Philosophy of Science Survey

Week 6

PHIL 2160. Ohio University. Spring 2021.

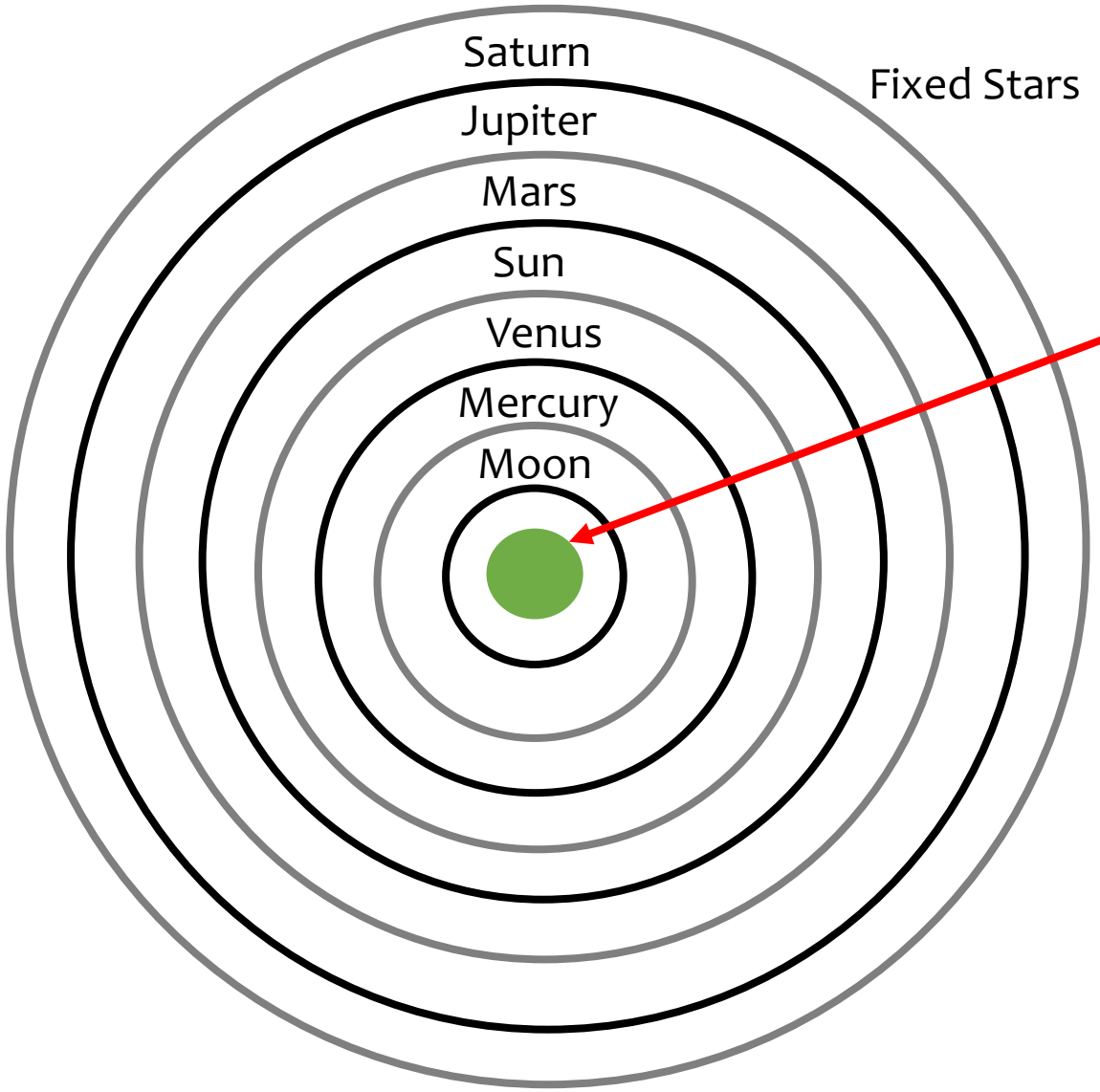
Chapter 9: The Structure of the Universe on the Aristotelian Worldview

The Structure of the Universe on the Aristotelian Worldview

Three groups of points:

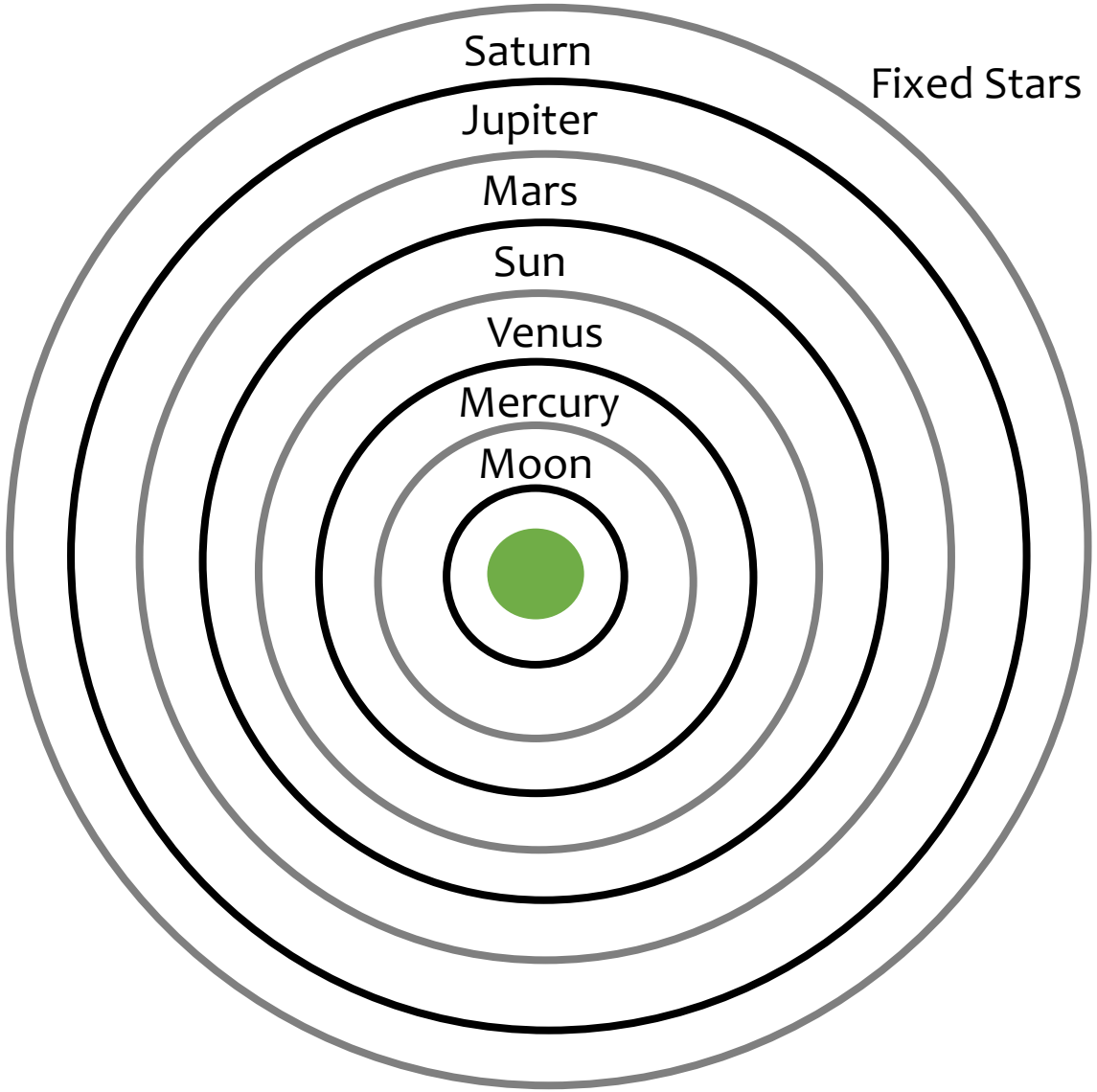
1. The structure of the Aristotelian universe
2. Aristotelian teleology and essentialism
3. Applications of teleology and essentialism

Aristotelian Universe



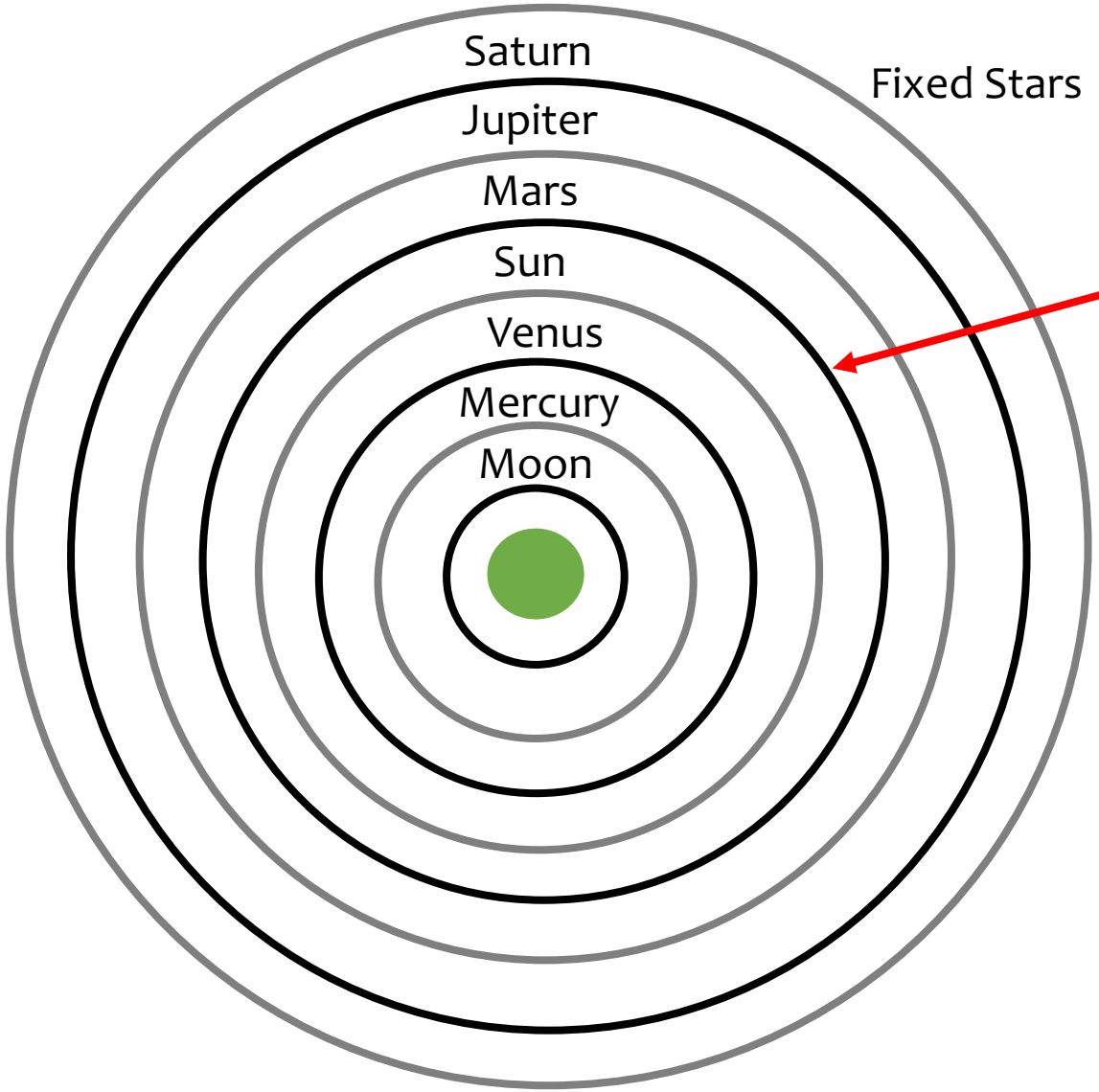
Earth
Spherical, stationary, and at the center of the universe

