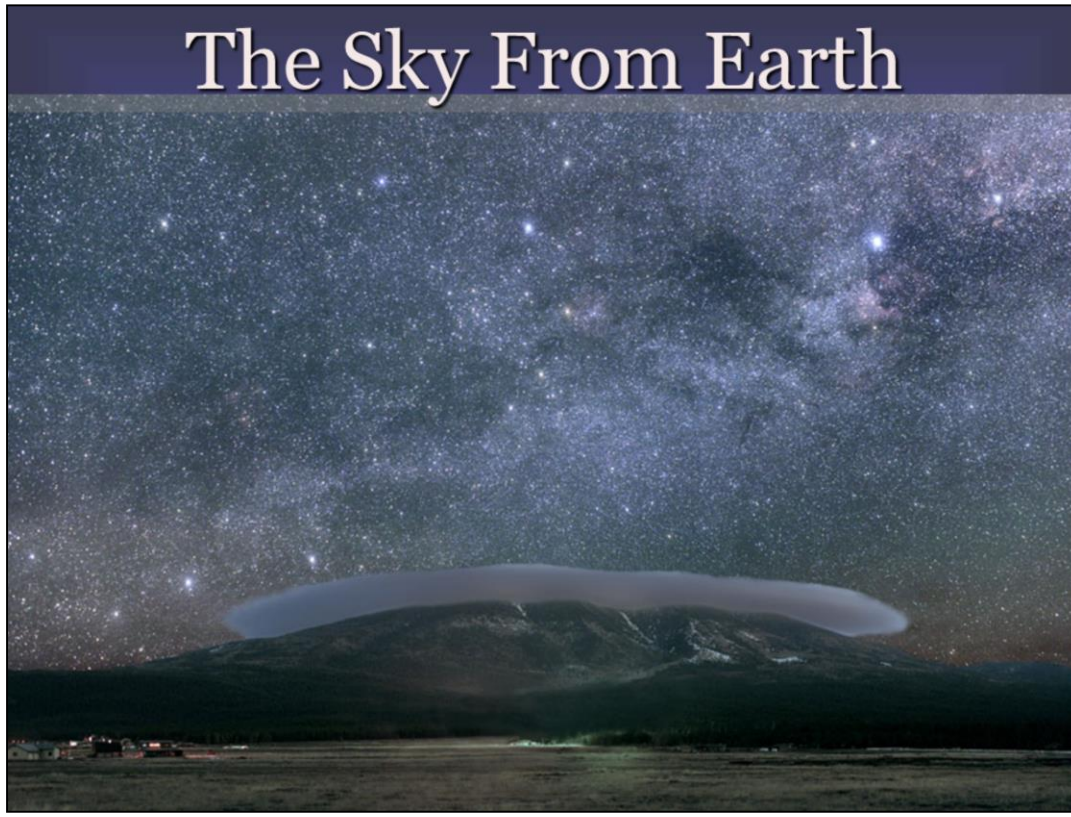


When we walk outside and look into the sky, what do we see?

How does our view change with time?

Why does the night sky change in the way that it does?

Overview

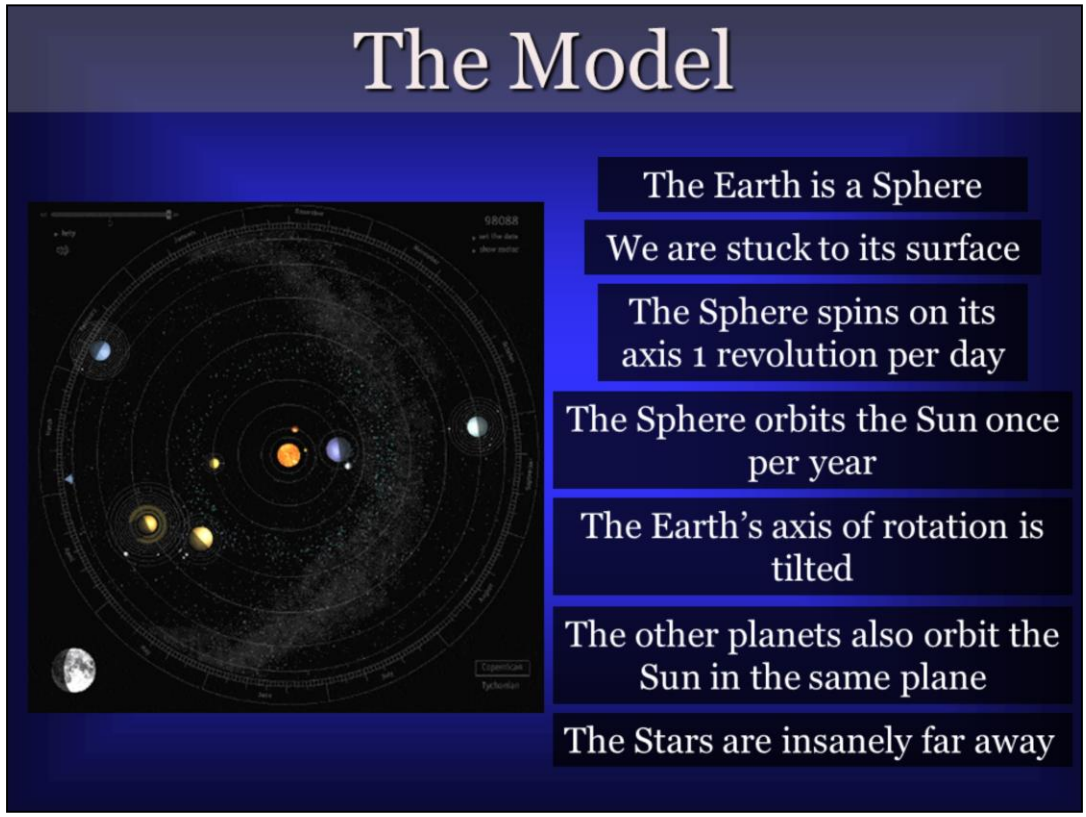
A. Definitions:
    1. The Model:
        1. Solar System Components
        2. Solar System Motions
    2. Celestial Sphere
    3. Celestial Hemisphere
    4. Meridian
    5. Celestial Equator
    6. Zenith
    7. Sidereal Day
    8. Solar Day

Overview

B. From Earth, WHAT do we see and WHY do we see it?
   1. The Celestial Dome (hemisphere)
   2. The Motion of the stars with respect to:
      1. Position on Earth
      2. Time
   3. The Motion of the Sun with respect to:
      1. Position on Earth
      2. Time, (short and long time periods)
      3. The background stars
   4. How do the Planets move with respect to:
      1. Time
      2. The background stars

Overview

C. Why Does the Moon Phase?
D. What Causes the Seasons?



This is our model of the solar system.

We are stuck to the surface of a spinning sphere that's in orbit around the Sun.

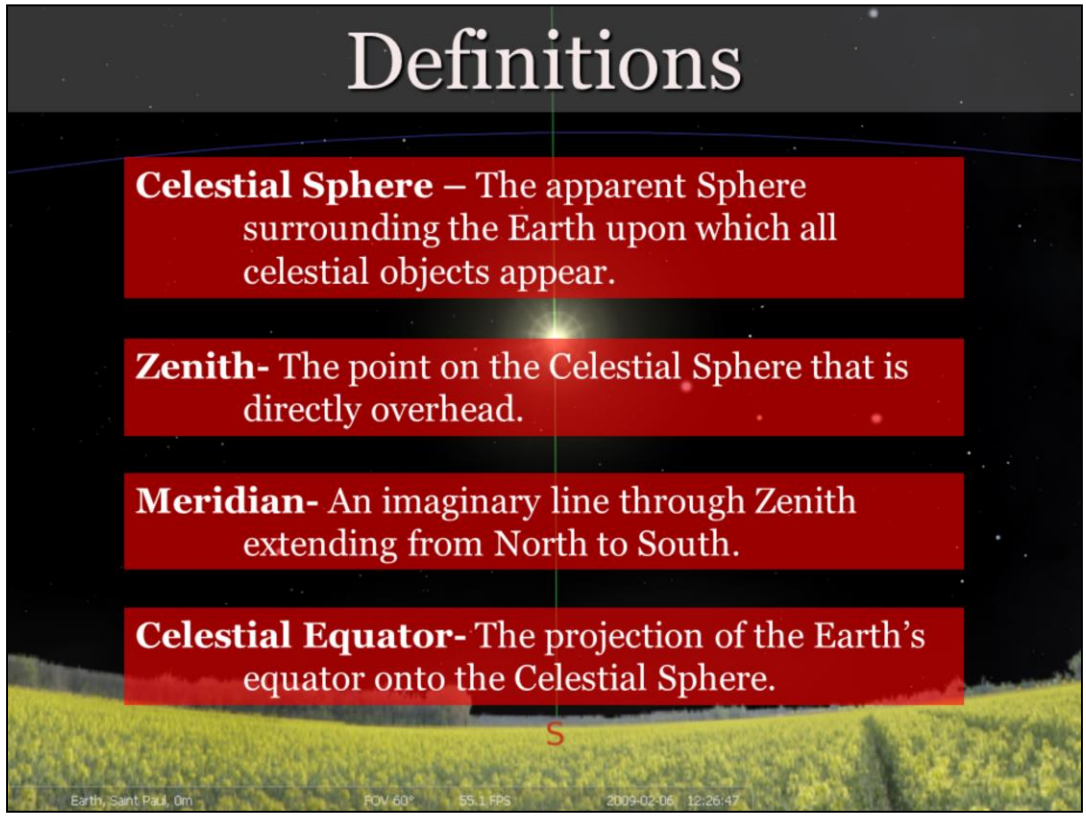
All of the other planets are ALSO spinning and orbiting the Sun.

