

Aristotle & Ptolemy:  
Trying to Make the Geocentric Model Work  
Astronomy  
Lesson 2

Aristotle was one of the most famous philosophers and scientists of the Ancient world. Aristotle was born in 384 BCE in Stageira in northern Greece. He was the son of the royal physician, Nichomachus. When he was 17, Aristotle went to Athens to study with Plato at Plato's Academy. Aristotle remained at the Academy for 20 years as a student and later as a teacher.

Aristotle was a brilliant student and teacher, but opposed some of Plato's philosophies. Specifically, Aristotle taught a realist view: scientific and mathematical tools are not merely tools, they characterize the way the universe actually is. So, upon Plato's death in 347 BCE, Aristotle left the Academy and traveled through Greece developing his own ideas and philosophies. In 336 BCE he moved back to Athens and started his own school, the Lyceum.

Aristotle is said to have written over 170 texts on subjects ranging from zoology to psychology to logic. In particular, Aristotle studied the heavenly bodies in order to formulate a detailed description of their behavior. He did not use mathematics to support any of his claims about astronomy because he deemed mathematics too perfect to be applied to the less-than-perfect planets—why might this pose problems based on what we know about scientific observation and experiments today?

Through his observations, Aristotle developed the concept of the geocentric universe, or one in which the Earth is the center of the universe. Aristotle chose this model because Greek society popularly believed that the Earth was the center of the universe, and the physics and theory of motion Aristotle had developed were based upon a geocentric universe—keep in mind that the Greeks referred to our solar system as the universe because they didn't realize there was anything else out there.

However, there was one piece of Aristotle's work that just didn't fit with his observations—retrograde motion. Does anyone one know what this is? Retrograde motion is the apparent path of a planet across the night sky. Over the course of a single night, a planet will move from East to West across the sky, similar to the sun and the stars. But, if you continue to observe a planet from one night to the next, while it appears to move from West to East against the background stars most of the time, occasionally, the planet's motion will appear to reverse direction, and the planet will, for a short time, move from East to West against the background stars. This reversal is known as retrograde motion, and it really threw the Greeks for a loop!

(This is a movie of the apparent retrograde motion of Mars:  
<http://mars.jpl.nasa.gov/allabout/nightsky/nightsky04-2003animation.html>.  
Source: NASA, License: Public Domain)

### *Ptolemy*

Ptolemy (85 – 165 CE) attempted to finally solve the problem of retrograde motion. In order to explain the retrograde motion, his models used epicycles: small circles attached to the orbital circle of the planet. These epicycles meant that the planet's distance from Earth changed and the planet would be closer to Earth as the planet traveled to the "Earth-side" of its epicycle and farther from Earth as the planet traveled to the far-side of its epicycle. The epicycles also explained why the planet appeared brighter during the retrograde motion.

(Another great animation of retrograde motion, this attempts to show how the epicycles compensate for the phenomenon –  
<http://csep10.phys.utk.edu/astr161/lect/retrograde/epicycle-move.gif>)

The epicycles seemed to fix some of the problems with retrograde motion, but as the Greeks continued to make observations of the night sky, they continued to need more complex epicycles to explain their observations.

But, really, the problem didn't lie in the epicycles, although they were fun. Rather, the problem was with the Pythagorean Paradigm:

- The planets, Sun, Moon, and stars move in perfectly circular orbits
- The planets, Sun, Moon, and stars maintain a constant speed in their orbits
- The Earth is at the exact center of the motion of the celestial bodies

And, all of these assumptions were about to come into question....

Images to use in lesson:



Aristotle. Statue of Aristotle in front of a university building in Freiburg, Germany.

License: CC-BY-SA  
Author: maha-online.

Source: <http://www.flickr.com/photos/maha-online/64458832/sizes/1/>



Aristotle and Plato in *School of Athens* by Sanzio

Source:  
[http://en.wikipedia.org/wiki/File:Sanzio\\_01\\_Plato\\_Aristotle.jpg](http://en.wikipedia.org/wiki/File:Sanzio_01_Plato_Aristotle.jpg)  
License: Public Domain



Ptolemy depicted in the 16<sup>th</sup> Century

Source: [http://en.wikipedia.org/wiki/File:Ptolemy\\_16century.jpg](http://en.wikipedia.org/wiki/File:Ptolemy_16century.jpg)  
License: Public Domain



Ptolemy as depicted by a medieval artist

Source: <http://en.wikipedia.org/wiki/File:Ptolemaeus.jpg>  
License: Public Domain



Stageira, Greece

License: CC-BY-SA

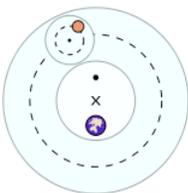
Source:  
[http://commons.wikimedia.org/wiki/File:Stageira\\_\(New\)\\_Greece\\_-\\_Locator\\_Map.png](http://commons.wikimedia.org/wiki/File:Stageira_(New)_Greece_-_Locator_Map.png)



Aristotle's Universe

License: Public Domain

Source:  
[http://starchild.gsfc.nasa.gov/docs/StarChild/universe\\_level2/cosmology.html](http://starchild.gsfc.nasa.gov/docs/StarChild/universe_level2/cosmology.html)



The Basic Ptolemaic Model with Epicycles – a planet rotating around Earth in an epicycle

License: Public Domain

Source:  
[http://en.wikipedia.org/wiki/File:Ptolemaic\\_elements.svg](http://en.wikipedia.org/wiki/File:Ptolemaic_elements.svg)