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

Celestial Coordinates and the Day

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SOAR Lifelong Learning in the North Country

Potsdam 1816 THE STATE UNIVERSITY OF NEW YORK

ST. LAWRENCE UNIVERSITY

In Memory

Jim Barry

SOAR Champion

Photo by Marc Staves 2011

The Tilted Teacup Ride

- Coordinates and the Day: 9/6/22
  - Celestial Navigation
- The Year: 9/13/22
  - The Age of Aquarius
- The Month and Moon Phases: 9/20/22
  - The Harvest Moon
- The Day in All its Glory: 9/27/22
  - The Analemma

The Tilted Teacup Ride

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Photo by Marc Staves 2011

Where on Earth?

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

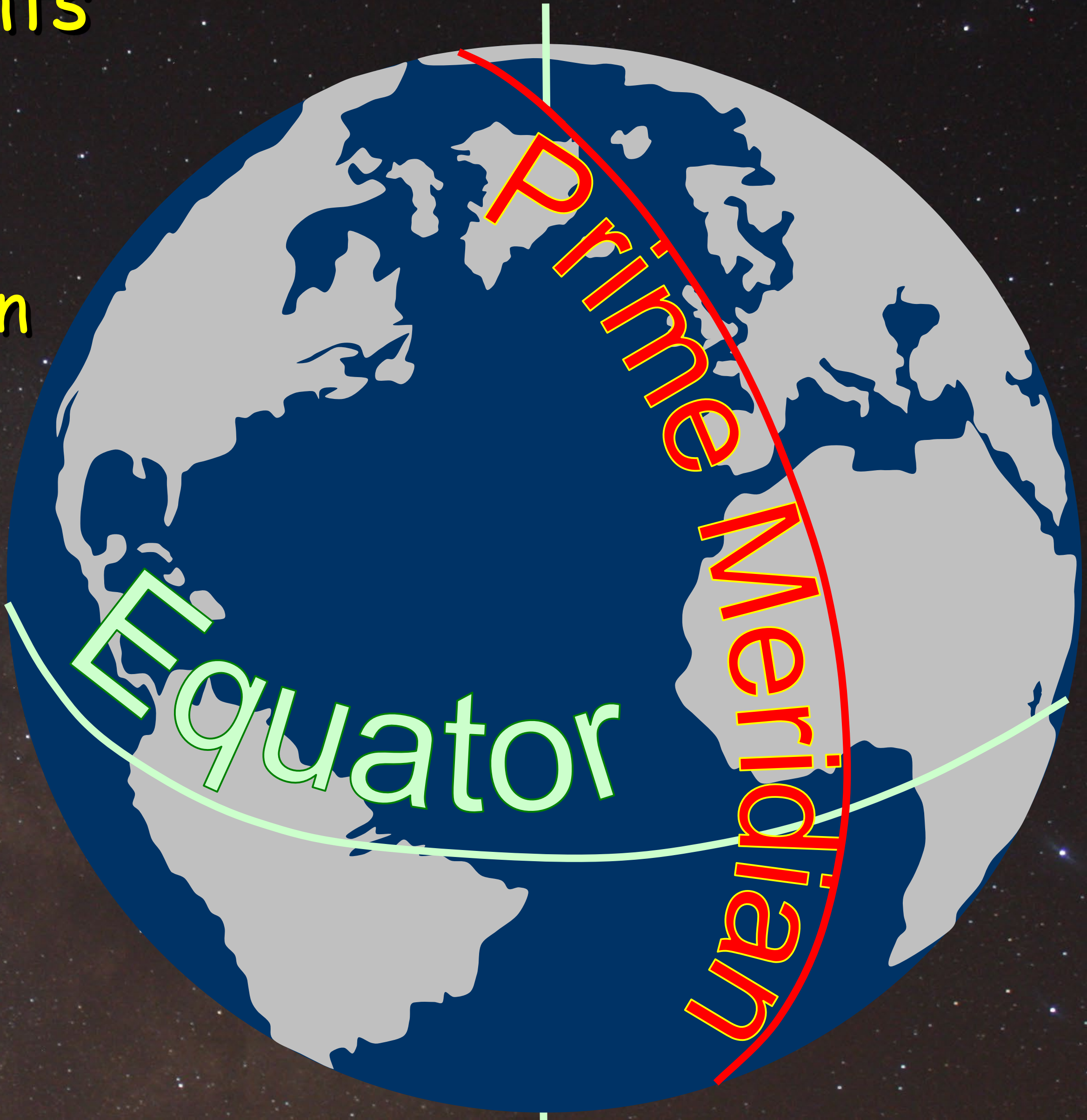


Photo by Marc Staves 2011

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

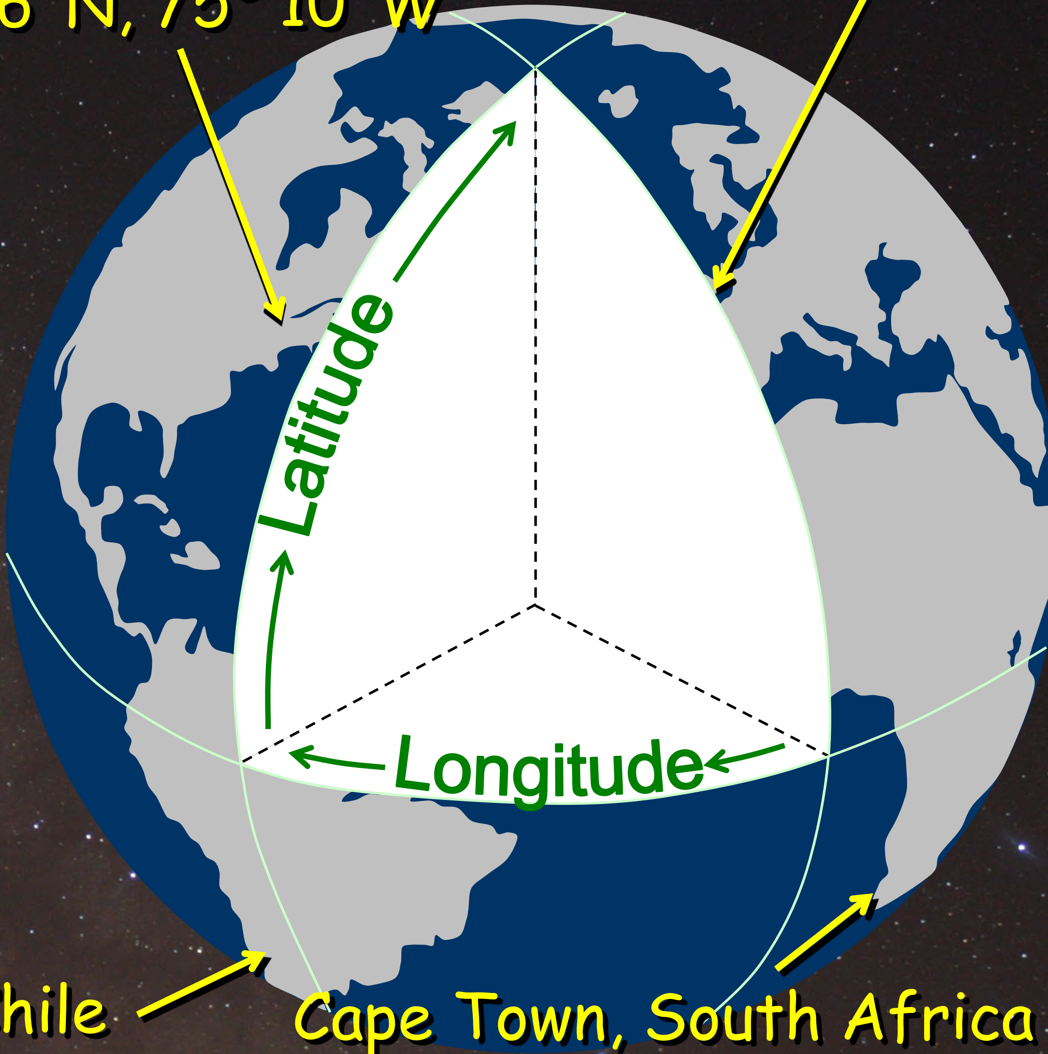


Photo by Marc Staves 2011

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)