Aristotelian Universe



Order of celestial bodies
5 planets in addition to the sun and moon in the order shown

Aristotelian Universe

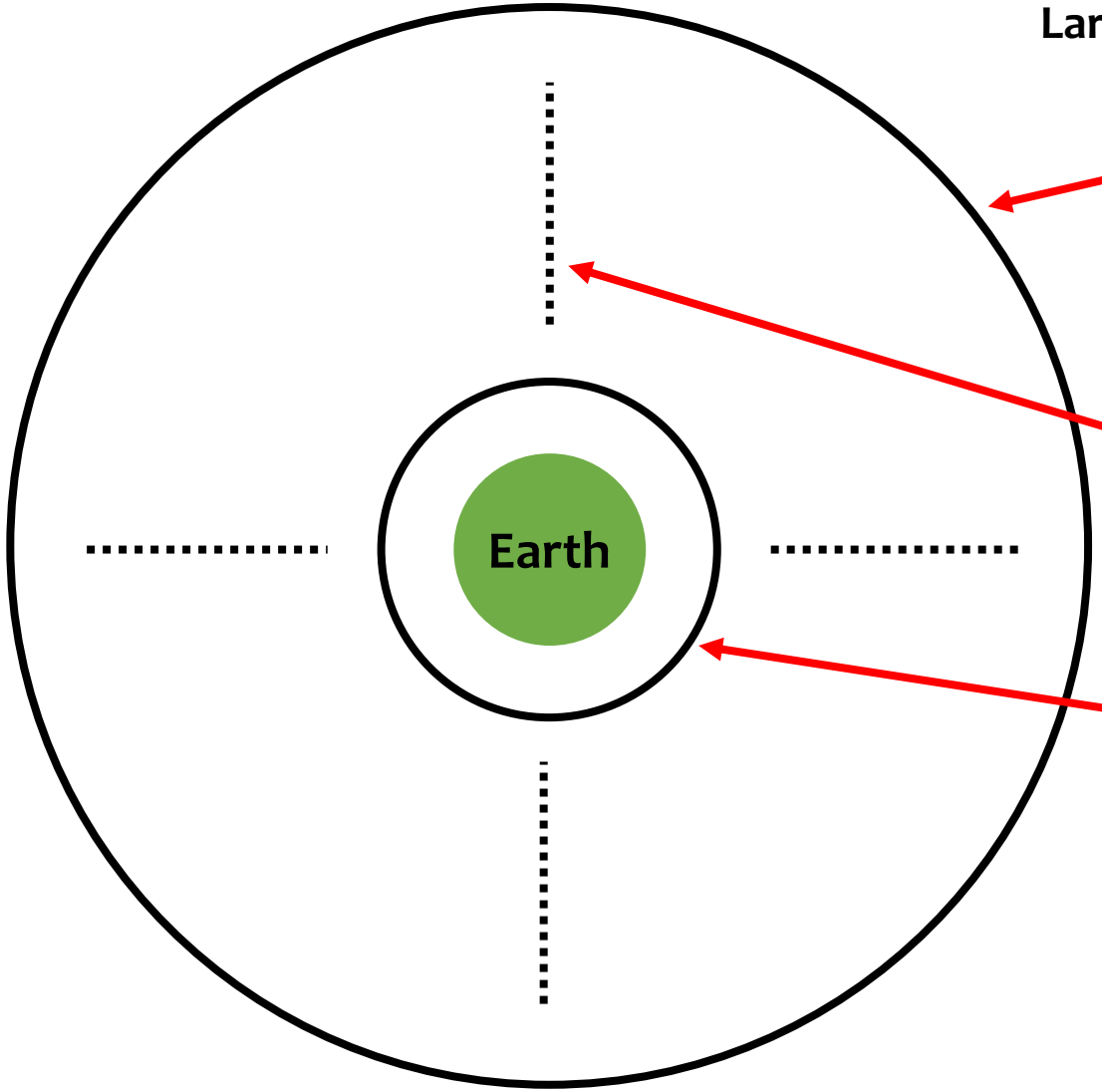


Crystalline spheres
Each celestial body is embedded in a crystalline (transparent) sphere. (The diagram is showing a cross section.)

Each sphere turns on its axis, carrying the celestial body embedded in it.

Each sphere completes a revolution at a different rate. The sphere of the fixed stars takes about one day to complete a revolution.

Aristotelian Universe



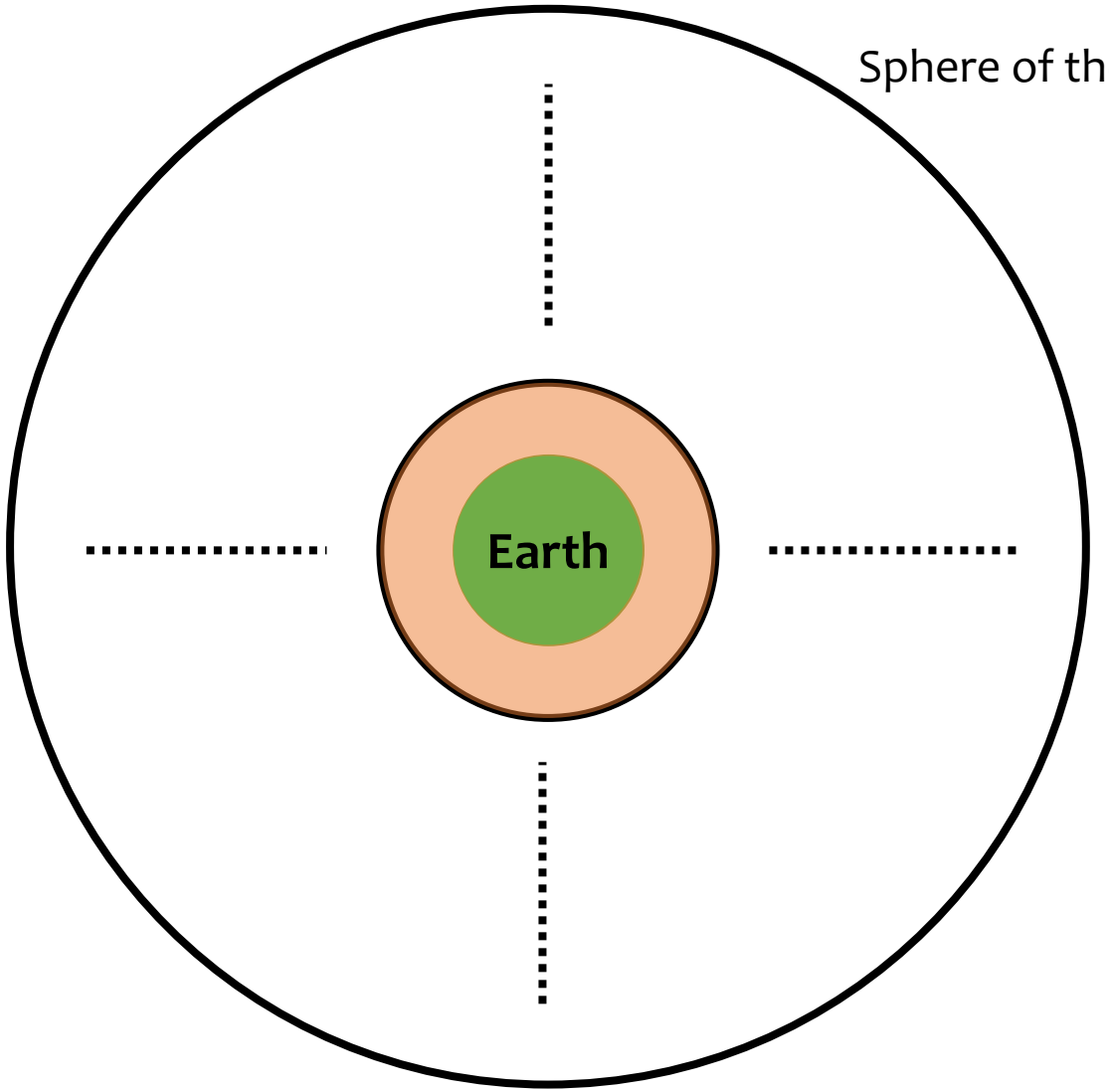
Large scale structures

Sphere of the Fixed Stars
The outer boundary of a universe.

