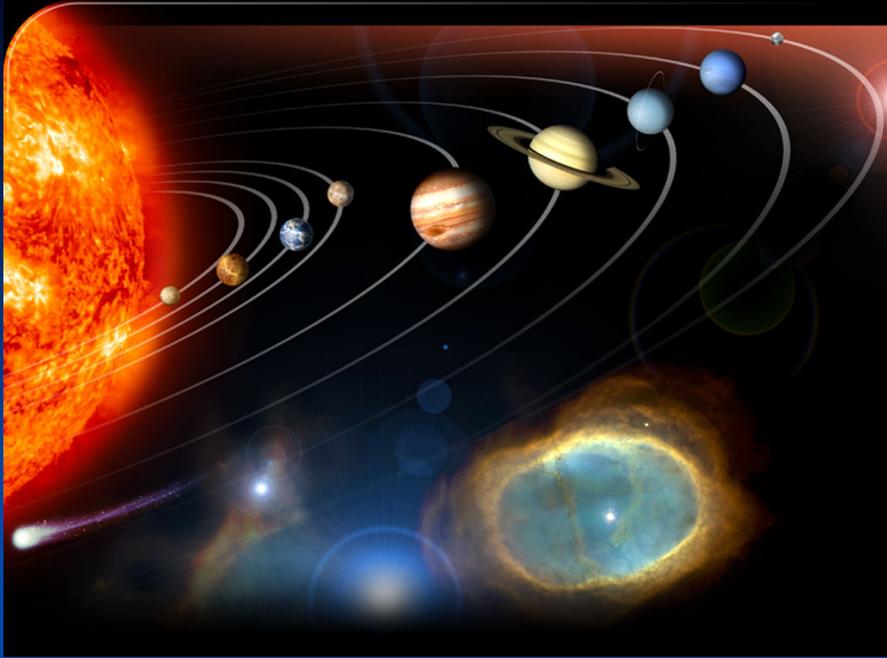


# Exploring Space

How OBSERVATIONS  
tell us about  
OUR PLACE IN SPACE  
and  
WHAT'S IN SPACE

Program by Rick Kang



# Who's Rick Kang?

- Education/Public Outreach Coordinator –  
**Oregon Astrophysics Outreach**  
visiting many classrooms in Oregon  
<http://oregonsky.org/>
- Tourguide -University of Oregon's  
**Pine Mountain Observatory**  
You can visit Fri/Sat evenings  
June-September (east of Bend)  
<http://pmo.uoregon.edu/>

# Pine Mountain Observatory



# Program

- TODAY: BIG CHANGES, EARTH' s MOTIONS
  1. Major changes we observe
  2. Earth' s place and motion in space relative to Sun

- TOMORROW: Disks, Dots, and Invisible Objects
  1. Nature of Sun and Moon
  2. Wandering Dots
  3. Bright but distant Points
  4. All the other stuff that's not so easy to see

# Some words we' ll use:

1. Apparent
2. Evidence
3. Relative
4. Spectrum

Definitions?

# Some words we' ll use:

1. **Apparent:** appears, looks like
2. **Evidence:** proof
3. **Relative:** compares to
4. **Spectrum:** range of colors, actually a range of energies of light