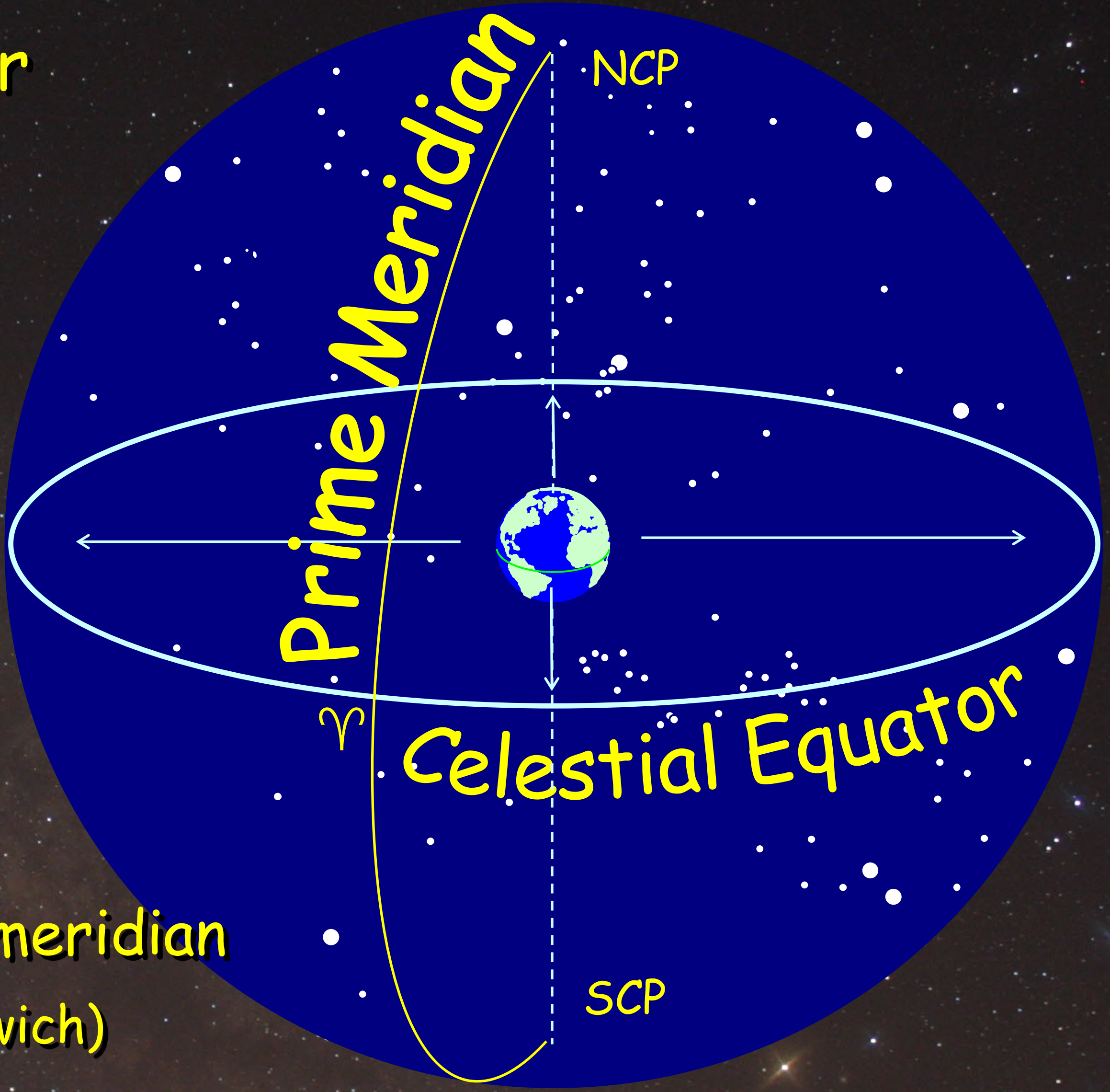


Photo by Marc Staves 2011

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°

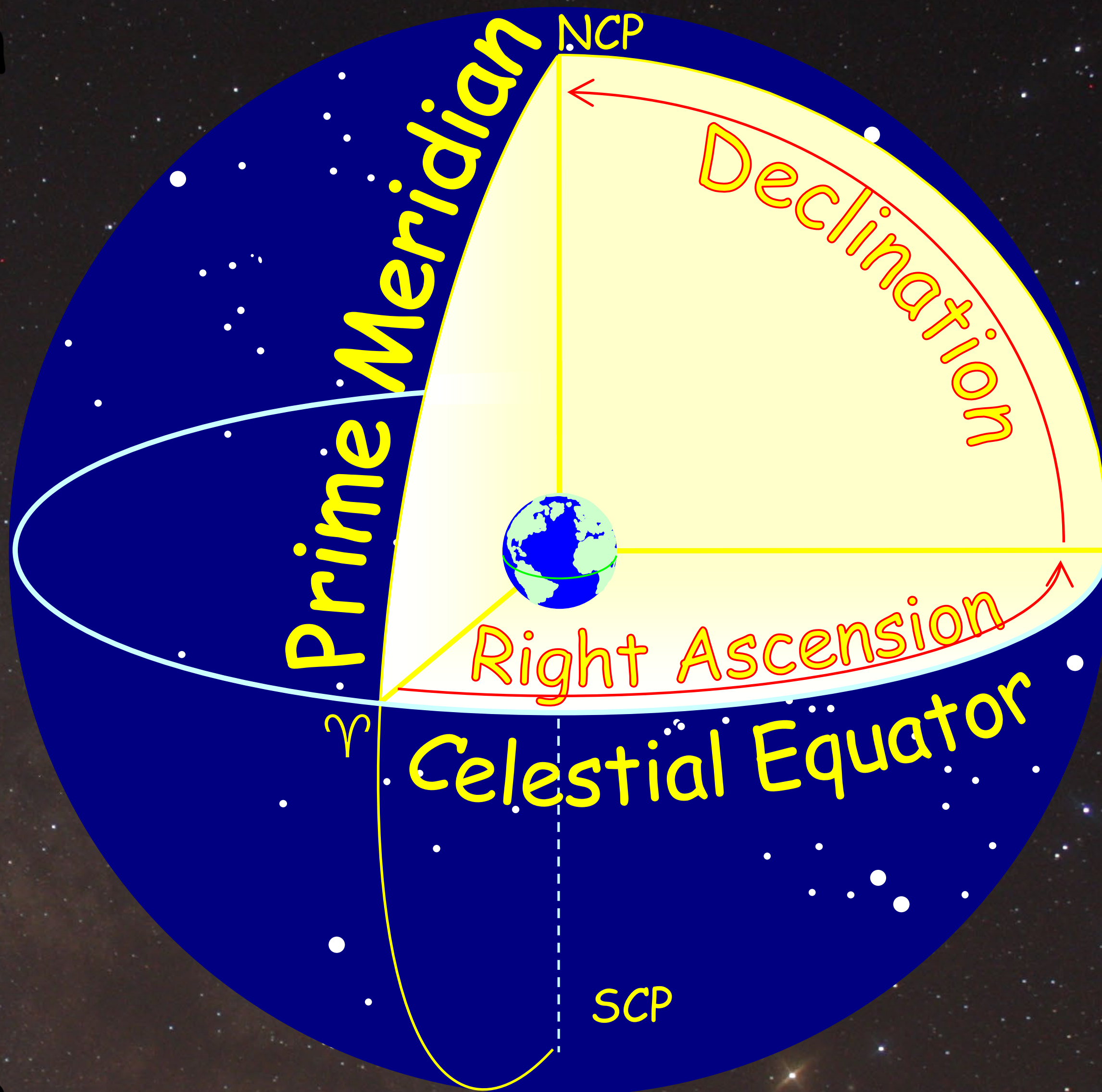


Photo by Marc Staves 2011

Celestial Coordinates

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

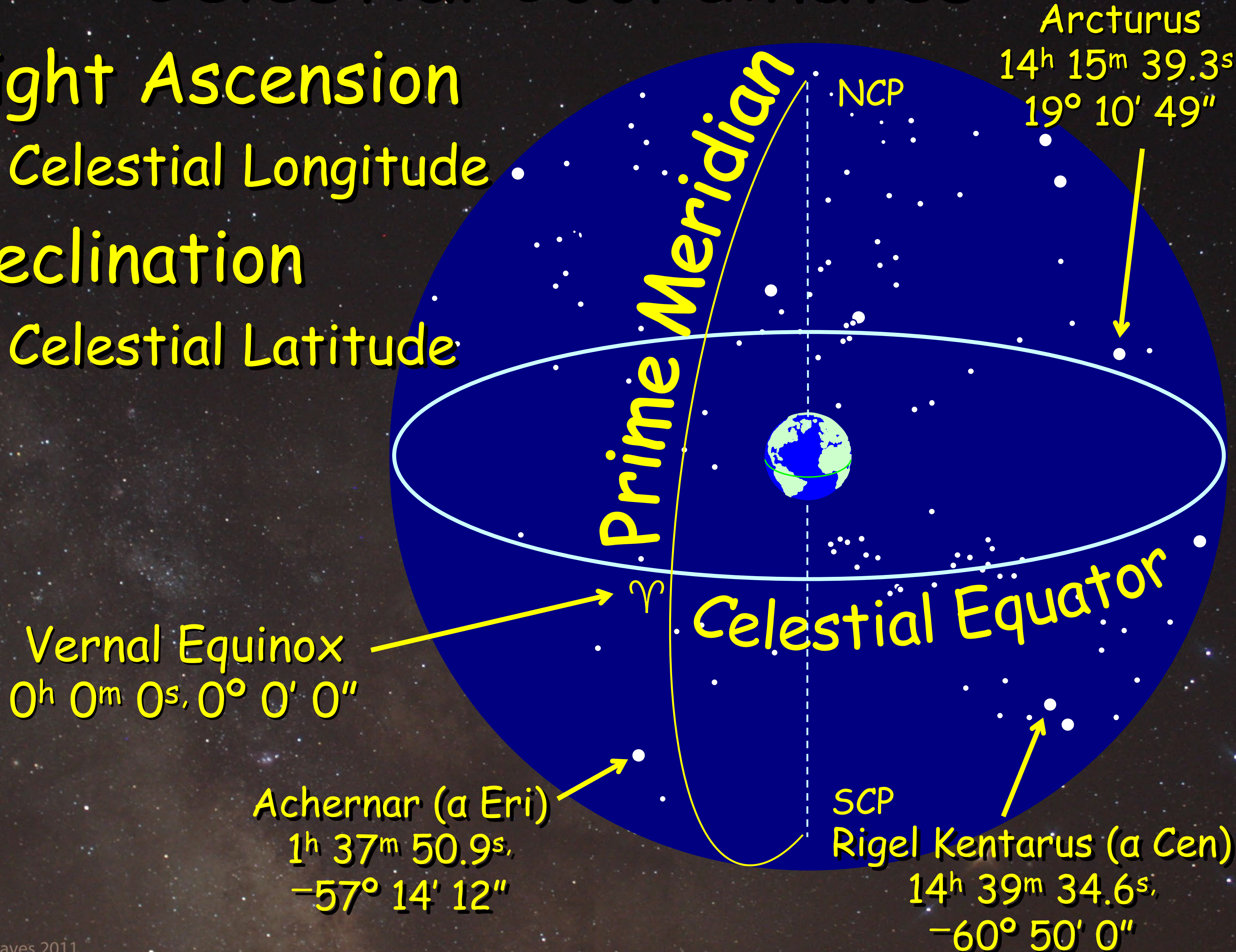


Photo by Marc Staves 2011

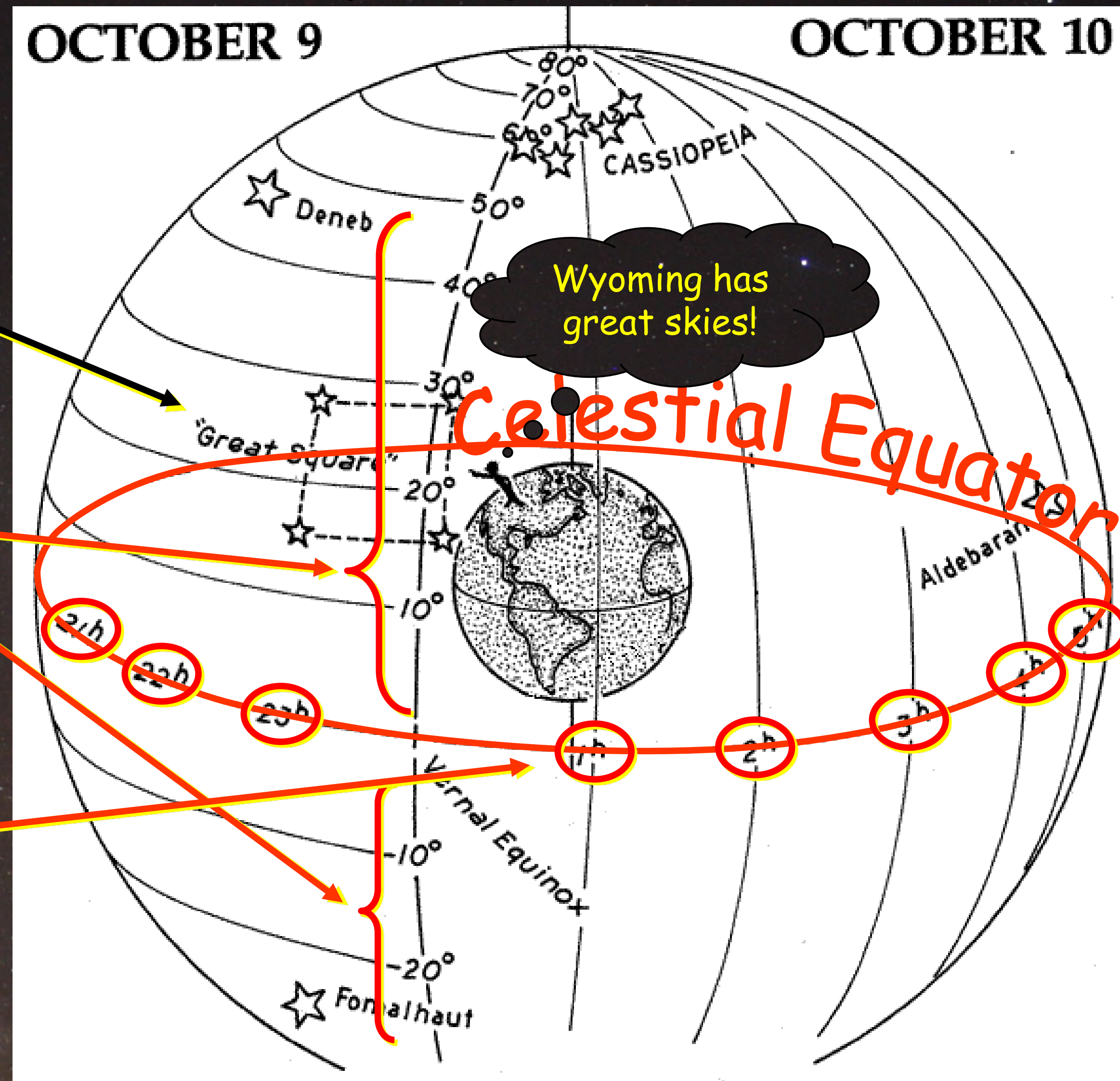
Celestial Coordinates

☆ 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



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Observers On Earth

- ☆ See different sky depending on Latitude

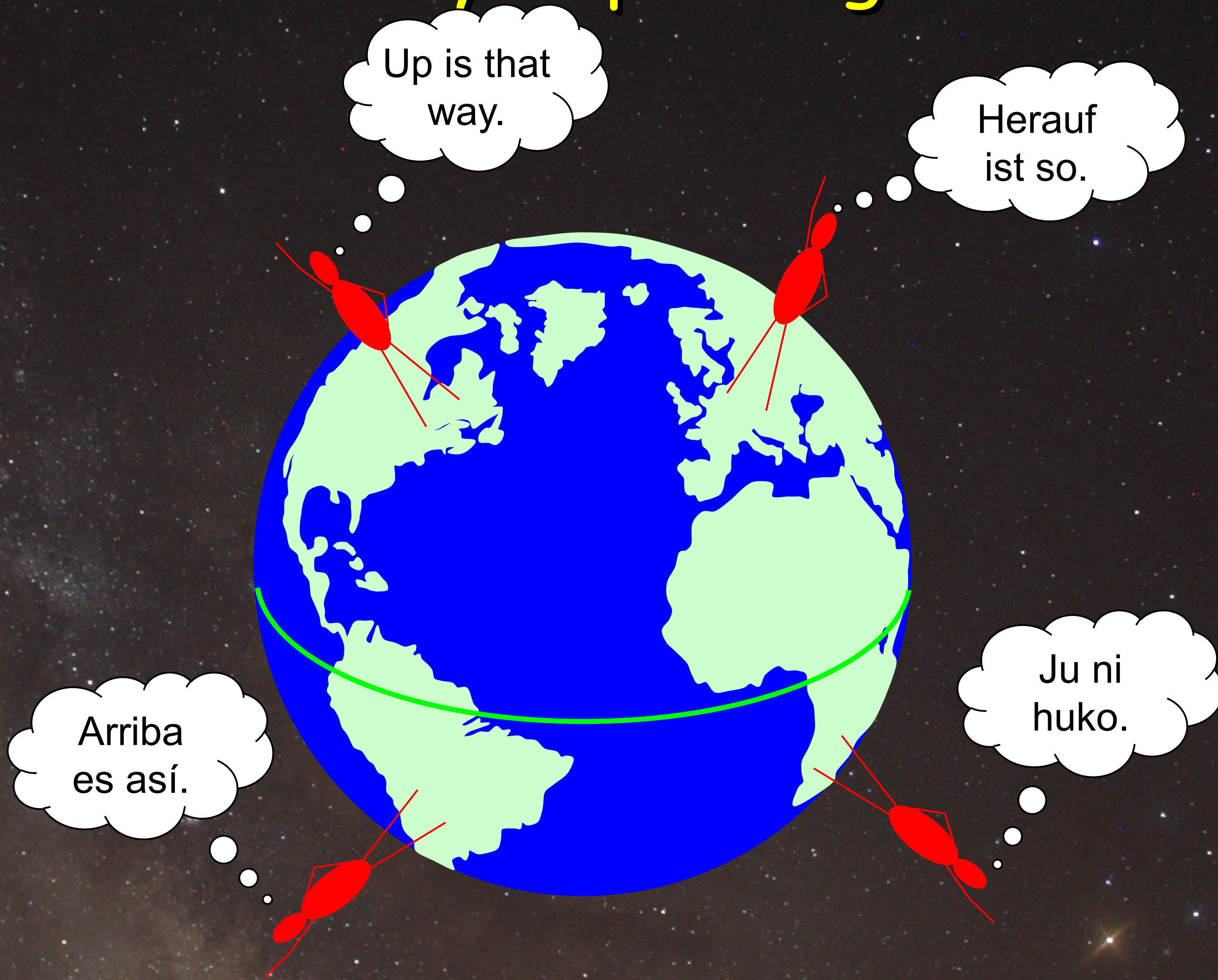


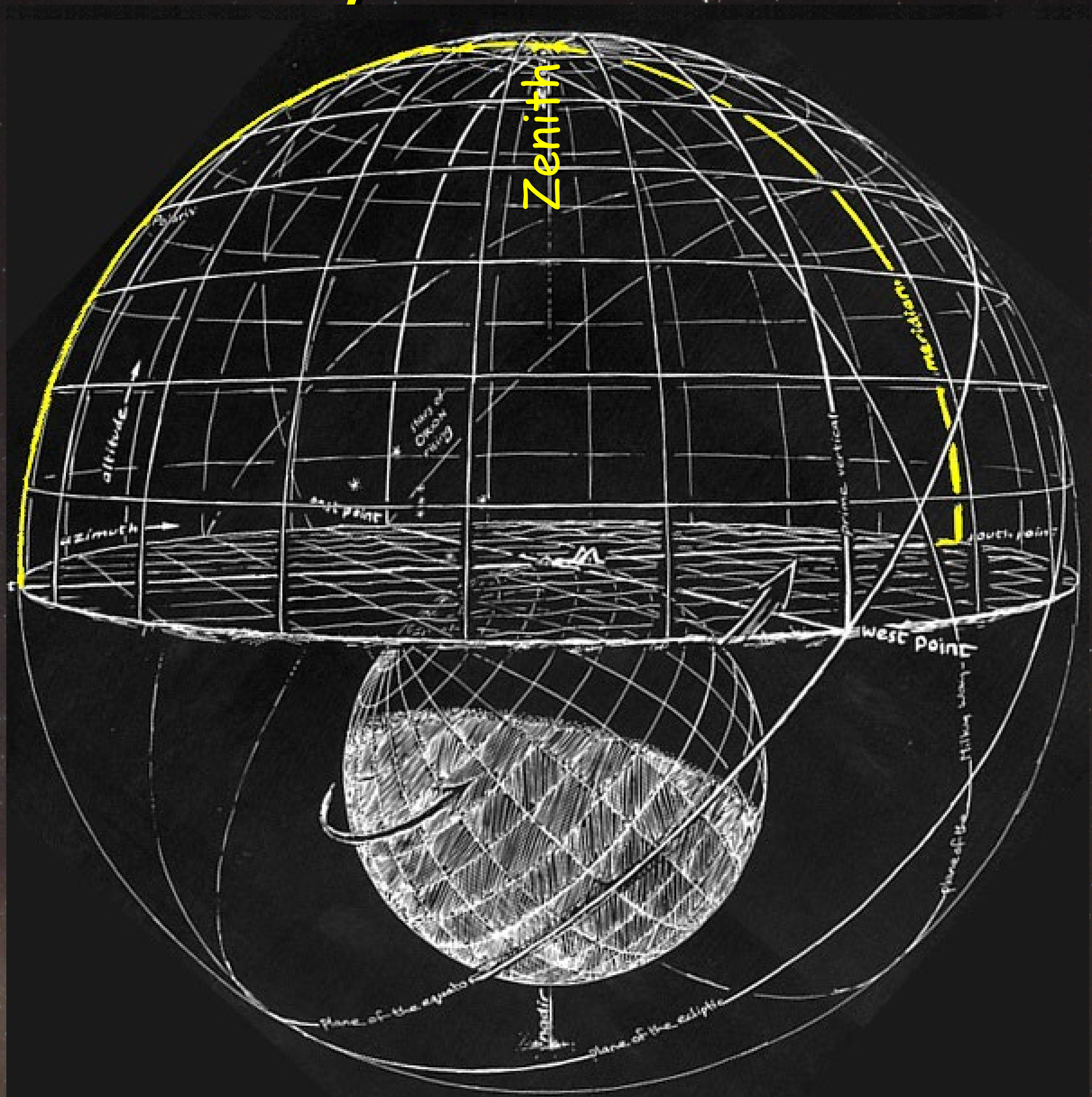
Photo by Marc Staves 2011

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



Tilted Sky

- ☆ Fun with your mind …

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

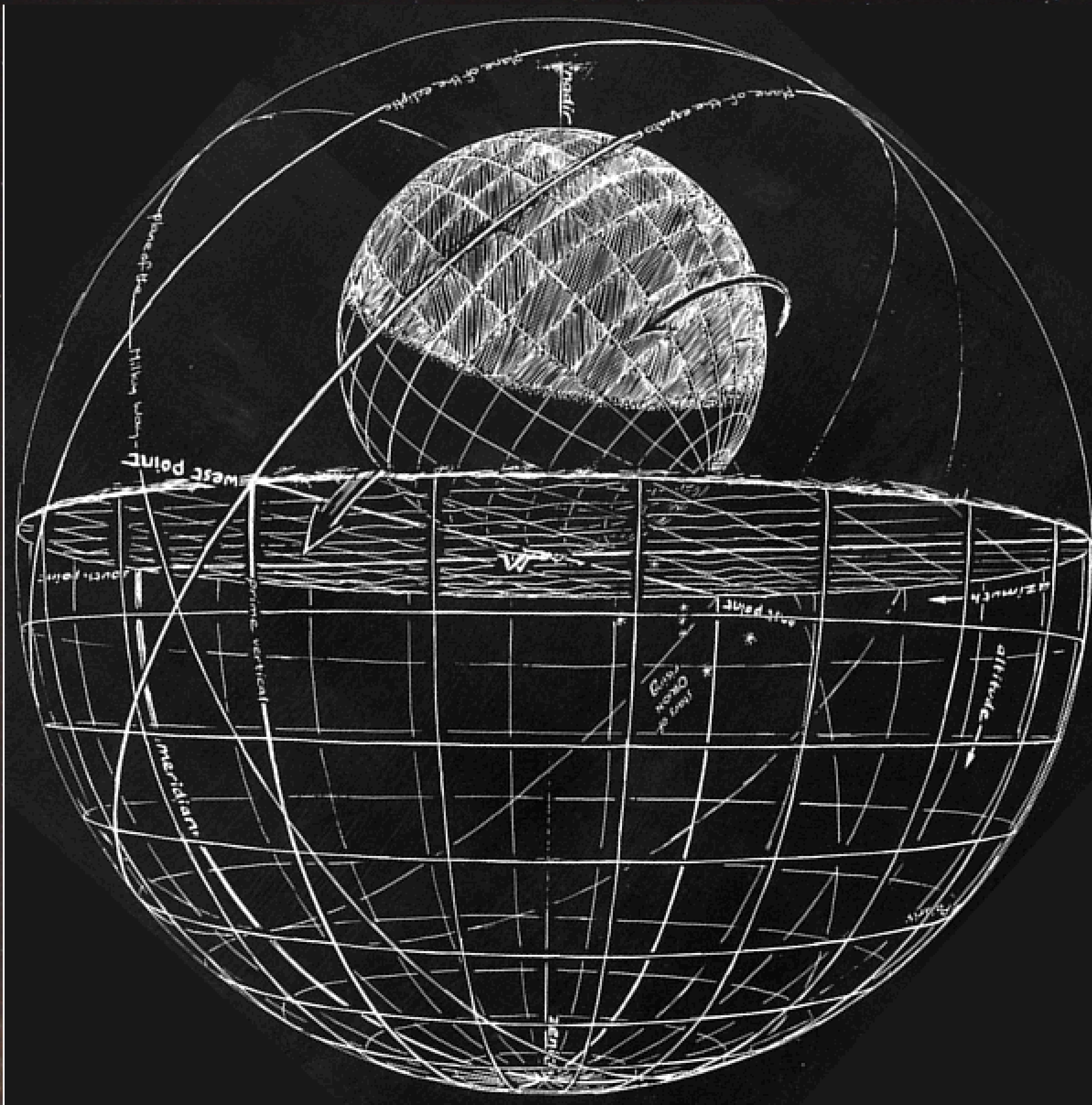
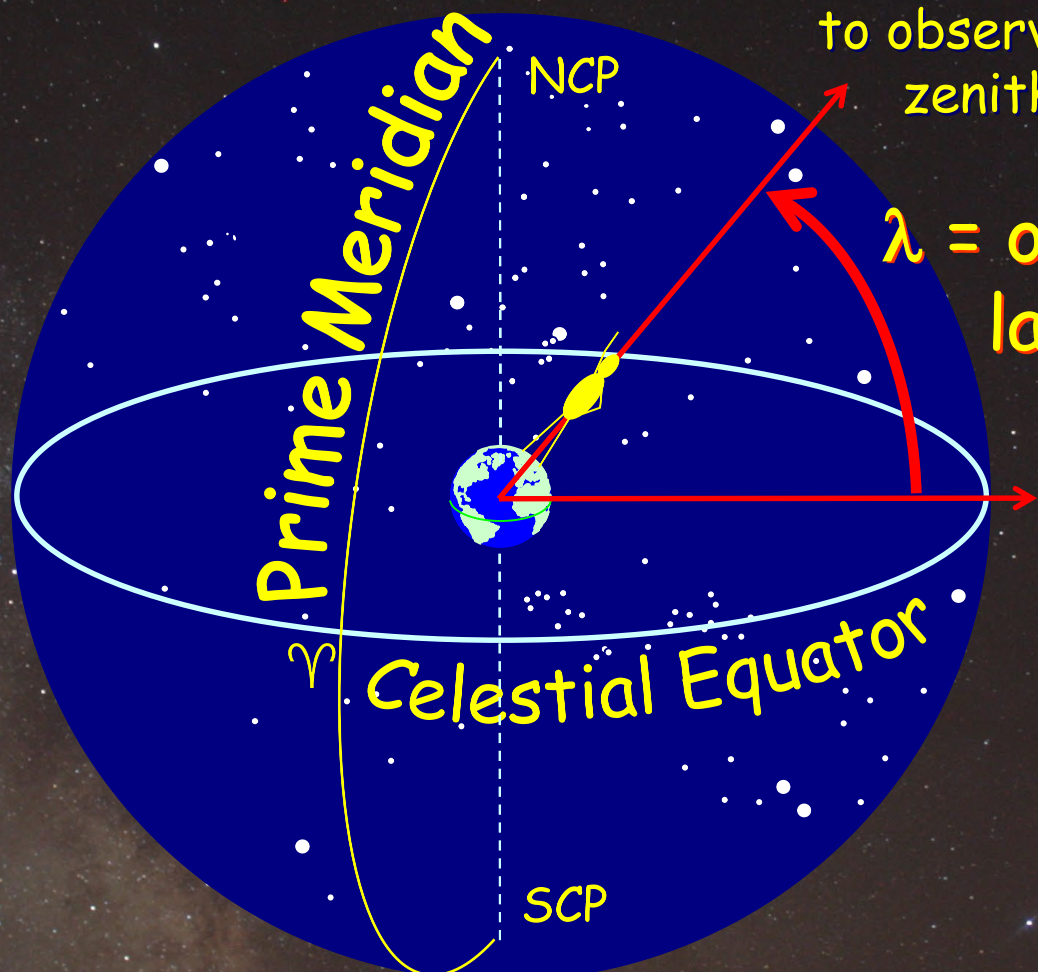


