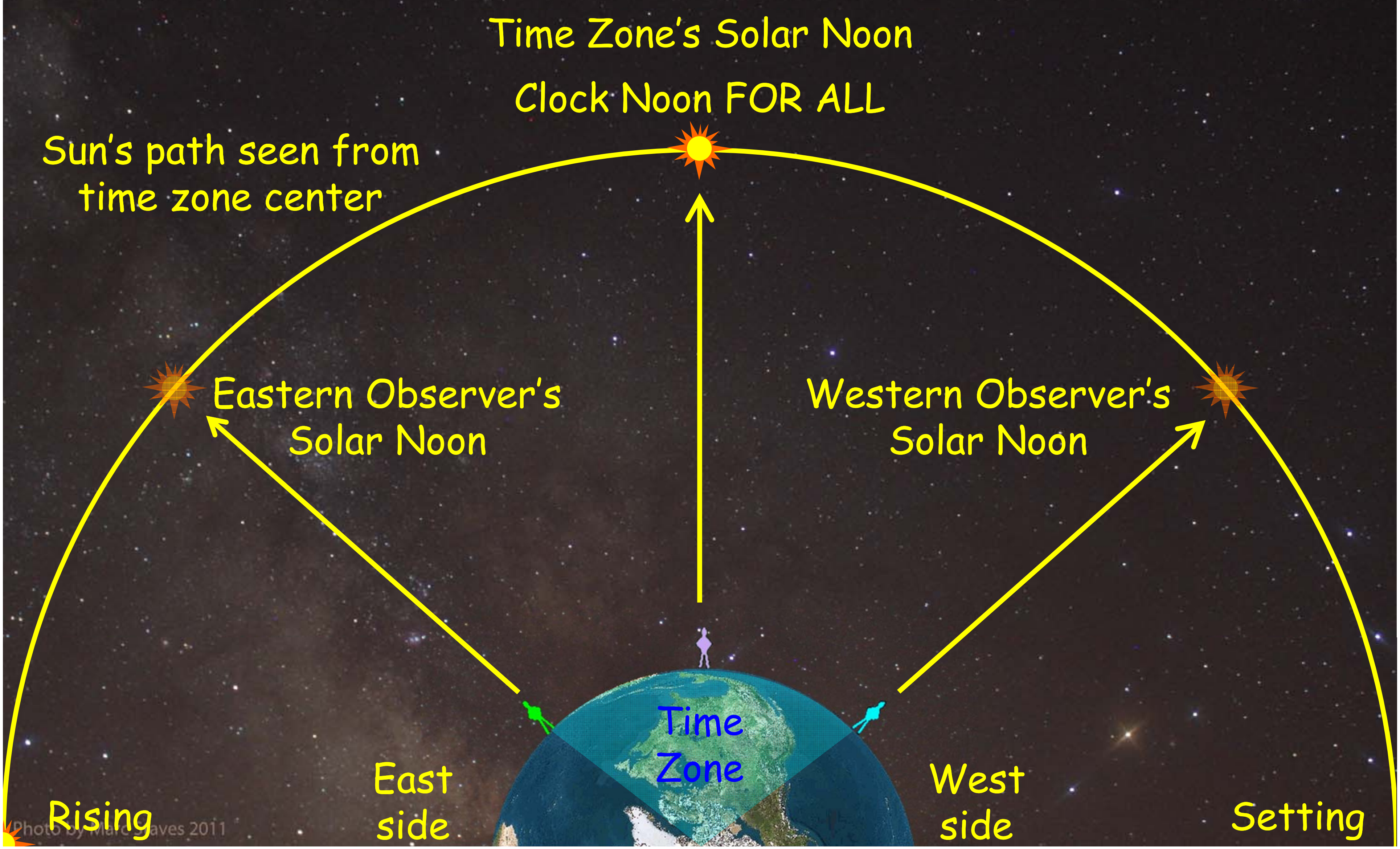
- ☆ Conversion
  - EST (Eastern Standard Time) = UTC – 5hr
    - eg. 2pm (14:00) EST = 19:00 UT
  - EDT (Eastern Daylight Time) = UTC – 4hr
    - eg. 2pm (14:00) EDT = 18:00 UT