**What' s the MAJOR CHANGE  
about SKY  
that we observe  
every day?**

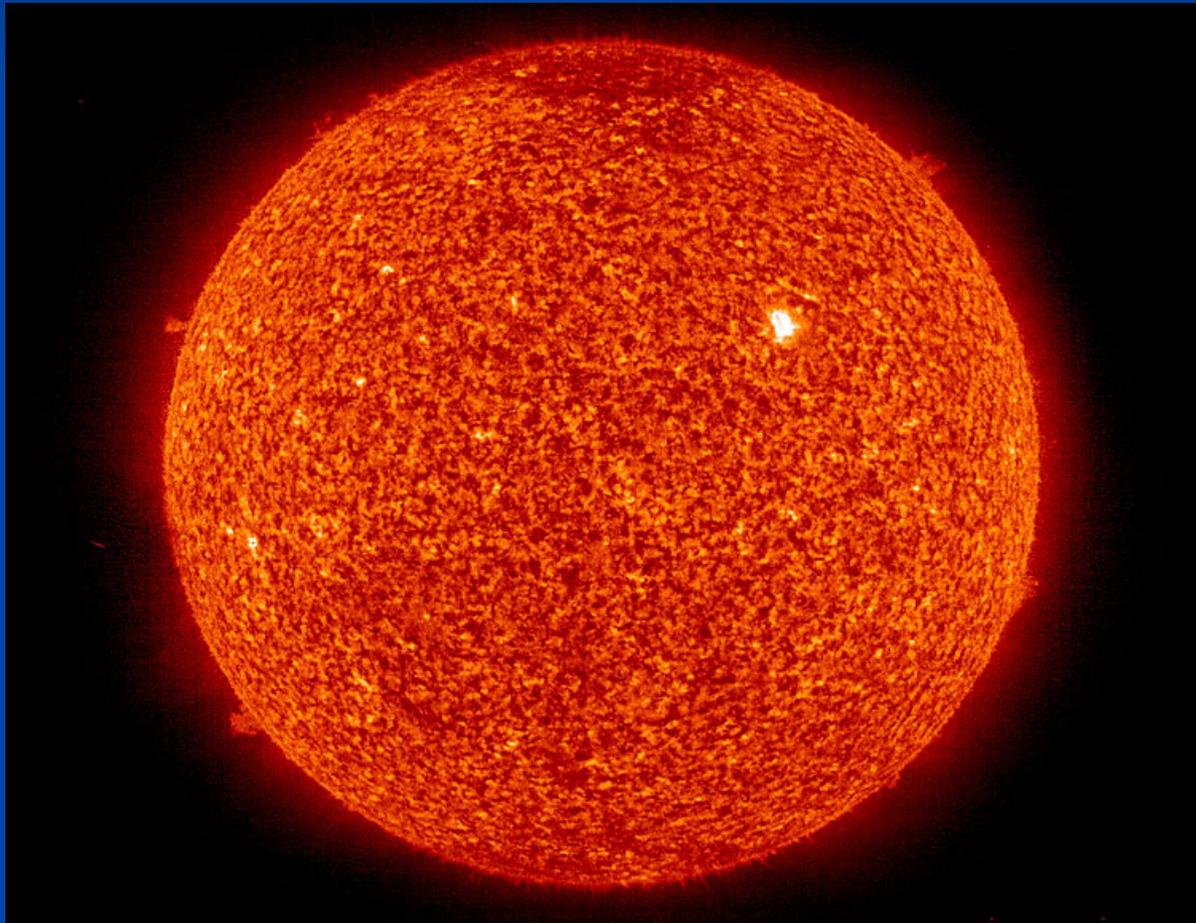
# What's the MAJOR CHANGE we observe every day?

- DAY & NIGHT



What OBJECT' s **Presence of  
Absence** causes night/day?

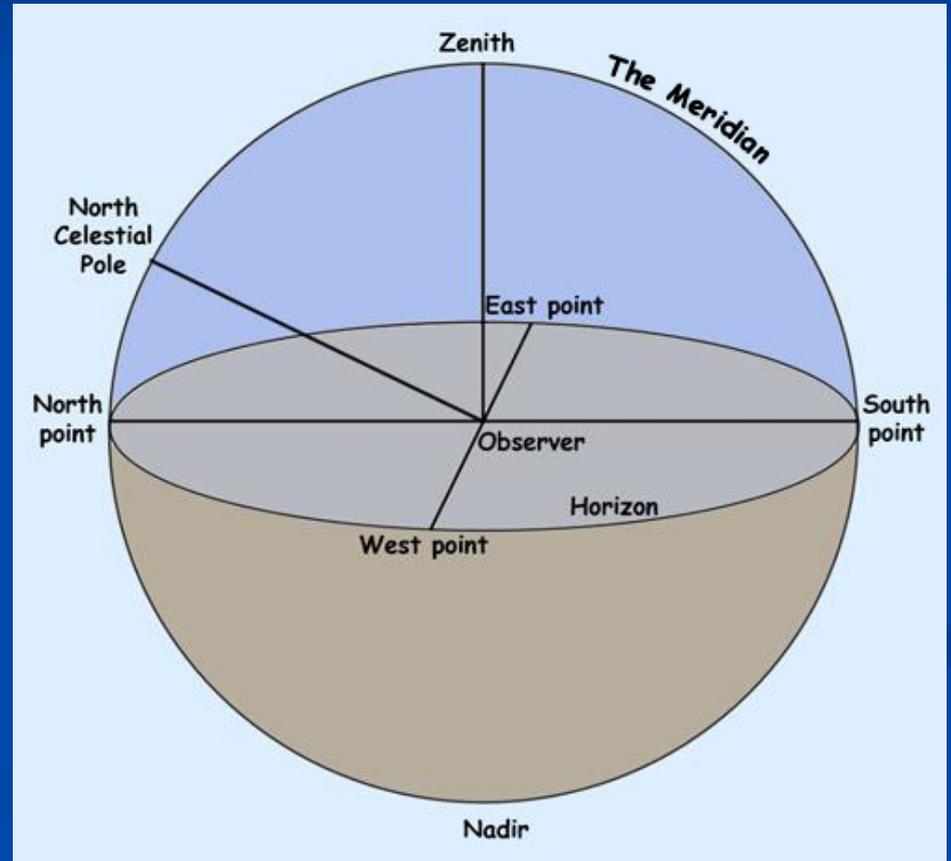
**Our home STAR, our SUN, don't  
ever look at it directly, INSTANT  
BLINDNESS!  
Details tomorrow.**