Photo by Marc Staves 2011

Viewing the Sky

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



Sky Angles

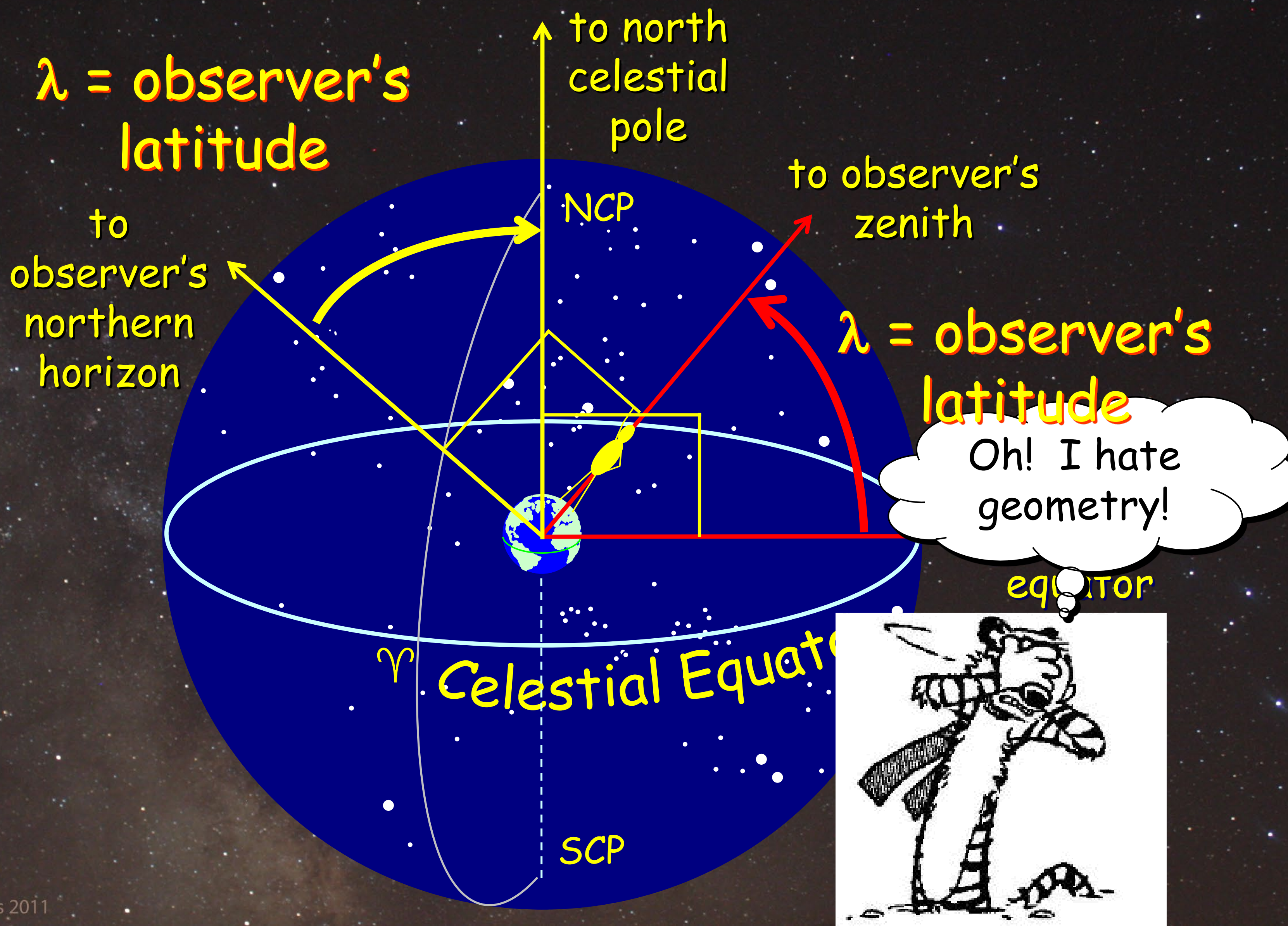
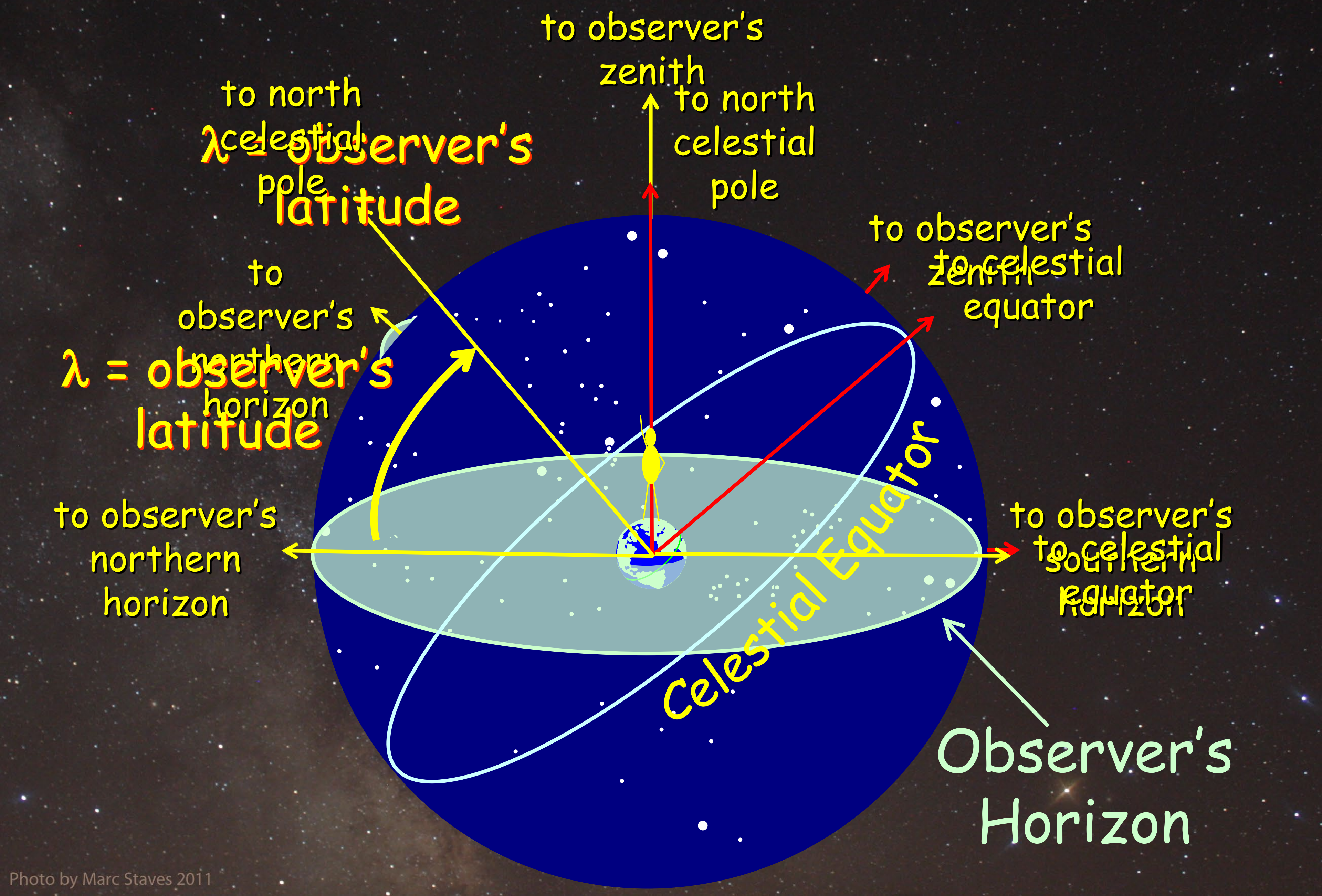


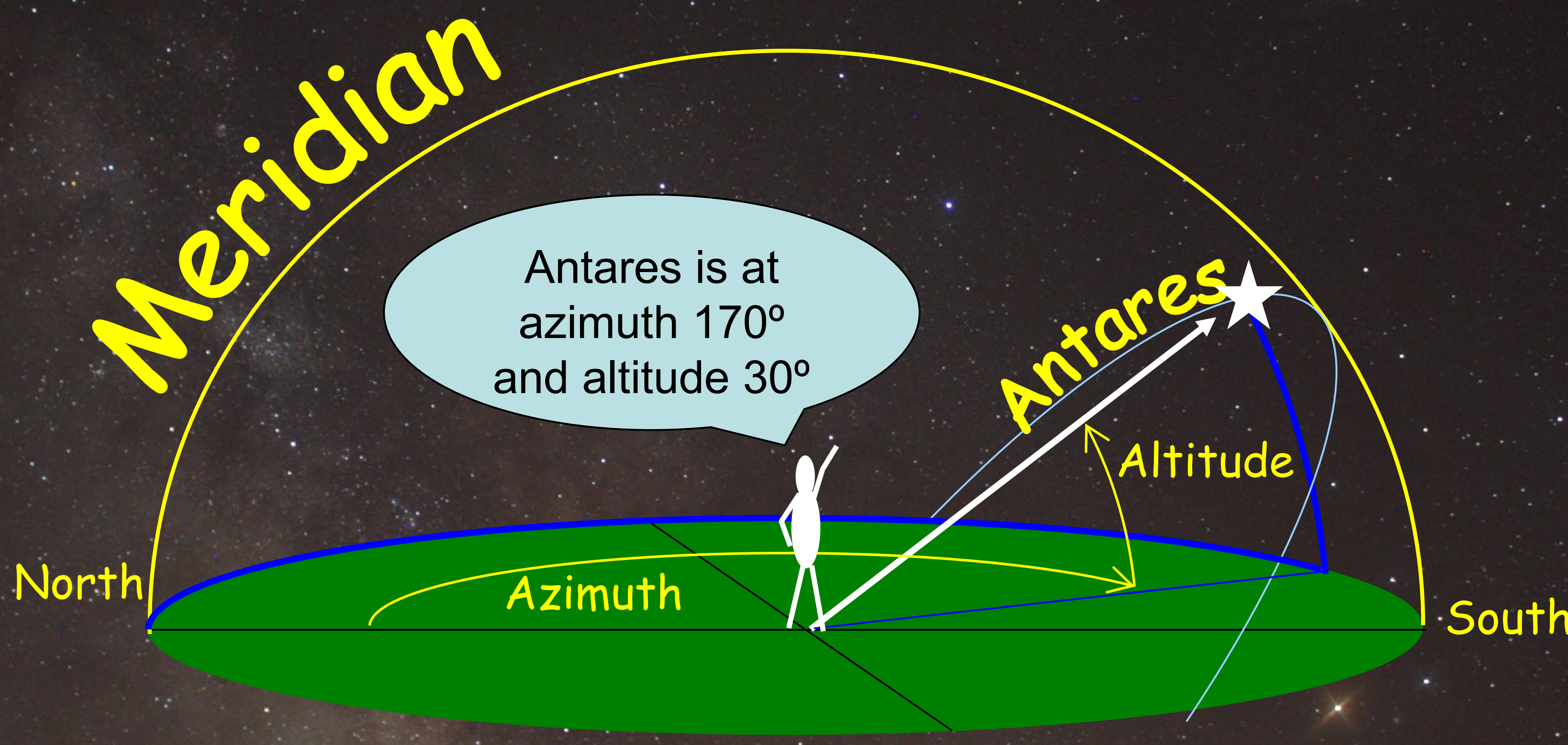
Photo by Marc Staves 2011

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

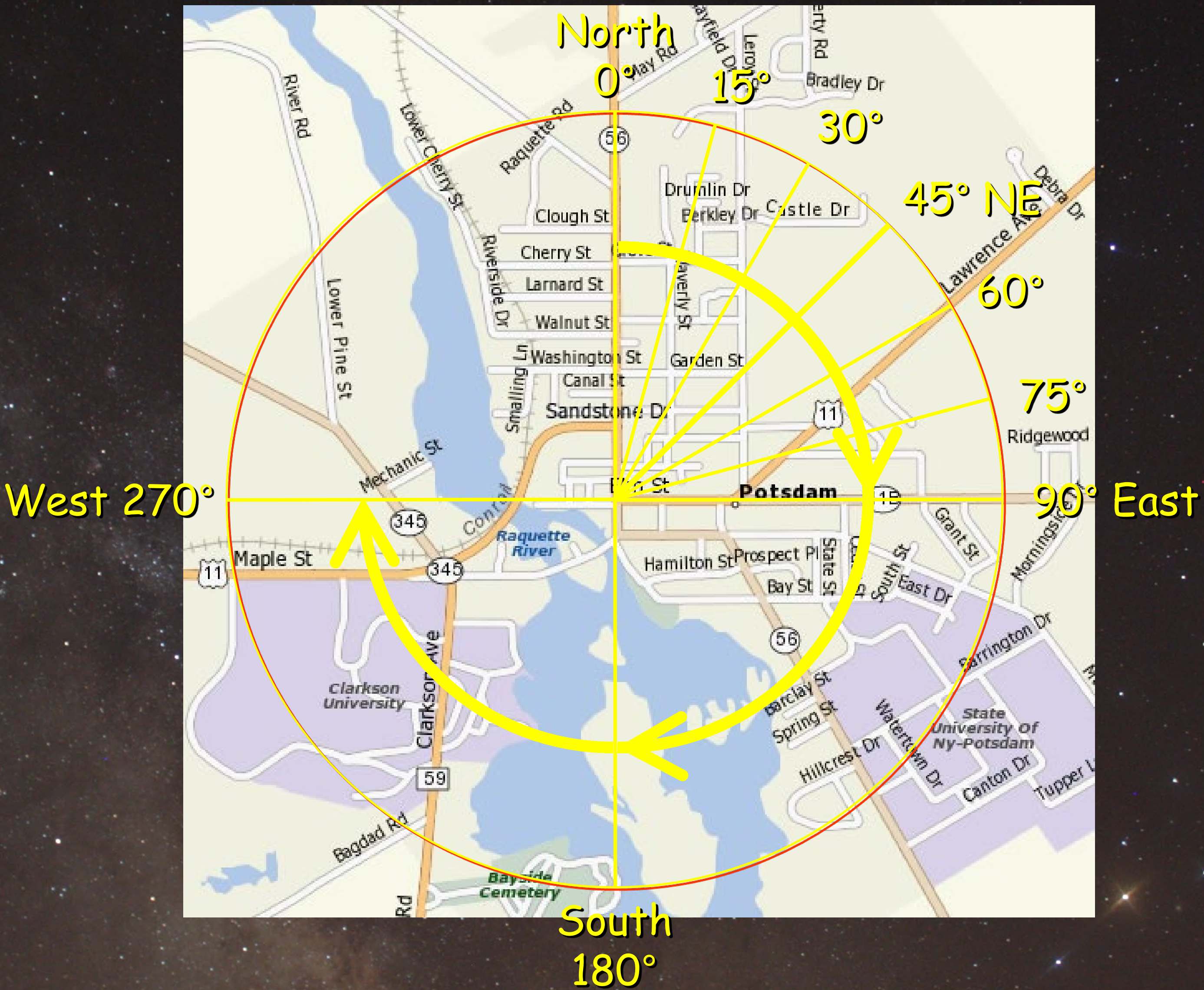
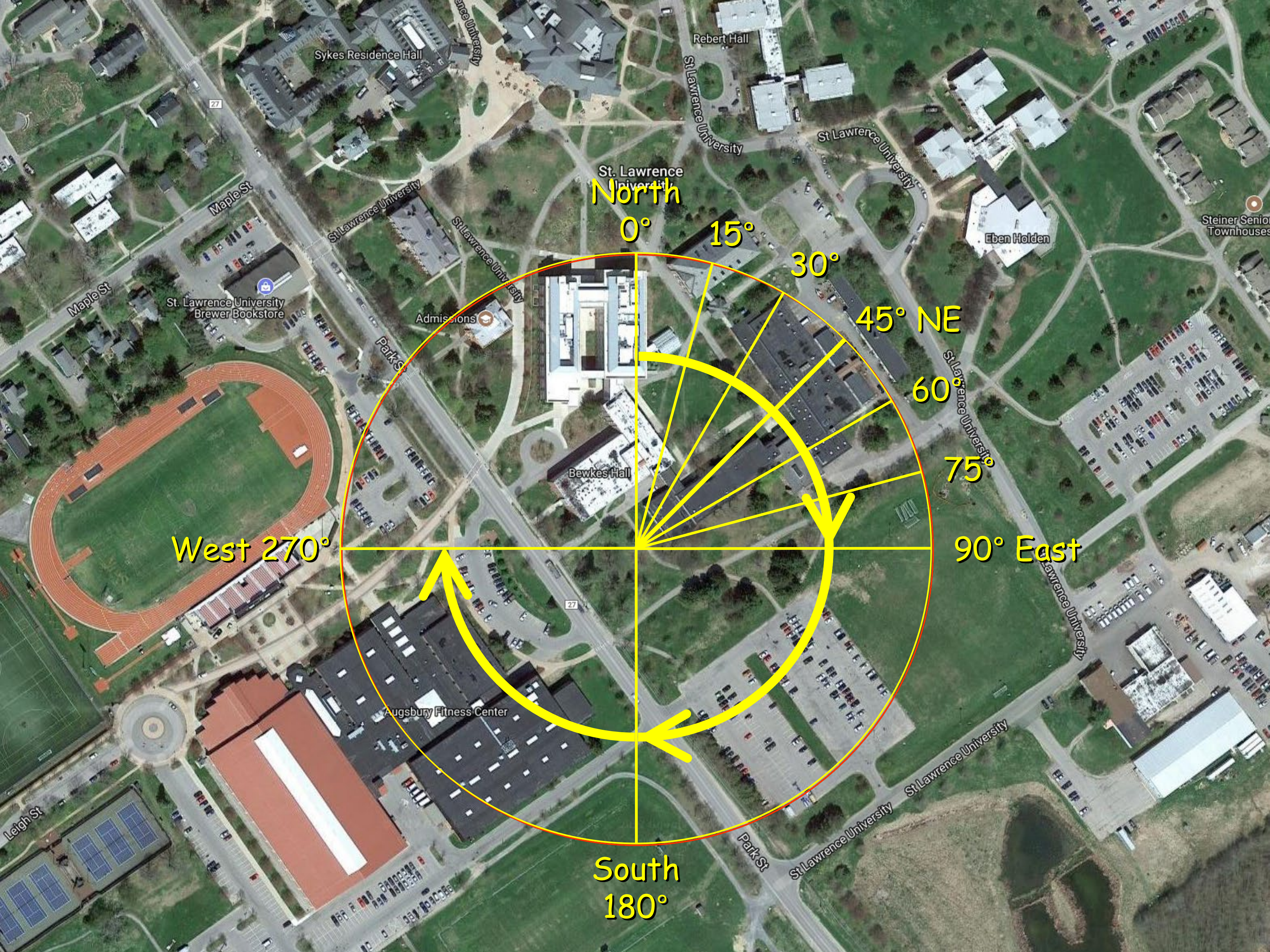
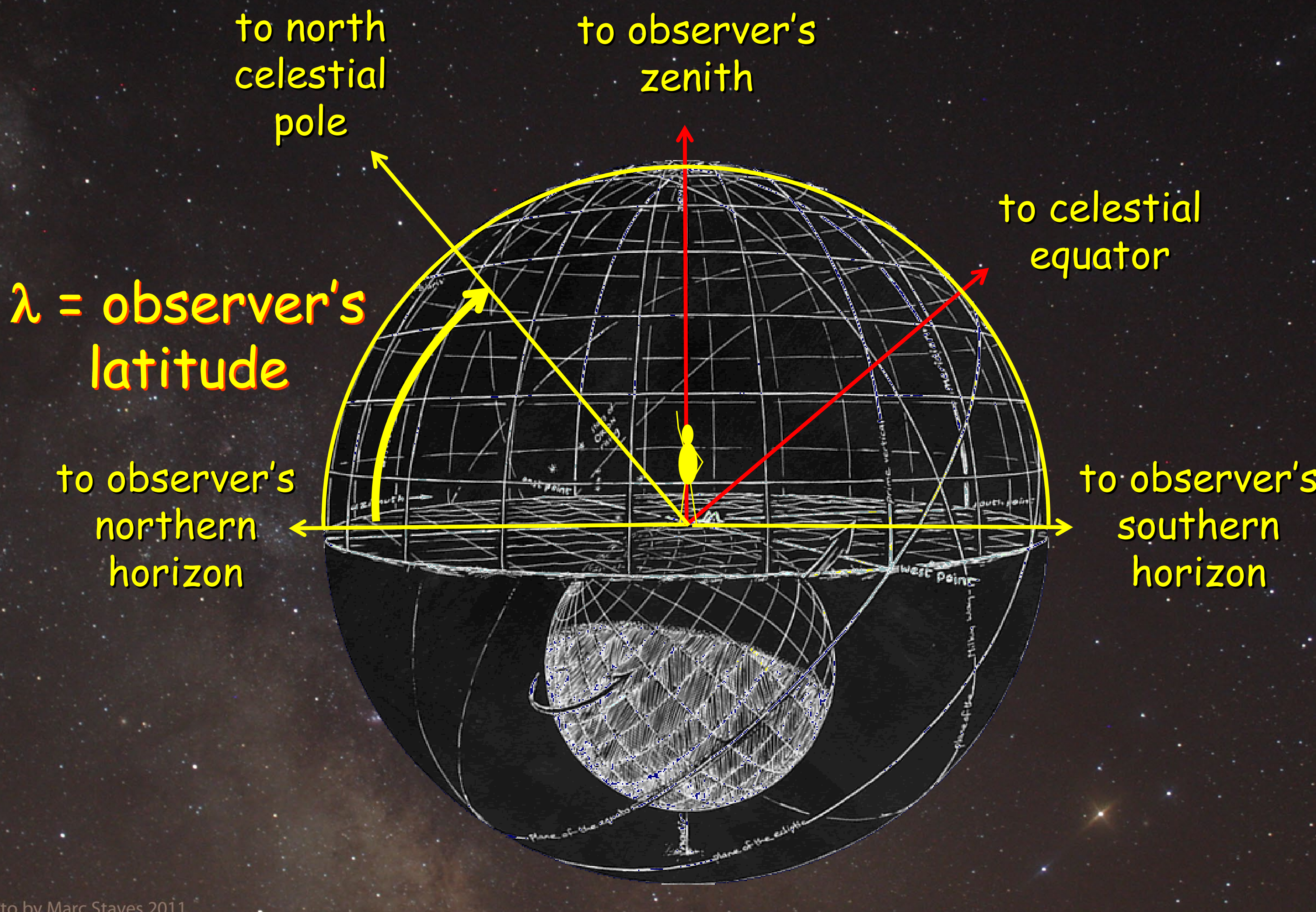