All of this spinning and rotating is something like trying to figure out the paths of children on a playground from the vantage-point of a spinning merry-go round.

But it's worse because OUR merry-go round is in motion, moving around the Sun and spinning at the same time.

Even worse.. The merry go round is tilted at a jaunty 22 degree angle with respect to the ground.

How do we connect our view of space from the surface of the Earth with this model of a spinning orbiting sphere?


Definitions
Celestial Sphere – The apparent Sphere surrounding the Earth upon which all celestial objects appear.
Zenith- The point on the Celestial Sphere that is directly overhead.
Meridian- An imaginary line through Zenith extending from North to South.
Celestial Equator- The projection of the Earth's equator onto the Celestial Sphere.
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What happens when we change lattitude?

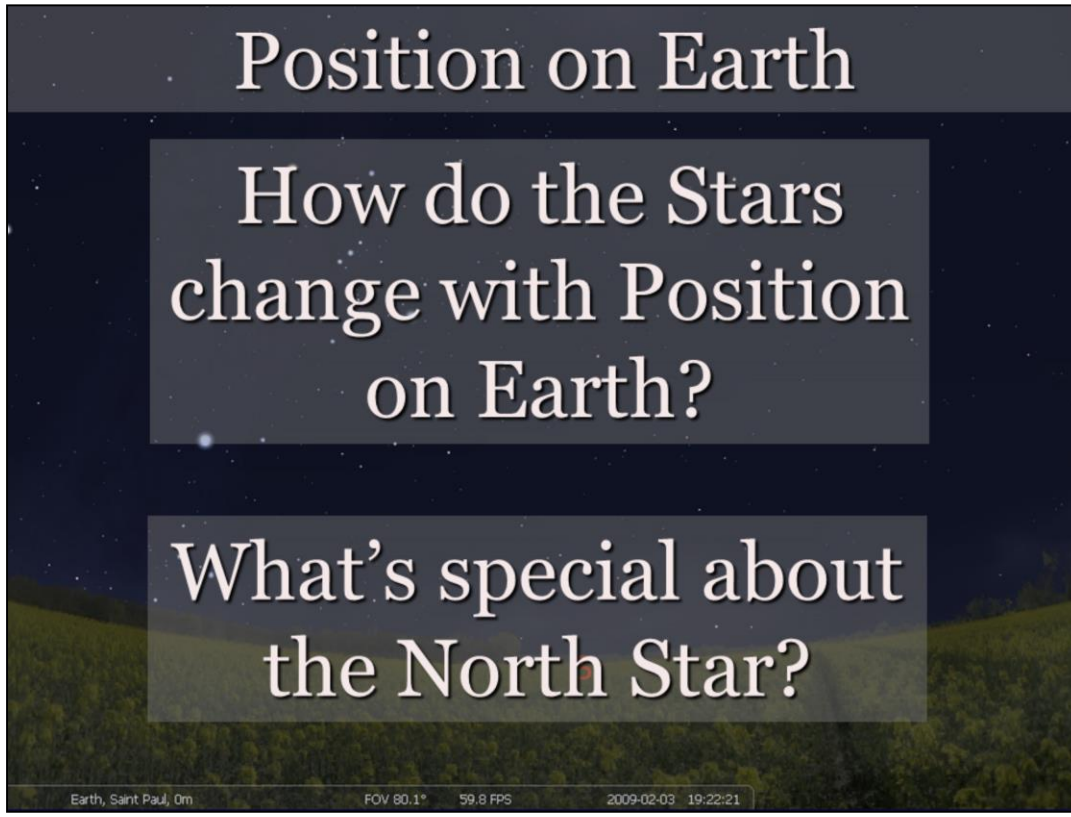
So… Facing South, the stars move “up”

Facing North the stars move “down”

What’s going on?

When we change position, our local zenith (direction to “up”) points somewhere else in the sky.

Our horizon tilts North to South so that we’re looking at a different celestial hemisphere



What happens when we change our position to a more southerly lattitude?

Southern stars move “up”

Northern stars move “down”

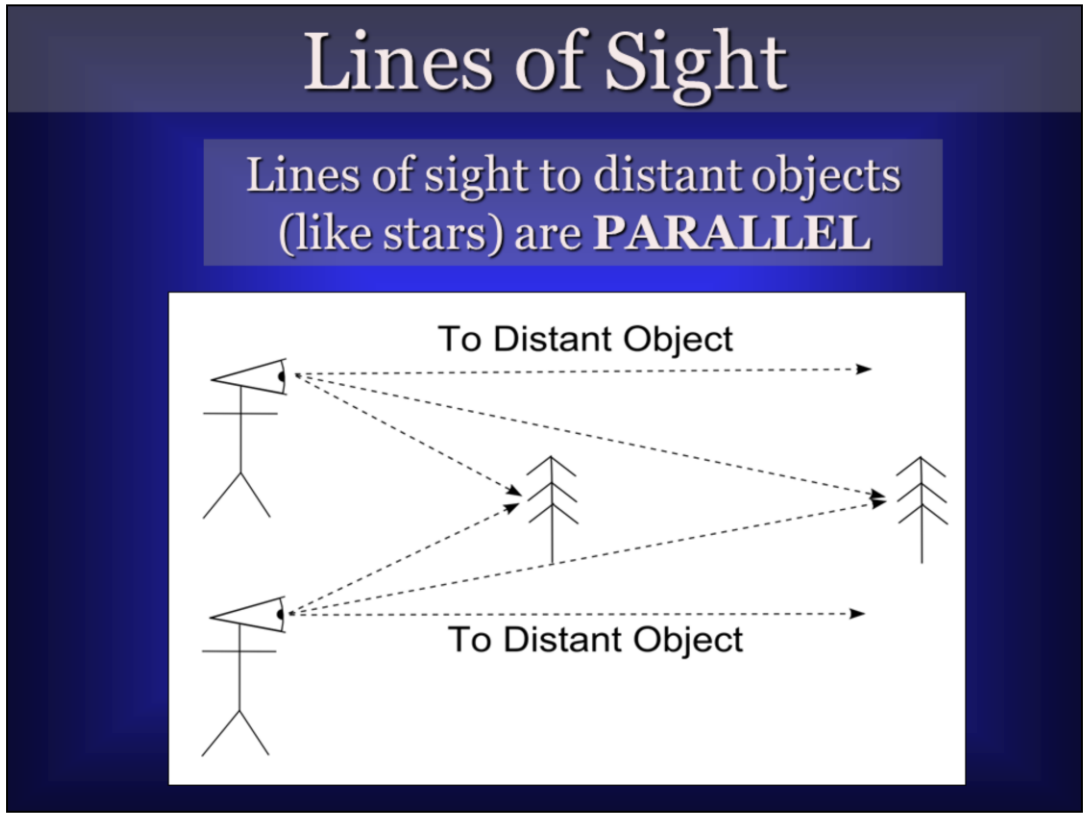
What’s going on?

When we change Latitude, our “local zenith” points somewhere else in the sky.

Our local horizon is unique, and we are viewing a unique celestial hemisphere.

The North Star is at Zenith when you are standing on the North Pole.