Spheres of the planets (not shown)

Sphere of the Moon
Separates the super- and sublunar regions (see next)

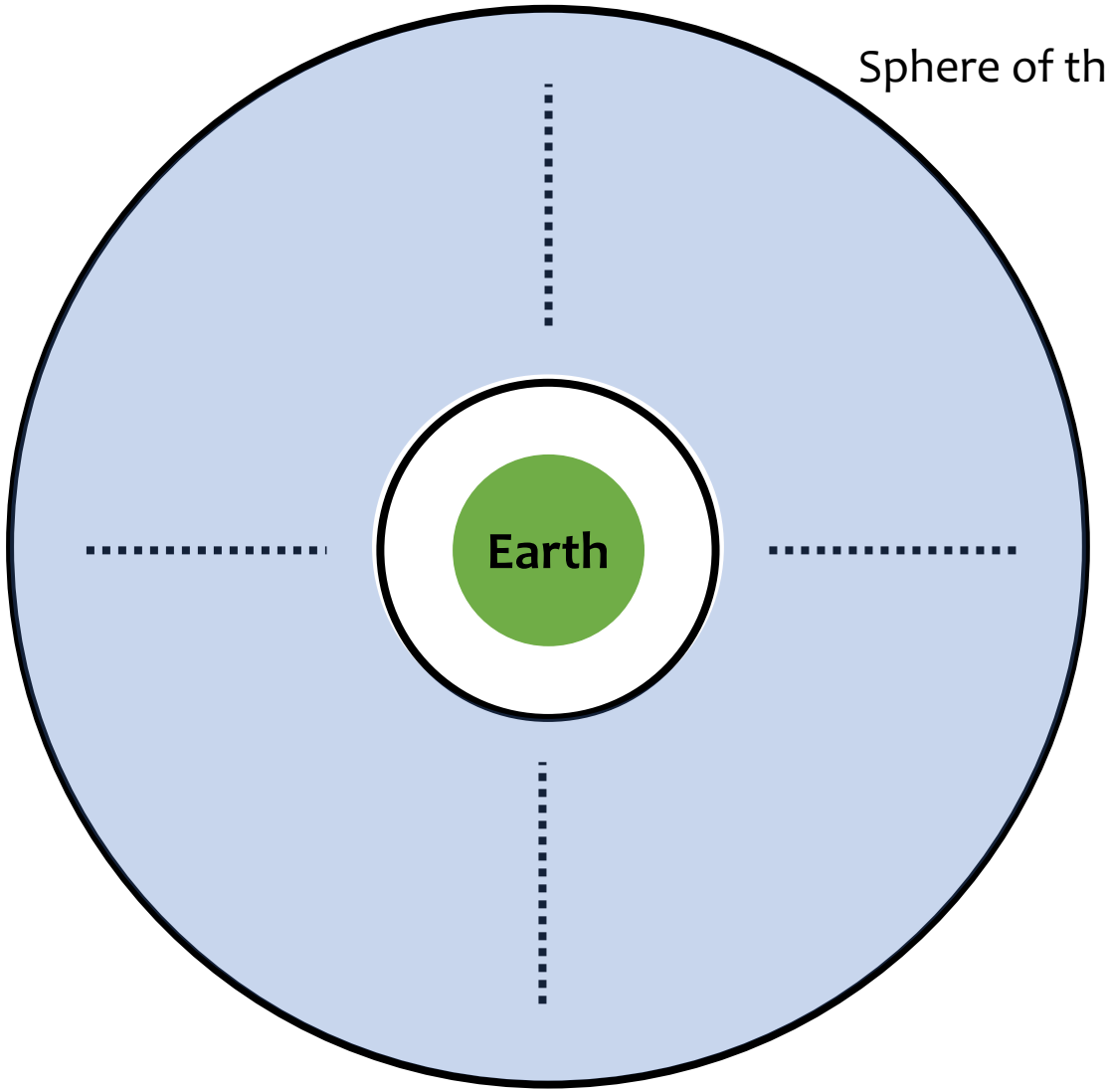
Aristotelian Universe



Sublunar Region
The region below the sphere of the moon (excluding the moon itself), including the earth.

Composed of four elements: earth, water, air, fire

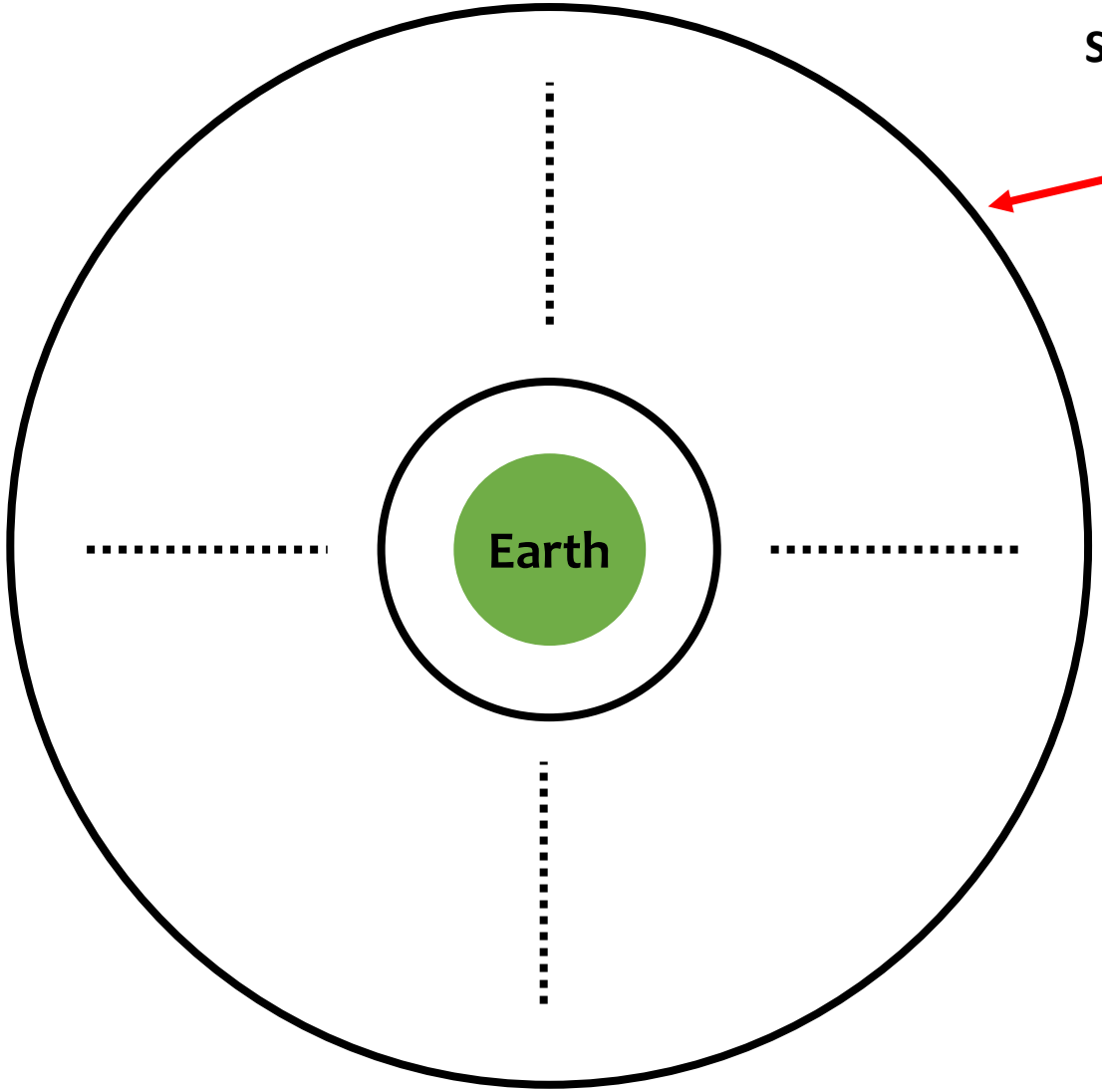
Aristotelian Universe



Superlunar Region
The region above the sphere of the moon (including the moon itself).

Composed of the fifth element, ether.

Aristotelian Universe



Size of the Universe

Sphere of the Fixed Stars
Stars were at the same distance from the earth.

The universe was thought to be large (by any standard), but the Aristotelian universe turned out to be much smaller than what we think the size of the universe to be today.

https://en.wikipedia.org/wiki/Milky_Way

Aristotelian Teleology and Essentialism

- *Telos* = purpose, goal, function of a thing
- Aristotelian teleology has two parts:

1. The universe is teleological.
   - Everything in the universe has a purpose, goal, or function.
2. Scientific inquiry aims at understanding why something exists or behaves as it does, and this understanding requires knowing the purpose of a thing.
   - Understanding why is explanation in a deeper sense as opposed to the minimal sense we talked about last week.

- (1) and (2) are mutually supporting, interlocking beliefs.

Aristotelian Teleology and Essentialism

- To understand (2), it's helpful to focus on the difference between two types of explanation.
- A ***teleological explanation*** (Aristotelian or not) answers a why-question by citing a purpose, goal, or function.
  - Why-questions are questions like "Why does this do that?" or "Why does this exist?"
- A ***mechanistic explanation*** answers a why-question by citing, not a purpose or a goal, but a mechanical or physical process leading to an object or behavior of interest.

Aristotelian Teleology and Essentialism

Example 1

- Why is your clock moving?
- Possible answers:

A. Because I want to keep time.

B. Because I charged it, and the internal parts of the clock are moving properly.

- Which one is a teleological explanation? [Top Hat]

Aristotelian Teleology and Essentialism

- Example 1 is a case of an artifact.
- In general, an artifact has a purpose that is intended by a user.
  - I intend to use a clock to keep time, so the purpose of the clock is to keep time.
- For Aristotle, to fully answer a why-question about an artifact (its existence and behavior), it's not enough to give only a mechanical explanation.

Why do these buildings have the shapes they do?

A mechanical explanation would describe the material of the buildings, diameters of the bottom and top parts, and how the weight of the upper part is supported by the lower part.

Bernd Becher and Hilla Becher

Why do these buildings have the shapes they do?

A teleological explanation would cite the purposes or functions of these buildings. They are water towers. So *to hold as much water as possible*, the upper part is large. And *to dispense water by gravity*, the building is tall. (*Italics* are the purposes.)

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Aristotelian Teleology and Essentialism

Example 2

- Why does a bird sing?
- *To attract mates.*
  - This is a teleological explanation because it cites the purpose or function of bird songs.
- This example is about living things.
- For Aristotle, to fully answer a why-question about a living thing, we need to know its functions (or functions of its parts).