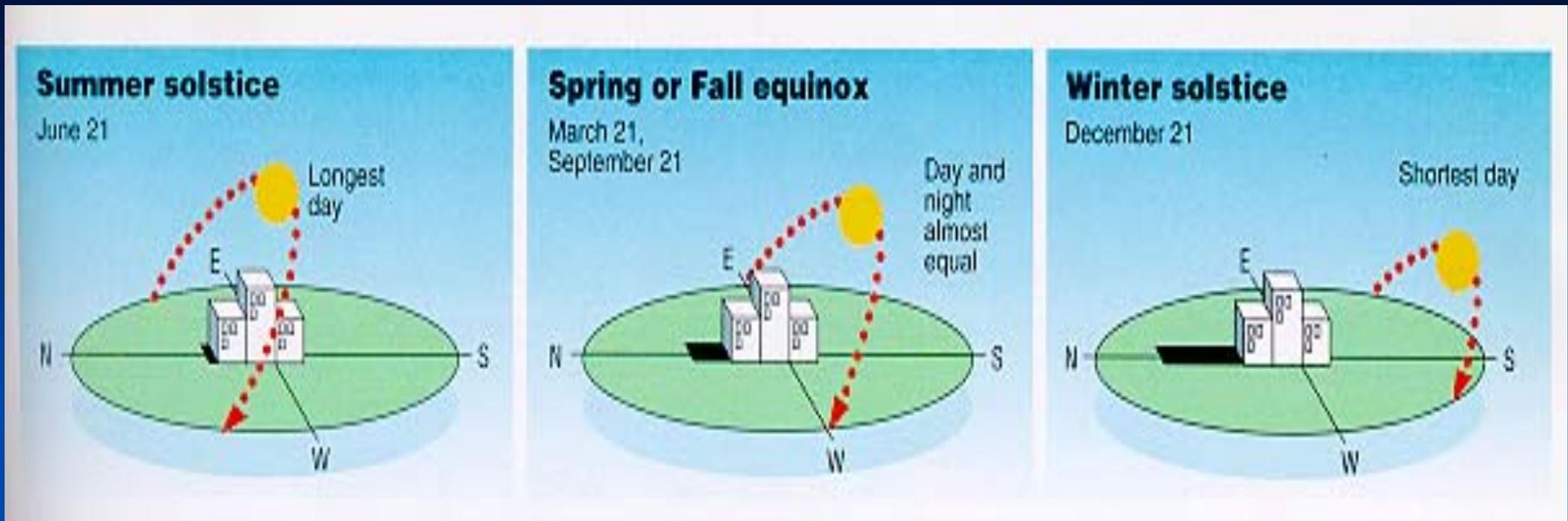


# Can you point out the APPARENT PATH of the SUN across our sky?

- Consider where (which direction-North, East, South, West the Sun RISES, where its HIGHEST point is, and which direction it SETS.

# Describe the Apparent Motion across DOME of SKY as time goes by





- Sun rises in EAST in morning, culminates (highest) in SOUTH at “HIGH NOON”, sets in WEST in evening.

**Do any other objects in sky  
behave that way (rise, transit,  
set)?**

# Do any other objects in sky behave that way (rise, transit, set)?

- Moon
- All the other Dots/Points of light
- Let's take a look using Stellarium
- download free at <http://stellarium.org/>

# Circular apparent motion

- Appears centered on POLARIS, the NORTH STAR
- Objects further from POLARIS appear to move along larger circles
- Objects whose paths are cut off by HORIZON appear to RISE and SET - see STELLARIUM again!