U.S. Naval Observatory

Photo by Marc Staves 2011

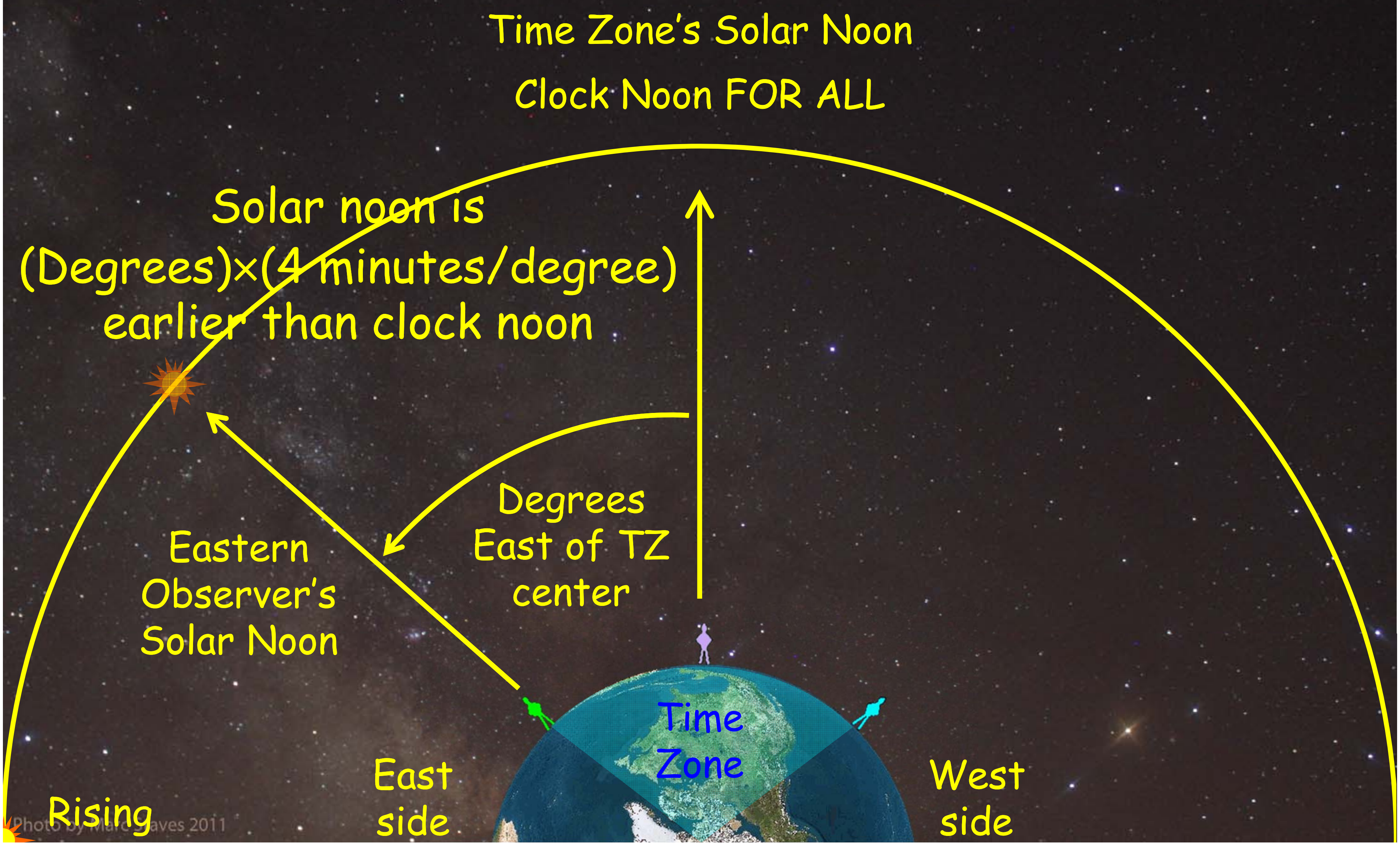
Solar Time vs. Clock Time

- ☆ Solar time varies across time zones



Solar Time vs. Clock Time

- ☆ Solar time varies across time zones