Aristotelian Teleology and Essentialism

- Examples 1 and 2 cover artifacts and living things, and teleological explanations are familiar in our (contemporary) thinking about these things.
  - Biology and engineering are full of talk about functions.
- Some of DeWitt's examples also come from biology.
  - Why do apple trees have apples? *To disperse seeds*.
  - Why does the heart beat? *To pump blood*.
- Note that in all cases, the question is a why-question ("why does this do that?") and an answer cites a purpose.

Aristotelian Teleology and Essentialism

- What is special about Aristotelian teleology is ***why-questions about non-living, non-artefactual things also received teleological explanations***.
  - Non-artefactual just means naturally occurring.
- Why-questions about physical objects and their behaviors would fall under this category.
  - Why does a rock fall?
  - Why do planets move in the way they do?
  - Why does fire move upward?
  - Etc

Aristotelian Teleology and Essentialism

Example 3

- Why does a rock fall?
- An Aristotelian teleological explanation: A rock is made primarily of the element earth, and the purpose of earth is to be at the center of the universe. So a rock falls *in order to be at the center of the universe*.
- To us, this explanation should sound strange.
- Notice that it sounds strange to us because our worldview is no longer Aristotelian (more on this later).

Aristotelian Teleology and Essentialism

Compare Example 3 with this:

Example 4

- Why does an acorn become an oak tree?
- An Aristotelian teleological explanation: Because the goal of an acorn is to become an adult tree.
- Aristotle's explanation of why a rock falls is analogous to this explanation of why a seed becomes a tree.
  - We might think that this explanation is also strange, but maybe less strange than the explanation of falling rock. (See next)

Aristotelian Teleology and Essentialism

- We saw that teleology is familiar in our thinking about artifacts and living things, especially their behaviors and parts.
- But Examples 3 and 4 suggest that certain teleological explanations feel strange to us.
- This is because unlike the Aristotelian worldview, our worldview recognizes purposes in a smaller range of things and behaviors.

Aristotelian Teleology and Essentialism

Revisit Example 3

- Why does a rock fall?
  - An Aristotelian teleological explanation: A rock is made primarily of the element earth, and the purpose of earth is to be at the center of the universe. So a rock falls *in order to be at the center of the universe*.
  - To us, this explanation should sound strange.
- We don't think there is any purpose for a rock to fall. To answer this question, we would describe forces that act on a rock which result in its fall.
- That is, we would give a mechanistic explanation.

Aristotelian Teleology and Essentialism

Revisit Example 4

- Why does an acorn become an oak tree?
  - An Aristotelian teleological explanation: Because the goal of an acorn is to become an adult tree.
- We don't think there is any purpose for an acorn itself to become an oak tree. To answer this question, we would describe the process of plant development from an acorn to a mature tree.
  - To us, "*Why* does an acorn become an oak tree?" is more like "*How* does an acorn become an oak tree?"
- That is, we would give a mechanistic explanation.
  - But we could give teleological explanations about parts of an acorn, parts of a plant, etc.

Aristotelian Teleology and Essentialism

- Aristotle didn't just stop with teleology. He also asked how teleological behaviors are made possible.
- His answer was essentialism: everything has its natural behavior (or motion), which is determined by composition and arrangements of its parts.
  - A natural behavior is what a thing does when left by itself without any obstruction (e.g., a natural motion of a rock is to fall).
  - A natural behavior of a thing is *essential* in the sense that it defines what that thing is (e.g., it's not a rock if it floats in air).
  - A thing with complex internal composition (like many living things) can have complex natural behaviors.

Aristotelian Teleology and Essentialism

When acorns are left undisturbed, they eventually become oak trees.

So, for Aristotelians, the natural behavior of an acorn is to become a tree, which is also the purpose of an acorn.

The acorn's ability to become a tree is determined by its internal composition.

Aristotelian Teleology and Essentialism

- Remember that Aristotle and his immediate followers developed the Aristotelian worldview before Christianity.
- After the Catholic Church dominated Europe, the Aristotelian worldview became its official scientific worldview.
- The Aristotelian worldview already had Catholic-friendly ideas (a few examples):
  - Everything in the universe has a purpose. (This is true for the Catholics, because God created the universe. That is, everything is God's artifact and has the purpose he intends.)
  - The earth is at the center of the universe. (This coheres with the Christian view that human beings are special in the universe.)

Aristotelian Teleology and Essentialism

- But the Church also modified or eliminated parts of the Aristotelian worldview.
  - Example: https://en.wikipedia.org/wiki/Condemnations_of_1210%E2%80%931277
- Notably, Aristotle's own view of the universe didn't include a creator god.
- The Church adopted the Aristotelian universe and incorporated Christian elements (example next).

Peter Apian's representation of the universe from his *Cosmographia* (1524) (https://en.wikipedia.org/wiki/Petrus_Apianus)

Note the Christianization of the Aristotelian universe: the outermost part is the empire of God.

Chapter 10: The Preface to Ptolemy's *Almagest*

The Aristotelian Core Beliefs and Ptolemy's Arguments

A. *The Earth is spherical.*
   1. Confirmation reasoning (passages [1]–[3], [5]–[6])
   2. Disconfirmation reasoning (passages [4]–[6])

B. *The Earth is stationary.*
   1. Common-sense arguments
   2. Argument from objects in motion
   3. Argument from stellar parallax

C. *The Earth is at the center of the universe.*
   1. Common-sense argument
   2. Teleological argument
   3. Argument from the spherical Earth

The Aristotelian Core Beliefs and Ptolemy's Arguments

A. ***The Earth is spherical.***
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   2. **Disconfirmation reasoning (passages [4]–[6])**

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The Earth as Spherical

Confirmation reasoning (basic scheme; review Week 3)

1. If the Earth is spherical, we should observe O.
2. We do observe O.
3. So, probably the Earth is spherical.

- Ptolemy's passages [1]–[3] and [5]–[6] (as marked in the textbook) contain confirmation reasoning.

The Earth as Spherical

Passage [1]

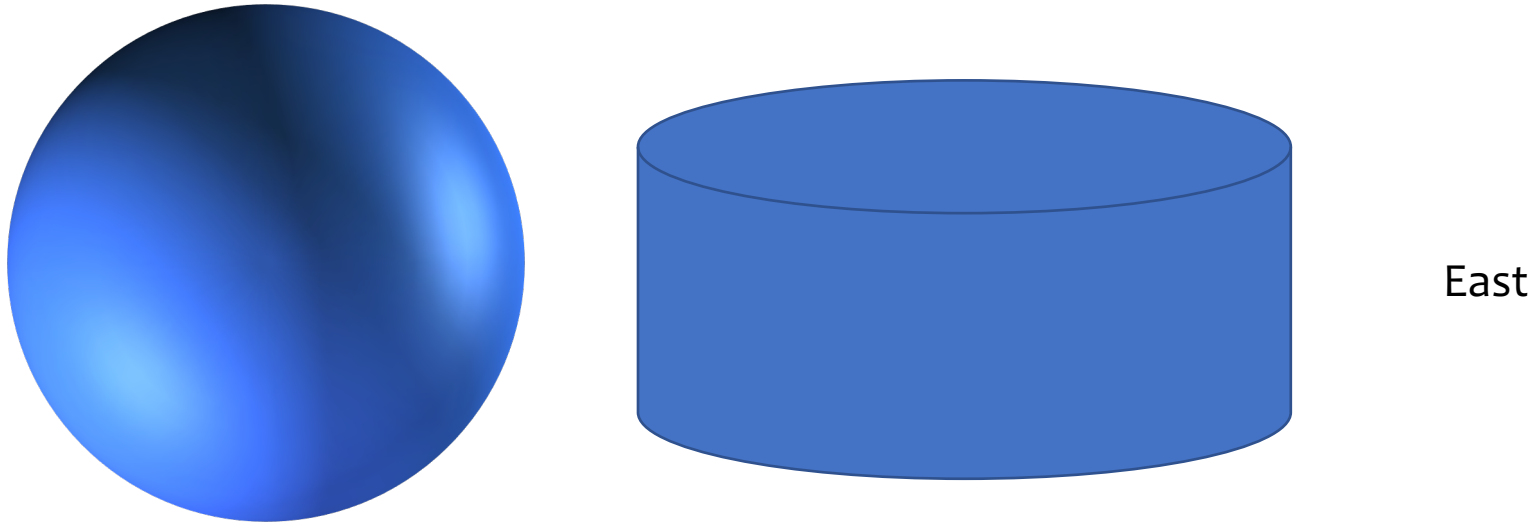
1. If the Earth is spherical, we will observe the sun, moon, and stars as rising and setting at different times, depending on where we observe.
2. The sun, moon, and stars do rise and set at different times, depending on where we observe them.
3. So, probably the Earth is spherical.

- Here **O** = the sun, moon, and stars rise and set at different times, depending on where we observe them.
- Passage [2] has the same reasoning with different **O**.

The Earth as Spherical

- The arguments so far only support the curvature of the Earth in east-west direction.
- The cylindrical Earth would also predict the same observations.

West



East

The Earth as Spherical

- In other words, the following theories are *underdetermined* by our observations of the rising and setting times of the sun, moon, and stars.

1. The Earth is spherical.
2. The Earth is cylindrical in the east-west direction.

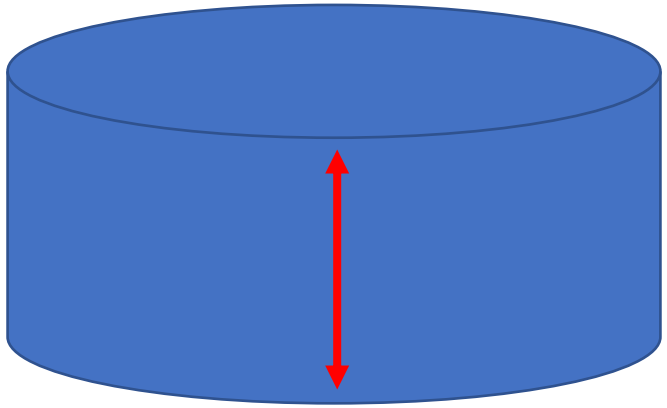
- Ptolemy's argument in passage [5] addresses this issue.
  - We'll skip passage [4] for now.

The Earth as Spherical

Passage [5]

1. If the Earth is cylindrical in the east-west direction, we should be able to observe the same stars as we travel north or south.
   - In other words, the north-south direction (see red arrow) is the same as flat Earth.
2. But we observe different stars as we travel north or south.
3. So the Earth is not cylindrical.

