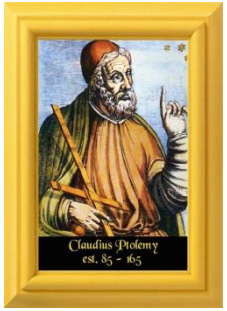
Was Ptolemy Pstupid?



Why such a silly title for today's lecture?

Sometimes we tend to think that ancient astronomical ideas were stupid because today we know that many of them were wrong.

But, while their models may have been wrong, many were scientifically sound – **i.e. based on the facts that were known at the time.**

It's not that we are smarter than Ptolemy, it's just that we have more facts in the form of better observations.

Ancient Astronomy

We'll never know who the first astronomers were, but we do know that almost all ancient cultures were very aware of the Heavens and the motion of the objects in the sky.

What we don't have any way of knowing is:

"What was their Model of the Universe?"

Unfortunately, until the time of the Greeks, nothing was recorded.

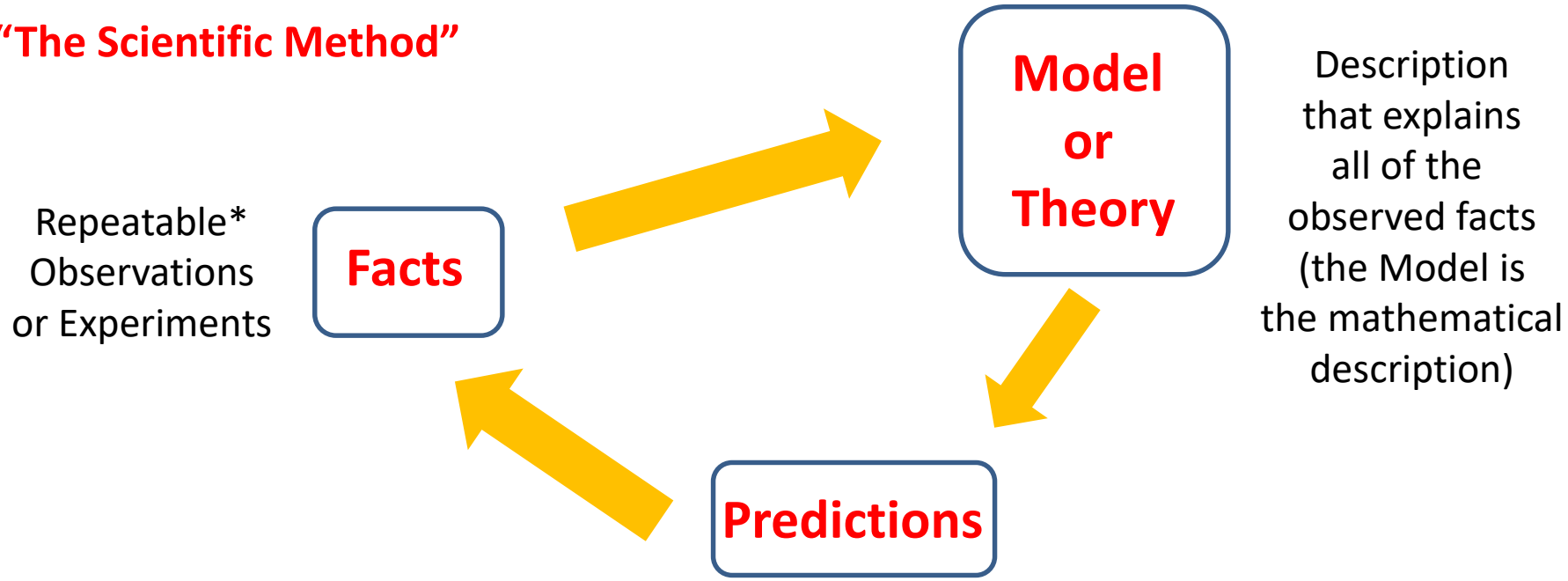
What is Meant by "Model of the Universe?"

In science, the word "Model" is sometimes used interchangeably with "Theory."

What do they mean?

In science, everyday words are frequently used, but their scientific definitions can be very different than their everyday definitions . . . **e.g. the word model.**

"The Scientific Method"



**Everyone is entitled to their own opinion, but there is only one set of facts.*

More on the "Scientific Method"

- **A scientific theory (or model) cannot be proved to be correct**, but it can be shown to be incorrect.