Photo by Marc Staves 2011


North
0°
15°
30°
45° NE
60°
75°
90° East
South
180°
West 270°
St. Lawrence University
Sykes Residence Hall
Robert Hall
St Lawrence University
Eben Holden
Steiner Senior Townhouses
Maple St
St. Lawrence University Brewer Bookstore
Admissions
Park St
Bewkes Hall
Augsbury Fitness Center
Leigh St
27

Horizon Coordinate System



Horizon Coordinate System

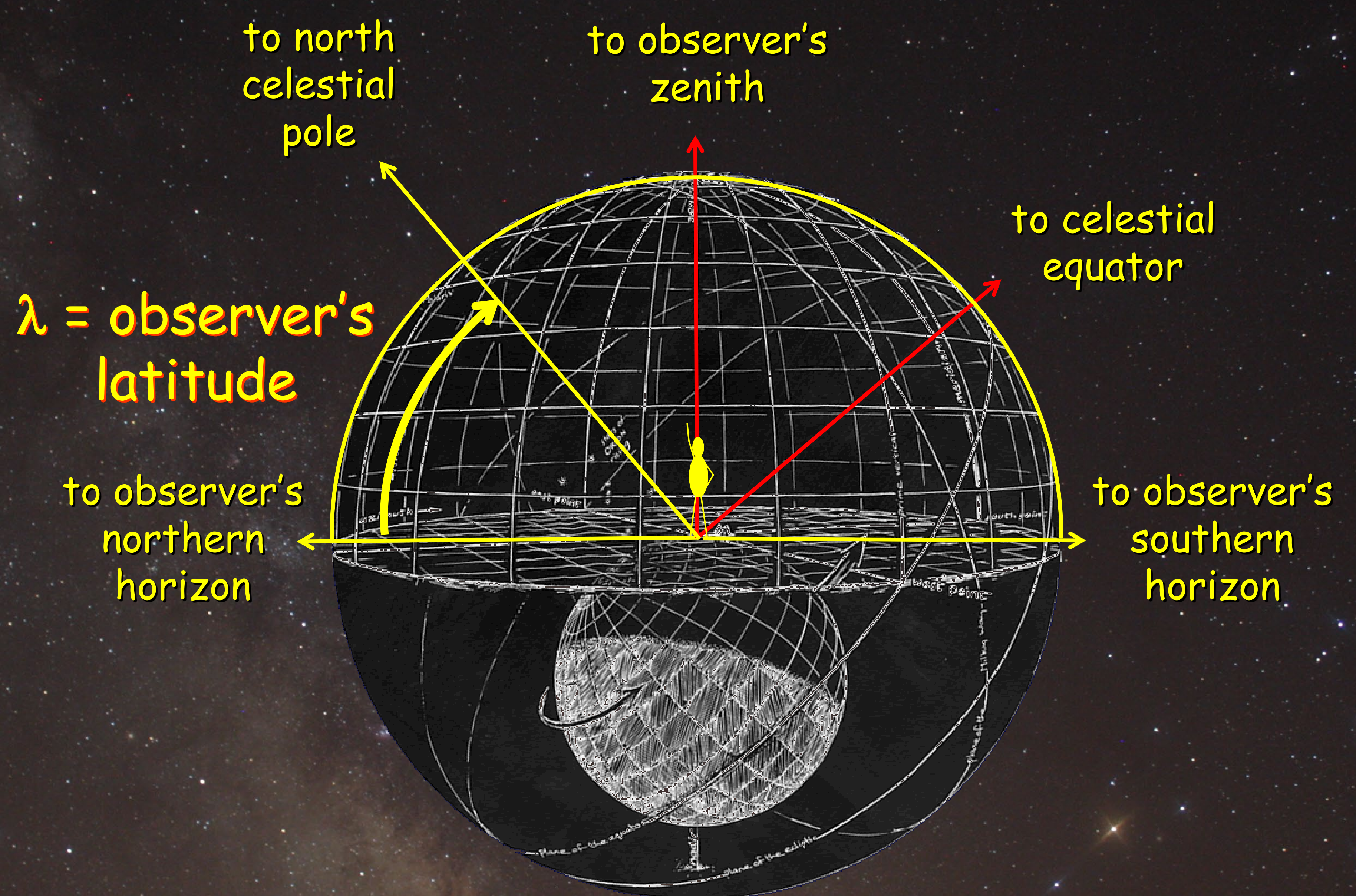
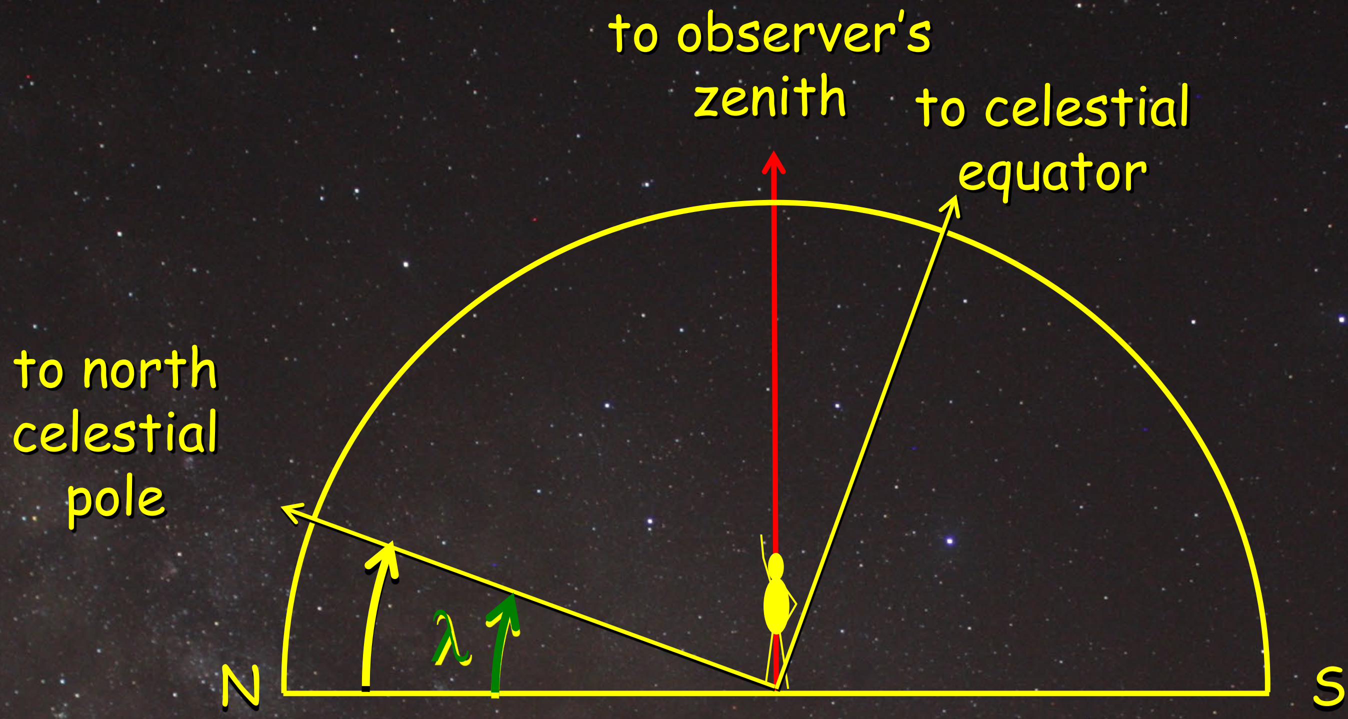


Photo by Marc Staves 2011

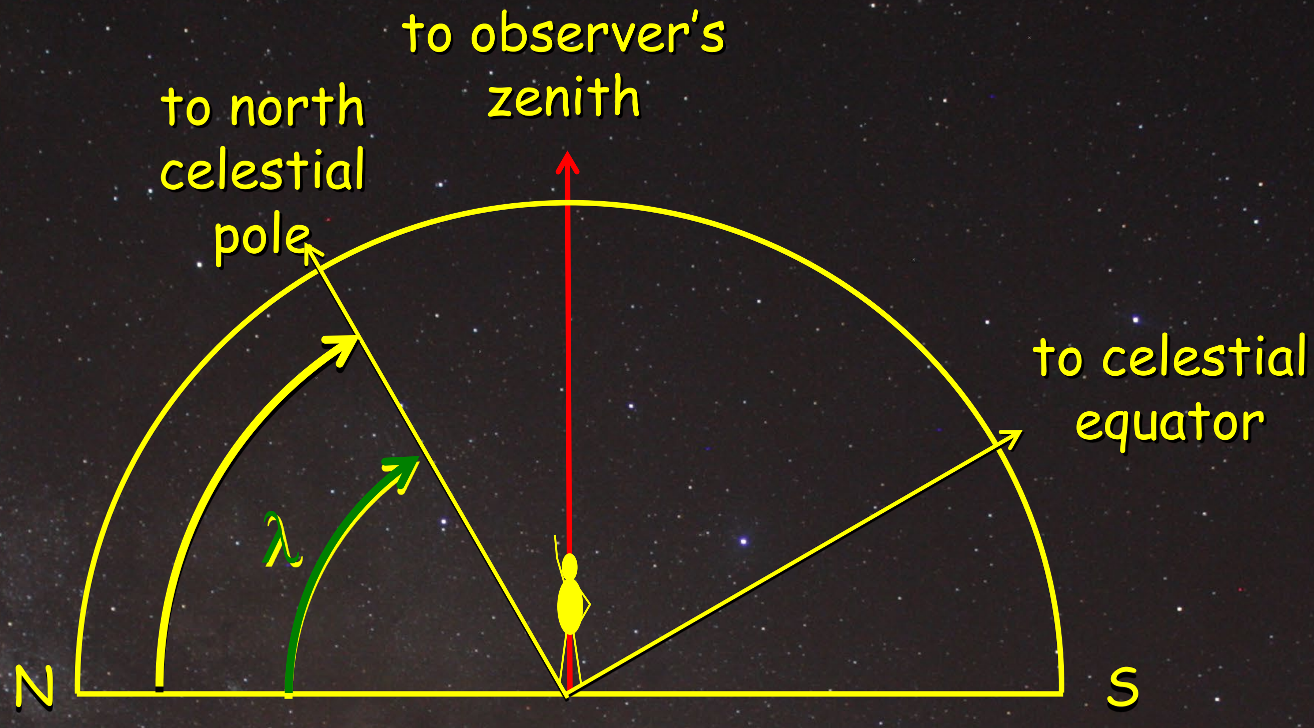
Question



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

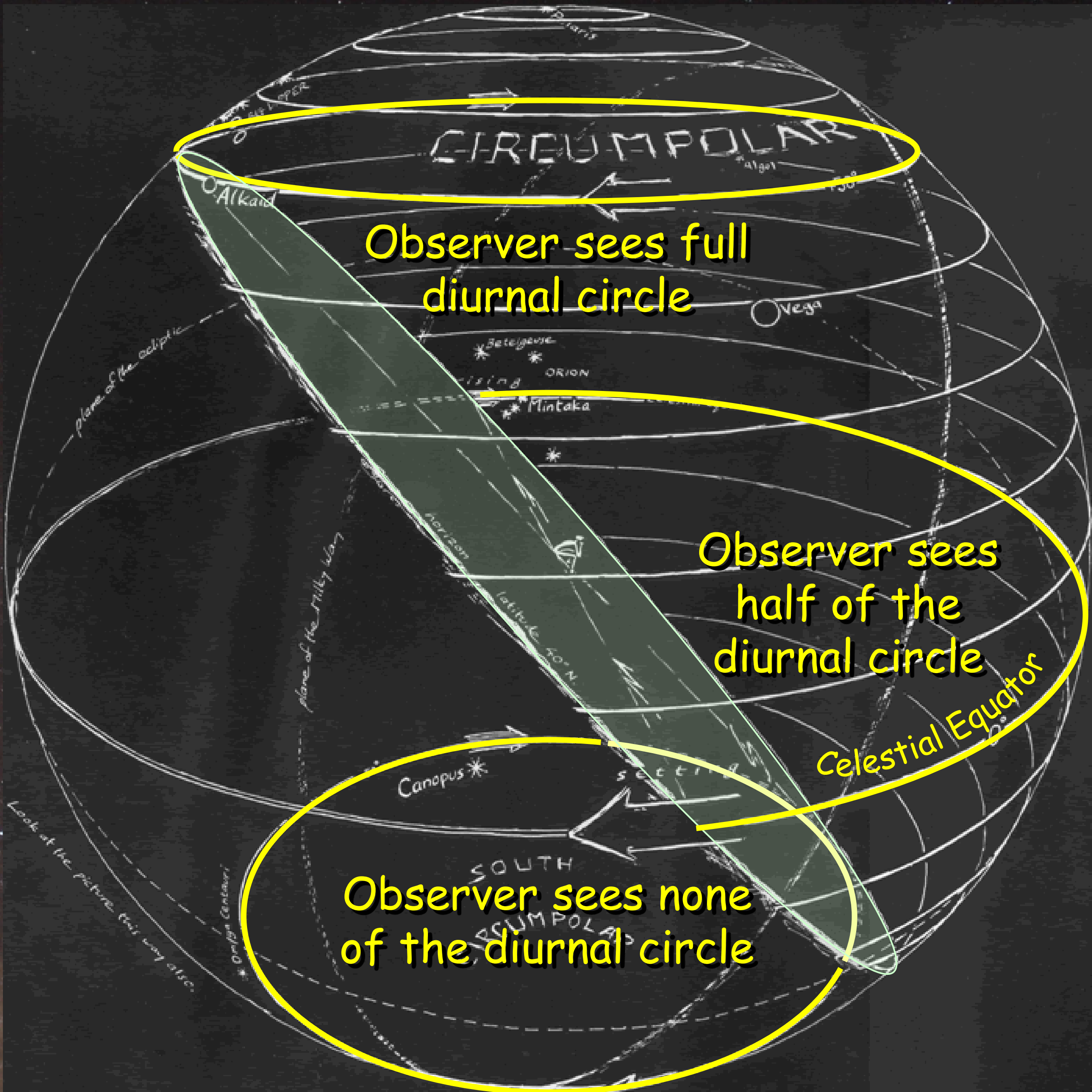
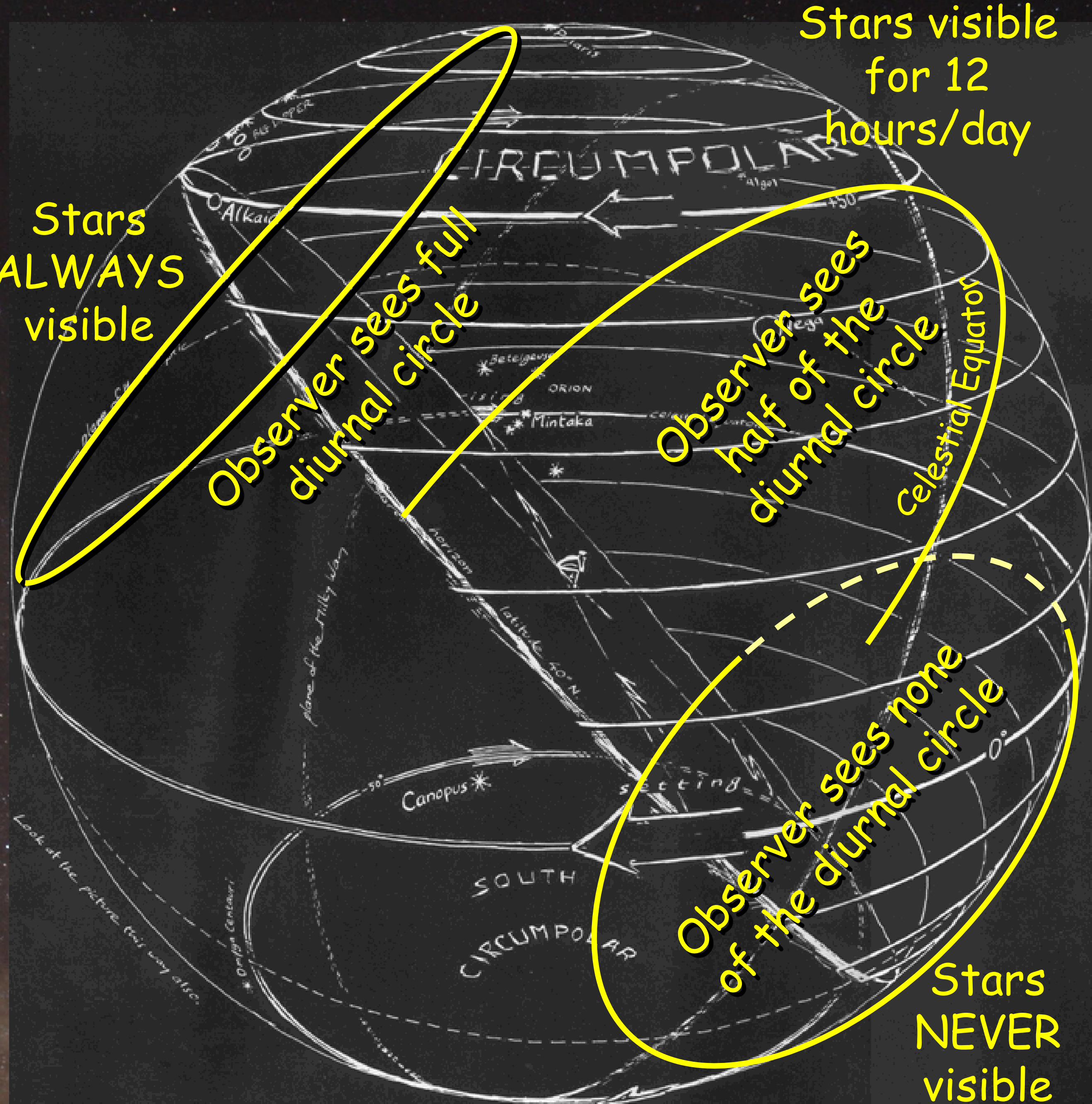