- This is disconfirmation reasoning.



The Earth as Spherical

- Passage [5] also serves as confirmation of the spherical Earth:

1. If the Earth is spherical, we should be able to observe different stars as we travel north or south.
2. We do observe different stars as we travel north or south.
3. So probably the Earth is spherical.

- This is confirmation reasoning.

The Earth as Spherical

- Passage [4] presents disconfirmation reasoning for other possible shapes of the Earth.
  - “concave,” “flat,” “pyramid,” “cube,” etc.
- We’ll use the flat Earth as an example, but Ptolemy’s arguments apply equally to other shapes.

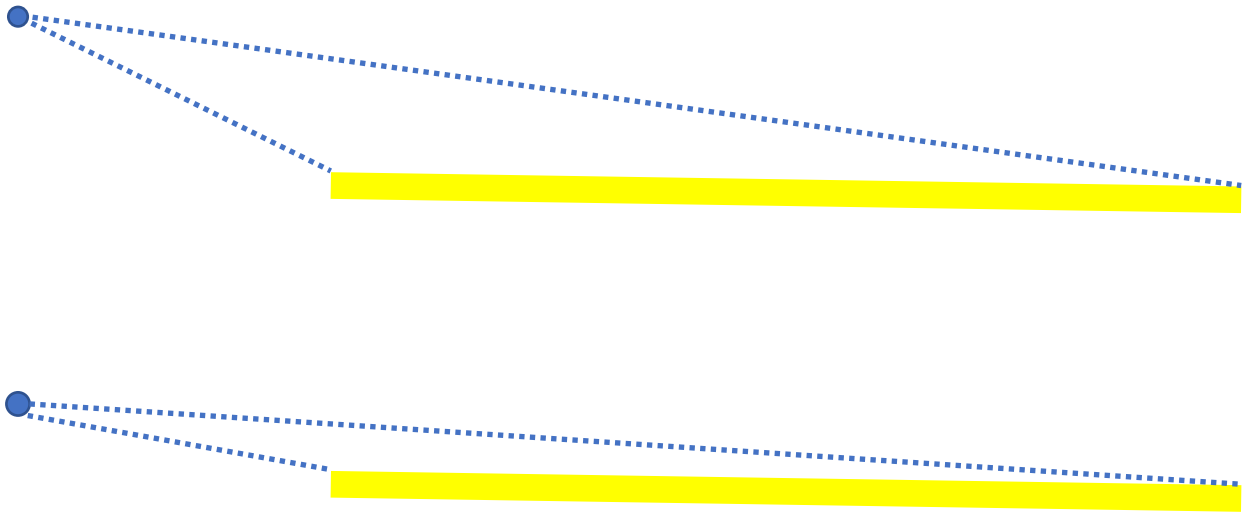
The Earth as Spherical

Passage [4]

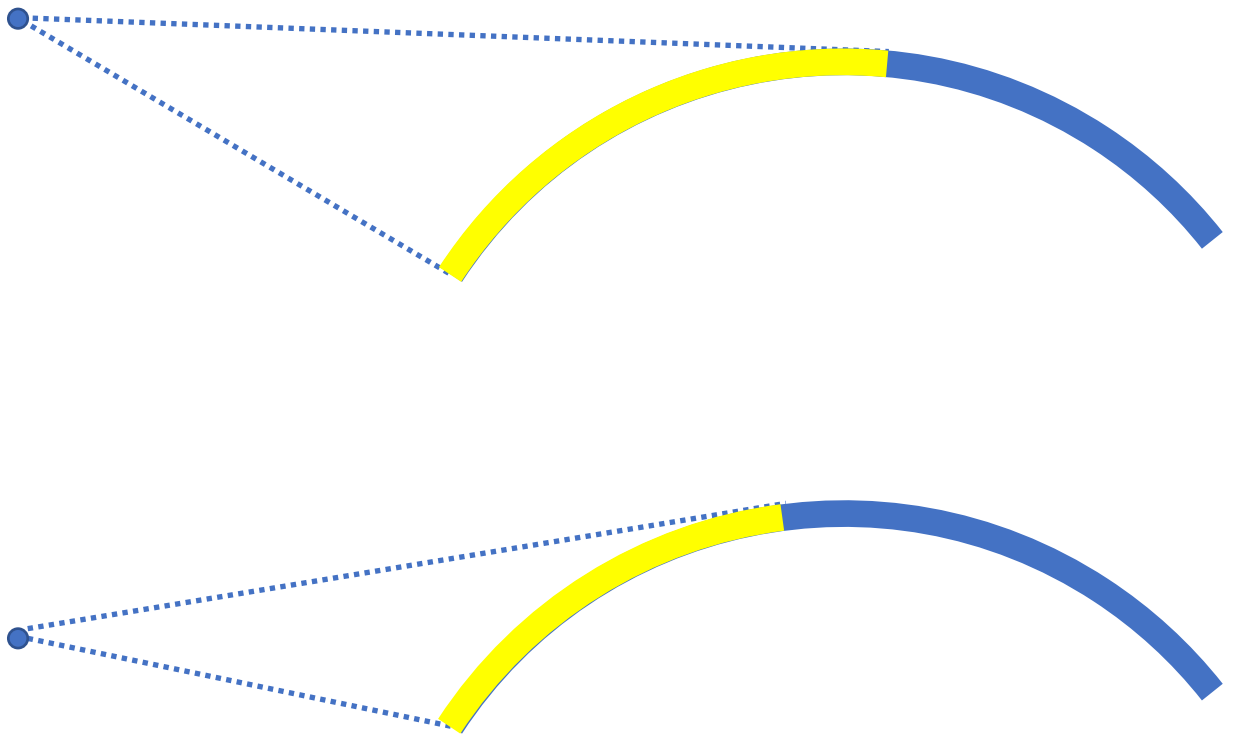
1. If the Earth is flat, the stars (or the sun or the moon) rise and set at the same time for all observers on the Earth.
2. But the stars rise and set at different times for observers at different locations on the Earth.
3. So the Earth is not flat.

- This is disconfirmation reasoning.
- As we saw in Passage [1], observations (2) are as predicted by the spherical Earth theory.

The Earth as Spherical



The Earth as Spherical



The Earth as Spherical

Passage [6]

1. If the Earth is flat, we should see the entire mountains all at once when we sail towards them.
2. But we see the tops first, and as we sail closer, we gradually see the lower parts.
3. So the Earth is not flat.

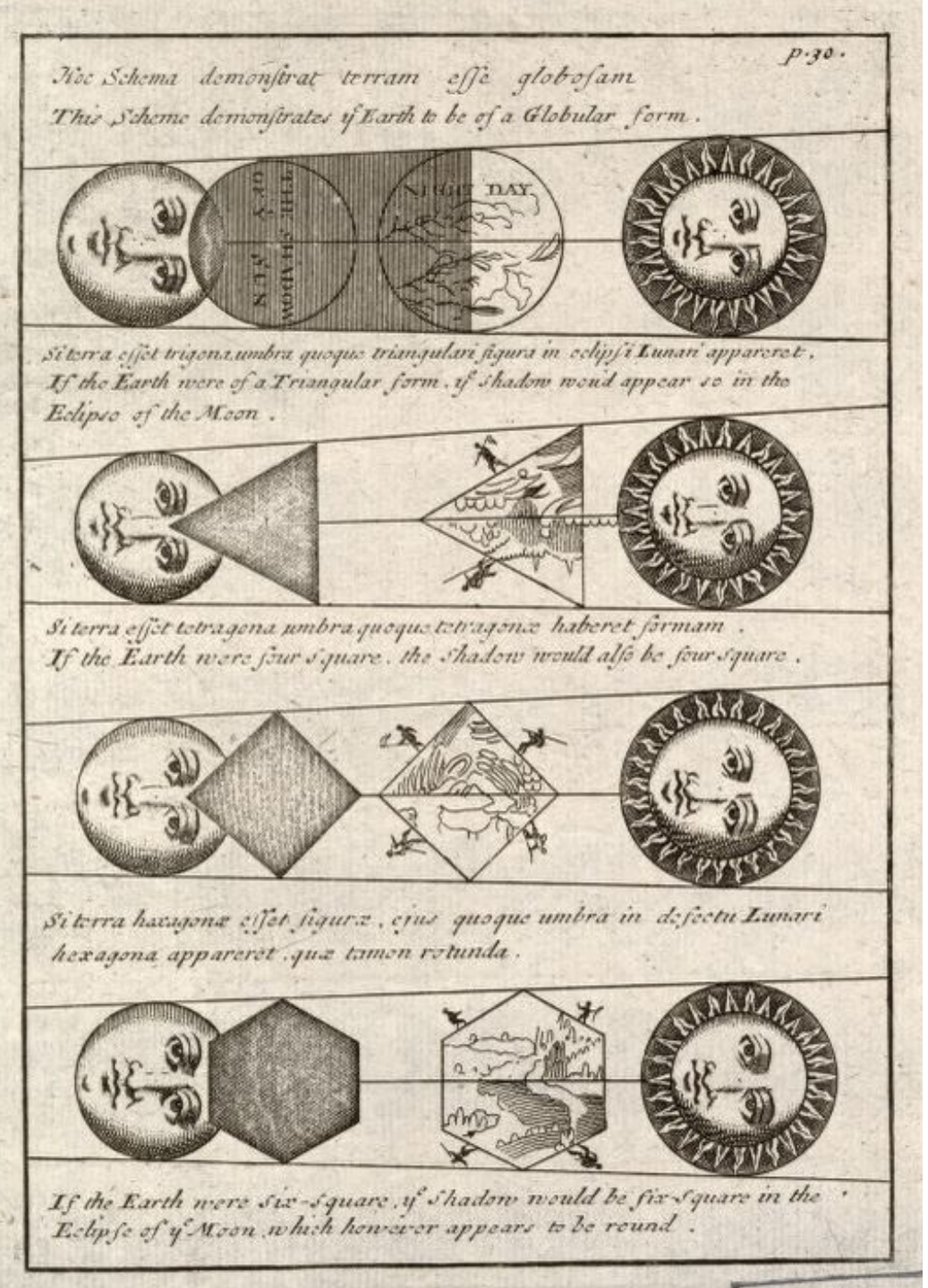
- This is disconfirmation reasoning.
- Observations (2) also serve in confirmation reasoning (next).