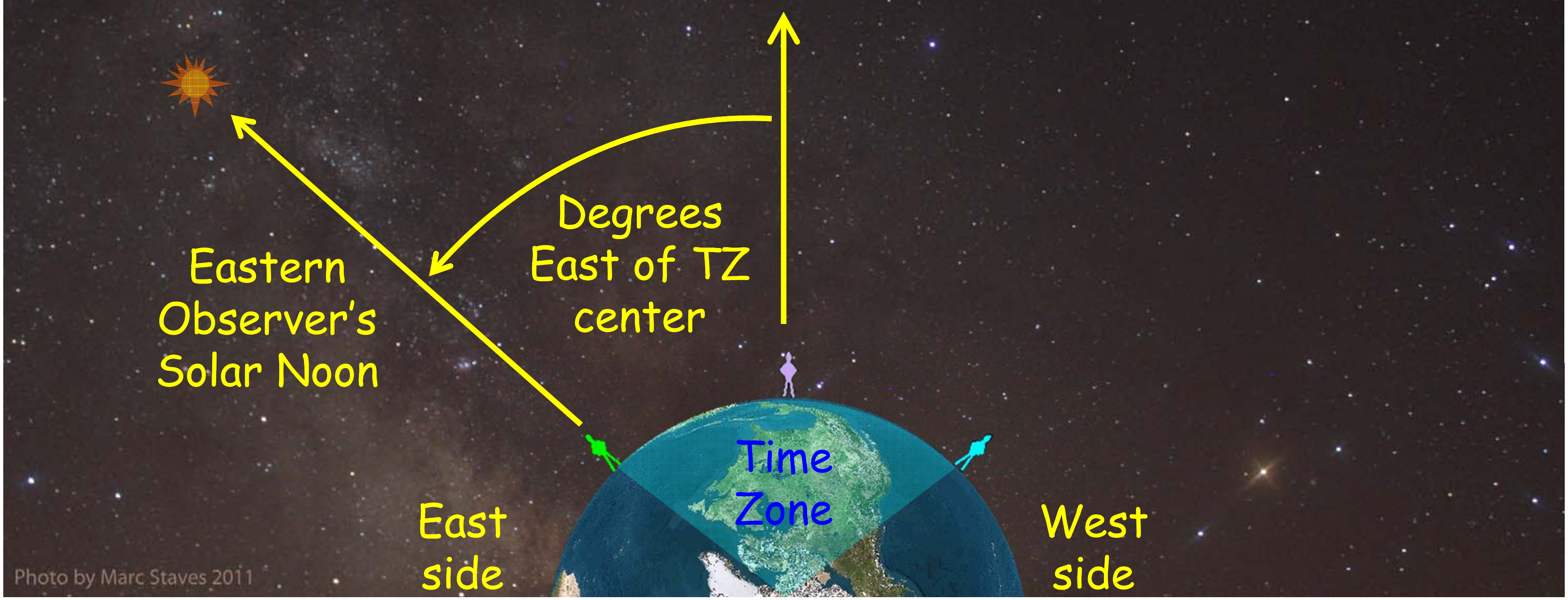


Question

Portland, Maine, 70° W is in the Eastern Time Zone (center: 75° W). Solar noon occurs at

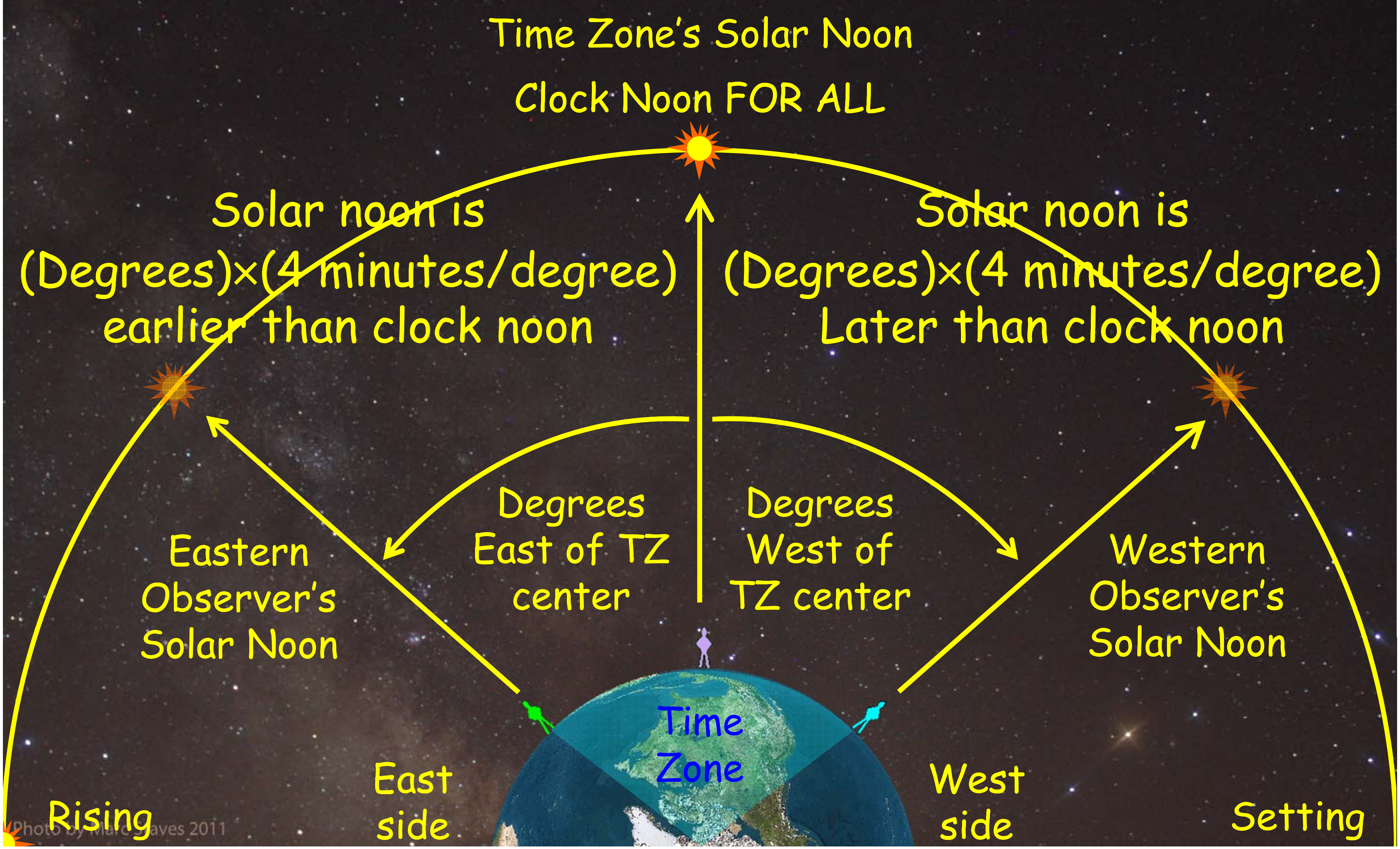
(Degrees)×(4 minutes/degree) = (5) x (4) = 20 minutes early

