The seasons

Astronomy 101
Syracuse University, Fall 2017
Walter Freeman

September 11, 2017

Winter is coming.

—Watchwords of House Stark
(*A Song of Ice and Fire*, George R. R. Martin)

Winter is coming.

—Syracusians, as we buy snow tires and 50 pound bags of salt

Announcements

- I am behind answering email
- I should have all emails answered by noon tomorrow
- No help session next Friday (I'm out of town)

Ask the physicist: black holes?

Finishing from last time

Did you finish Lecture Tutorials pp. 11-12 (solar/sidereal day?)

A: Yes
B: Mostly
C: No

Finishing from last time

Did you finish Lecture Tutorials pp. 12-15 (ecliptic, parts 1-2)?

A: Yes
B: Mostly
C: No

What is one incorrect explanation for why we have summer and winter?

A popular misconception is that the distance of the Earth compared to the Sun defines the season. The Earth revolves around the Sun at nearly the same distance from the Sun, so this explanation does not make sense.

–Zach

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Because earth is farther from the sun in winter, and closer to the sun in summer. [We know this isn't right because] The sun does not get any larger or smaller during these seasons.

–Doug

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Hades, the ancient Greek god of the underworld, kidnapped/seduced Persephone, the goddess of springtime. After many shenanigans involving a pomegranate and the deaths of many humans, Zeus, king of the gods, decreed that Persephone would spend half the year in the underworld with Hades, who was now her husband. During this half of the year, the earth would be left barren and cold, thus accounting for the winter months. The other half of the year, Persephone would return to the earth's surface and rejuvenate it, bringing about summertime.
In this day and age, I wouldn't really have to try too hard to convince them that this story isn't real. I'd point out that there is actually no factual evidence to show the existence of Ancient Greek deities, and would remind them that the sun is a flaming orb of hydrogen rather than a dude in a chariot.

–Rachel

Because the sun is farther from us in the winter than in the summer... [We know this isn't right because,] If the seasons depend on the distance, the whole Earth should experience the same season [at] the same time. However, the seasons in the southern hemisphere are different from the seasons in the northern hemisphere.

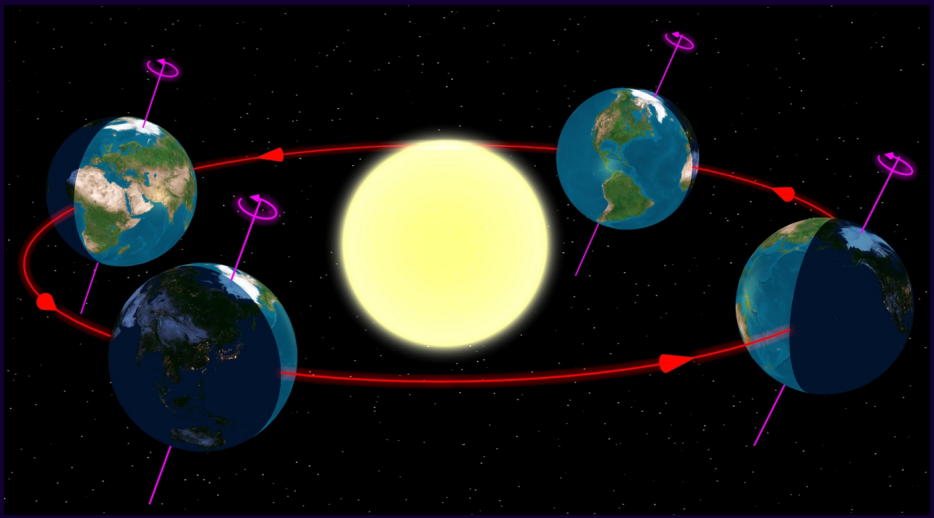
–Anna

The tilt of the Earth's axis

The Earth's axis of rotation is not lined up with its orbital axis.

It's tilted by 23.4 degrees.

The axis of rotation changes only very slowly (over millennia).



Let's look at this in animations

- My cartoon
- On *Celestia*

What consequences does this have for the sky?

As the year progresses, thinking only about noon, will the Sun:

I. Move higher and lower in the sky
II. Move east/west relative to the stars

A: I only
B: II only
C: I and II
D: None of the above

A demonstration in Stellarium

Let's use *Stellarium* to examine the Sun at different times of year.

Notice:

- The Sun is higher or lower in the sky depending on the time of year
- The Sun moves westward with respect to the stars:
  - Every *solar day*, the Sun's east/west position (azimuth) stays fixed, but the stars move East
  - Every *sidereal day*, the stars' position stays fixed, but the Sun moves West

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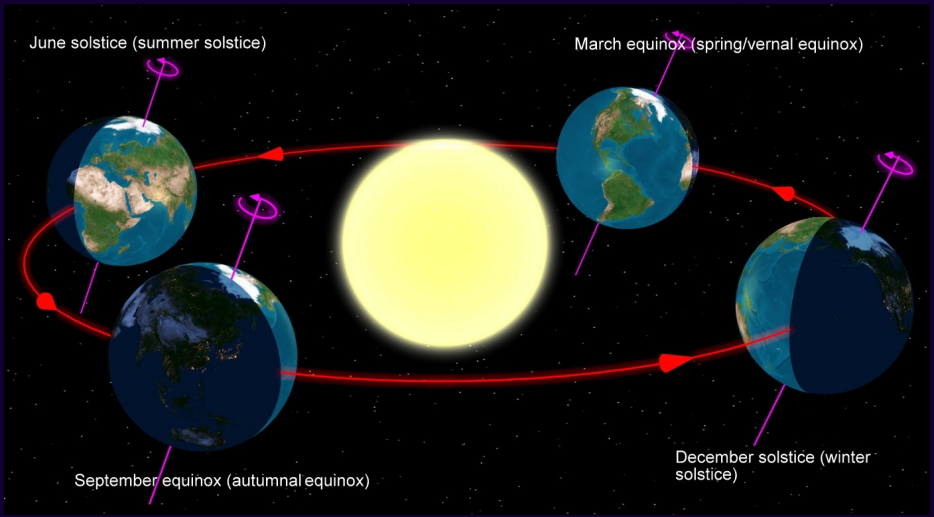
  - Every *sidereal day*, the stars' position stays fixed, but the Sun moves West
  - "One solar day is a bit more than one sidereal day"
  - "One sidereal day is a bit less than one solar day"