The Earth as Spherical

Passage [6]

1. If the Earth is spherical, we should see the tops of mountains first and then the lower parts as we sail towards the mountains.
2. We do see the tops first and then the lower parts as we get closer.
3. So probably the Earth is spherical.

- This is confirmation reasoning.
- Of course, instead of sailing towards mountains, you can look at a large ship sailing away (the hull disappears first and the top of the mast last.)

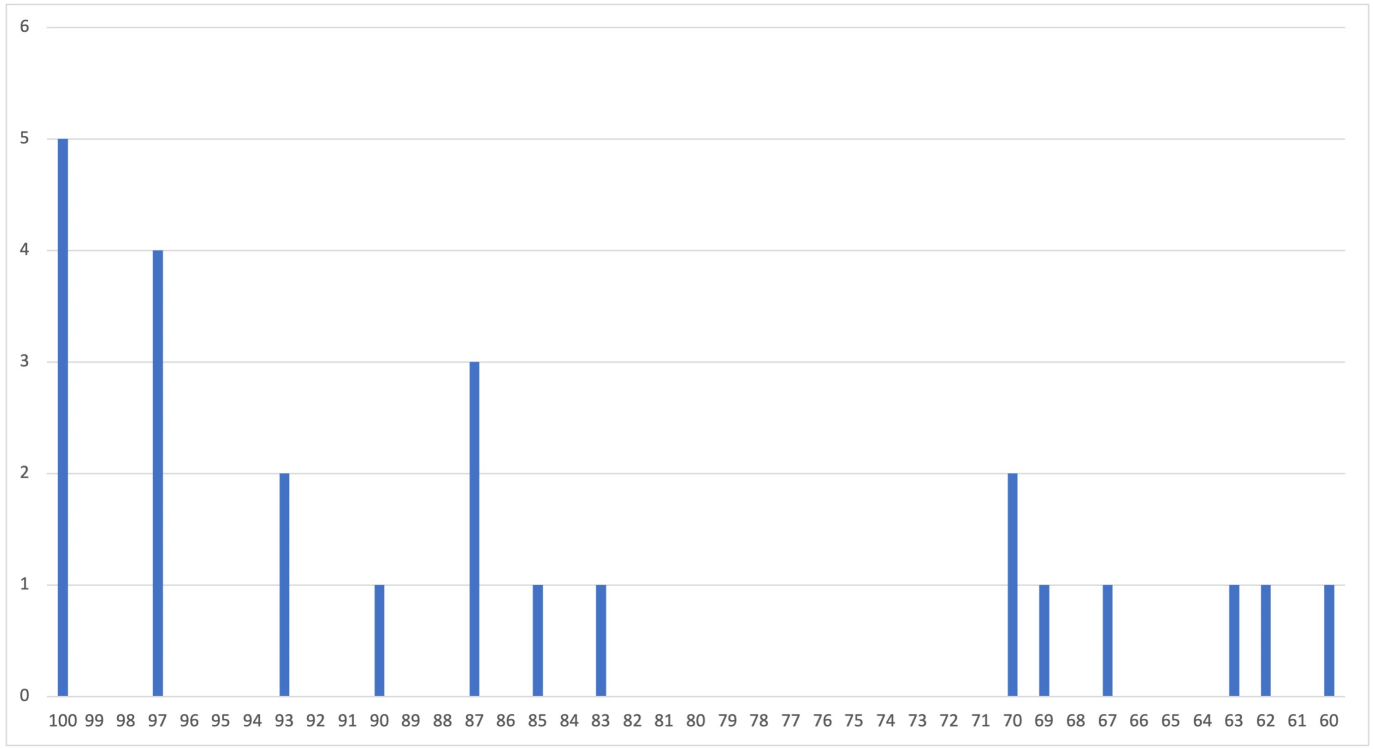


Other ancient arguments for the spherical Earth included the shapes of a lunar eclipse.

Diagrams of solar eclipse, from *Universal Geography*, 1711.

For more, see: https://www.loc.gov/collections/finding-our-place-in-the-cosmos-with-carl-sagan/articles-and-essays/modeling-the-cosmos/ancient-greek-astronomy-and-cosmology/

Exam 1



Mean = 84
Median = 88

The Aristotelian Core Beliefs and Ptolemy's Arguments

A. *The Earth is spherical.*
   1. Confirmation reasoning (passages [1]–[3], [5]–[6])
   2. Disconfirmation reasoning (passages [4]–[6])

B. *The Earth is stationary.*
   1. Common-sense arguments
   2. Argument from objects in motion
   3. Argument from stellar parallax

C. *The Earth is at the center of the universe.*
   1. Common-sense argument
   2. Teleological argument
   3. Argument from the spherical Earth

The Earth as Stationary

Common-sense arguments

- DeWitt describes several. We'll just look at one example comparing the stationary Earth and the rotating Earth.

The Earth as Stationary

Common-sense arguments (example)

1. If the Earth revolves on its axis in a day, then we are traveling at over 1,000 miles per hour.
   - See DeWitt's text for how we (and the ancients) arrive at this speed.
2. If we are traveling at over 1,000 mph, we should be able to notice the effects of the Earth's motion.
   - The reason for this belief is also common-sense: we can notice the effects of the motion in other circumstances on earth.
3. But we do not feel the effects of the Earth's motion.
4. So the Earth is not moving.

- This is disconfirmation (deductive) reasoning.

The Earth as Stationary

- Recall that *in deductive reasoning, if the premises are true, the conclusion must also be true*. (This is the security you get from deductive reasoning.)
- This means that *in deductive reasoning, if the conclusion is false, one or more of the premises must also be false*.

The Earth as Stationary

Common-sense arguments (example)

1. If the Earth revolves on its axis in a day, then we are traveling at over 1,000 miles per hour.
2. If we are traveling at over 1,000 mph, we should be able to notice the effects of the Earth's motion.
3. But we do not feel the effects of the Earth's motion.
4. So the Earth is not moving.

- This is deductive, but the conclusion is false. So one or more of the premises must be false. Which one?

The Earth as Stationary

Argument from objects in motion (full version from DeWitt)

1. If the Earth is in motion, and if the view of motion depicted in Figure 10.1 (see the book and next) is correct, then thrown objects will land behind us.
   - What's in red is an auxiliary hypothesis.
2. But thrown objects do not land behind us.
3. So the Earth is not in motion, or the view of motion depicted in Figure 10.1 is not correct.

- Note that the conclusion is now in the form of "not T, or not A"

Fig. 10.1 from DeWitt

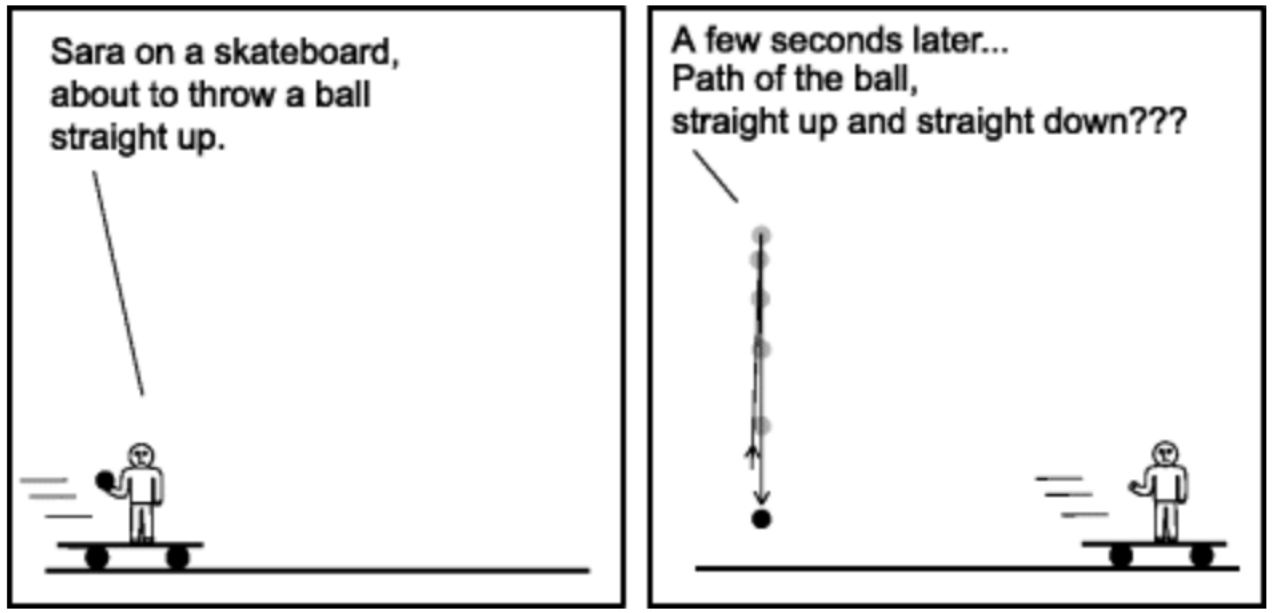
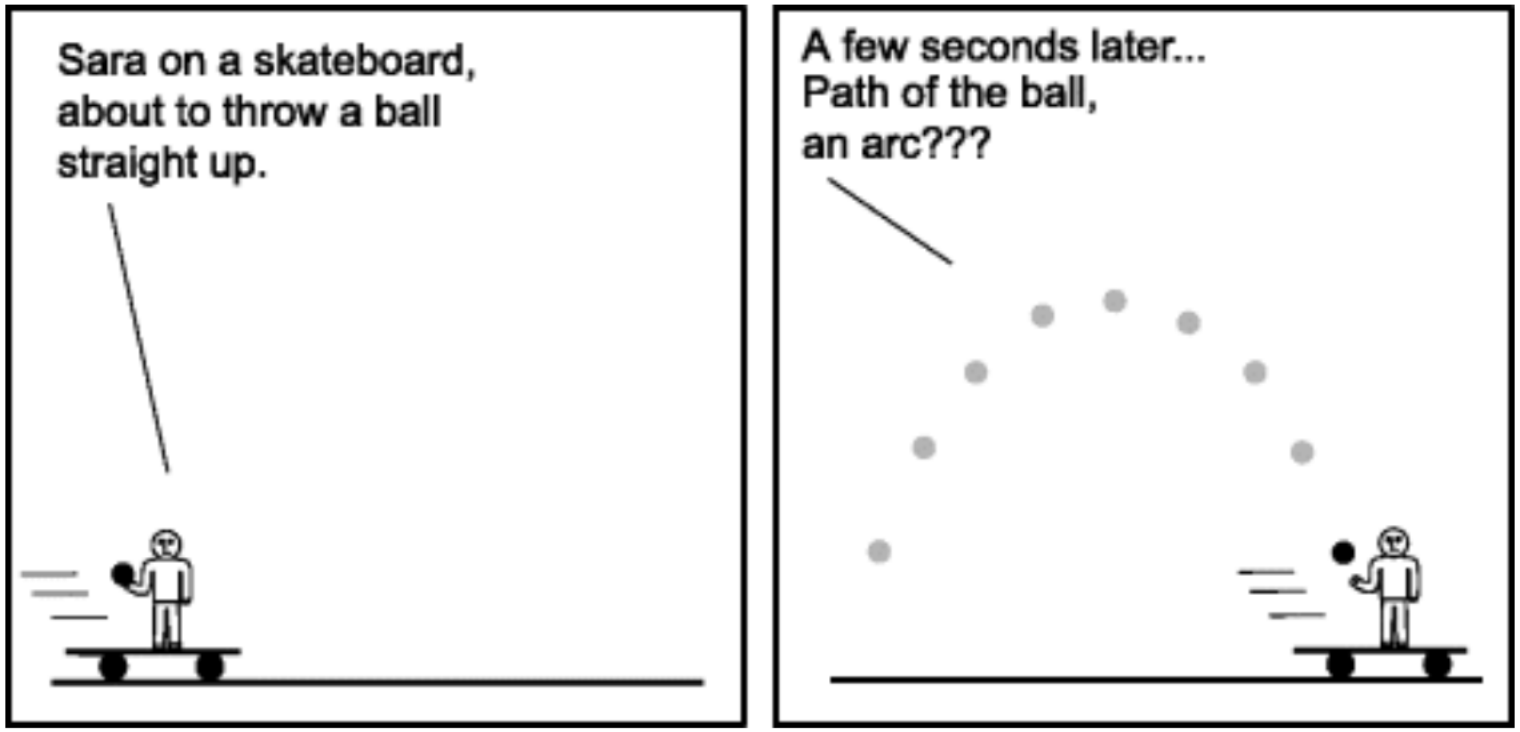