# Star Trails (time exposure)



# Explanation for this effect?

- Something is MOVING
- What are the CHOICES for what's moving?

# Explanation for this effect?

- Something is MOVING
- What are the CHOICES for what's moving?
  
- EITHER THE SKY, or THE EARTH
- HOW COULD WE DECIDE?

**Arguments lasted over  
thousands of years, until SPACE  
AGE**

# Arguments last over thousands of years, until SPACE AGE

- Earth shows no evidence of motion – no reason? Center?
- Constellations (star patterns) remain fixed in their patterns
- Could Earth be fooling us?
- Spacecraft provide external data.

# Conclusion: Earth ROTATES

- Spins around its **AXIS** (vertical pole through middle, extending out top and bottom (**NORTH POLE, SOUTH POLE**)).
- Relative to **SUN**, makes one spin (rotation) in 24 hours.
- Why does **POLARIS** appear as center of sky circles?

# Examples of AXIS of rotation



# Please stand, rotate **SLOWLY**

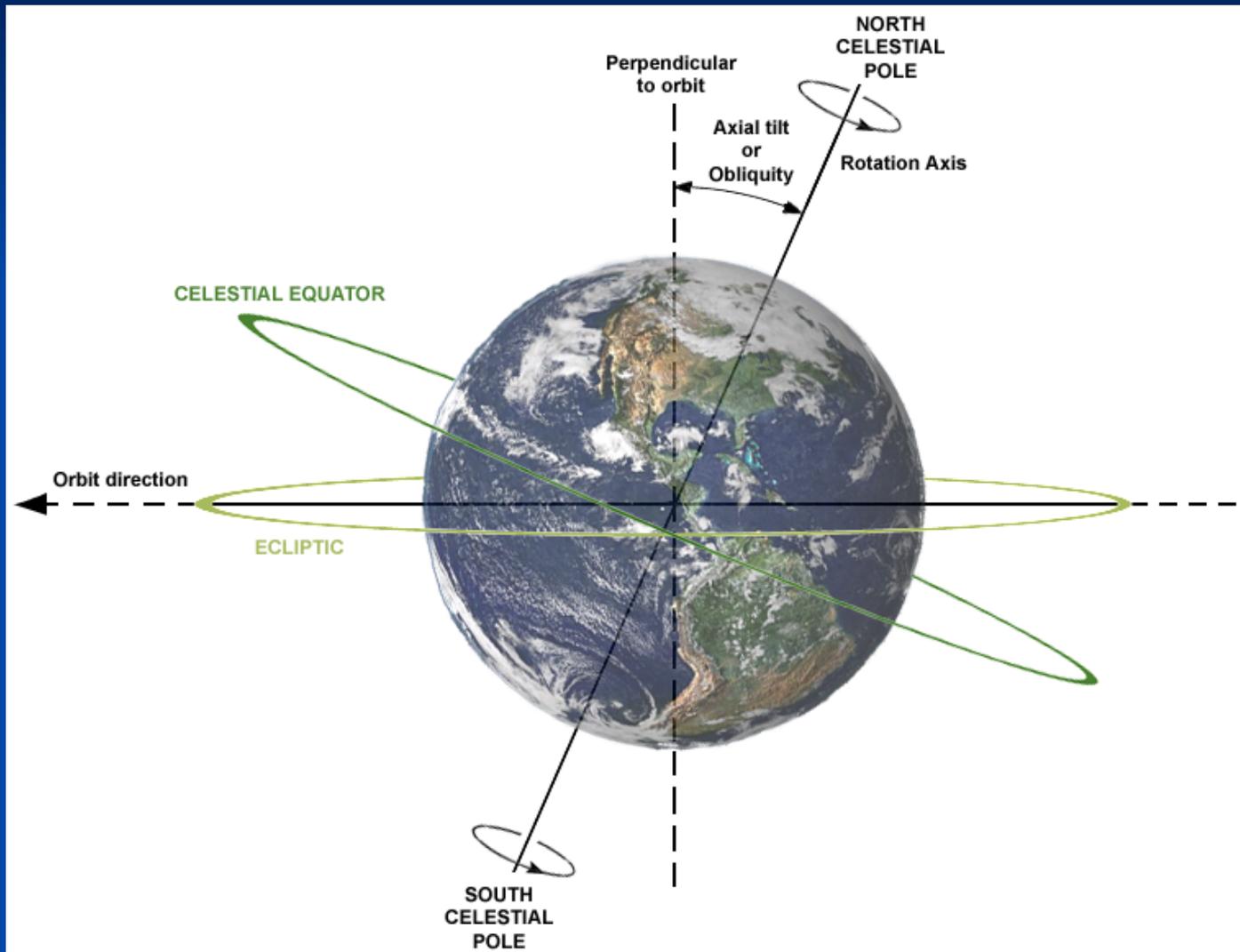
- Your head is the **EARTH**.
- Watch objects in room “**SKY**” rise and set as you **ROTATE**.
- Now, look all around you, can you find a spot somewhere in the room, as you’re **ROTATING**, that appears to **STAND STILL**? Point.
- Find a second stationary spot.
- Sit back down when you’ve found **BOTH STATIONARY SPOTS**.