- New observations or experiments can either support or refute a theory, but they can't show it's **always** true.

- If a new fact is discovered that is inconsistent with the theory (or model), the theory (or model) must be modified or discarded.

- **Occam's Razor:** if there is a choice between two or more theories that explain all of the facts equally well, the **simplest theory** is **probably** the correct one.

A Guess at an Ancient Model of the Universe

When ancient peoples studied the heavens, they (like us) had to notice several facts:

The Stars appear in apparent unchanging patterns (Constellations):

The patterns are the same year after year and are in the night sky at the same time of the year every year. (*at least based on human lifetime scales*)

The paths of the Sun and the Moon through the fixed stars were regular and predictable.

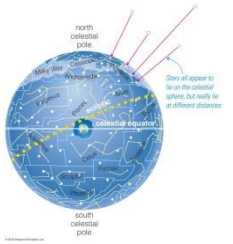
Structures like Stonehenge and the Sun Dagger could be built to track the motion of the Sun and Moon through the stars, and predict the seasons and eclipses.

A Guess at an Ancient Model of the Universe

Based on these simple facts, a **Plausible Model for the Universe** could be:

- **The Earth is fixed at the center.**
  (Makes abundant sense: Do you feel the Earth moving?
  Watch the Sun, Moon, and Stars; they obviously are going around the Earth.
  What naked-eye observation could you do today to show
  that it's the Earth going around the Sun?)

- **The stars are on a concentric Earth-centered sphere that rotates around the Earth once per day** – *like the Celestial Sphere*.



- **The Sun and the Moon reside on their own spheres that rotate around the Earth at slightly different speeds than the sphere of the stars. Thus, we see them *move* relative to the stars.**

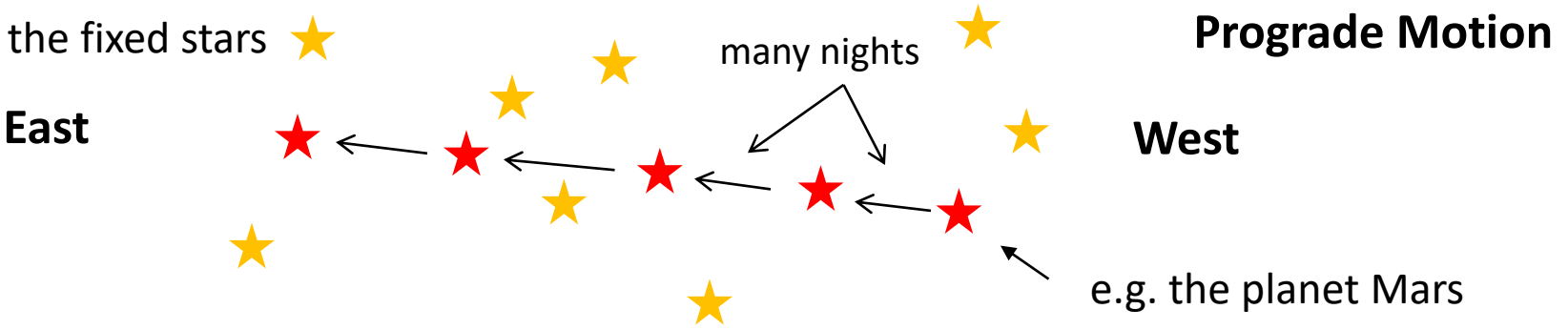
The Problem of the Planets

Very careful observations of the sky reveals that there are some **"stars" that don't stay put relative to the other stars**, but wander around through the constellations.