Solar noon in Portland at 11:40 am



Solar Time vs. Clock Time

- ☆ Solar time varies across time zones

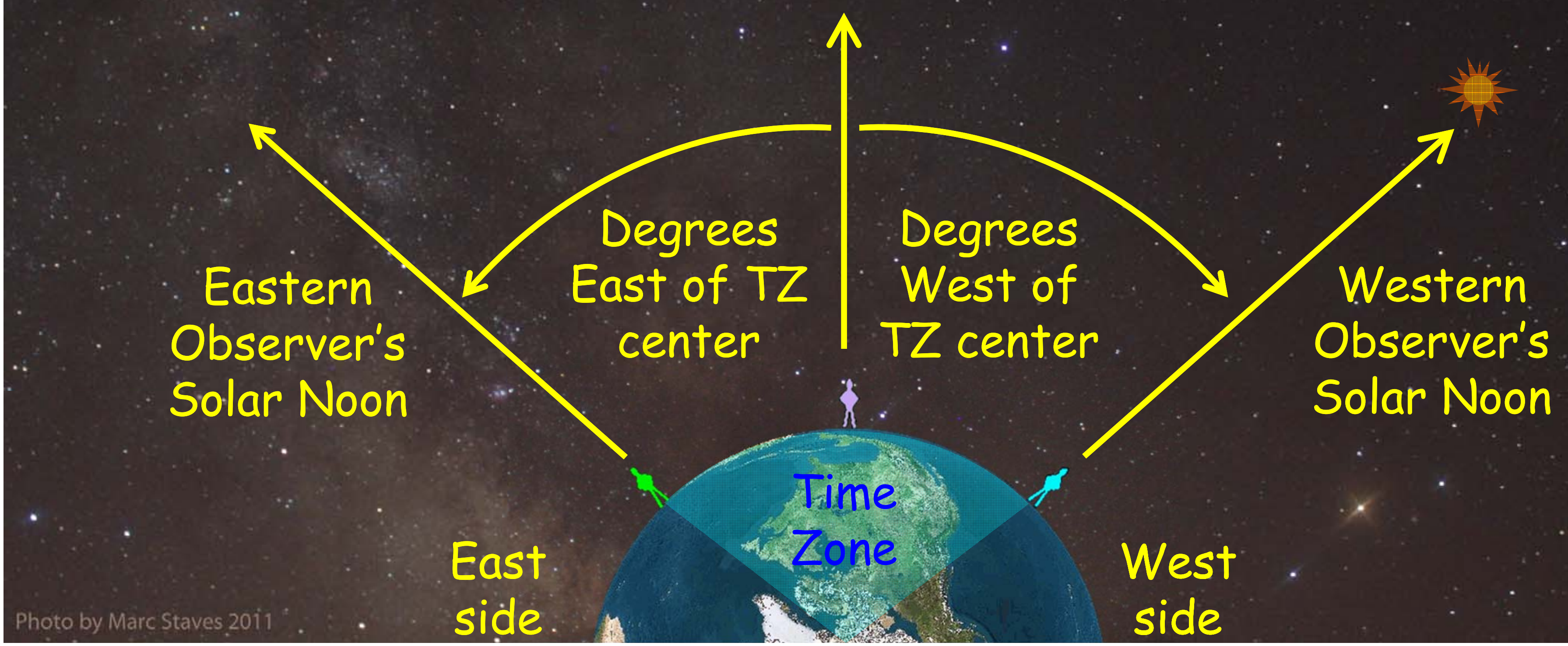


Question

Yuma, AZ, 115° W is in the Mountain Time Zone (center: 105° W). Solar noon occurs at