**POLARIS must be located**

# POLARIS must be located

- Directly ABOVE Earth's NORTH POLE.
- Let's track Polaris in our sky as we travel South from the North Pole, why is Polaris handy for NAVIGATION?
- There's no South Pole star ☹️.

# Earth's orientation to sky



**How does sky appear to change  
from night to night?**

# How does sky appear to change from night to night?

- Constellations appear slightly to RIGHT, or WEST, at SAME TIME, NEXT NIGHT.  
(see Stellarium)
- If we observe at SAME TIME each night, that cancels the effect of Earth's ROTATION...something else must cause the nightly shift!

# Let's MODEL the shift:

- For our Earth person, she/he sees sky shift to right next night at same time, we'll let person move, but NOT ROTATE!

# Let's MODEL the shift:

- For our Earth person, she/he sees sky shift to right, person can move, but NOT ROTATE.
- Only choice: Shift/Slide to LEFT.
- Next night, again slide to left, slide night by night...
- What path should Earth take (straight line, curve, square)???

# Why a curved path? How do we know we ORBIT around the Sun?

- If our path is circular, by definition, CIRCLES have uniform RADIUS (distance from center to rim).
- Can we measure Solar distance without leaving Earth?
- Look around at various students sitting in room, how do they differ depending on distance from you?

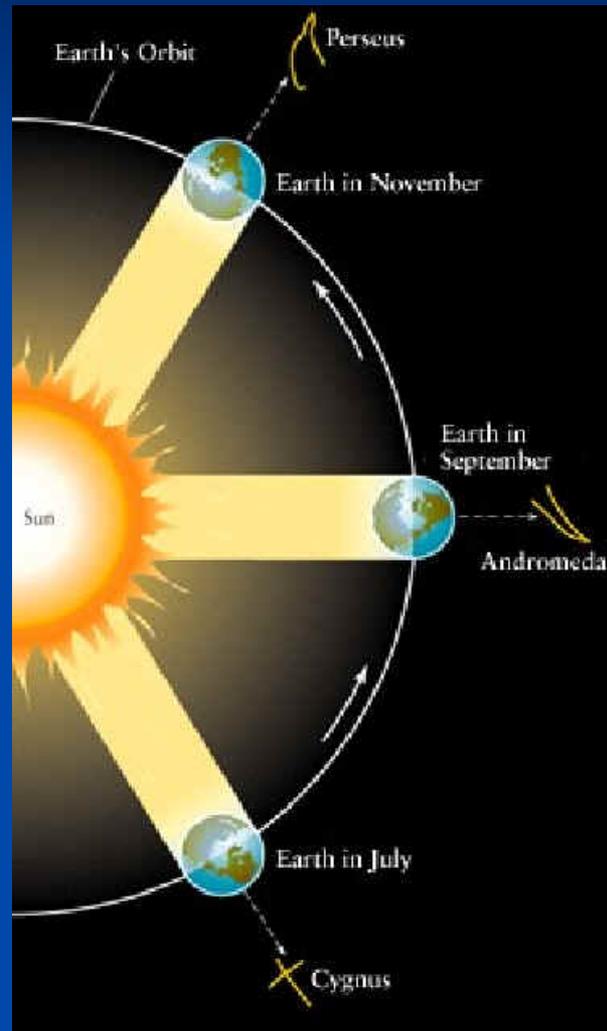
# Apparent SIZE!

