Exploring Space

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

Program by Rick Kang
Who’s Rick Kang?

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  visiting many classrooms in Oregon

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  [http://pmo.uoregon.edu/](http://pmo.uoregon.edu/)
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/](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!
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
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- 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

- Vertical Axis
- Horizontal Axis

Skater

Earth: Axis 23.5° Angle

To the Sun

Log: Horizontal Axis
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.