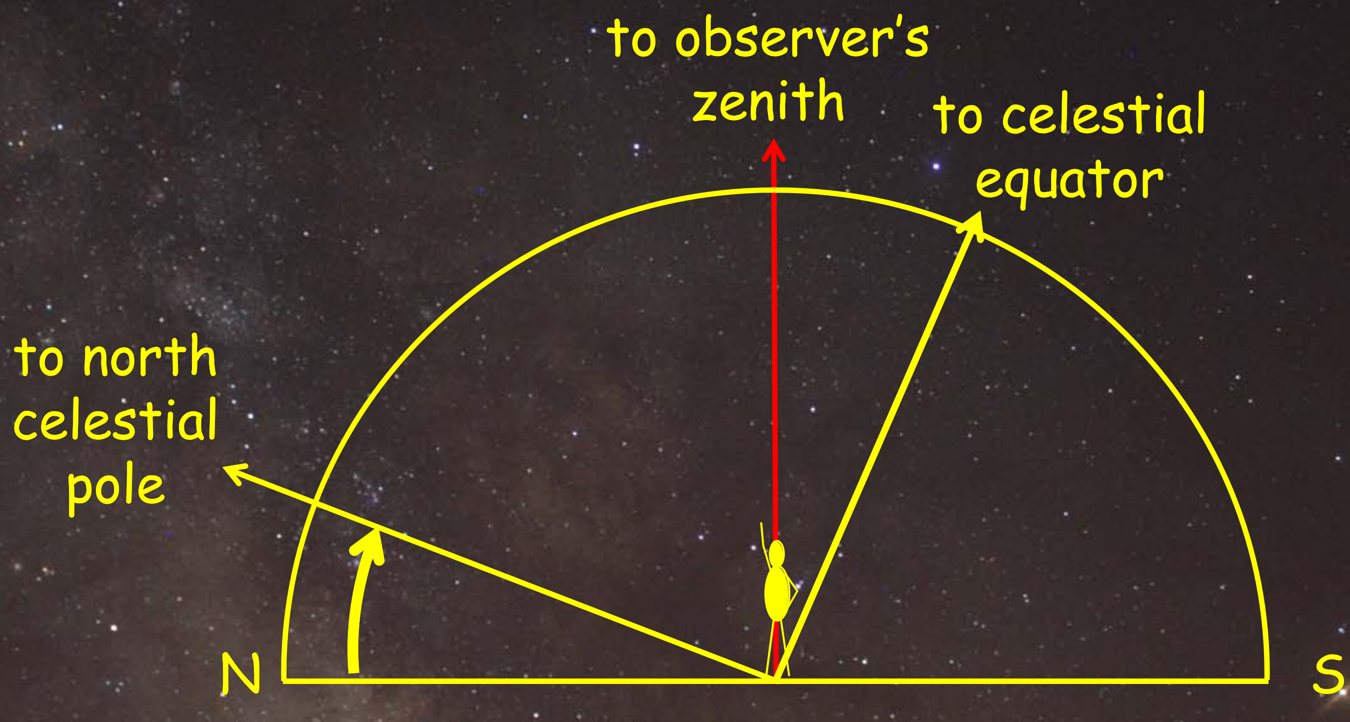
a) 11:20 am, b) 11:40 am, c) 12:20 pm, d) 12:40 pm

(Degrees)×(4 minutes/degree) = (10) x (4) = 40 minutes late



Celestial Navigation

- ☆ Finding Latitude & Longitude from
  - Altitude of Polaris (NCP)
  - Transit time of star
    - Looked up in an ephemeris (eg. Field Guide)



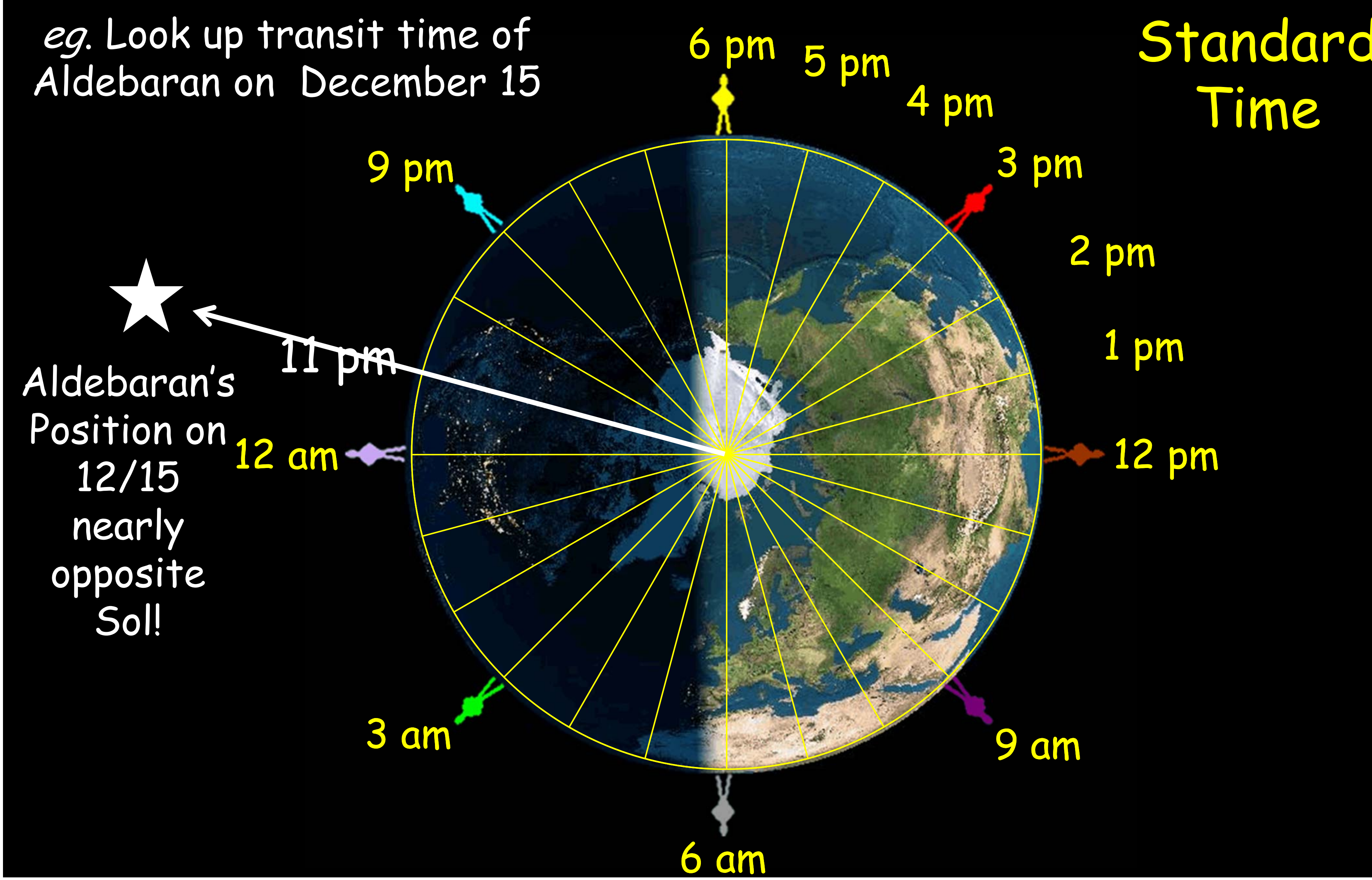
Observer at 20° N

Photo by Marc Staves 2011

Star Transit Time

Gives position of star with respect to the sun

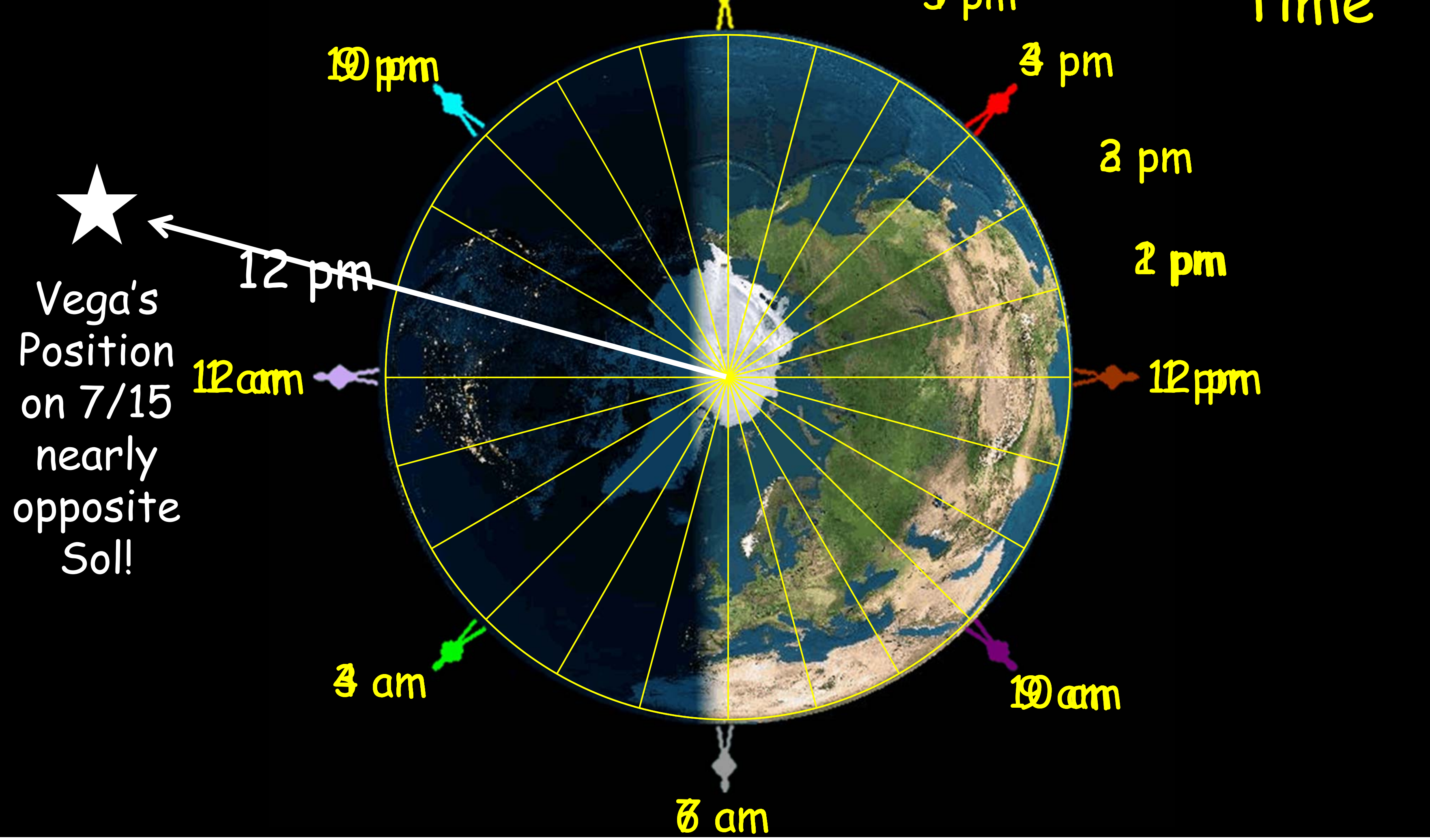
eg. Look up transit time of Aldebaran on December 15



Star Transit Time

Gives position of star with respect to the sun

eg. Look up transit time of Vega on July 15 (Daylight time)



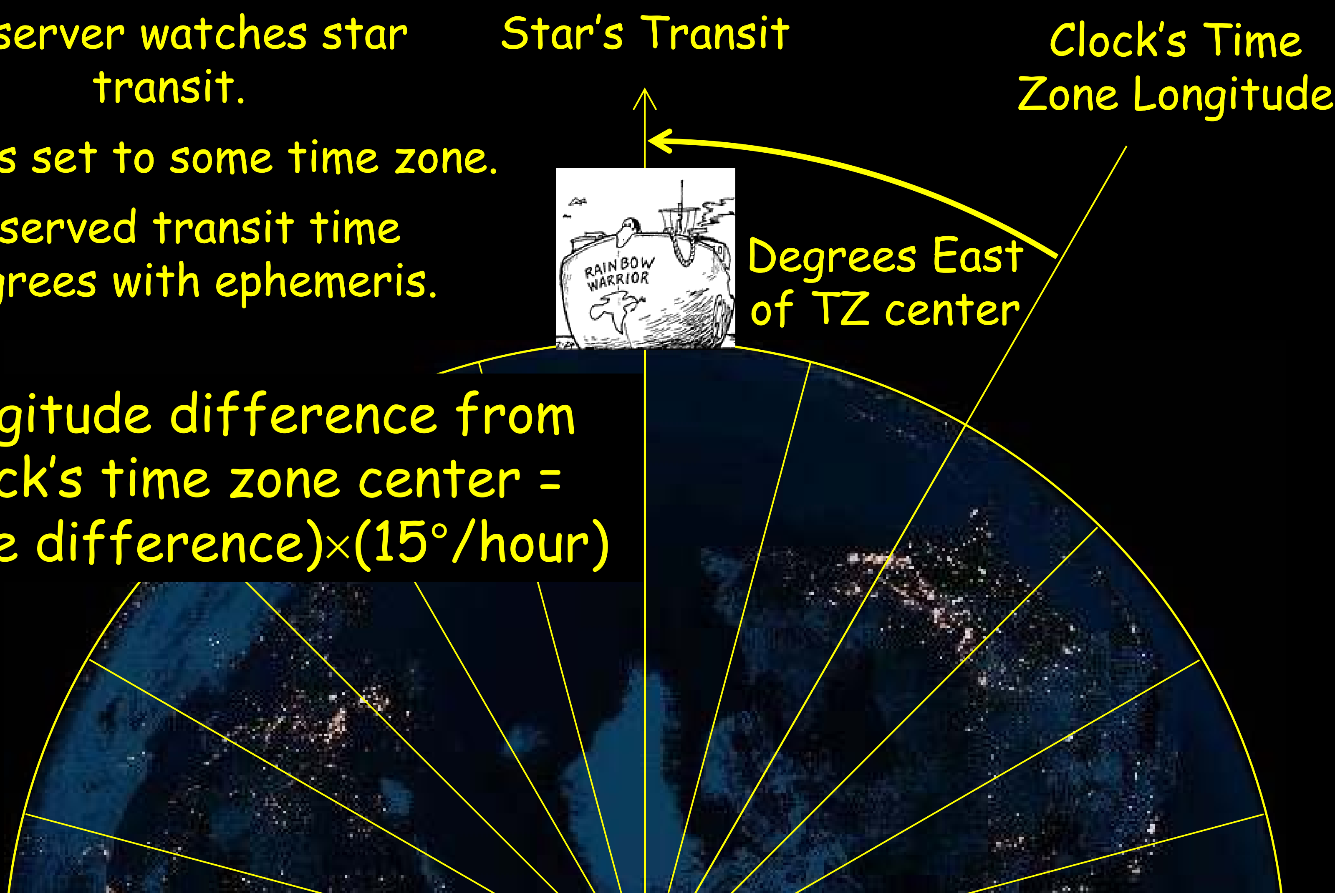
Celestial Navigation

- ☆ Difference between observed and expected transit times gives longitude

Observer watches star transit.

Clock is set to some time zone.

Observed transit time disagrees with ephemeris.



Longitude difference from clock's time zone center = (Time difference)×(15°/hour)

Celestial Navigation