The solstices and equinoxes

We give special names to the points in Earth's orbit where the Earth's axis is tilted directly toward/away from the Sun:

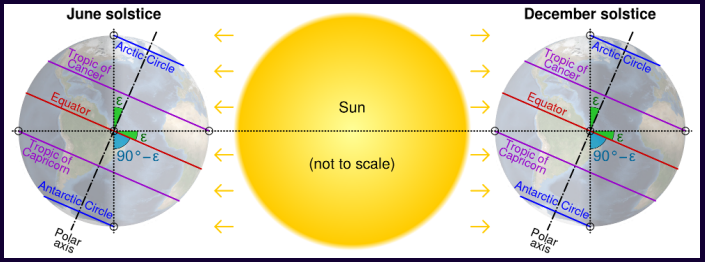


The solstices and equinoxes

Many cultures have ascribed significance to the annual movement of the Sun.

Perhaps the most famous artifact of this is Stonehenge:

The tropics

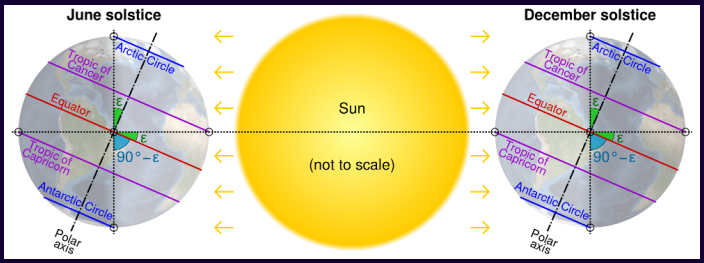


The region on Earth where the Sun alternates between the northern sky and the southern sky is called the tropics.

- The northern boundary is called the Tropic of Cancer
- The southern boundary is called the Tropic of Capricorn
- These occur at 23.4° N/S latitude

On the June solstice, the sun reaches the zenith along the Tropic of Cancer.
On the December solstice, the sun reaches the zenith along the Tropic of Capricorn.

The Arctic and Antarctic



The region where the sun either never rises or never sets during part of the year is called the Arctic (north) or Antarctic (south).

- North of the Arctic Circle, the sun never rises on the December solstice, and never sets on the June solstice.
- South of the Antarctic Circle, the sun never sets on the December solstice, and never rises on the June solstice.
- These occur at $90 - 23.4^\circ = 66.6$ N/S latitude

What consequences does this have on Earth?

Thinking only about noontime (when the sun is highest in the sky), will the sun ever reach the zenith in Syracuse (latitude 43° N)?

A: Yes
B: No

What consequences does this have on Earth?

Thinking only about noontime (when the sun is highest in the sky), will the sun ever reach the zenith in Lima, Peru (latitude 12° S)?

A: Yes
B: No

What consequences does this have on Earth?

Which is true about the Sun on June 21 in Svalbard (latitude 78° N)?

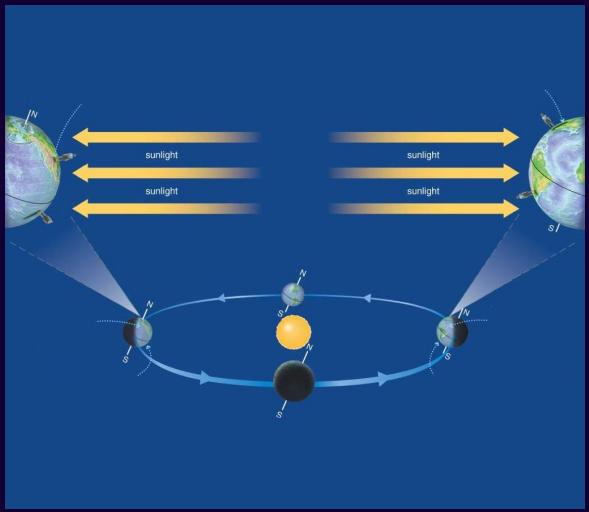
A: It will never rise
B: It will never set
C: It will reach the zenith of the sky
D: It will travel from east to west in the northern sky
E: It will travel from east to west in the southern sky

The seasons

The tilt of the Earth toward/away from the Sun controls the amount of sunlight we get at different times of year!

This happens for two important reasons. Thinking about the Northern hemisphere...

- The Sun is visible in the sky for longer in June than in December
- Sunlight strikes the Earth more directly in June than in December



Complete Lecture Tutorials pp. 93-98.

The seasons

This is why the Earth is hotter in summer.
It has nothing to do with the distance from the Sun!

Exit question

What if the Earth's axial tilt were increased to 30° from 23°?

A: Syracuse would have hotter summers
B: Syracuse would have colder winters
C: More of Earth would be in the tropics
D: More of Earth would be in the arctic
E: Another Stark would meet a bad end

Discuss the answer with your neighbors, then write a short explanation down, along with your NetID or SUID and name, and turn it in on your way out. *There may be more than one answer!*