Photo by Marc Staves 2011

View of Observer

Rotate into the observer's frame of reference



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View of Observers

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

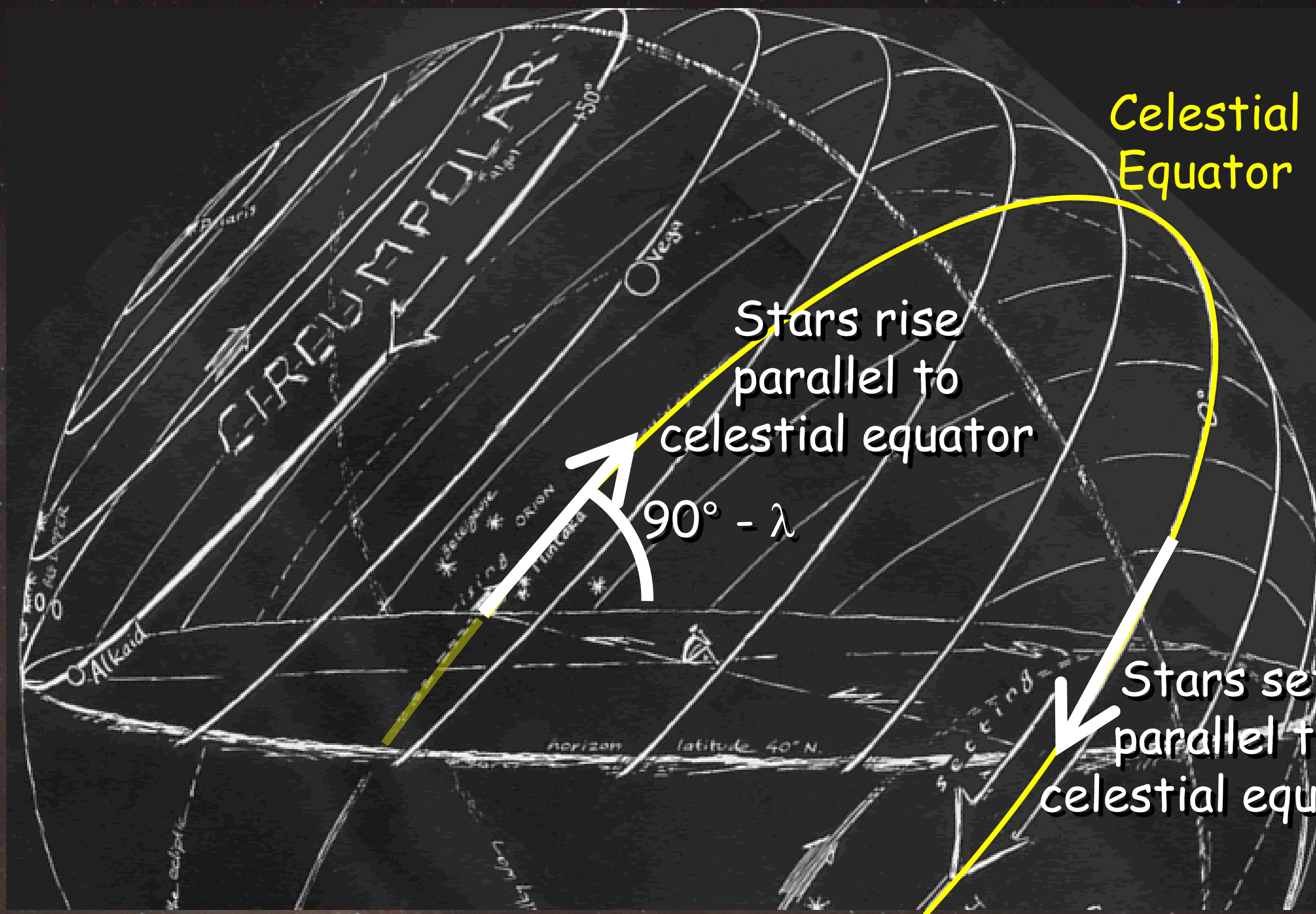
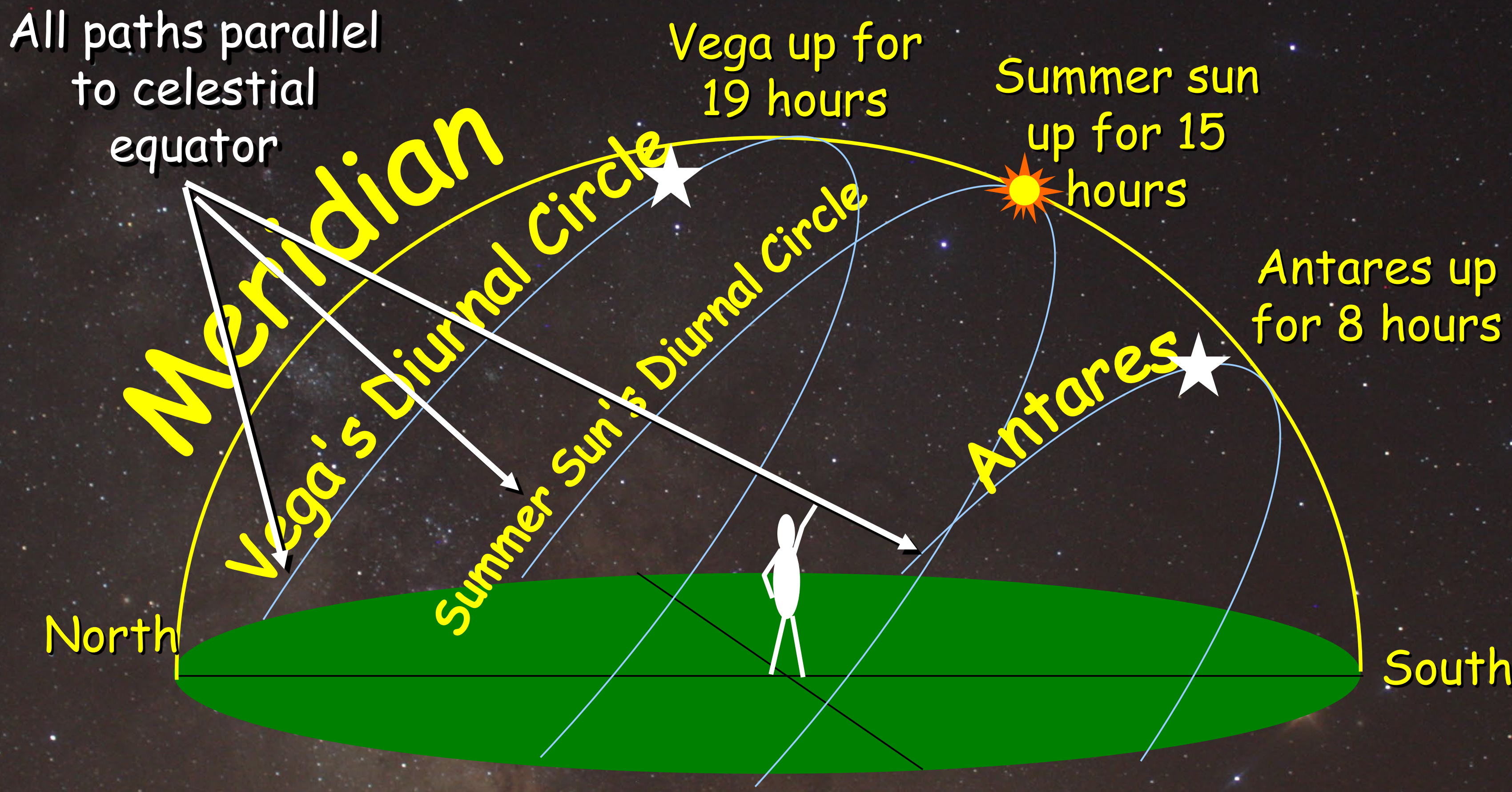


Photo by Marc Staves 2011

Star Paths

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

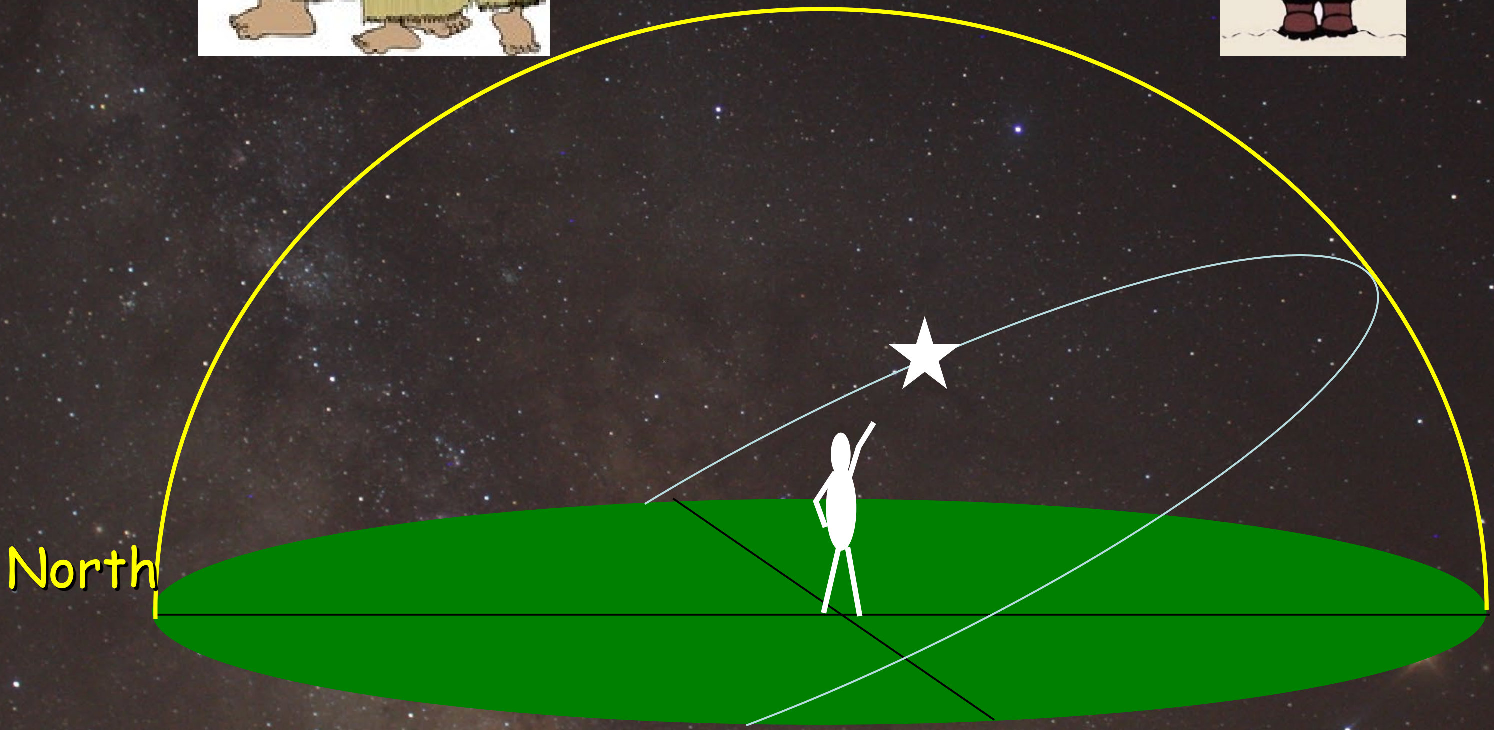


Question

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

a) 

b) 

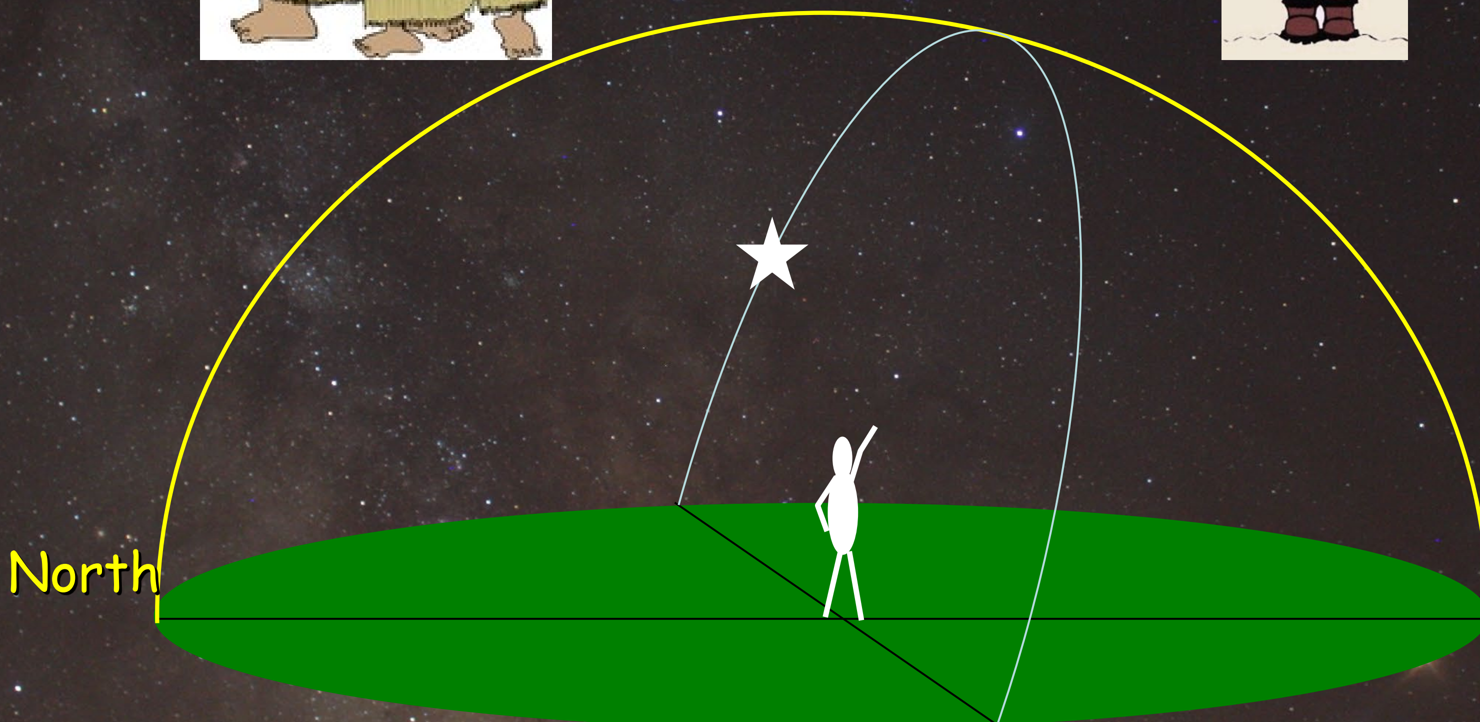


Question

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

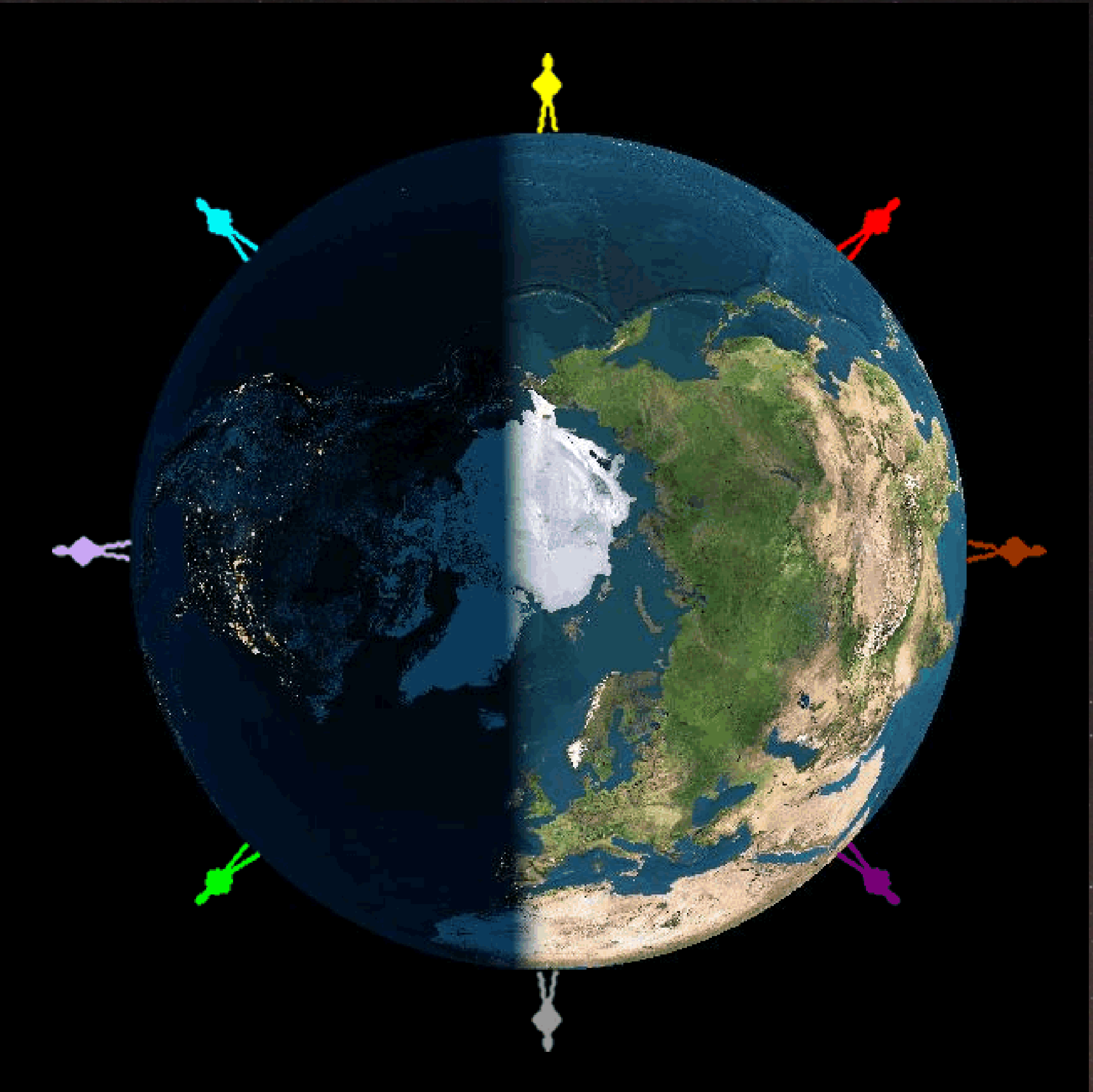
a) 

b) 



Time of day

- ☆ Earth Rotates Once Each Day



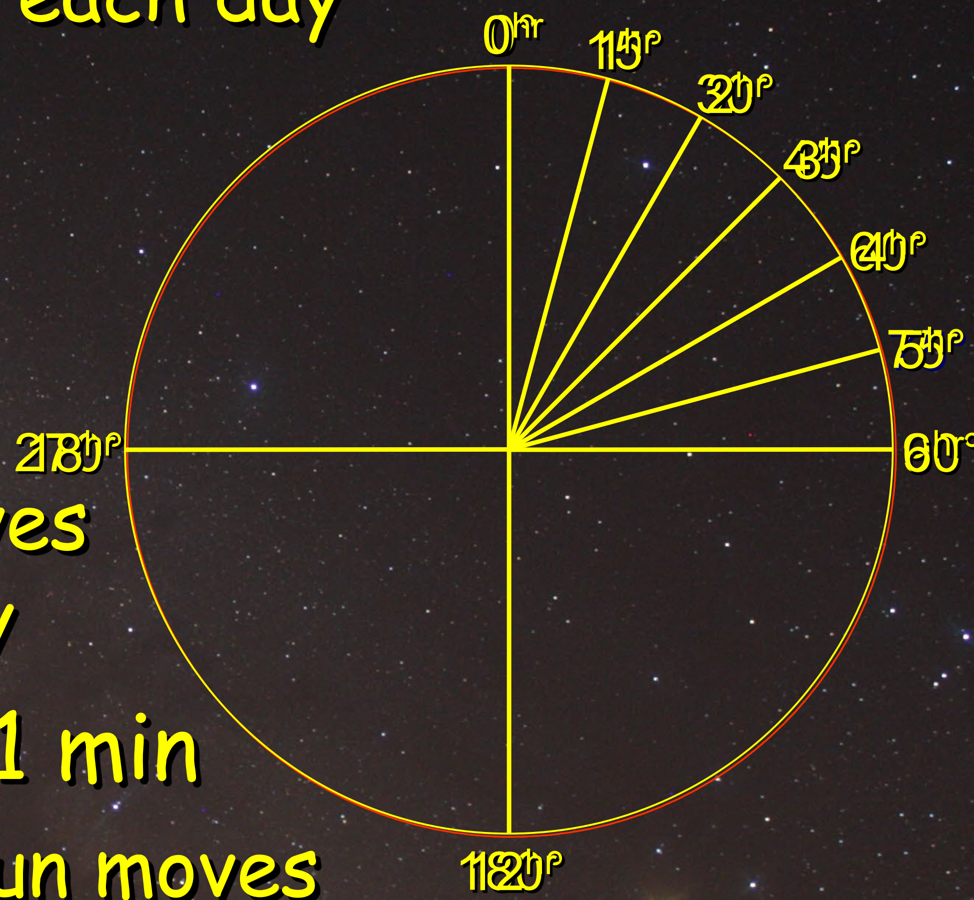
- 360° with respect to Earth-Sun line
- All Earthlings ride along