Colorado Day!

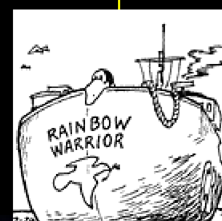
☆ Example: Transit of Deneb on August 1

Observer sees Deneb transit at 11 pm EDT

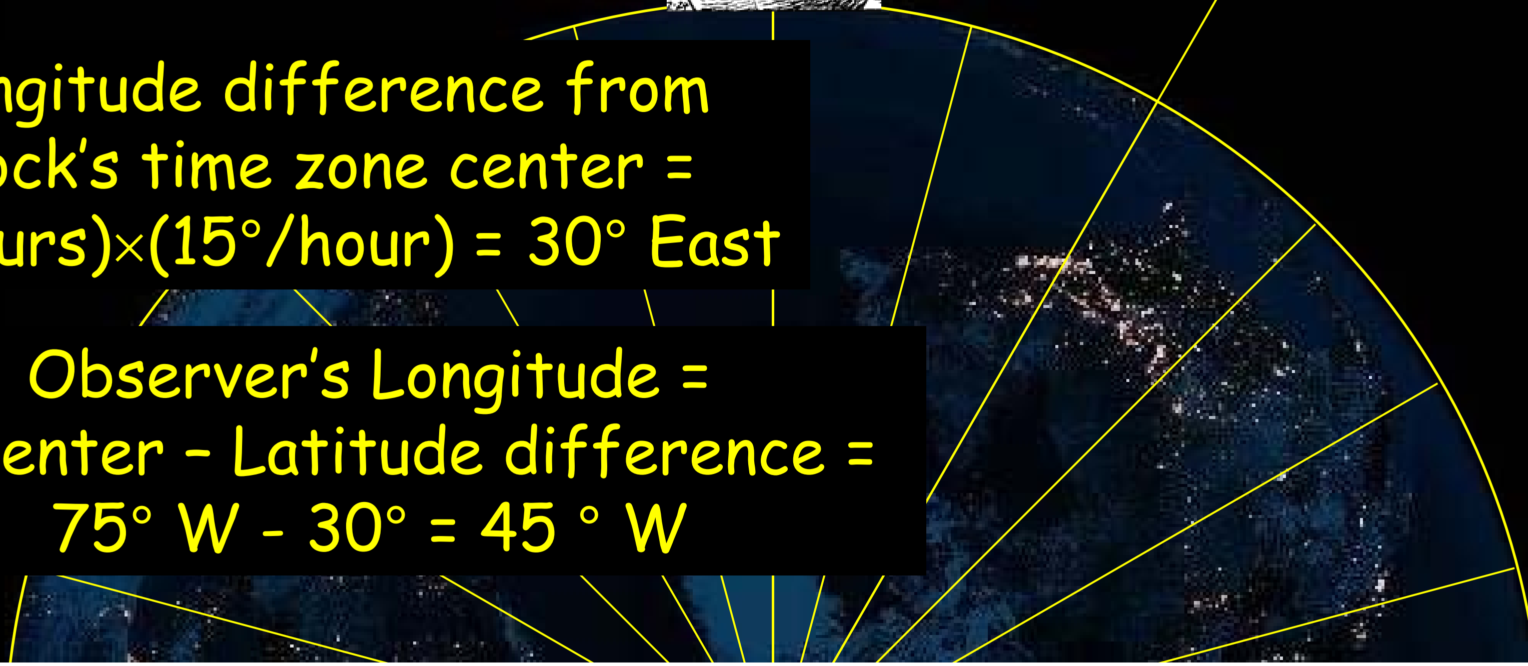
At 1 am Deneb will transit TZ center at 75° W

Looks up transit time in FG

On 8/1 Deneb transits at 1 am



Early ⇒ East of TZ center



Longitude difference from clock's time zone center = (2 hours)×(15°/hour) = 30° East

Observer's Longitude = TZ center – Latitude difference = 75° W - 30° = 45 ° W