Fig. 10.2 from DeWitt



The Earth as Stationary

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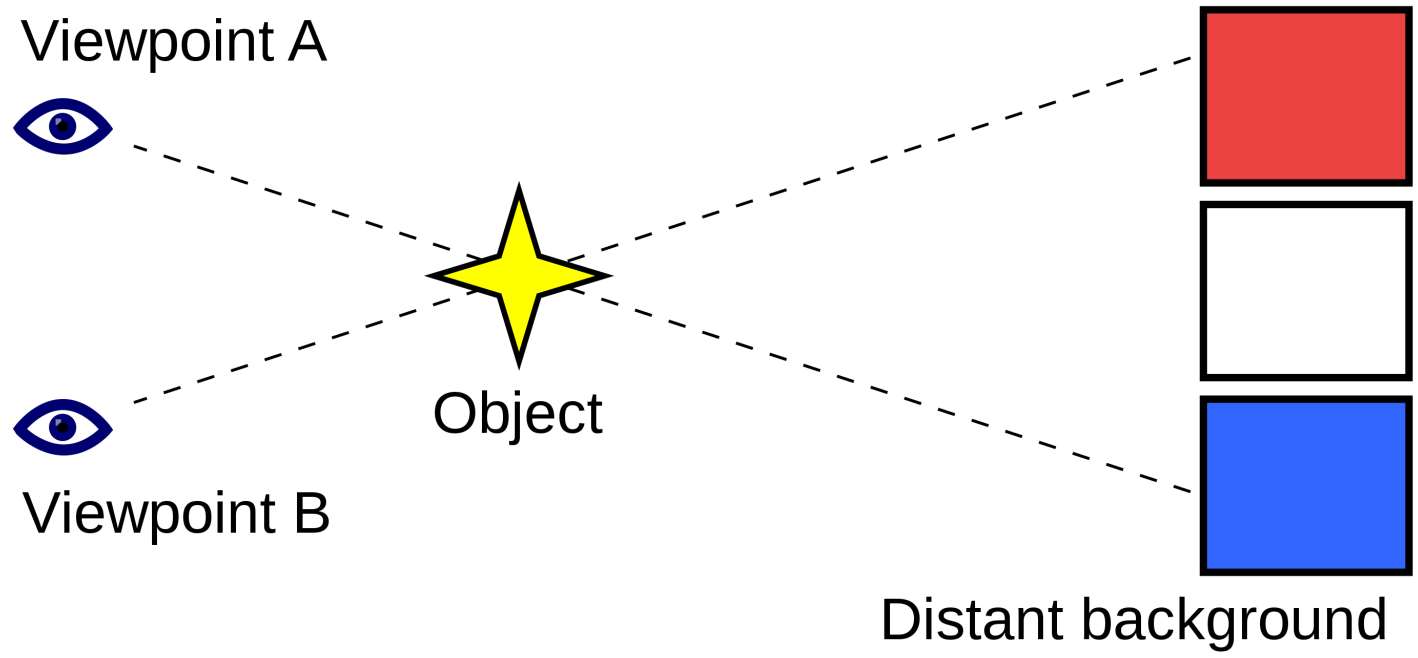
2. But thrown objects do not land behind us.
3. So the Earth is not in motion, or the view of motion depicted in Figure 10.1 is not correct.

- This reasoning is deductive, but the conclusion is false. So one or more of the premises must be false. Which one?

The Earth as Stationary

Argument from stellar parallax (a simpler version)

1. If the Earth is in motion (say in orbit), we should detect stellar parallax.
2. But we do not detect stellar parallax.
3. So the Earth is not in motion.



(Ordinary) Parallax

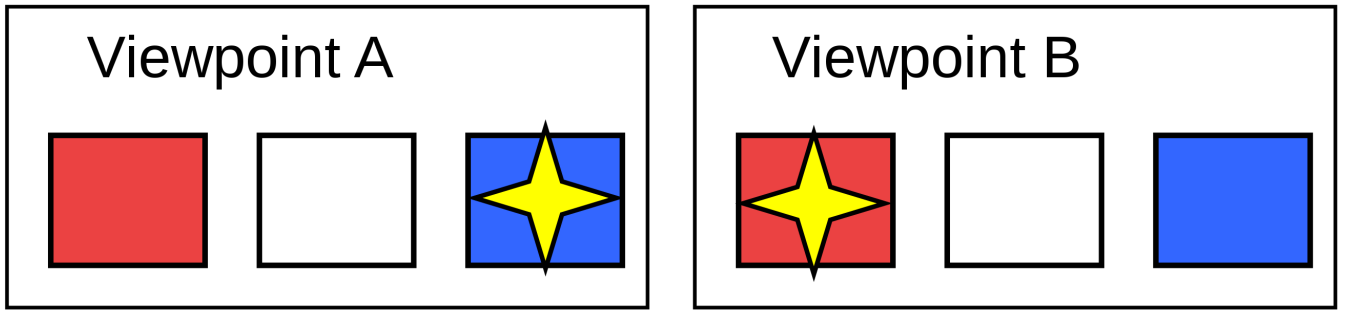


Diagram is from Wikipedia
(https://commons.wikimedia.org/wiki/File:Parallax_Example_en.svg)

Stellar Parallax

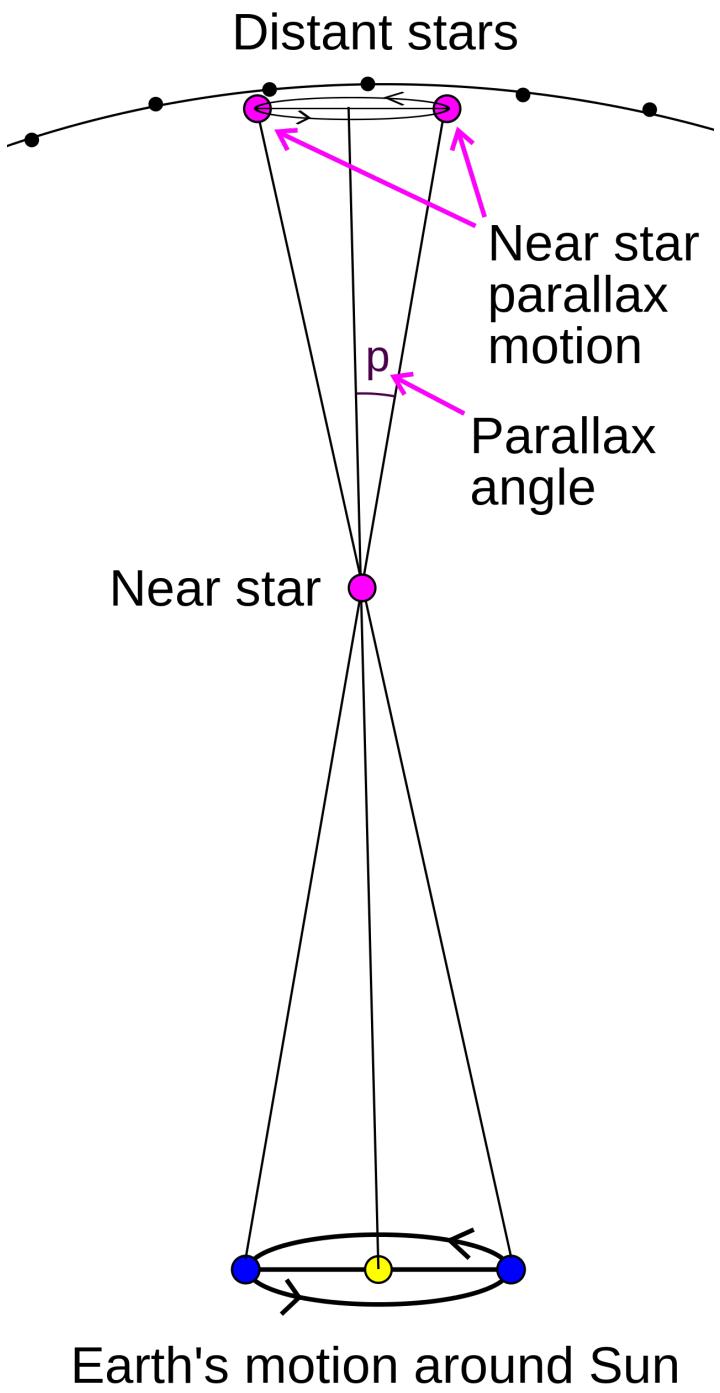


Diagram is from Wikipedia
(https://commons.wikimedia.org/wiki/File:Stellarparallax2.svg)

The Earth as Stationary

- We can easily detect ordinary parallax. Changing the viewpoint by an inch (or even less) would cause detectable parallax.
- If the Earth is moving around the sun, in 6 months, we will be almost 200 million miles away from where we are now.
- But Ptolemy points out that we don’t detect stellar parallax.