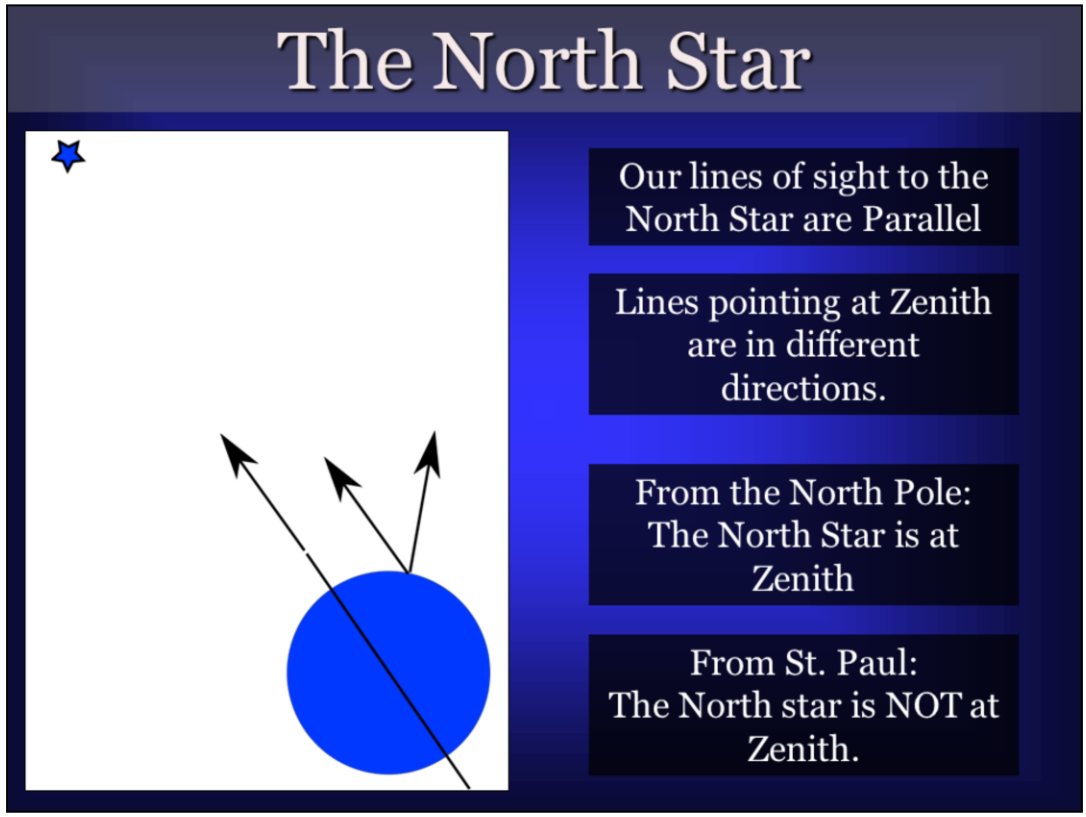
We can determine our Latitude by looking at the elevation of the North Star above our local horizon.



If two observers are looking at a nearby object, their lines of sight will intersect at the object.

As the object moves further away, the angle between the lines of sight decreases.

Lines of sight to objects that are VERY distant are parallel.



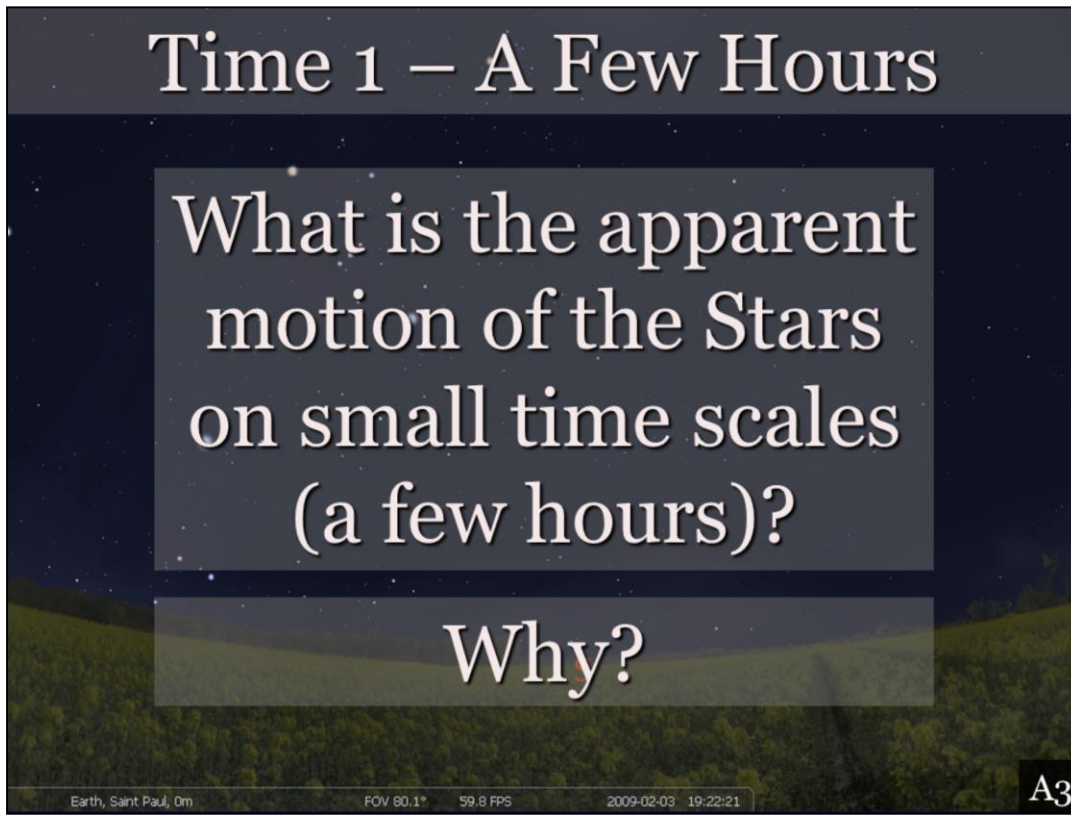
Where does the North Star appear in the sky at the North Pole versus St. Paul?

Relative to the horizon, the North Star will appear in different places for observers in

different locations on the planet due to the curved surface of the Earth.

From the North Pole, the North Star is at Zenith.

From St. Paul, North Star is in the Northern sky about 45 degrees above the horizon.



How do the stars move in time?

Facing south, they arc across the sky reaching their highest point due south of us.

Facing north, they travel in circles around Polaris, the “North star”

Notice that some stars in the north NEVER set. They just travel in circles around the North Star. These are called circumpolar.

Facing west, the stars follow a slanting path “down” and “north” as they “set” below the western horizon

Facing east, the stars follow a slanting path “up” and “south” as they “rise” above the eastern horizon.

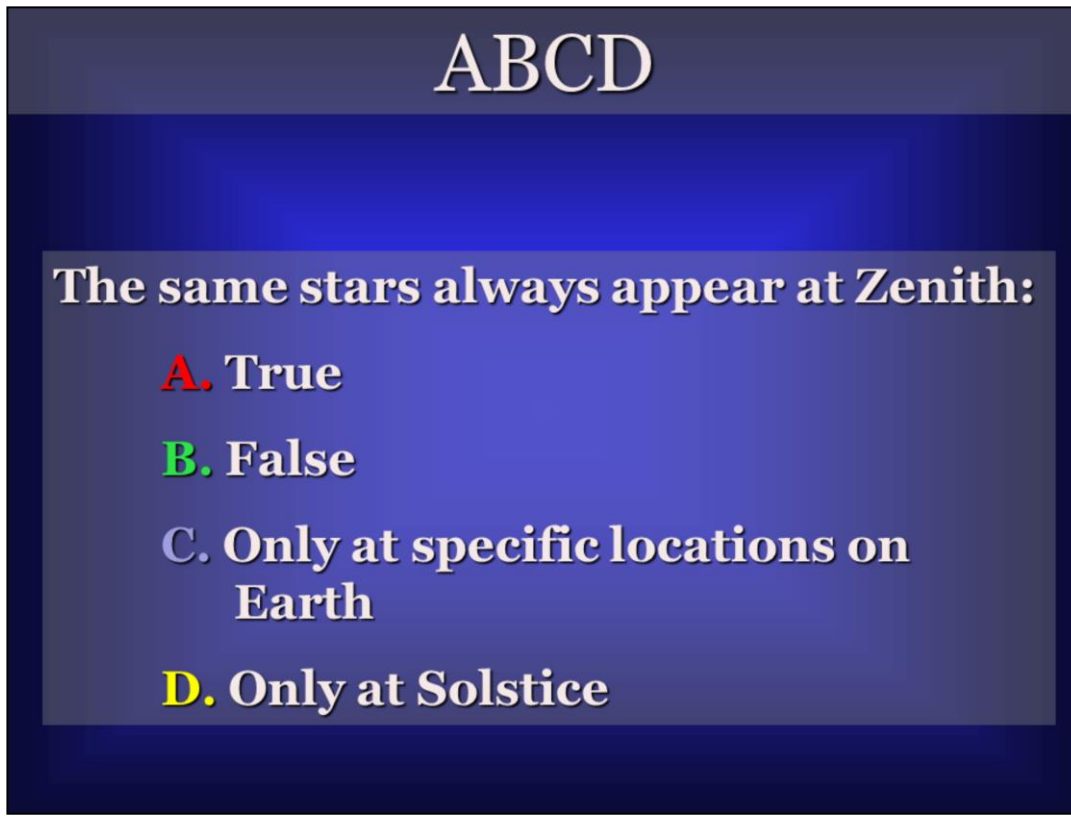
So- What’s REALLY going on?

The Earth is spinning and we’re stuck to the surface so our UP is constantly changing.