→ 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

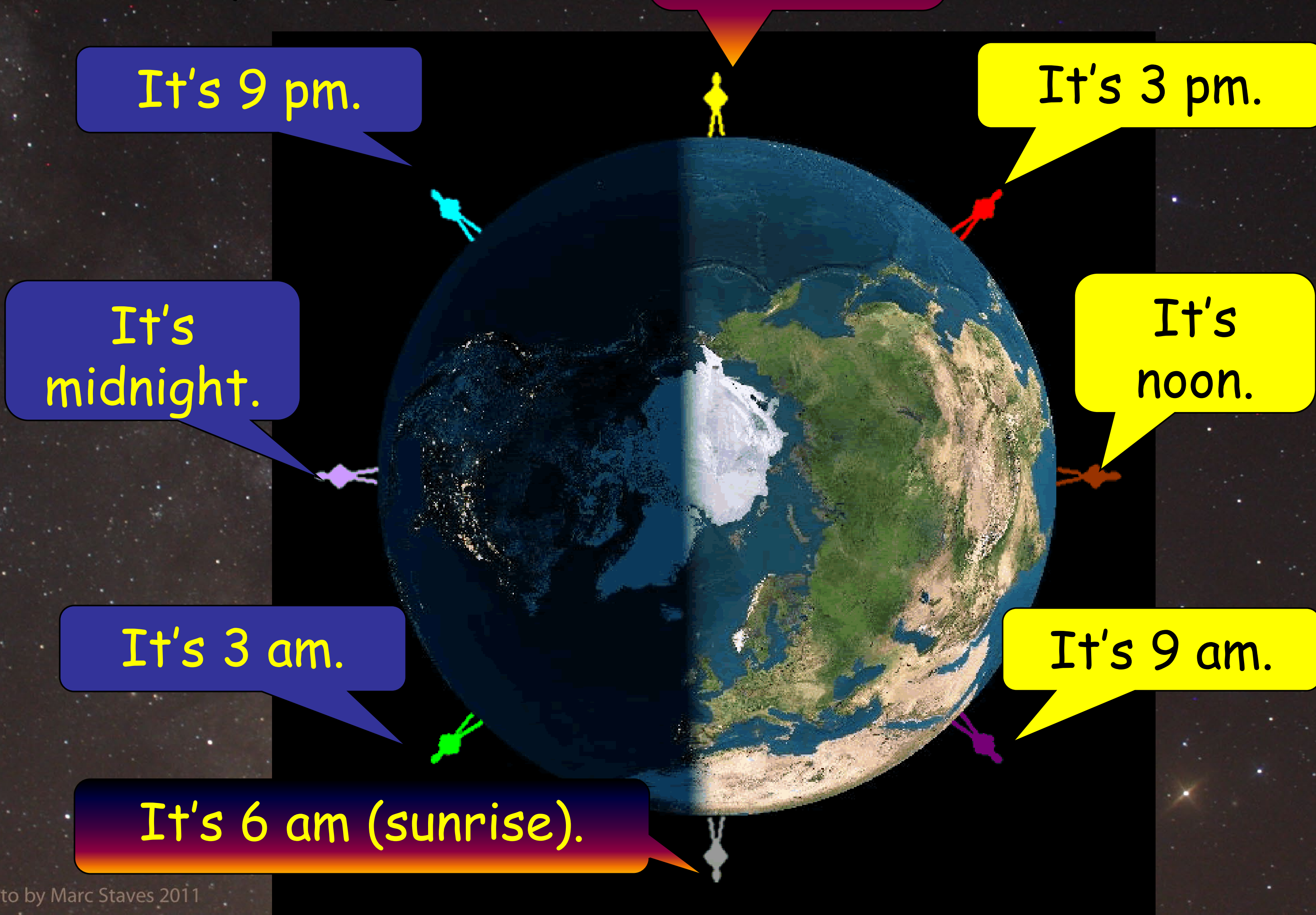
Observer's View of the Day

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

Photo by Marc Staves 2011

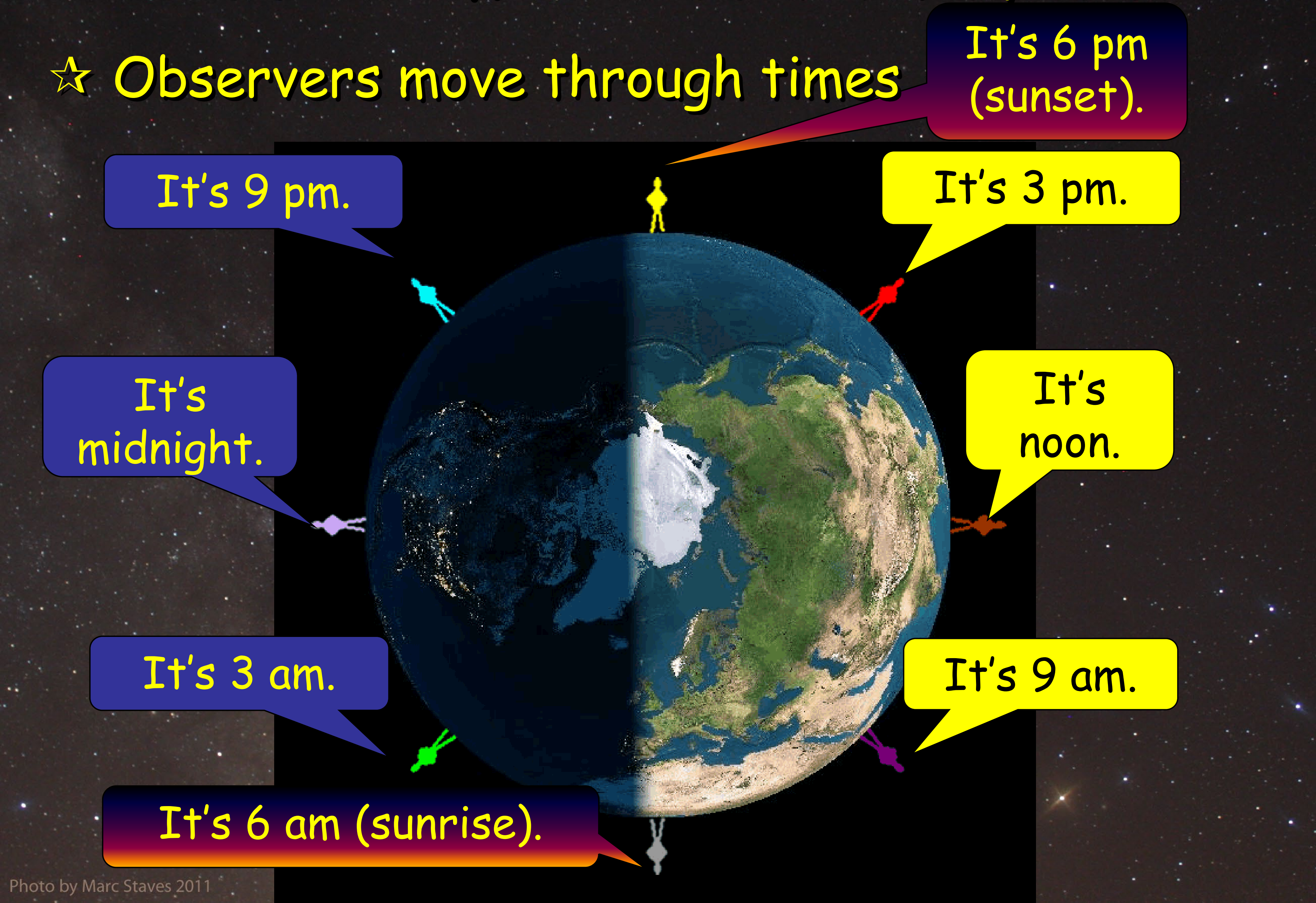
Standard Clock Time

- ☆ Every Longitude at ... fferent time



Clock Time = Position of Sol

- ☆ Observers move through times



Daylight Saving Time

☆ Shifts times one h… (USNO Explanation)

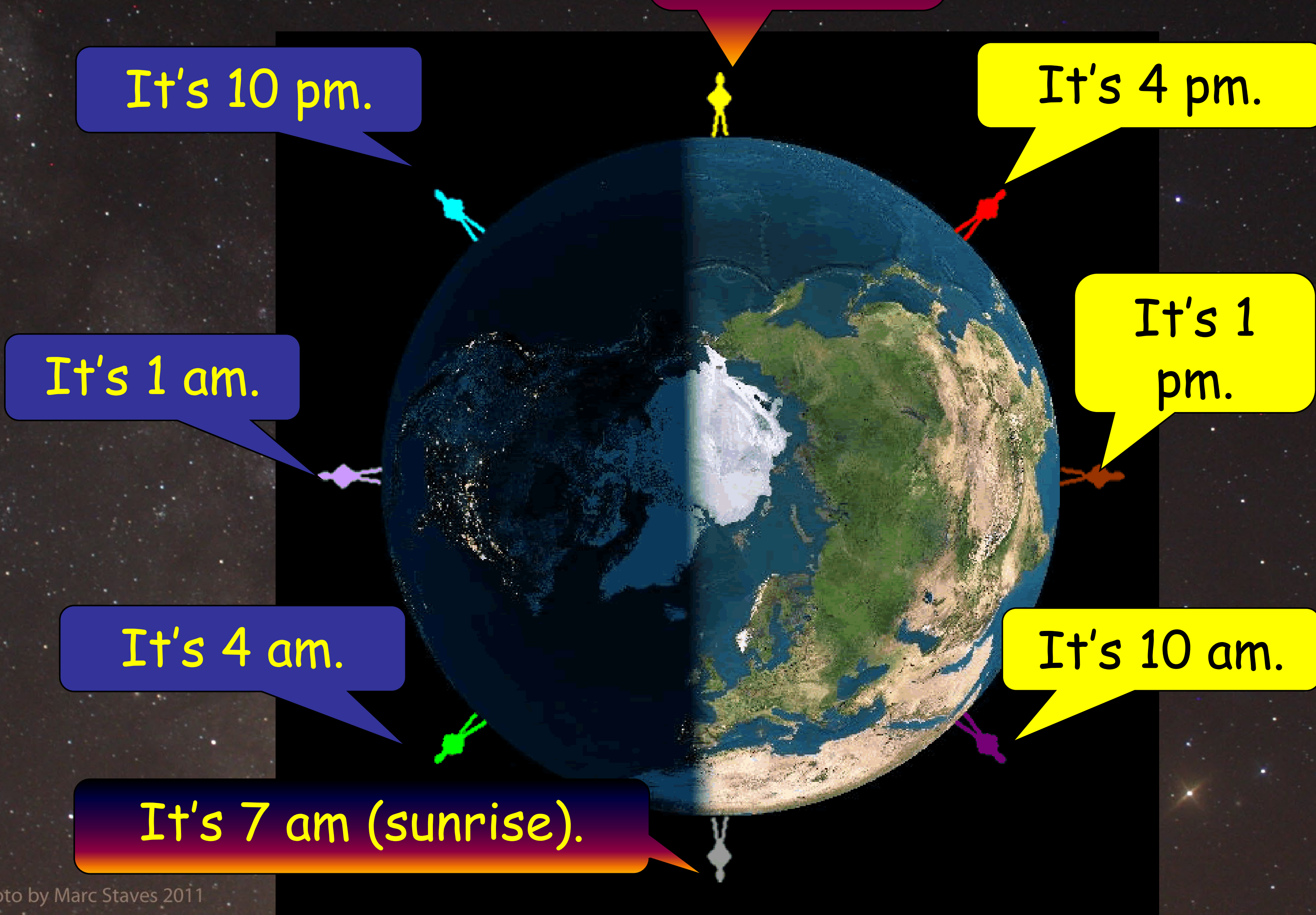
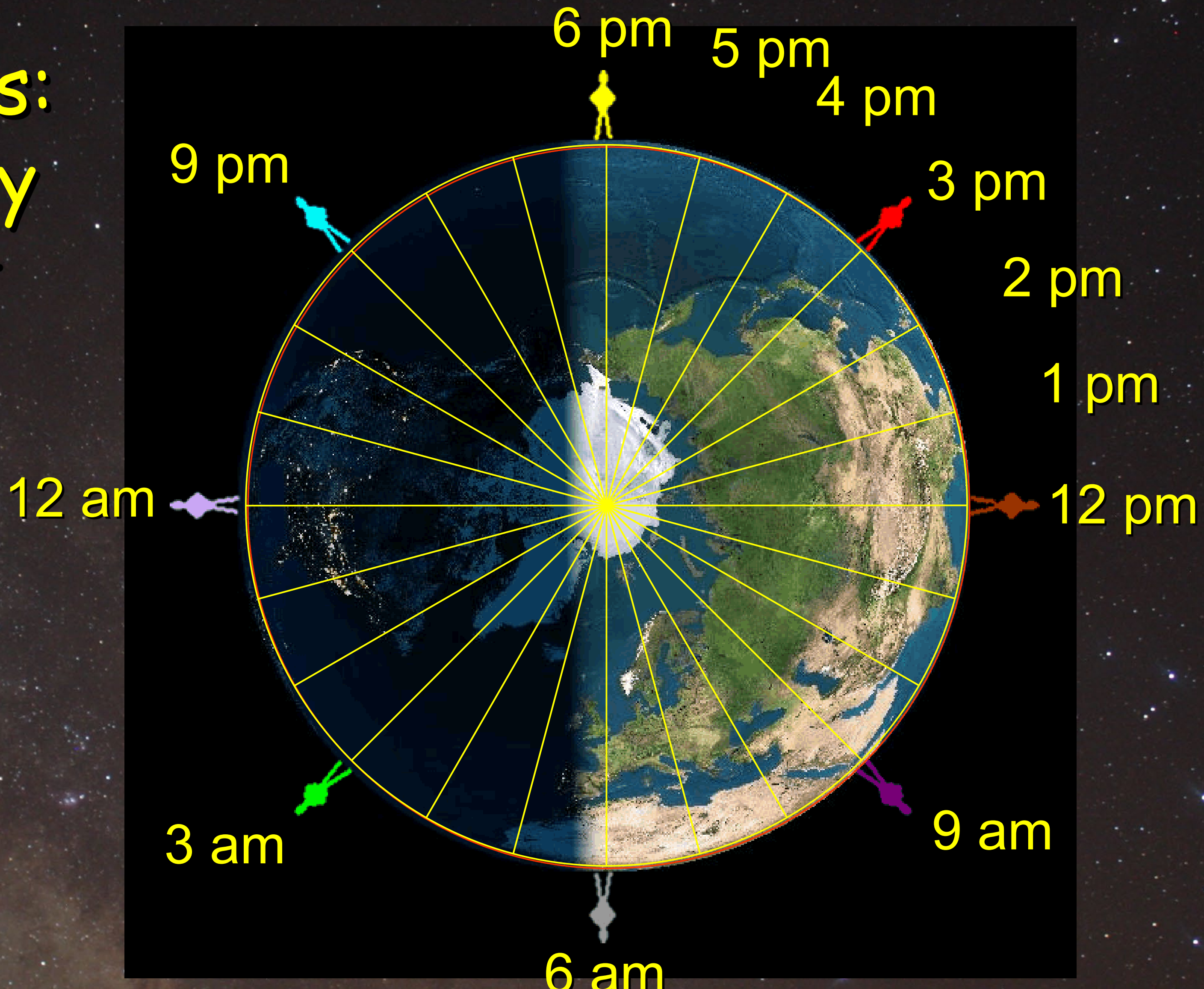


Photo by Marc Staves 2011

Clock Time

Time Zones:
24, roughly
15° apart



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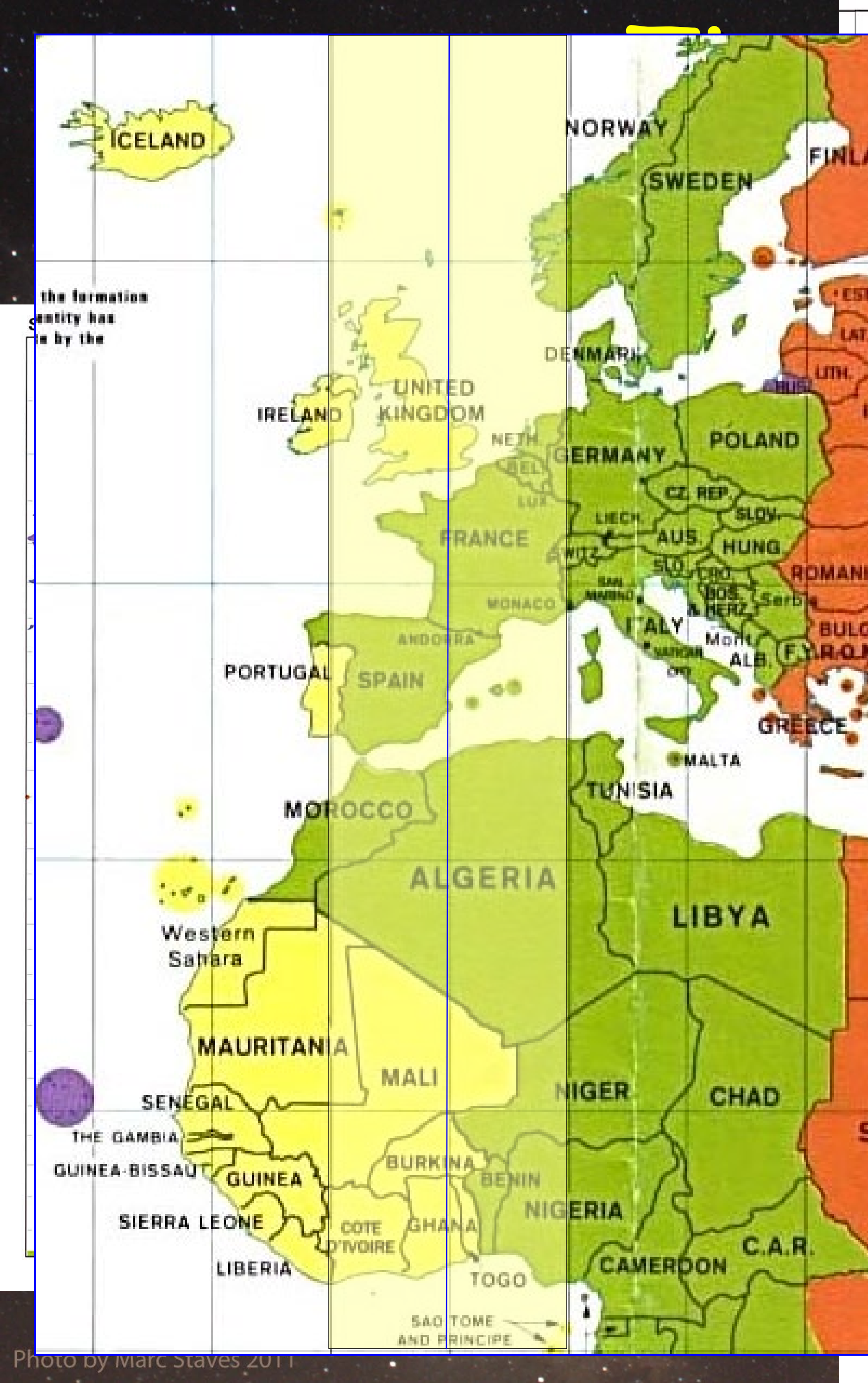
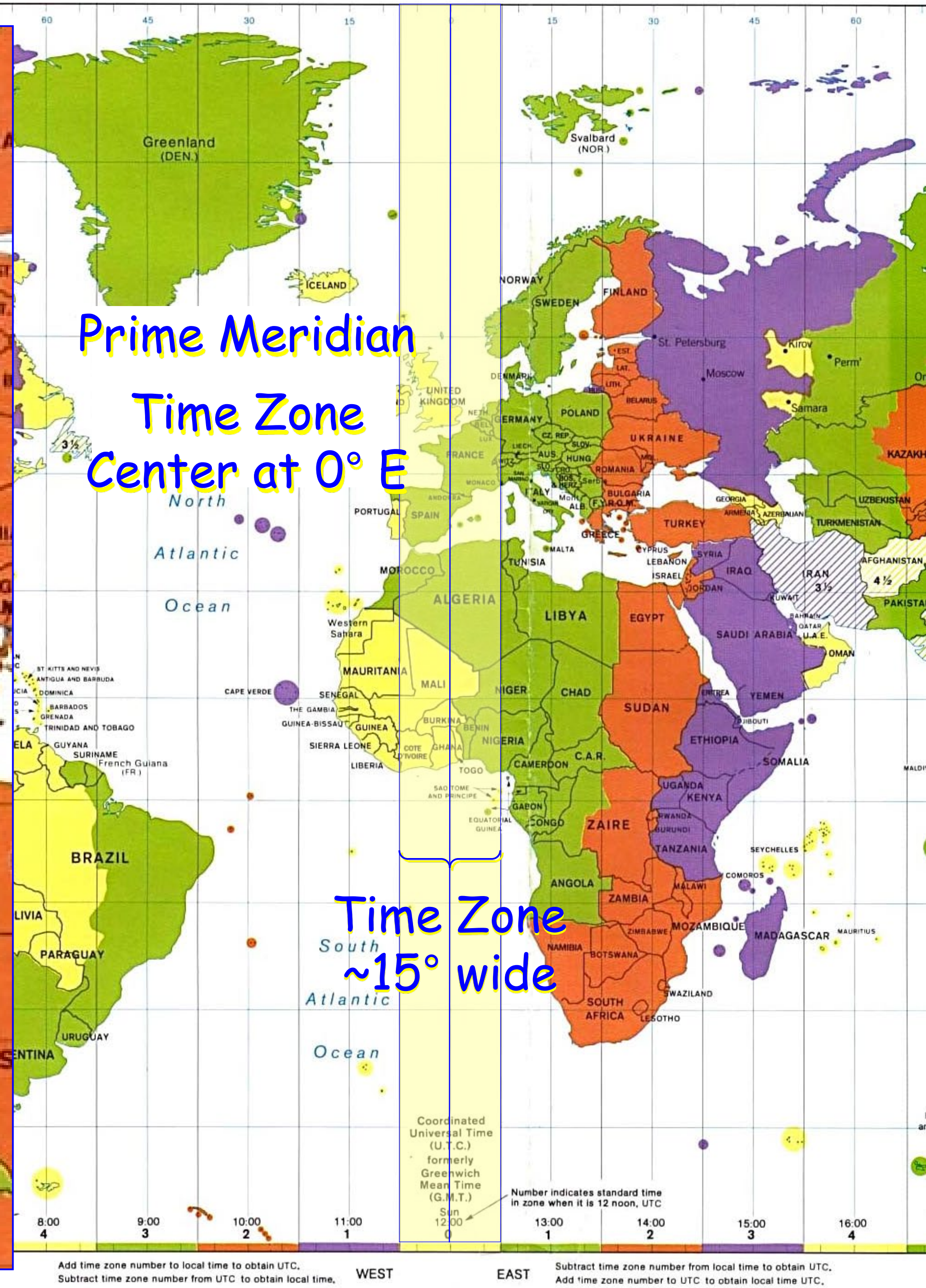
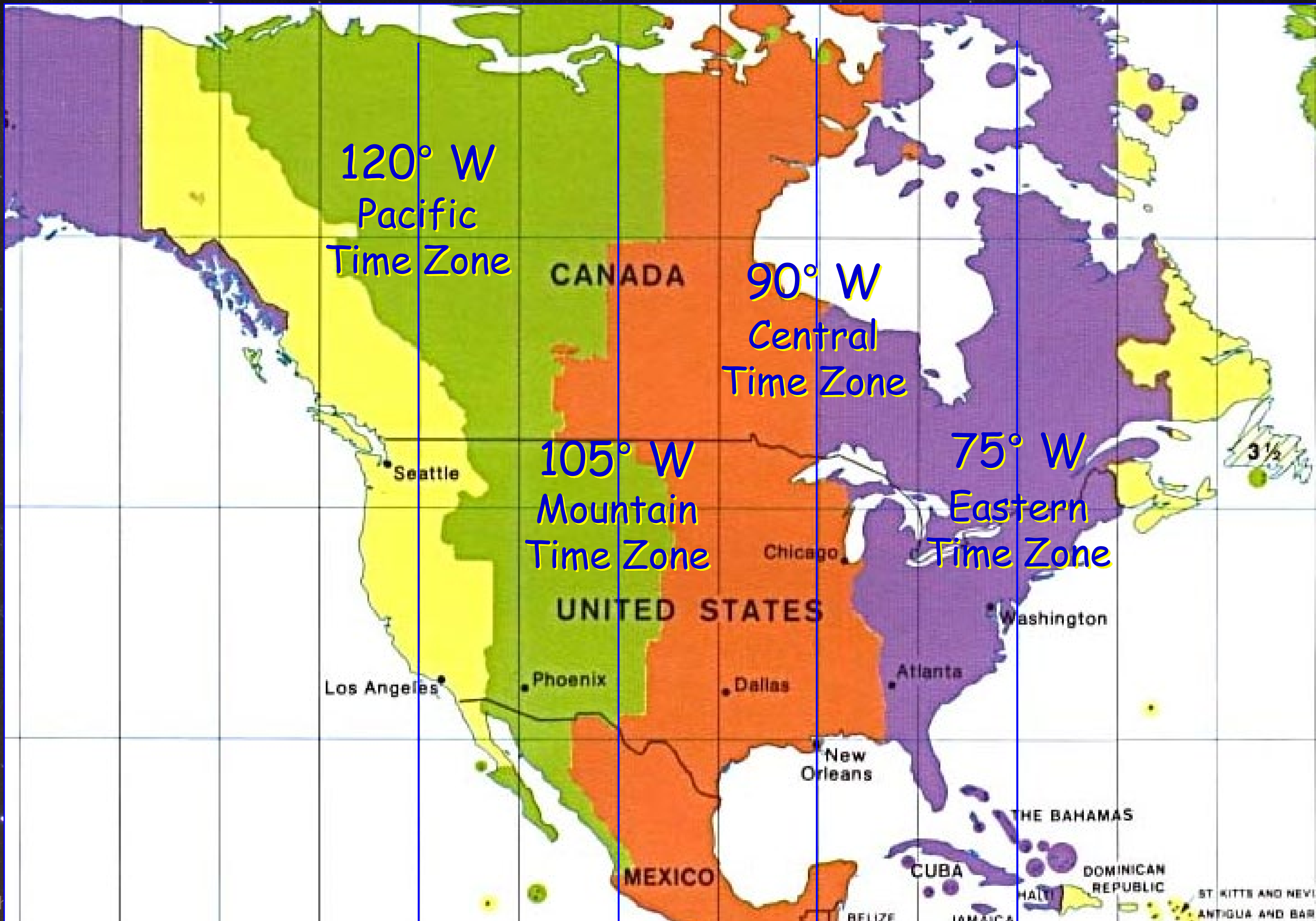

ICELAND
NORWAY
SWEDEN
DENMARK
UNITED KINGDOM
IRELAND
GERMANY
POLAND
FRANCE
PORTUGAL
SPAIN
ITALY
ROMANIA
GREECE
MALTA
TUNISIA
MOROCCO
ALGERIA
LIBYA
Western Sahara
MAURITANIA
MALI
NIGER
CHAD
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
SIERRA LEONE
LIBERIA
COTE D'IVOIRE
GHANA
TOGO
BENIN
BURKINA
NIGERIA
CAMEROON
C.A.R.
SAO TOME AND PRINCIPE
Photo by Marc Staves 2011


Prime Meridian
Time Zone
Center at 0° E
Time Zone
~15° wide
Greenland (DEN.)
Svalbard (NOR)
North Atlantic Ocean
South Atlantic Ocean
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
8:00 4
9:00 3
10:00 2
11:00 1
Sun 12:00 0
13:00 1
14:00 2
15:00 3
16:00 4
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 UTC.

North America Time Zones



Coordinated Universal Time

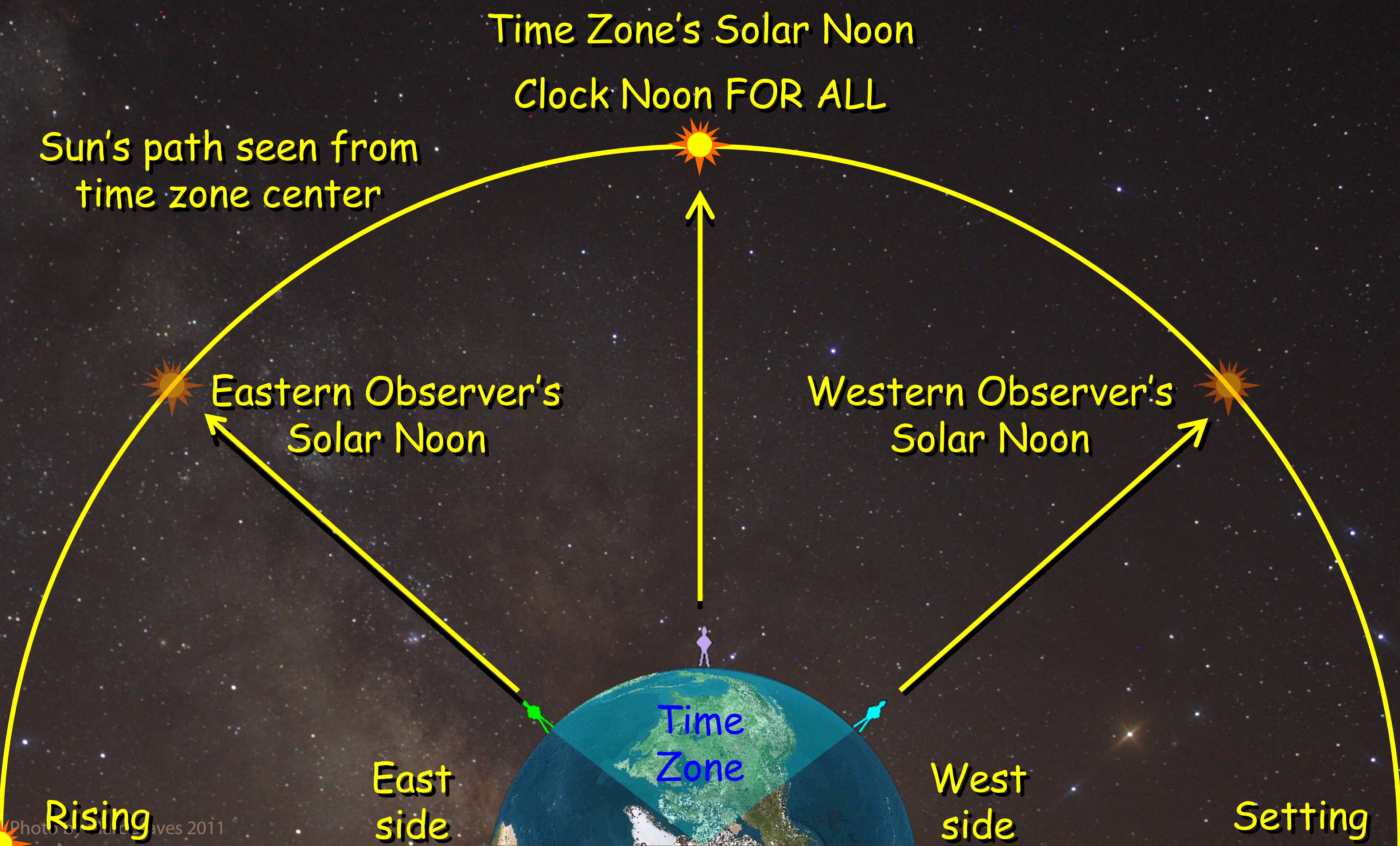
- UTC (UT or Zulu)
  - Time at Greenwich
    - no Daylight saving
- Conversion
  - EST (Eastern Standard Time) = UTC – 5hr
    - eg. 2pm (14:00) EST = 19:00 UT
  - EDT (Eastern Daylight Time) = UTC – 4hr
    - eg. 2pm (14:00) EDT = 18:00 UT

U.S. Naval Observatory

Photo by Marc Staves 2011

Solar Time vs. Clock Time

- ☆ Solar time varies across time zones



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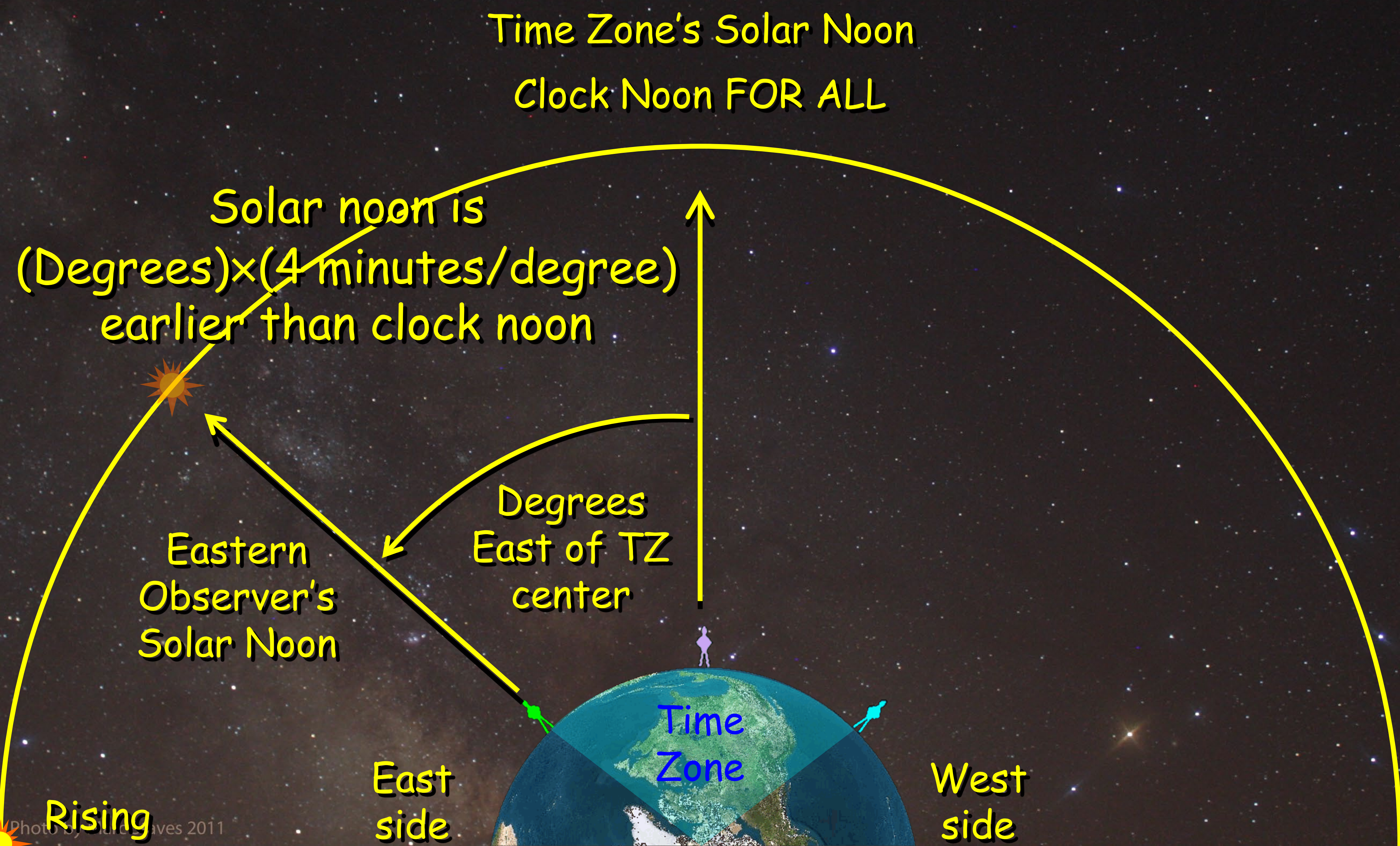
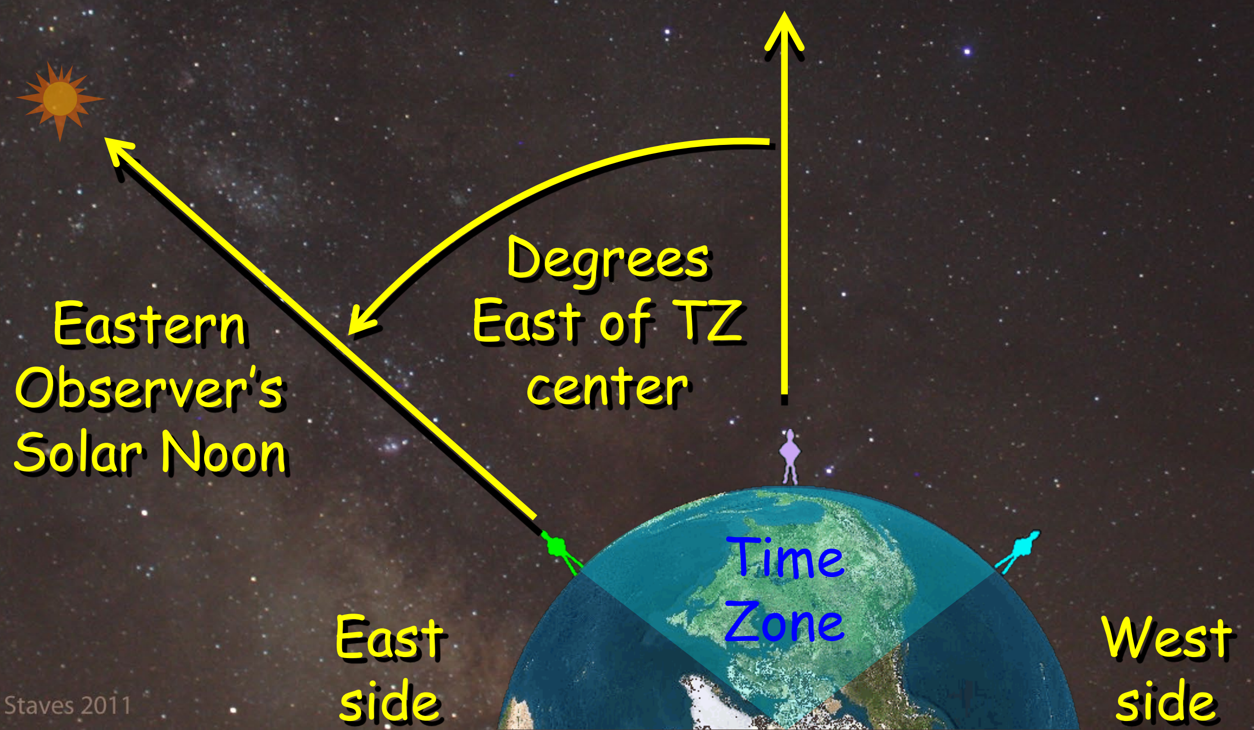


Question

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

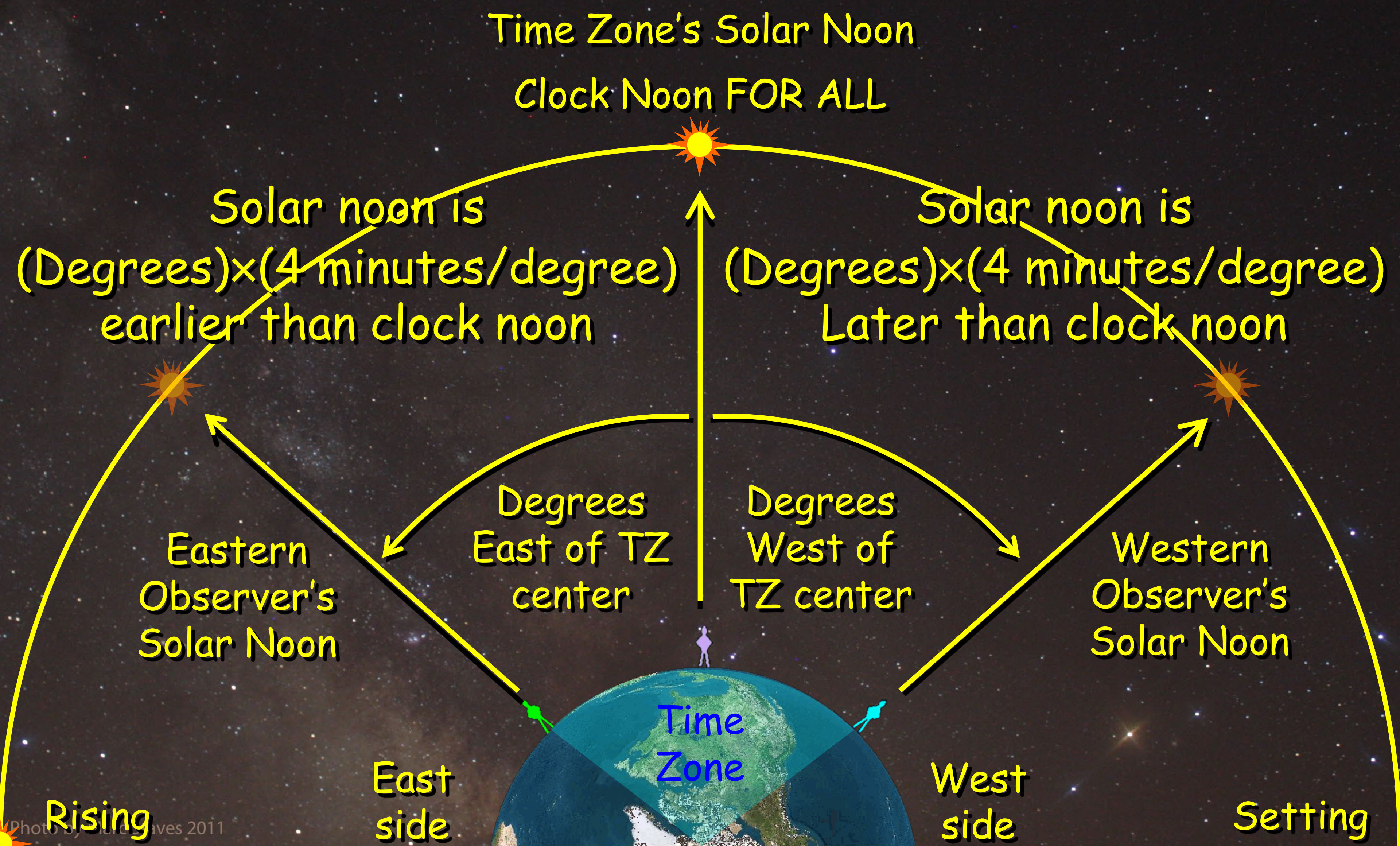
(Degrees)×(4 minutes/degree) = (5) x (4) = 20 minutes early