The Earth as Stationary

Argument from stellar parallax (a simpler version)

1. If the Earth is in motion (say in orbit), we should detect stellar parallax.
2. But we do not detect stellar parallax.
3. So the Earth is not in motion.

- This version doesn't account for a key auxiliary assumption.

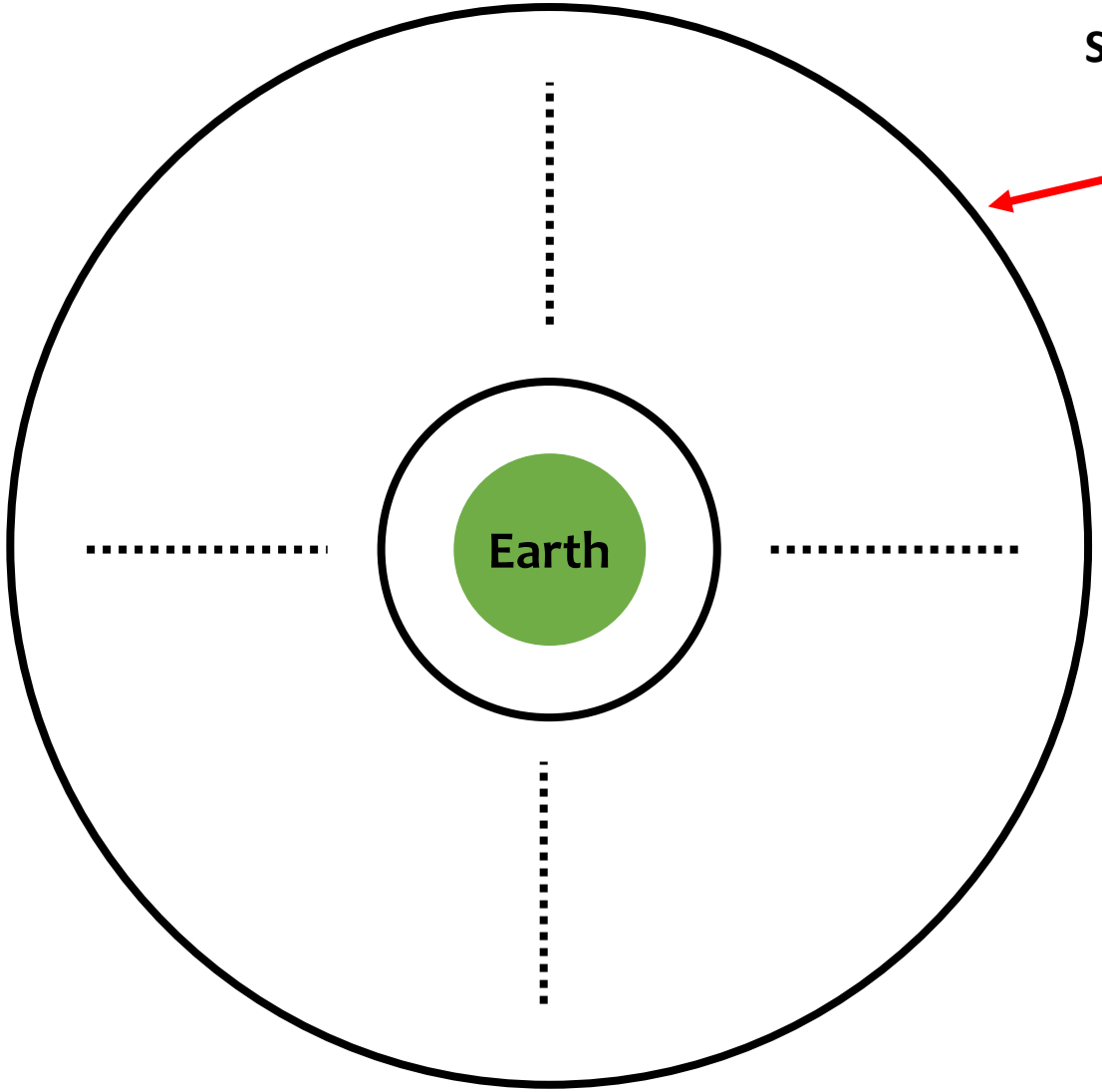
The Earth as Stationary

Argument from stellar parallax (full version)

1. If the Earth is in motion (say in orbit), and ***if the stars are not incredibly far away,*** then we should detect stellar parallax.
2. But we do not detect stellar parallax.
3. So the Earth is not in motion.

- The auxiliary hypothesis (in red) is of course coherent with the Aristotelian belief about the size of the universe.

Aristotelian Universe



Size of the Universe

Sphere of the Fixed Stars
Stars were at the same distance from the earth.

The universe was thought to be large (by any standard), but the Aristotelian universe turned out to be much smaller than what we think the size of the universe to be today.

The Earth as Stationary

Argument from stellar parallax (full version)

1. If the Earth is in motion (say in orbit), and ***if the stars are not incredibly far away,*** then we should detect stellar parallax.
2. But we do not detect stellar parallax.
3. So the Earth is not in motion.

- But this auxiliary hypothesis turns out to be false, and if the stars are incredibly far away, stellar parallax can be so small that we don't detect it.
- In fact, it's very difficult to detect stellar parallax. It was only in 1838 that the first accurate detection was made.

The Earth as Stationary

- The argument from objects in motion and the argument from stellar parallax were powerful arguments *against* the moving Earth and *in favor of* the stationary Earth.
- Neither argument can be refuted simply by accumulating more observations. (More on this later, but this point highlights the importance of theoretical considerations in science.)

The Earth as Stationary

- To convincingly reject the argument from objects in motion, we need a different (and often counterintuitive) theory of motion, like the one developed in the 16th and 17th centuries.
- To convincingly reject the argument from stellar parallax, we need a different belief about the size of the universe, like the one developed in the 16th and 17th centuries. This new belief is not easy to defend by observations.

Quiz 4

The Aristotelian Core Beliefs and Ptolemy's Arguments

A. *The Earth is spherical.*
   1. Confirmation reasoning (passages [1]–[3], [5]–[6])
   2. Disconfirmation reasoning (passages [4]–[6])

B. *The Earth is stationary.*
   1. Common-sense arguments
   2. Argument from objects in motion
   3. Argument from stellar parallax

C. The Earth is at the center of the universe.
   1. **Common-sense argument**
   2. **Teleological argument**
   3. **Argument from the spherical Earth**

The Earth at the Center of the Universe

Common-sense argument

1. If the Earth is at the center of the universe, the celestial bodies should appear to revolve around the Earth.
2. They do appear to revolve around the Earth.
3. So probably the Earth is at the center of the universe.

The Earth at the Center of the Universe

Teleological Argument

1. If the Earth is made mostly of the earth element, the Earth's natural place is the center of the universe.
2. The Earth is made mostly of the earth element.
3. So the Earth is at the center of the universe.

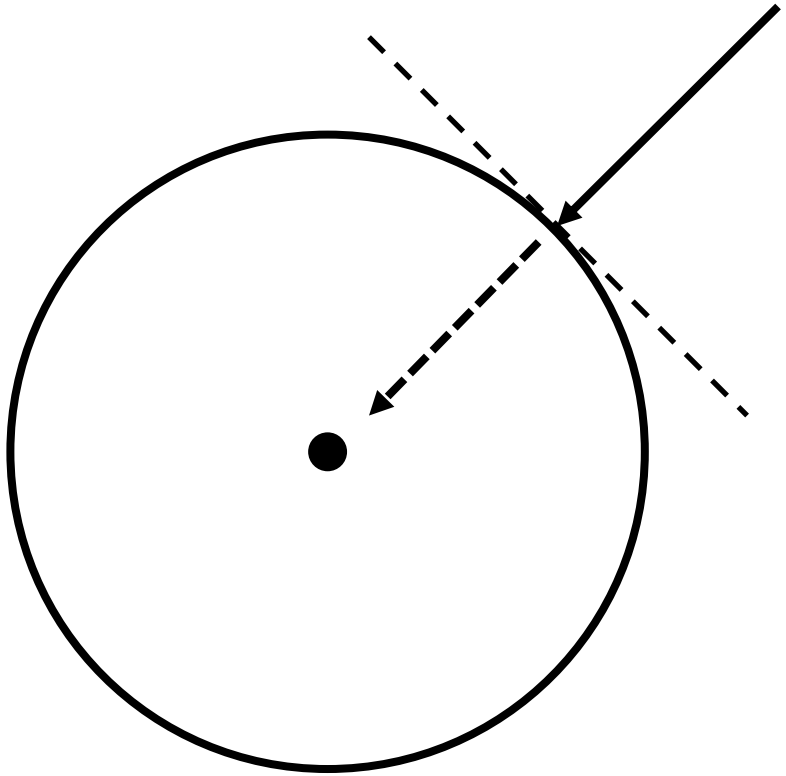
- This argument is teleological because it uses the *purpose* of the earth element to predict the location of the Earth.

The Earth at the Center of the Universe

Argument from the Spherical Earth

1. If (a) the Earth is spherical, and if (b) dropped objects fall perpendicular to the surface of the Earth, then the objects are falling towards the center of the Earth.
2. And if (c) the earth element naturally falls towards the center of the universe, and if dropped objects are falling towards the center of the Earth, then the center of the Earth must also be the center of the universe.
3. (a) and (c) are part of the Aristotelian worldview, and (b) is observed.
4. So the center of the Earth must be the center of the universe.

The Earth at the Center of the Universe



Dropped objects fall toward the center of the Earth. And given the belief that these objects are also falling toward the center of the universe, it follows that the center of the Earth must also be the center of the universe.