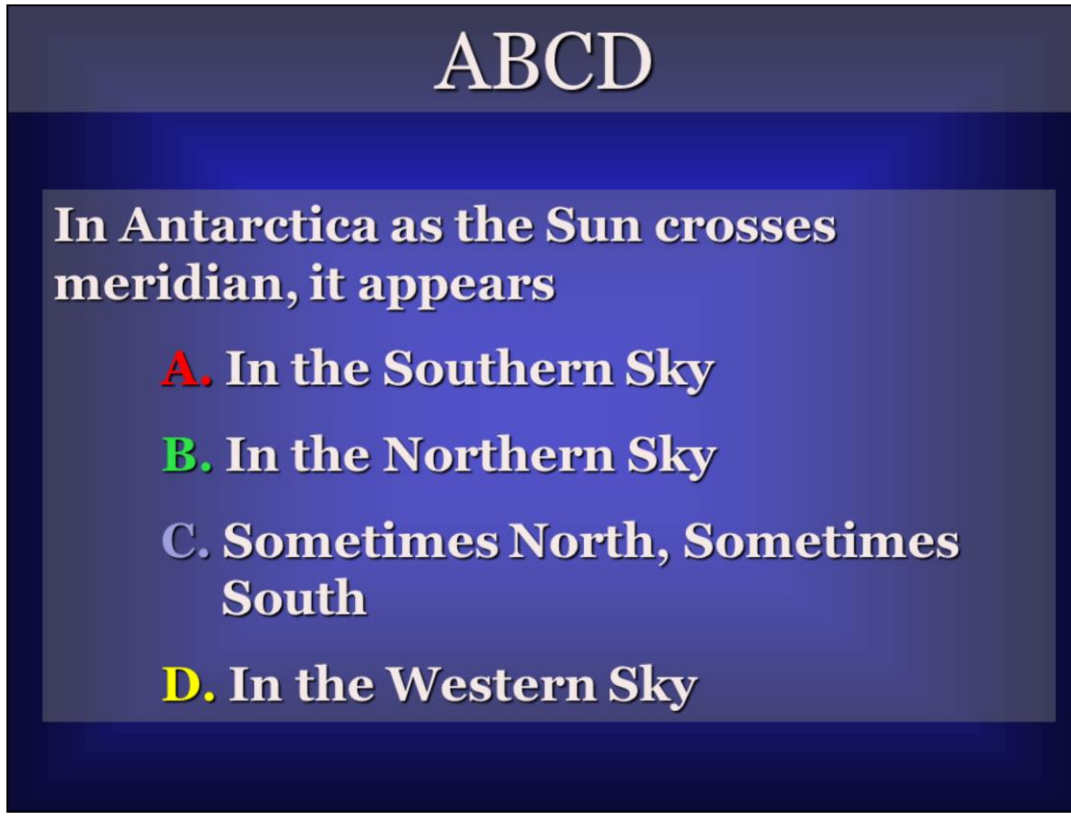
Really, the stars are motionless (on short time scales) and we are moving.

The celestial sphere appears to be rotating on an axis that is aligned with the poles on the Earth

The Pole star is over the north pole of the Earth.



C – At the poles



B

Because you're south of the equator (and south of the tropic of Capricorn) the Sun will always be in the North, like it's always in the south from St. Paul.

ABCD

A long exposure photograph shows the stars moving in perfect circles around zenith. (the stars neither rise or set). You are:

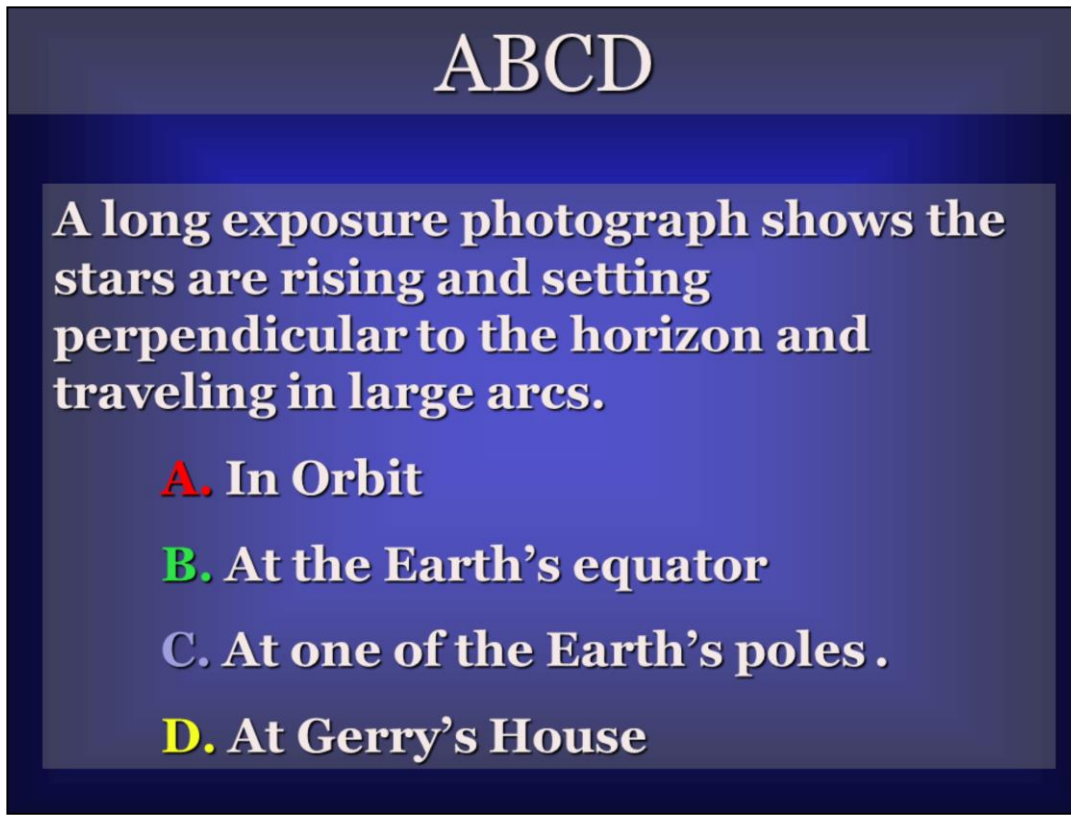
A. In Orbit

B. At the Earth's equator

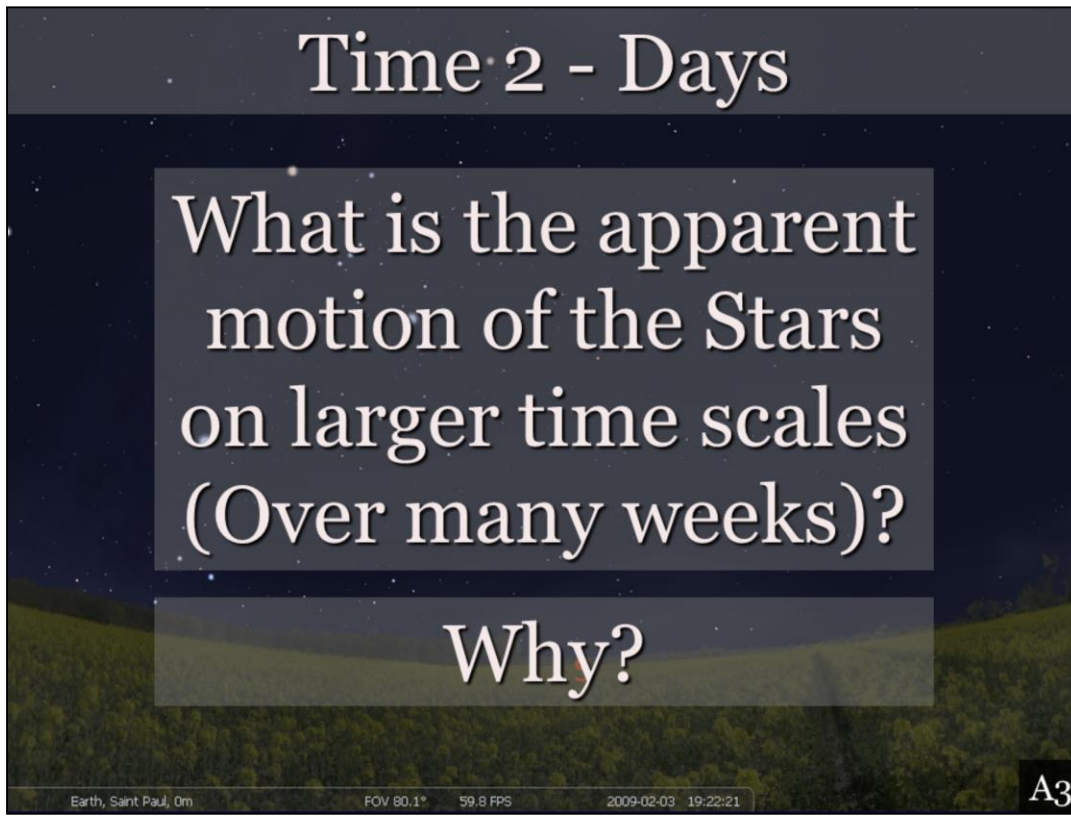
C. At one of the Earth's poles .

D. At Gerry's House

C


ABCD
A long exposure photograph shows the stars are rising and setting perpendicular to the horizon and traveling in large arcs.
A. In Orbit
B. At the Earth's equator
C. At one of the Earth's poles .
D. At Gerry's House

B



If I go outside and face directly South at the Meridian the midnight for a bunch of days in a row,

the stars appear to slowly slip gradually westward.