- Let's CAREFULLY take photos of Sun, THROUGH SPECIAL FILTER.
- Results: Solar Diameter appears pretty much the same throughout a YEAR (actually slightly smaller in Summer, larger in Winter!!!-we'll discuss that if we have time).
- So, if Diameter (Distance) remains almost CONSTANT, we must travel in a CIRCULAR orbit (technically an ELLIPSE).

# Other evidence of Orbit:

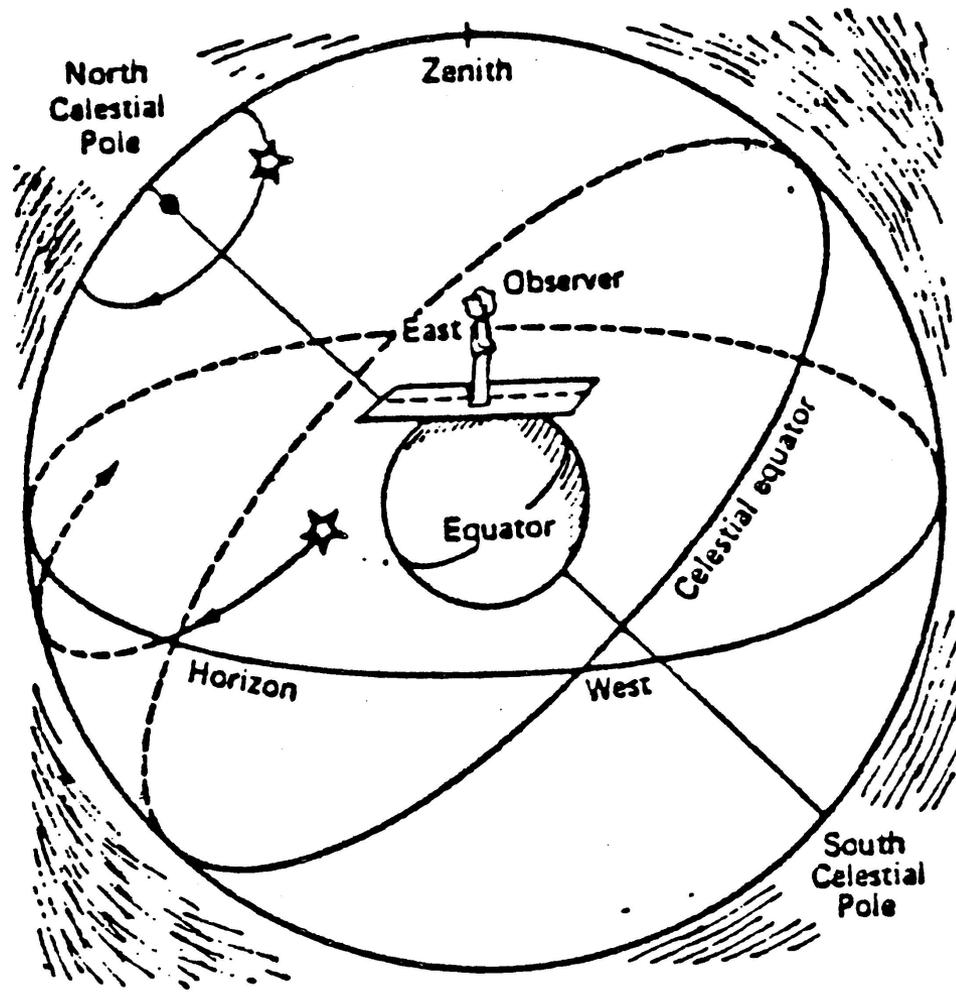
- Sky appears shifted each night.
- WE RETURN TO SAME SKY ANNUALLY (YEARLY).
- We must be in an orbital CYCLE (REPEATS).
  
- How many times have you orbited the Sun?

# Constellations appear to shift as we ORBIT Sun



# Summary for TODAY:

- Apparent Solar motion/presence causes Day and Night
- Sun rises in East, transits to South for us in USA, highest in South at local noon, but never gets overhead, sets in West.
- All other objects beyond our atmosphere also rise, transit, set, actually appear to circle around Polaris (North Star)
- This is actually because Earth rotates (spins) around AXIS that points at Polaris.
- Sky appears to shift West/Right slightly each night observed at SAME HOUR/MINUTE.
- This CYCLICAL ANNUAL SHIFT is due to Earth's ORBITAL MOTION, moving around the SUN, one orbit relative to the background sky each year.



**Figure 3-18** The celestial sphere, as seen from the outside.