# Lecture 8
Ptolemy

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- The man: Claudius Ptolemy
    - Lived about 100–170 CE.
    - In Alexandria, Egypt.
    - This is 1500 years before the telescope was invented.
- The book: *Almagest*
    - This is the earliest astronomy book that has survived. It's a systematic presentation of all the astronomy known at the time.
    - "Almagest" comes from Arabic meaning "the great book." Ptolemy's title was "Mathematical Treatise" (in Greek).
    - We'll discuss the first part of Book I, which sets out Ptolemy's general conception of the universe.

The celestial sphere
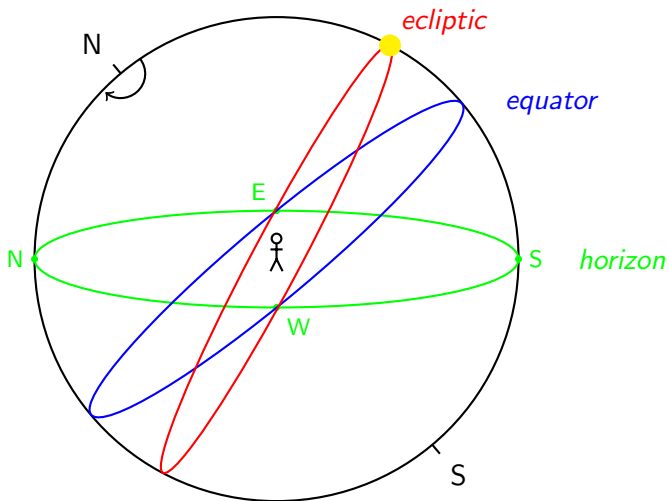
The zodiac divides the ecliptic into 12 equal parts.

Ptolemy argues that we are at the center of the celestial sphere.

Simplified version of Ptolemy's argument

- If we were above the center we would see less than half the celestial sphere. If we were below the center we would see more than half the celestial sphere. But in fact we see half the sphere, e.g., we see half the zodiac at any one time.
- If we were north or south of the center, then at equinox the sun wouldn't rise in the east and set in the west. But we see that it does.
- If we were east or west of the center:
    - The apparent sizes and distances of stars would be different when they are in the east than in the west, contrary to what we observe.
    - The time it takes a star to go from rising to its highest point would not equal the time it takes to go from its highest point to setting, contrary to what we observe.

The earth has, to the senses, the ratio of a point to the distance of the sphere of the so-called fixed stars. [43]

Simplified version of Ptolemy's argument

- It has been shown that we are at the center of the heavens.
- Wherever you go on Earth, the phenomena used to argue that we are at the center are still observed.
- Therefore, the size of the Earth is negligible compared to the heavens.

Ptolemy didn't say the stars look the same from everywhere on earth. They don't and he knew that.

The Earth doesn't move (ch. 7)

As a whole

Since it is always at the center, it can't be moving as a whole.

or by rotating once/day

- The earth's surface would be moving about 1000 miles/hour. *The result would be that all objects not actually standing on the earth would appear to have the same motion, opposite to that of the earth; neither clouds nor other flying or thrown objects would ever be seen moving towards the east.* [45]

- *If they said that the air is carried around in the same direction and with the same speed as the earth, the ... objects in the air would none the less always seem to be left behind by the motion of both [earth and air].* [45]

- *If those objects too were carried around, fused, as it were, to the air, then they would never appear to have any motion either in advance or rearwards.* [45]

Not uniform circular around Earth

- The planets move through the stars from west to east along the ecliptic, like the Sun but at different rates, e.g., Mars takes 2 years, Jupiter takes 12.

- This motion east is not uniform; the speed varies. Sometimes planets even reverse direction and go west for a while; this is called *retrograde motion*.

- The planets vary in apparent size, as viewed from Earth, which indicates their distance from Earth changes.

- But according to Aristotle, only uniform circular motion is natural to heavenly bodies.

- We'll now look at some techniques Ptolemy used to resolve this discrepancy.

Epicycle

deferent · Earth · planet · epicycle
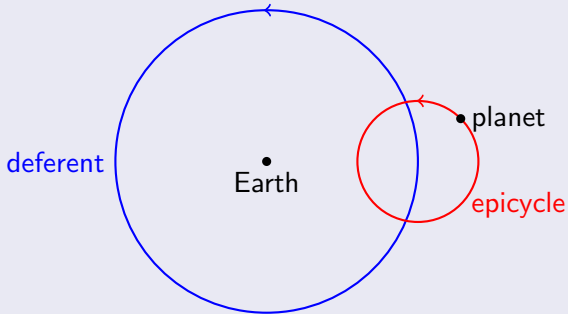
- This is a combination of two uniform circular motions.
- It gives retrograde motion if the (linear) speed of the epicycle is greater than that of the deferent.
- A slower epicycle can explain variations in speed.
- Epicycles also explain variations in apparent size.

Eccentric
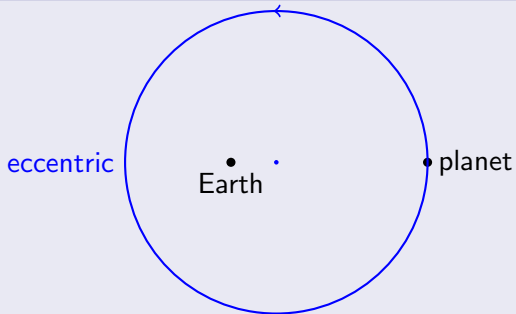
- An eccentric is a deferent in which the center is offset from Earth.
- Eccentrics are another way of explaining changes in apparent size and speed of planets.

1. Give Ptolemaic arguments for the following propositions. If Ptolemy responds to objections to the argument, give that also.
   (a) The earth is in the middle of the heavens.
   (b) The earth has the ratio of a point to the heavens.
   (c) The earth doesn't move, either as a whole or by rotating once/day.
2. Draw a diagram showing a deferent and an epicycle. Under what conditions will this system produce retrograde motion?
3. Explain what an eccentric is and what it can be used for in Ptolemy's astronomy.

References

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