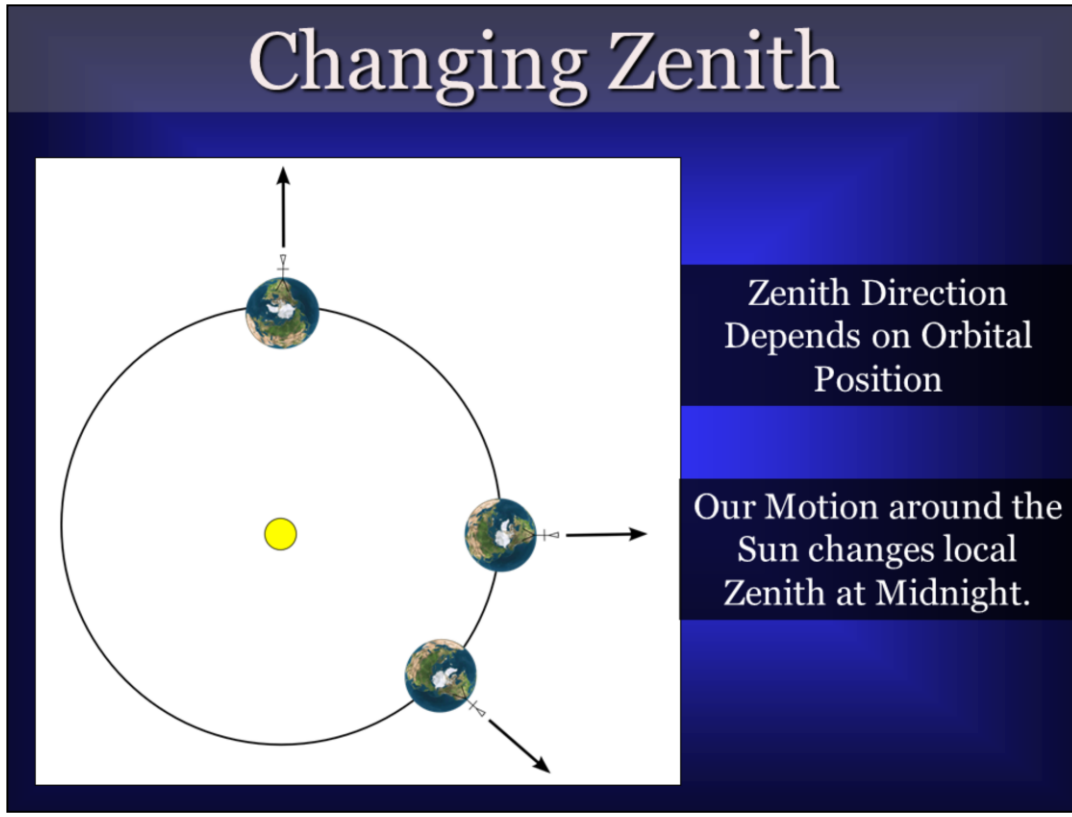
This is because we measure “days” based on the Sun and… We’re going around the sun.

Let’s look due South at midnight and watch.

I’m looking in the opposite direction from the Sun.

The Sun is REALLY far away… it’s between us and the stars…

As I go around the Sun, I’m always looking at different stars at midnight.



The direction of local zenith at midnight changes from night to night due to our orbital path around the Sun.

Therefore the particular set of stars that we can see at midnight throughout the year also changes.

ABCD

Stars that can be at night seen all year are:

A. Near the Celestial Poles

B. Near the Celestial Equator

C. Near the Sun.

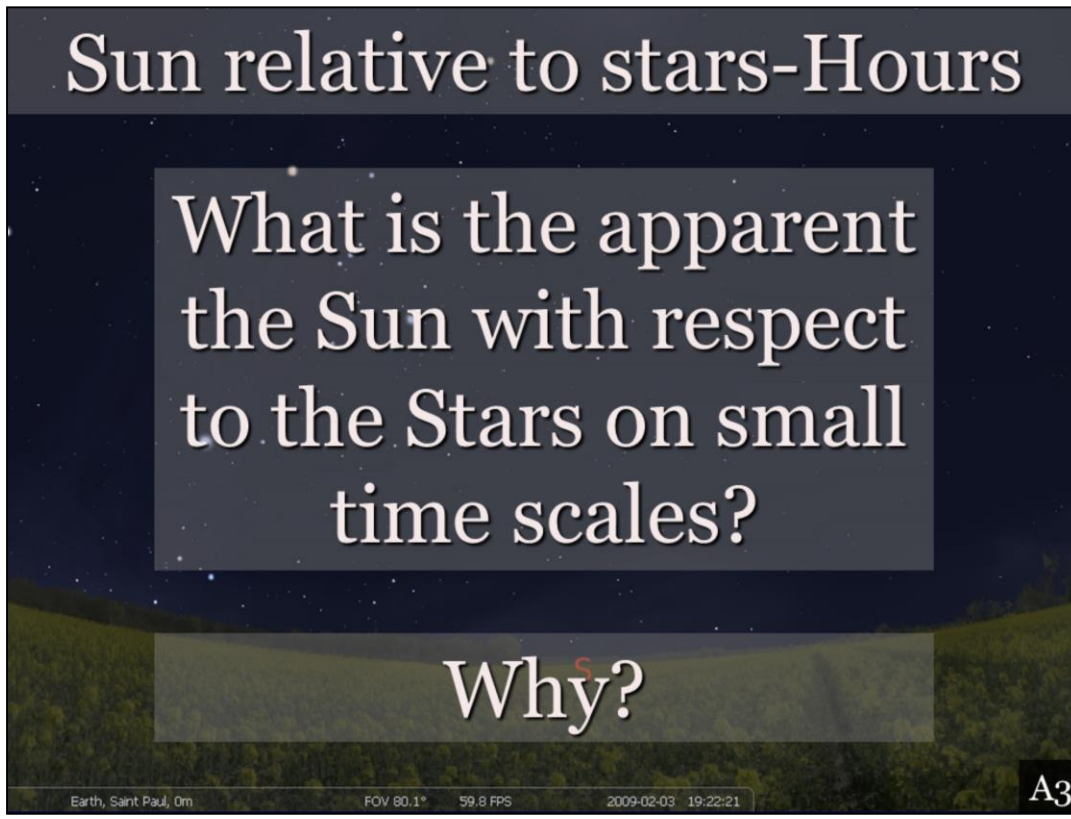
D. No stars can be seen all year.

Over a period of hours, the Sun moves with the background stars.
This short term motion is due to the Earth's rotation about it's axis.

Let's look at the Sun over the course of a year.

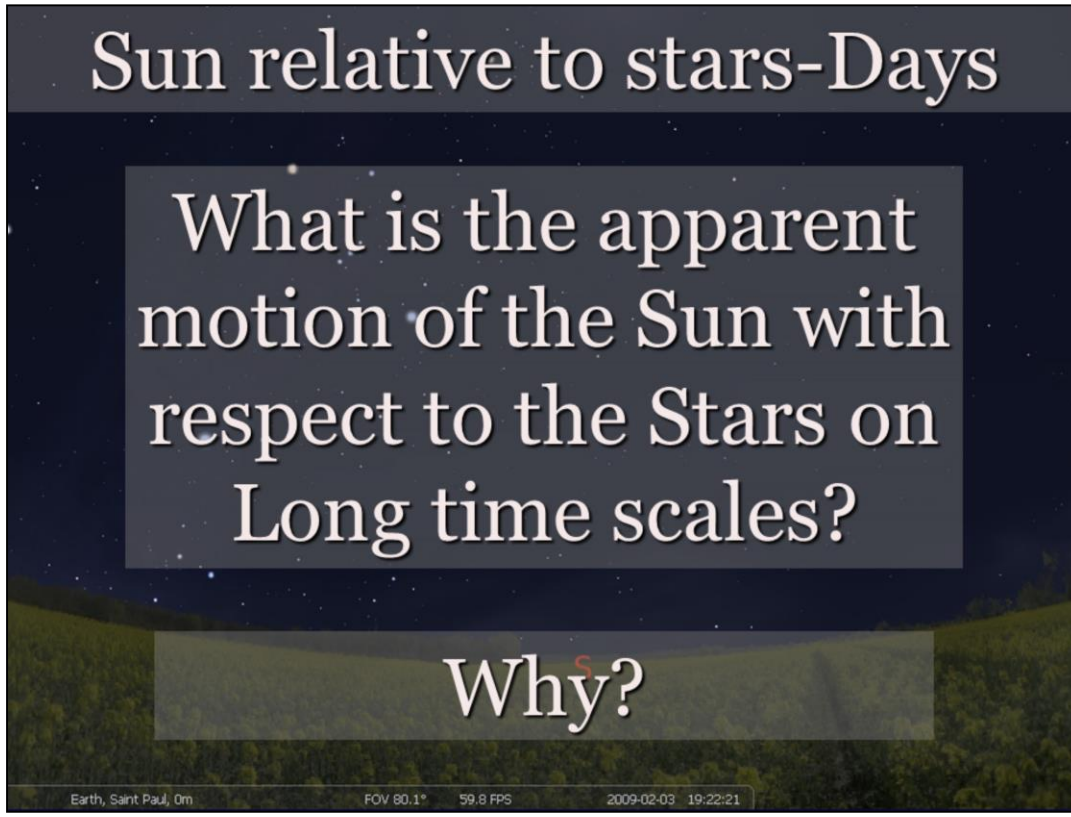
It follows the "ecliptic"

Why does it's apparent position among the background stars change?



Over short time scales, the Sun and the stars appear to track together.

Because:
The rotation rate is large compared to the orbital rate.



If we took a picture of the sky every 24 hours and played the sequence back like a movie:

the Sun would remain on the meridian and the background stars would appear to slowly shift west day by day.

If we took a picture of the sky every 23 hours and 56 minutes and played the sequence back like a movie:

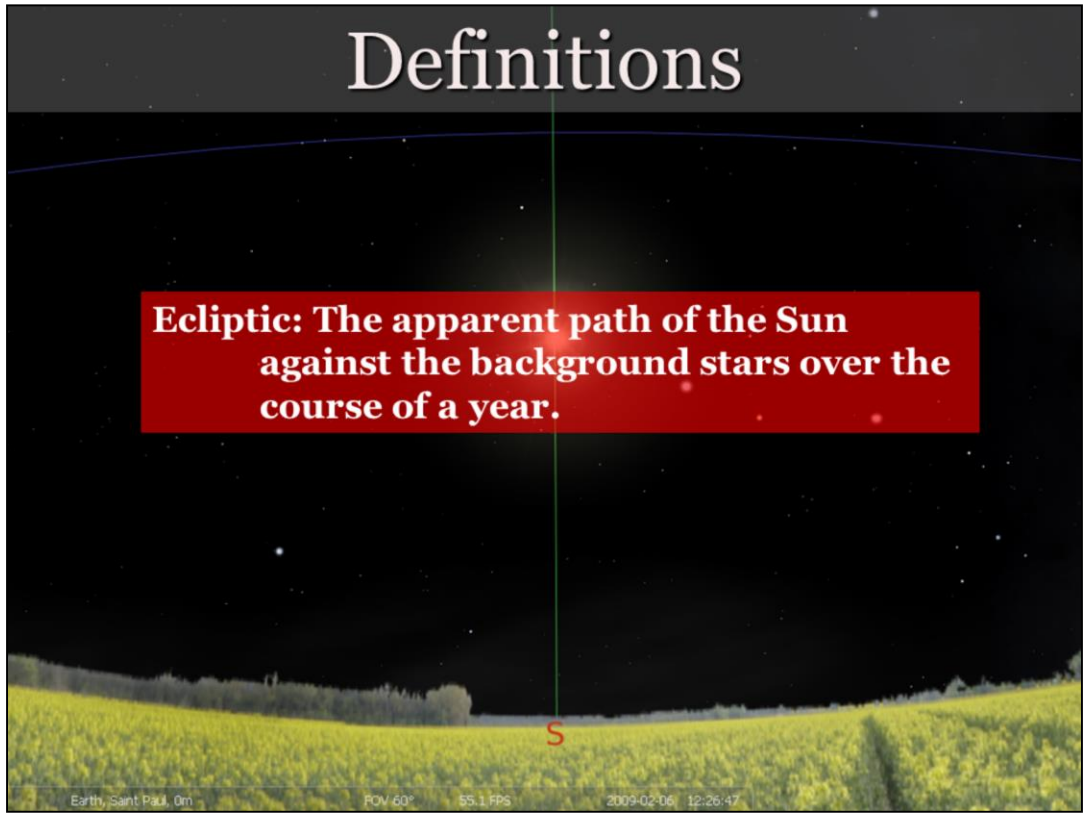
The STARS would remain in the same place in the sky and the Sun would appear to slowly shift east day by day.

Because:

The orbital motion of the Earth changes our perspective.

The stars are insanely far away, the Sun is very nearby, and the Earth is in orbit around the Sun.

From our perspective, the Sun the nearby Sun appears superimposed against different sets of distant stars as the Earth goes around.


Definitions
Ecliptic: The apparent path of the Sun against the background stars over the course of a year.
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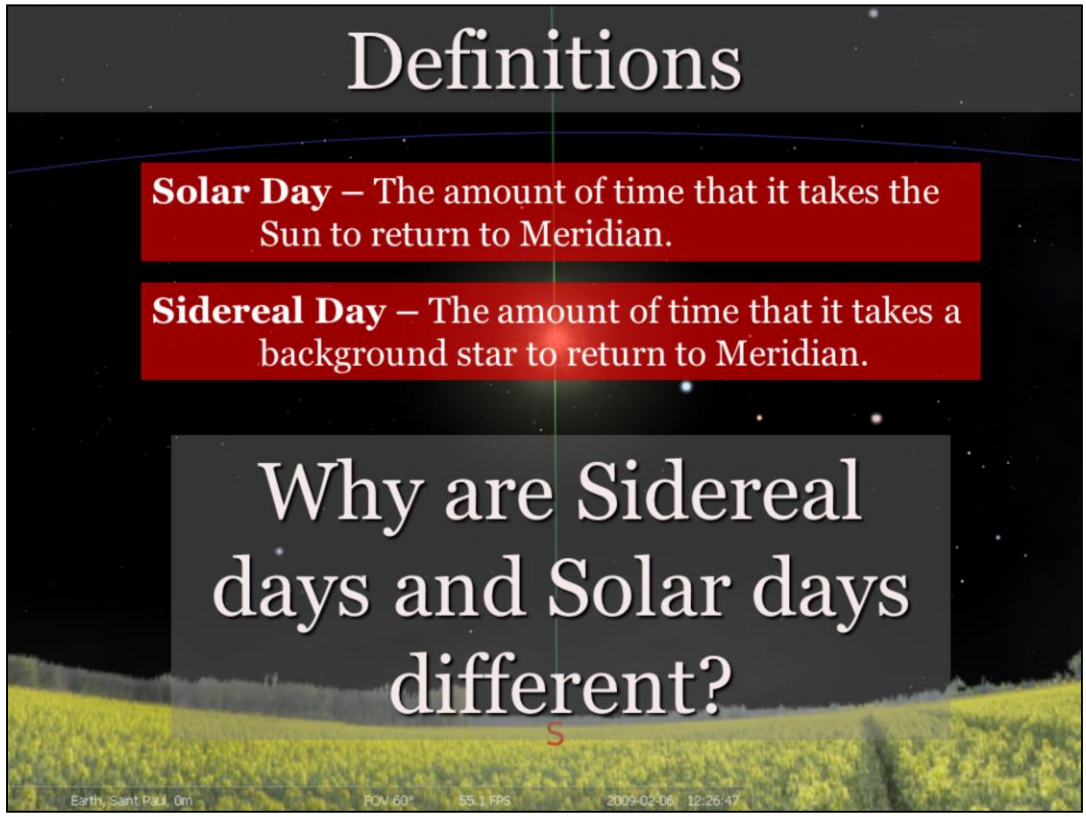
Definitions
Solar Day – The amount of time that it takes the Sun to return to Meridian.
Sidereal Day – The amount of time that it takes a background star to return to Meridian.
Why are Sidereal days and Solar days different?
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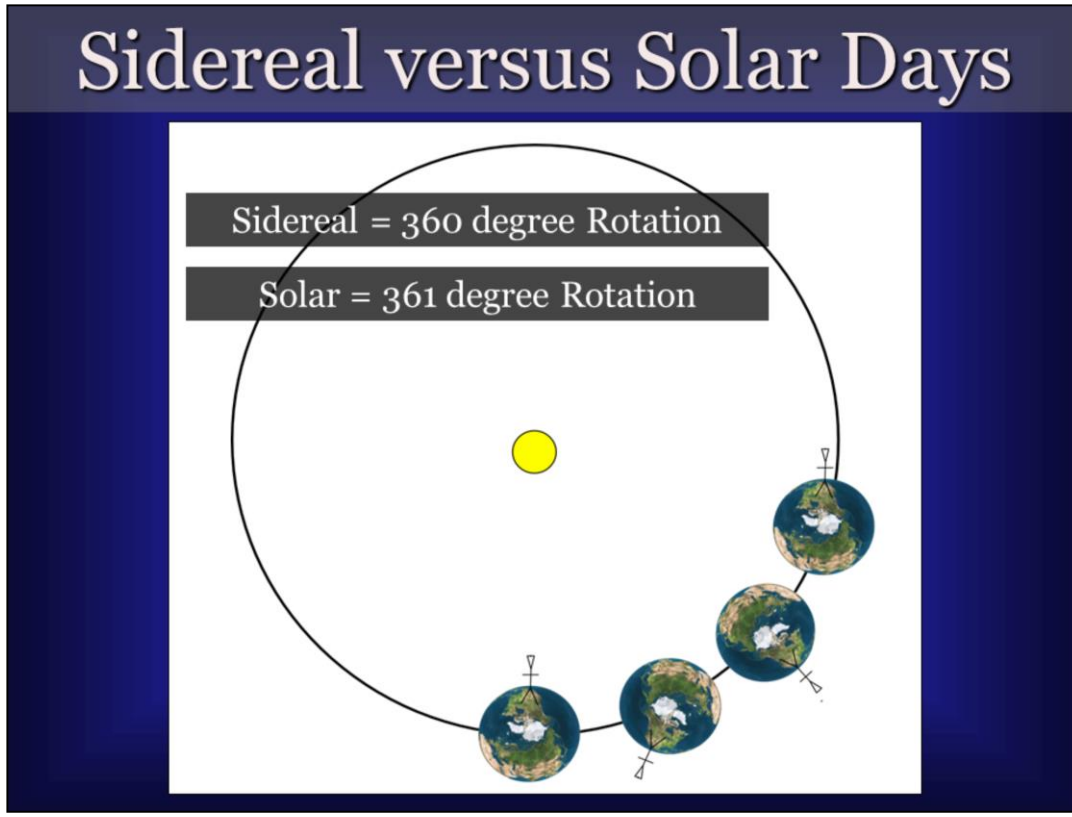


One sidereal day is one 360 degree rotation of the Earth. This takes 23 hours and 56 minutes.

