ASTR 105
Intro Astronomy:
The Solar System

In-class group projects starting today
Apparent Motions of Stars on the Sky

View from north pole

View from Equator

View from generic location
What would the sky look like from the North Pole (at night)?

A. All stars would be circumpolar
B. No stars would be circumpolar (everything would rise and set)
C. Exactly the same as from Stony Brook.
D. Some circumpolar stars, some normal; but would be different stars than Stony Brook.
E. There would be a big guy in a red suit flying all over the place.
Clicker Question

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If the North Star (Polaris) is 40° above your horizon, due north, where are you?

A. You are on the equator.
B. You are at latitude 40°S.
C. You are at latitude 50°N.
D. You are at longitude 50°E.
E. You are at latitude 40°N
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Latitude

Boulder is 40° N
North Star - Polaris

North
Latitude
South

At North Pole
Latitude = 90°

At Equator
Latitude = 0°

To measure latitude:
Measure angle between Polaris and the horizon
Clicker Question

At 9pm (PST) in San Francisco (38° N, 122° W) how does the sky compare to 9pm (EST) in Washington D.C. (38° N, 77° W)

A. Polaris (the north star) is higher in the sky
B. Polaris (the north star) is lower in the sky
C. Polaris would be at the same height, but the same stars would be much further west (i.e. closer to setting)
D. Polaris would be at the same height, but the same stars would be much further east (i.e. closer to rising)
E. The sky would look the same.
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So far, everything we’ve been talking about is **Daily Motion**

- Rising, setting, changing positions over a few hours...
Annual Motion – Apparent

- The Sun appears to move (along the ecliptic) a little bit each day
  - This is the origin of zodiac symbols

- People usually talk about what constellation the Sun is “in”
  - Referring to the constellation that the Sun is in front of (if we could see the stars during the day)
Annual Motions - Actual

Actual motion = Earth orbits the Sun.

Plane of orbit = **ecliptic**

Tilted orbit = **different heights**
How does the orientation of Earth’s axis change with time?

• Although the axis seems fixed on human time scales, it actually precesses over about 26,000 years.
  ⇒ Polaris won’t always be the North Star.
  ⇒ Dates associated with zodiac constellations also shift (i.e. your sign is wrong!)

Earth’s axis precesses like the axis of a spinning top
Clicker Question

What is precession?

A. The path that the Earth orbits around the Sun.
B. The gradual change of the Earth’s axis in space.
C. The apparent movement of the stars due to the Earth's rotation.
D. The reverse movement of the planets due to the Earth's orbit around the Sun.
E. The actual path of the planets in their orbit around the Sun.
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Clicker Question

Which way will stars appear to circle the South Celestial Pole from Tasmania (40º S) when looking South?

A. Clockwise
B. Counter-clockwise
C. It depends on the season
D. There is no south celestial pole so there will be no circumpolar stars.
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Do the planets reverse course?

- Planets usually move slightly eastward from night to night (not in the course of one night!!) relative to the stars.
- But sometimes they go westward relative to the stars for a few weeks: apparent retrograde motion.
We see apparent retrograde motion when we pass by a planet in its orbit.
Explaining Apparent Retrograde Motion

• Easy for us to explain: occurs when we “lap” another planet (or when Mercury or Venus laps us)

• But very difficult to explain if you think that Earth is the center of the universe!

• In fact, ancients considered but rejected the correct explanation
The Reason for the Seasons
Some common MISCONCEPTIONS:

CLOSER means MORE, right?
CLOSER means MORE right?

• Heat
  - The closer you are the hotter it is
CLOSER means MORE right?

- **Heat**
  - The closer you are, the hotter it is

- **Sound**
  - The closer you get, the louder it is
CLOSER means MORE right?

- **Heat**
  - The closer you are, the hotter it is

- **Sound**
  - The closer you get, the louder it is

- **Light**
  - The closer you get, the brighter it is
Complete this statement by following previous logic

When the Sun is ________, it is summer; and when the Sun is ________, it is winter.
Complete this statement by following previous logic

When the Sun is **CLOSER**, it is summer; and when the Sun is **FARTHER**, it is winter.
The REAL Reason for the Seasons
The REAL Reason for the Seasons
Sun’s altitude APPEARS to change throughout the year.

Sun’s position at noon in summer: higher altitude

Sun’s position at noon in winter: lower altitude
When the Sun is high in the sky, the amount of direct sunlight received is greater. This results in **SUMMER**
When the Sun is low in the sky, the amount of direct sunlight received is less. This results in WINTER.
When the Sun is high in the sky, the amount of direct sunlight received is greater. This results in **SUMMER**.

When the Sun is low in the sky, the amount of direct sunlight received is less. This results in **WINTER**.
How do we mark the progression of the seasons?

- We define four special points in our orbit (dates):
  - Summer solstice (June 21)
  - Winter solstice (December 21)
  - Spring (vernal) equinox (Mar 21)
  - Fall (autumnal) equinox (Sep 22)

- Northern hemisphere tilted towards the Sun
- Northern hemisphere tilted away from the Sun
- North and South: equal distance from the Sun
- Not to scale!
Why *doesn’t* distance matter?

- **Variation of Earth-Sun distance is small!**
  - about 3%
  - this small variation is overwhelmed by the effects of axis tilt, water distribution, and orbital speed.

*Summer Solstice at the Arctic Circle*
We can recognize solstices and equinoxes by Sun’s path across sky:

**Summer solstice:**
Highest path, rise and set at most extreme north of due east.

**Winter solstice:**
Lowest path, rise and set at most extreme south of due east.

**Equinoxes:** Sun rises precisely due east and sets precisely due west.
Summary: The Real Reason for Seasons

- Earth’s axis points in the same direction (to Polaris) all year round, so its orientation relative to the Sun changes as Earth orbits the Sun.
- Summer occurs in your hemisphere when sunlight hits it more directly; winter occurs when the sunlight is less direct.
- AXIAL TILT is the key to the seasons; without it, we would not have seasons on Earth.
a) Two students argue: John claims that these figures are correct, Jane claims that they are not. Who is right and why?

b) This image to the left shows the path of the Sun in the Northern Hemisphere. Draw the corresponding image for the Southern Hemisphere.

c) The image to the left shows a configuration in which the Sun is never to the zenith. Are there locations on Earth at which the Sun reaches the Zenith? If so, at what latitudes are they? At which time of the year do they reach the zenith? [hint: remember the tilt angle of the spin axis of the Earth].

d) Saturn is presently at a distance of about 10 AU from the Earth. How long does it take a radio signal from the Cassini spacecraft to reach the mission control center in California? Radio waves travel at the speed of light, which is $3 \times 10^5$ km/s. 1 AU is $1.5 \times 10^8$ km.