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

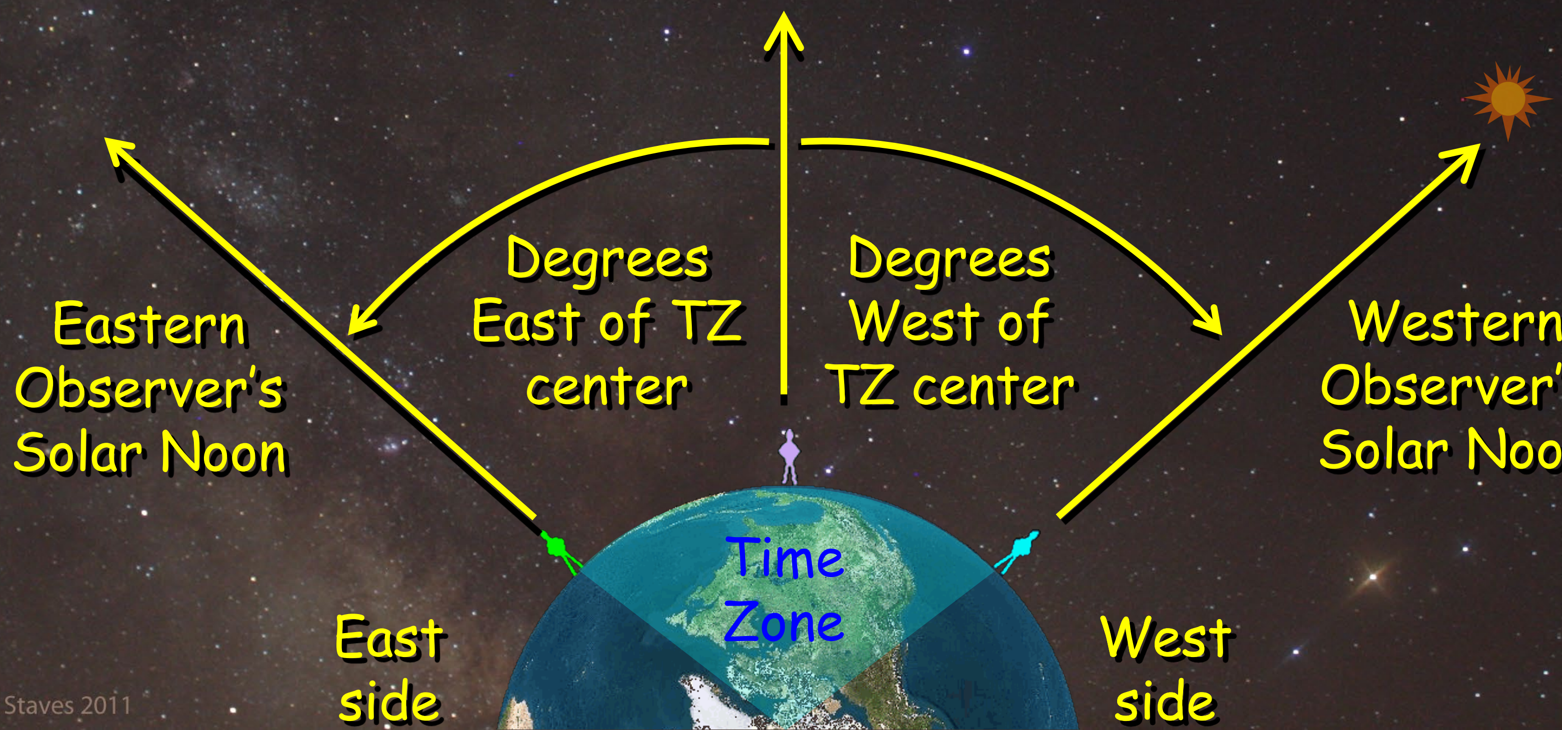
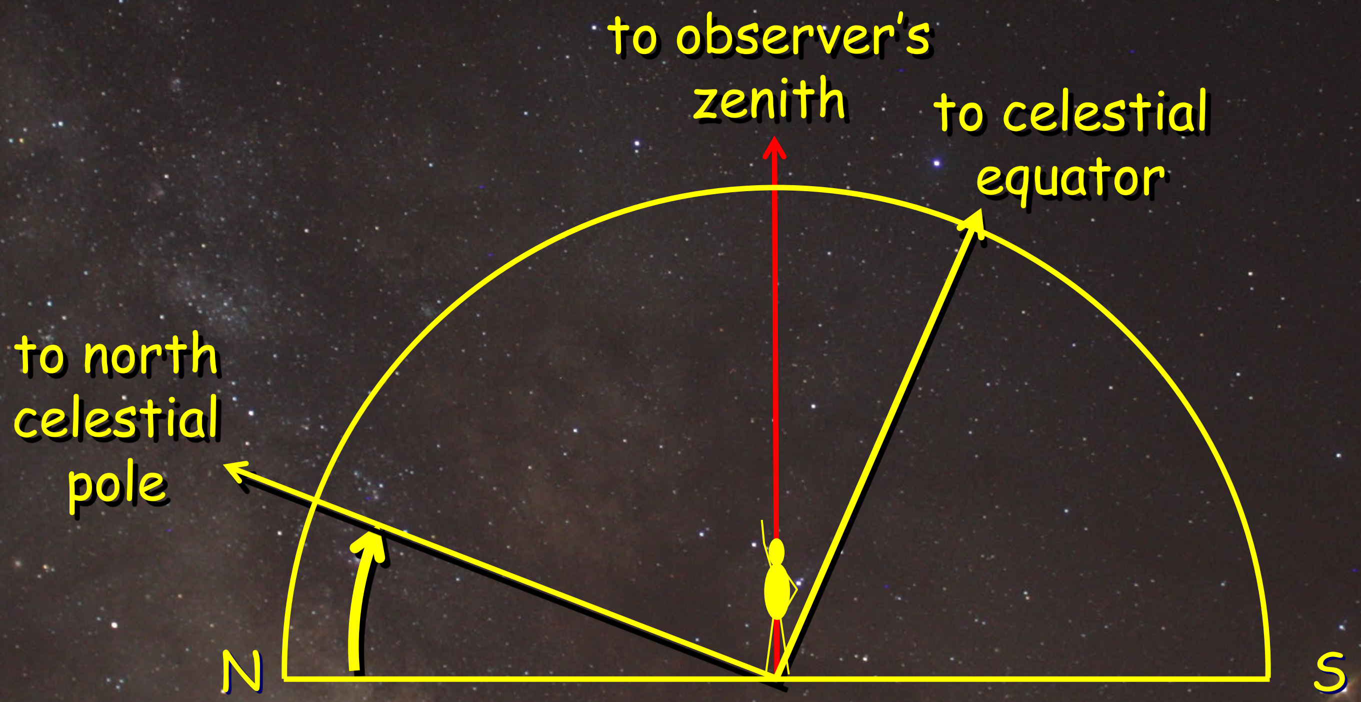


Photo by Marc Staves 2011

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

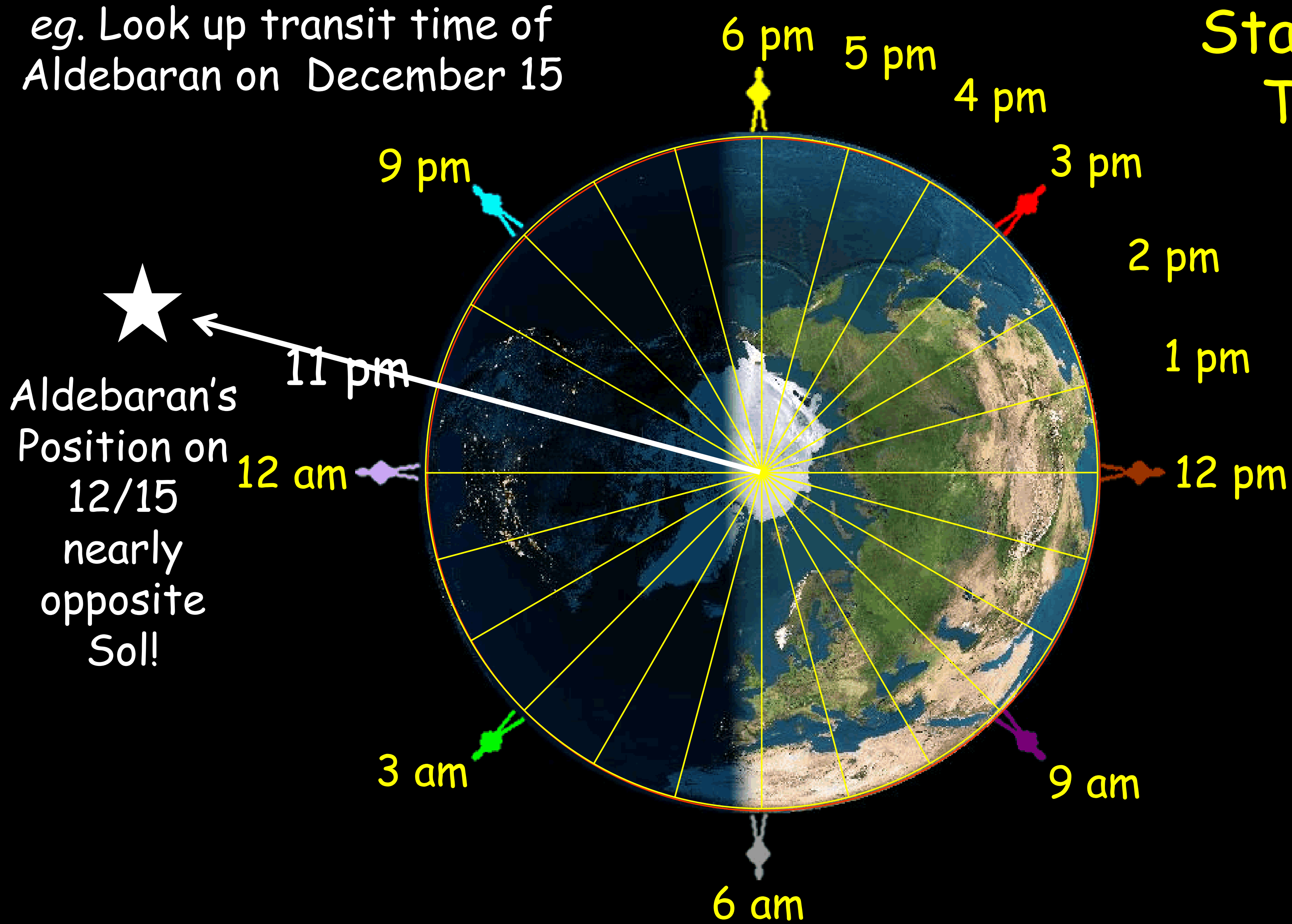
Photo by Marc Staves 2011

Star Transit Time

Gives position of star with respect to the sun

eg. Look up transit time of Aldebaran on December 15

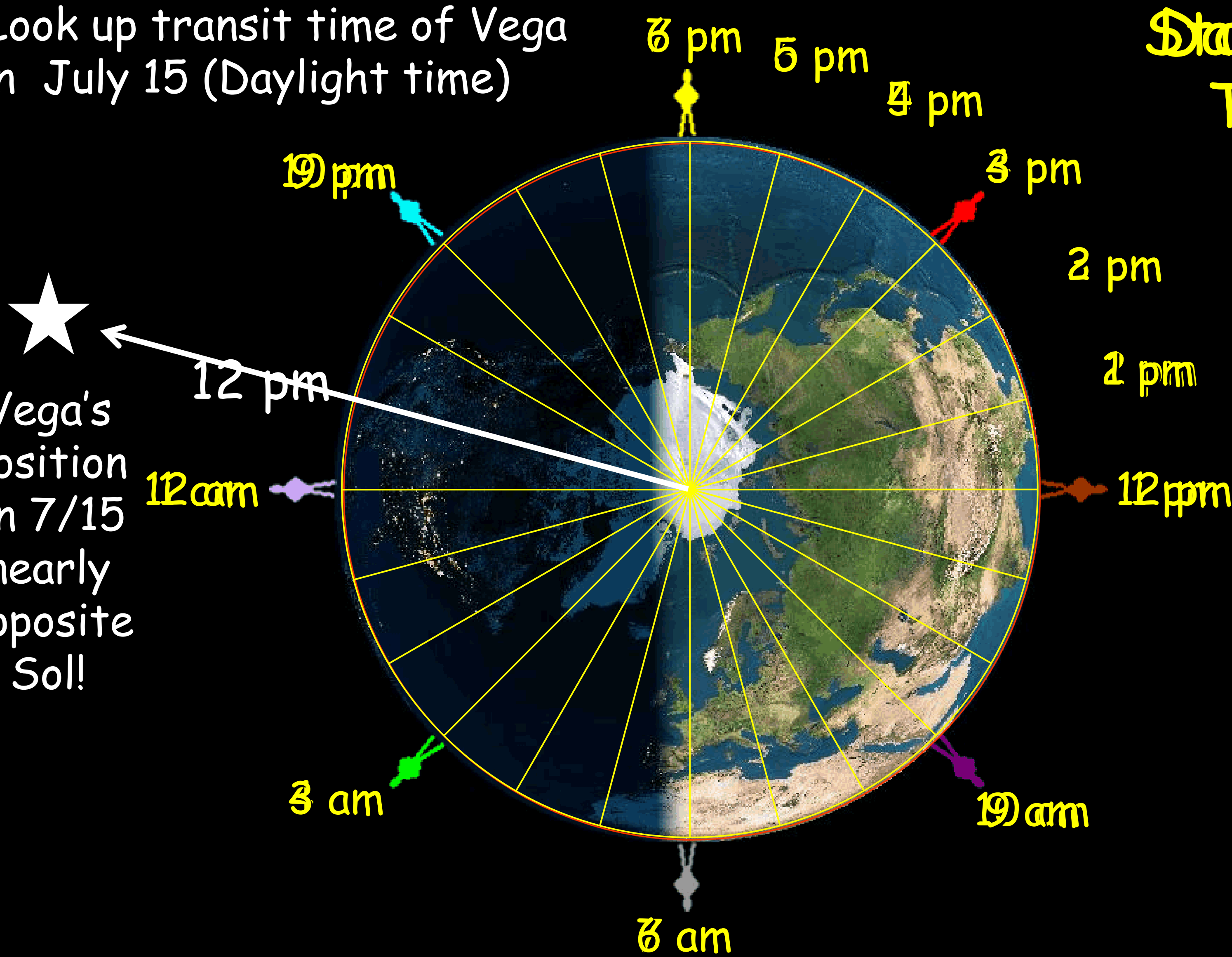
Standard Time



Star Transit Time

Gives position of star with respect to the sun

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



Vega's Position on 7/15 nearly opposite Sol!

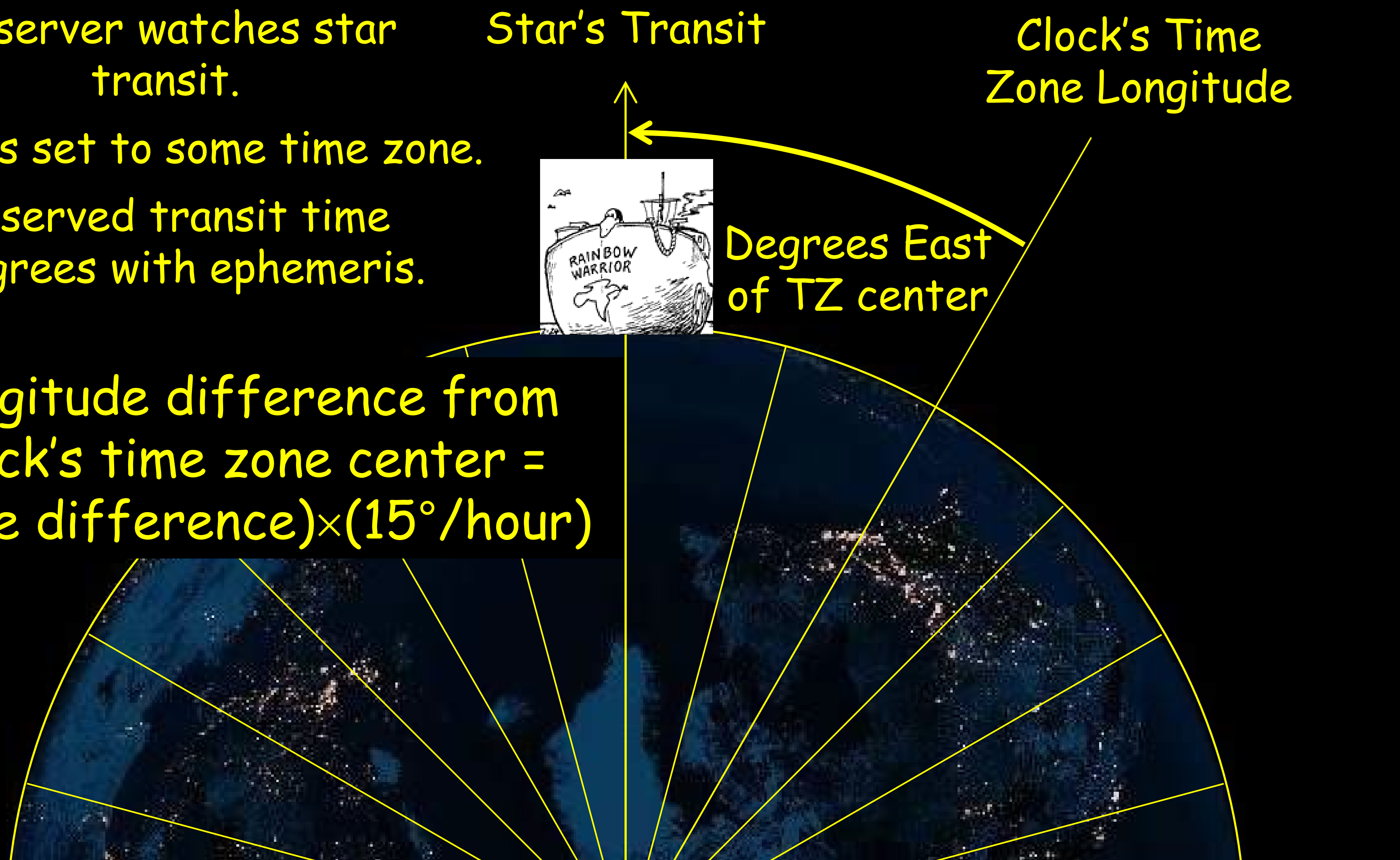
Celestial Navigation

- ☆ 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

☆ Example: Transit of Deneb on August 1

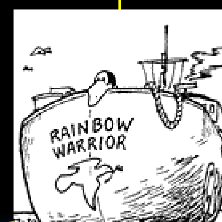
Colorado Day!

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

Navigation Challenge

- ☆ Try it on your own with handout
- ☆ See you next week!
- ☆ Slides will be available at

http://myslu.stlawu.edu/~aodo/SLU/SOAR/index.htm

Photo by Marc Staves 2011