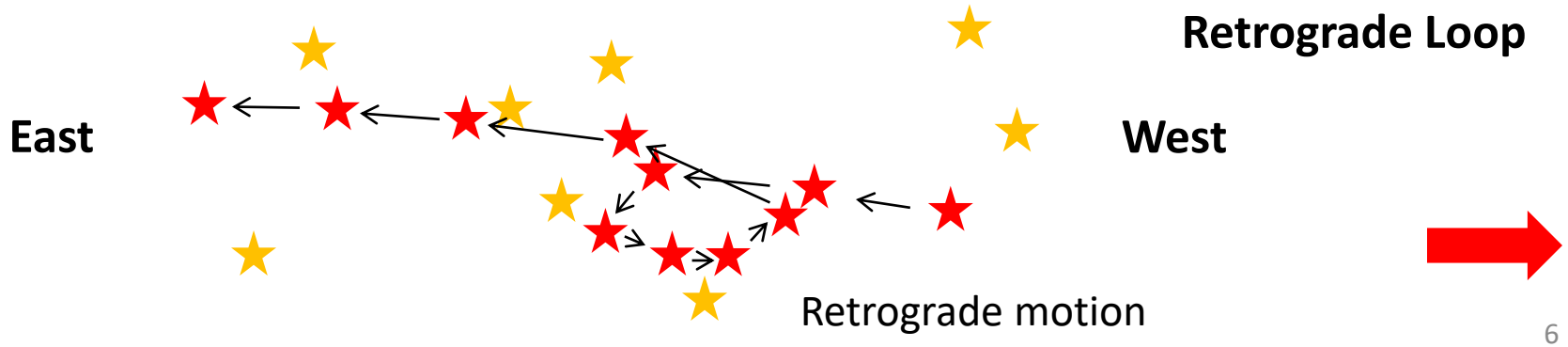
In ancient times, how many of these "wandering stars" were known? (LC)

The Greeks would later name these **five** wandering stars **"Planets".**

What do we mean by Wandering through the Stars?



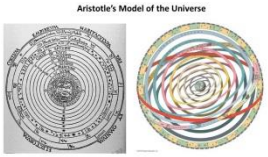
Sometimes a Planet would do this:



The Astronomy of the Greeks

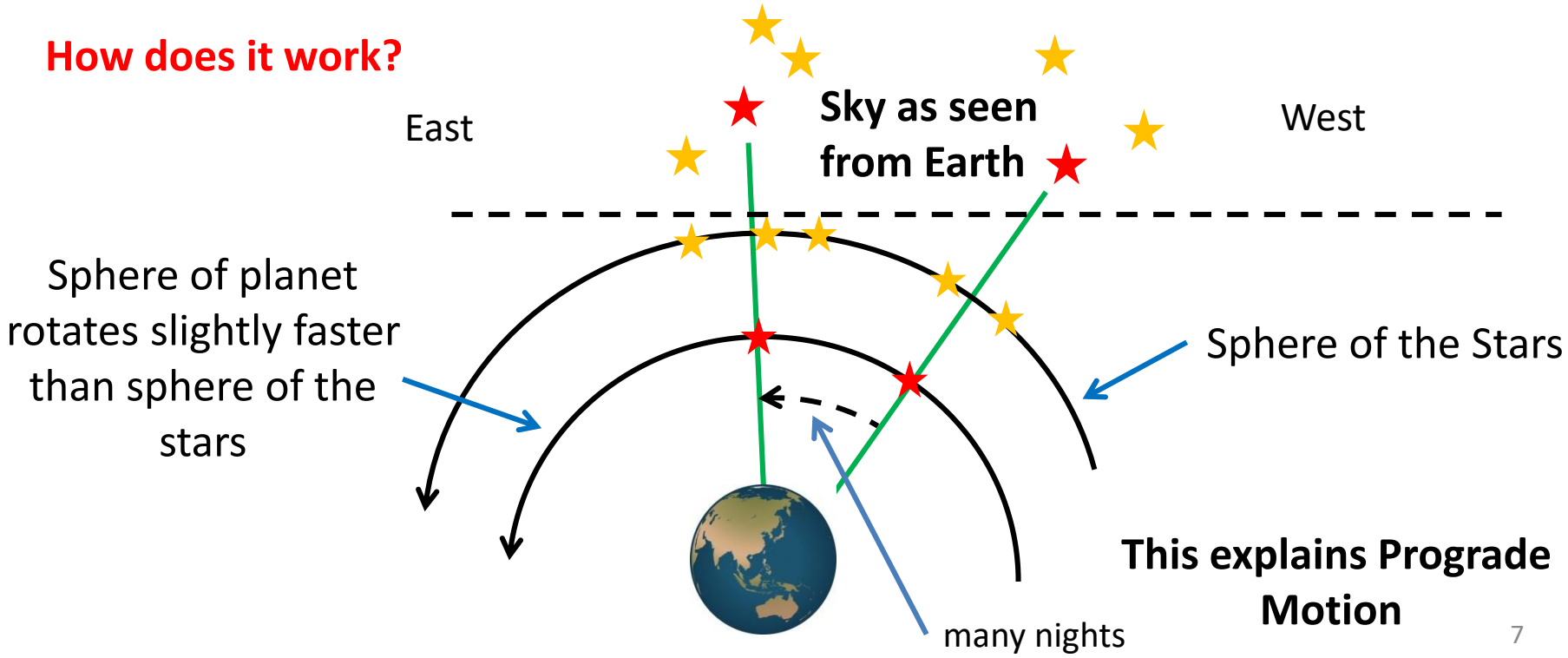
Greek astronomers were the first (*that we know*) to develop a Model of the Universe that could explain the Planets. Although Aristarchus proposed a Heliocentric model, the **Geocentric Model of Aristotle, modified by Ptolemy**, became accepted and regarded as correct for over 1500 years.