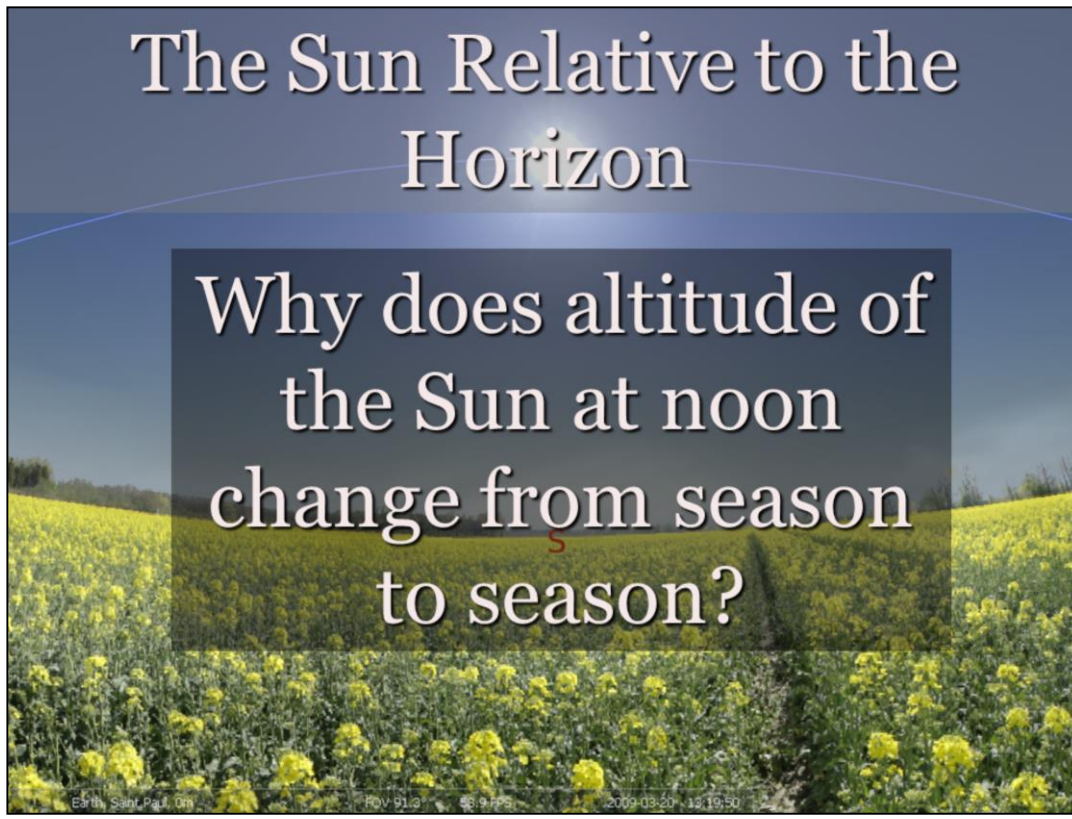
The stars are in the distant background. So, after rotating 360 degrees, we'll be facing the same set of stars.

But, in the time that it's taken to rotate 360 degrees, we've moved around the Sun a little bit.

As a result, we're no longer facing the Sun.

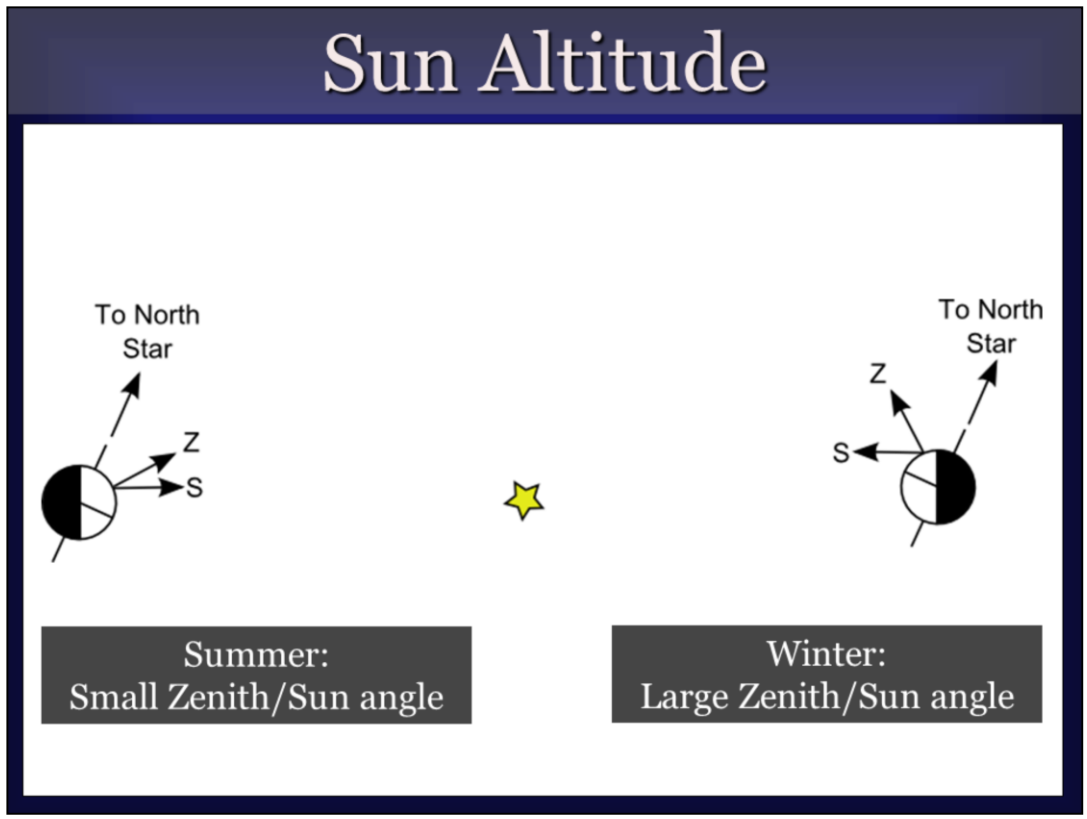
We have to rotate an addition degree to get allllll the way to noon.

This additional rotation takes another four minutes giving us our 24 hour "solar" day.



If we look at the Sun's position in the sky at noon over an entire year, we'll see that it's elevation above the horizon changes.

In the summer, our Local Zenith is closer to the Sun
In the Winter, our Local Zenith is far from the Sun.



Why does the altitude of the Sun at noon change from season to season?

The Earth maintains its orientation in space… North pole pointing always at the North Star.

So, in the Summer, the North Pole is aimed at Polaris.

In the Winter, the North Pole is aimed at Polaris.

From St. Paul:

In the Winter, the angle between our local Zenith and the Sun at noon is large (Sun far from zenith and low on the horizon)

In the Summer, the angle between our local Zenith and the Sun at noon is small (Sun close to Zenith, far from the horizon)

The Celestial Equator always hits the horizon exactly to the East and exactly to the West.

Our latitude on Earth changes the angle that the celestial equator makes with the horizon.

During northern hemisphere winter, the Sun appears SOUTH of the Celestial Equator.

During northern hemisphere summer, the Sun appears NORTH of the Celestial Equator.

In the northern hemisphere summer, the sun is above the Tropic of Cancer (23 degrees north latitude)

In the northern hemisphere winter, the sun is “above” the Tropic of Capricorn (23 degrees south latitude)

the Earth pierces the Tropic of Capricorn

At the Equinoxes, the Sun is above the equator.

the Earth pierces the Equator.


ABCD
At Summer Solstice, the direction of sunsets is:
A. Directly West
B. Directly East
C. North of West or East
D. South of West or East

D

ABCD

The Sun's apparent position is North of the Celestial Equator in the Summer and South of the Celestial Equator in the winter because:

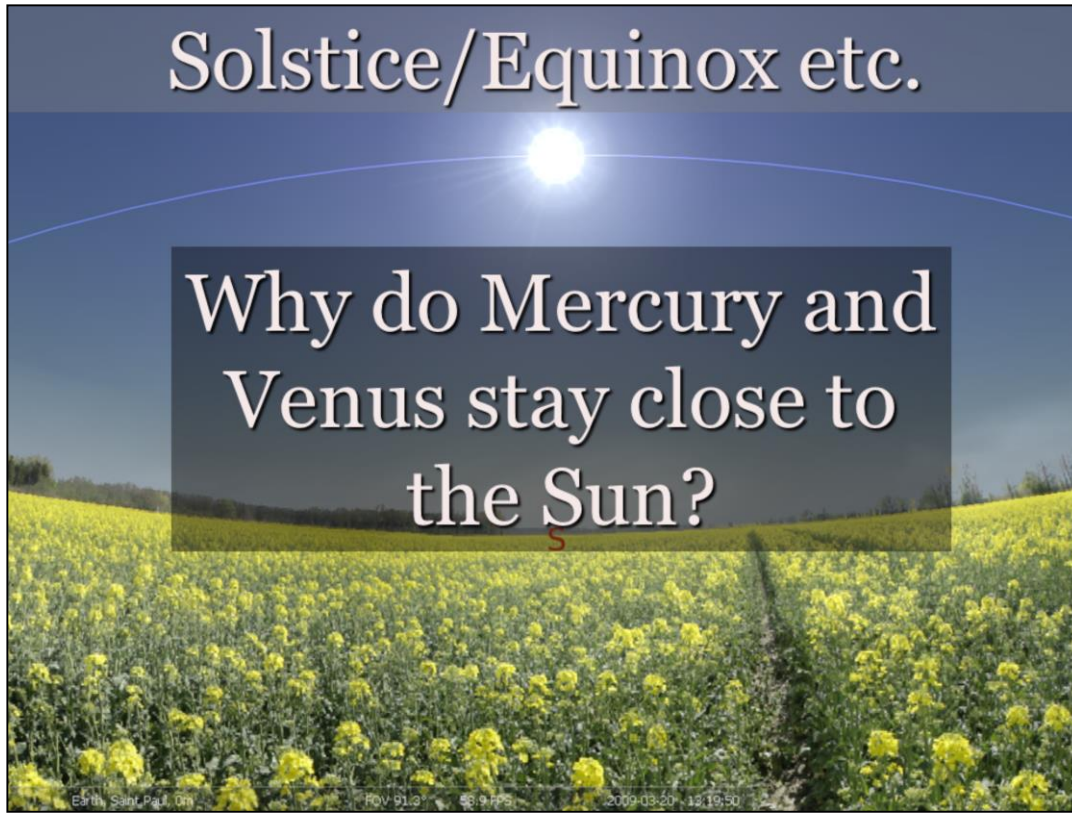
A. The Moon pulls on the Sun

B. The Earth's orbit is tilted

C. The Sun is tilted and it orbits the Earth

D. The Earth's axis is tilted with respect to the plane of its orbit.

D


Solstice/Equinox etc.
Why do Mercury and Venus stay close to the Sun?
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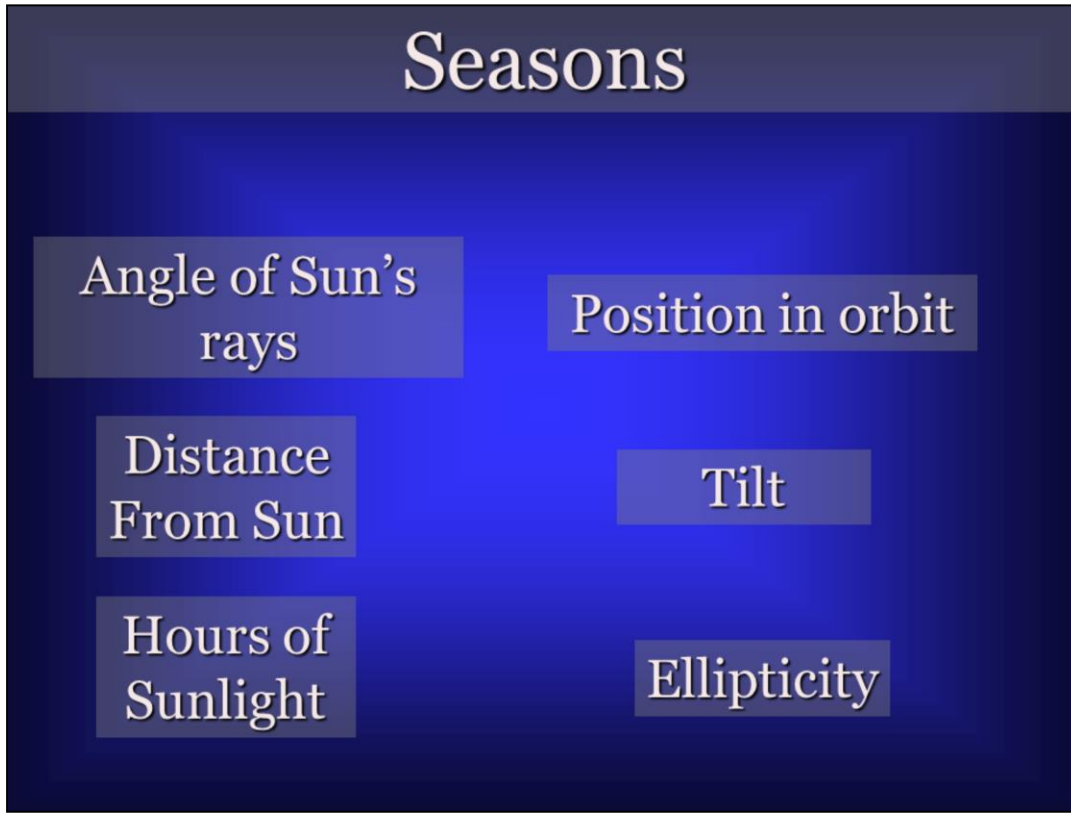
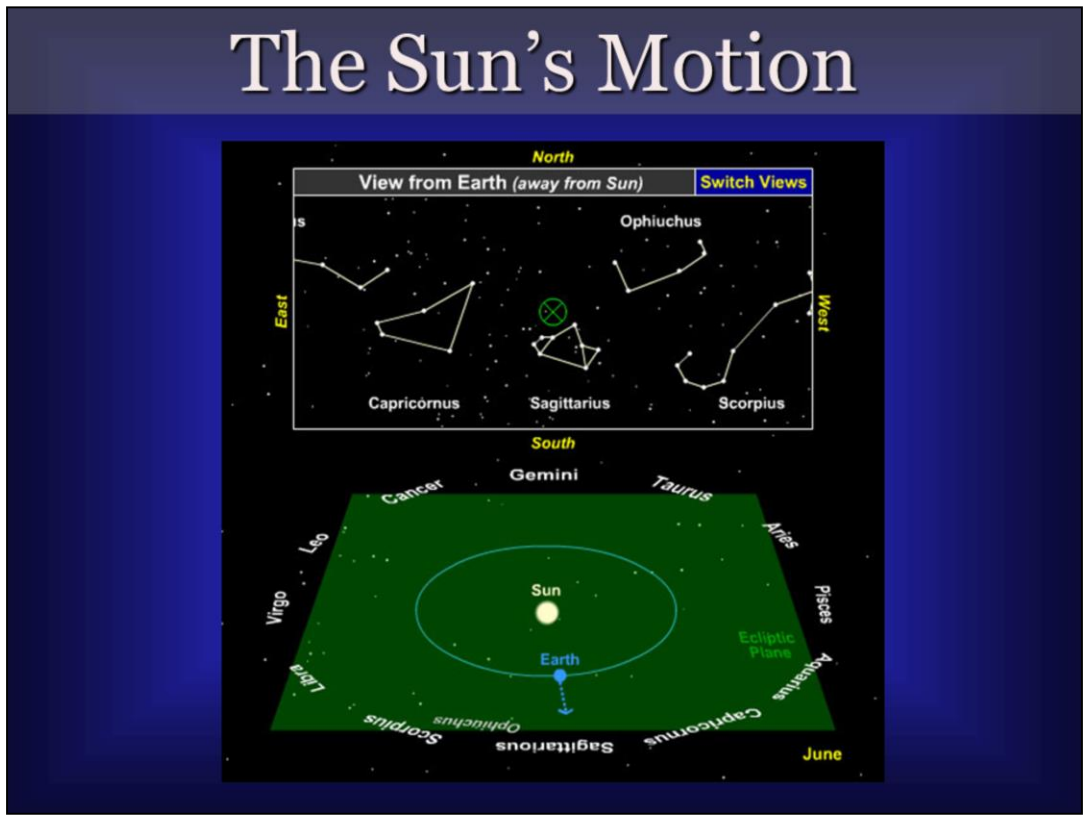
What's the reason for the Season's?



What's the reason for the Seasons?

In class discussion… Take good notes.



An animation showing how the position of the Earth in its orbit around the Sun effects the stars that are visible at night.

Also in Stellarium, as we move ahead one solar day at a time, the Sun appears to move from below (south of)

the celestial equator to above (north of) it.

Notice also the unusual movement of Jupiter. (and of Mars if we can catch it in the act)