Geocentric Model of Aristotle (c. 350 B.C.)

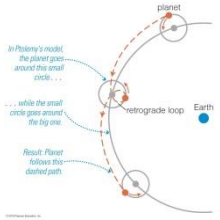


Earth at the center of eight concentric spheres that rotate around the Earth independently at slightly different speeds.

How does it work?



The Astronomy of the Greeks



Ptolemy's Epicycles (c. 140 A.D.)

To explain **retrograde motion** of the planets, Ptolemy proposed that each Planet resides on a smaller rotating circle, **the epicycle**, attached to its sphere.

The Ptolemaic Model:

- Gave fairly accurate predictions of planetary motions, i.e. astronomers could predict where a planet would be in the future – at least to within observational accuracy.

- Was later adopted by The Church and became the accepted *Model of the Universe* for more than 1500 years.
  What famous U.S. college taught the Ptolemaic System? (LC)
  (When Harvard opened in the 17th century, this was what was taught in their Course on Natural Philosophy!)

- As observations of the locations of the planets got better and better, the model had to be modified to agree with observations; e.g. more epicycles were added and the Earth had to be moved slightly from the center.

The Copernican Revolution

In 1543, the Polish priest Nicolas Copernicus revived the idea of a Sun-Centered (**Heliocentric**) system. **Why?**

His motivation was not based on any observations that showed that the Ptolemaic system was wrong. He just thought that a Heliocentric system described planetary motion in a simpler manner.

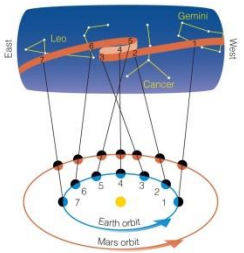
The Copernican Heliocentric Model:

- **Earth is a sphere that rotates about an axis causing the daily passage of the heavens.**
- **Earth orbits the Sun in a circle as do the other planets, with planets nearer to the Sun moving faster than planets far away.**
- **The stars are on a fixed <u>immobile</u> sphere very far away.**

The Copernican Revolution

How does the Copernican System explain Retrograde Motion of the Planets?

It is caused by the relative motion of the Earth and the other planets – we're observing the planets from a moving platform.



The Copernican Model is far simpler than the Ptolemaic Model, but when used to predict the future location of the planets, it gave predictions that weren't any better than Ptolemy's. **Why? (LC)**

Copernicus assumed circular orbits which turns out to be wrong.

So, during the late 16th and early 17th centuries, the debate between "World Views" raged in Europe. **Even William Shakespeare may have been influenced and had a role to play.**

The Copernican Revolution

Observations in Support of the Copernican Model:


In 1609, the Italian, **Galileo Galilei**, built his own telescope and became the first to use one for astronomical observations.

Among other things, like the Moon and Milky Way, **Galileo made two observations that supported the Copernican Model:**

1. **The Phases of Venus . . which of these phases is impossible in the Ptolemaic mode? (LC)**

   The Gibbous Phase of Venus is not possible in the Ptolemaic model, but does occur in the Copernican model.

2. **The Satellites (Moons) of Jupiter**

   These objects orbit Jupiter, not the Earth.
   Everything doesn't have to go around the Earth.

Galileo's introduction of the telescope to astronomy changed everything – and made him a rich man! The story of Galileo and his troubles with the Church is told in a NOVA video, ***Galileo, a Battle for the Heavens,*** based on the book, ***Galileo's Daughter,*** by Dava Sobel**.** Here's a clip: