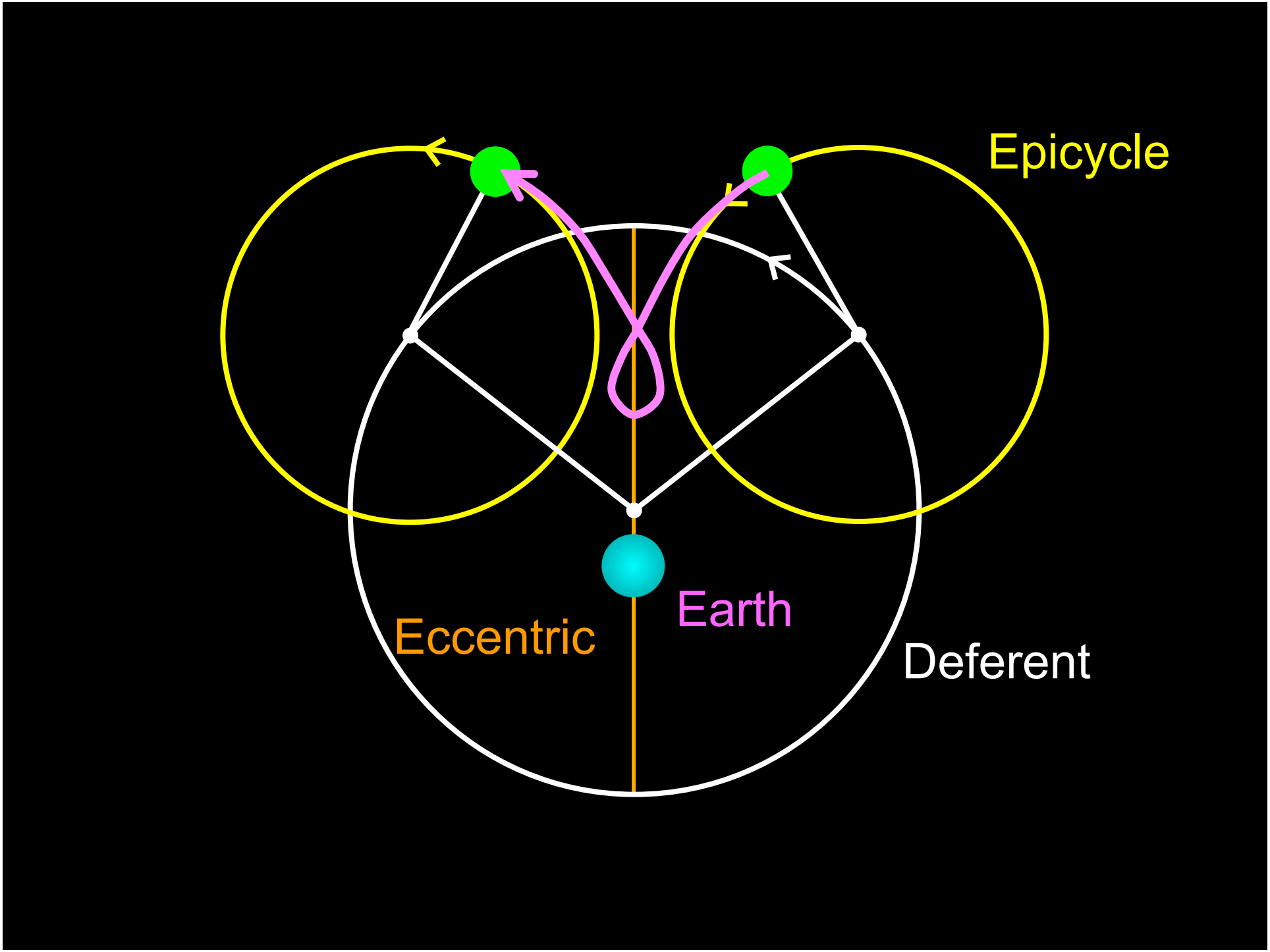
Enter Epicycles

Hipparchus of Nicaea (165-127 BC)

- Greatest astronomer of the classical period
- Discovered the Precession of the Equinoxes
- Developed the system of stellar magnitudes

Elaborated a New Geocentric System

- Introduced epicycles, building on ideas of Apollonius of Perga.
- Located the Earth slightly off-center on an *Eccentric*

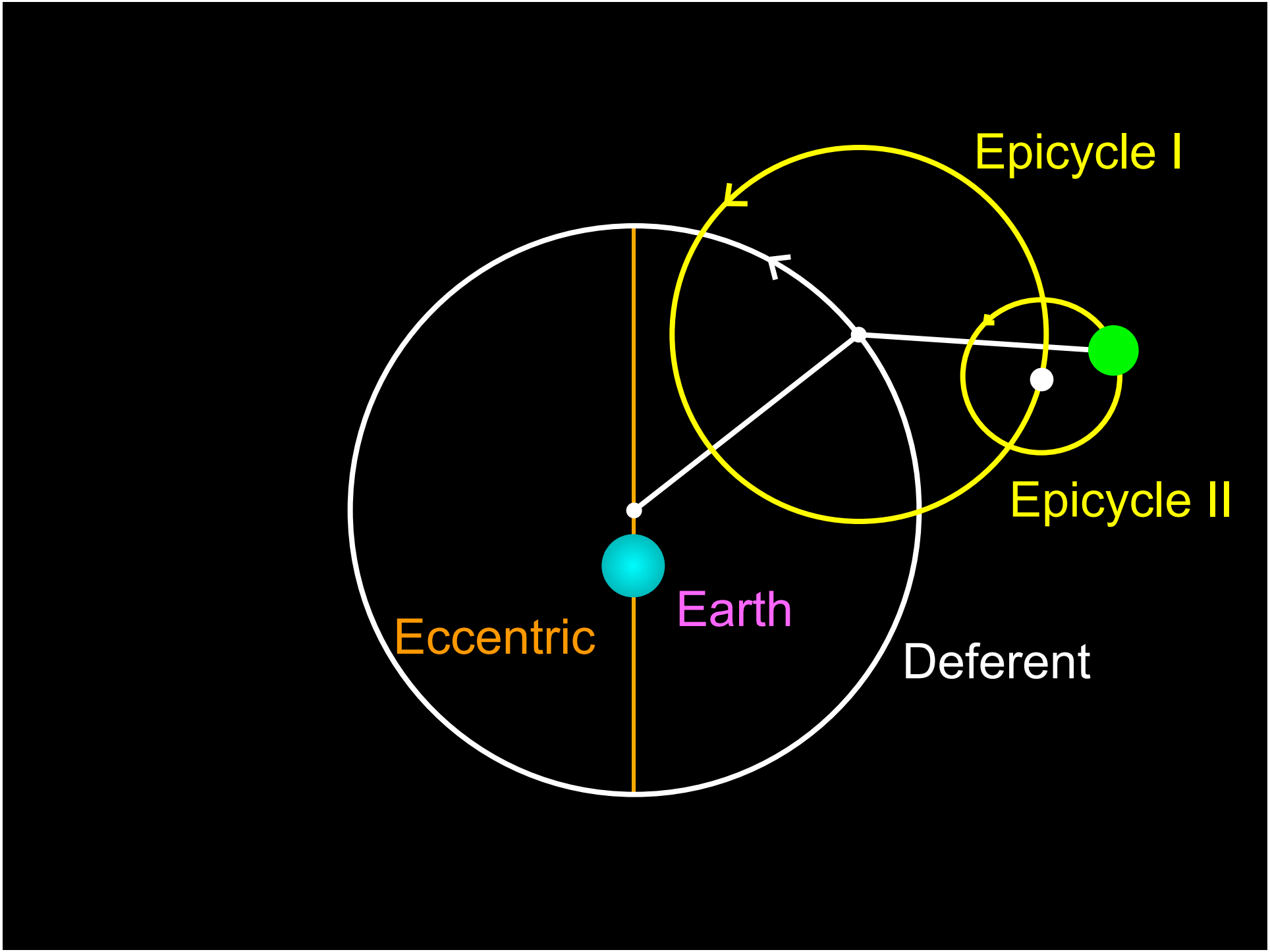

Epicycle
Eccentric
Earth
Deferent

Epicycles & Eccentrics

Epicyclic models have a number of successes:

- Combined motion of deferent & epicycle reproduces the retrograde motion of planets
- Superior planets are closer & brighter at opposition when moving retrograde
- Placing the Earth at “an eccentric” away from the deferent center explains the non-uniform motions of the Sun, Moon and Planets

Can fine-tune the model by adding additional epicycles


Epicycle I
Epicycle II
Earth
Eccentric
Deferent

Claudius Ptolemais (Ptolemy - c. 150 AD)

Great Astronomer & Geographer of the late classical age

Wrote the *Mathematical Syntaxis*

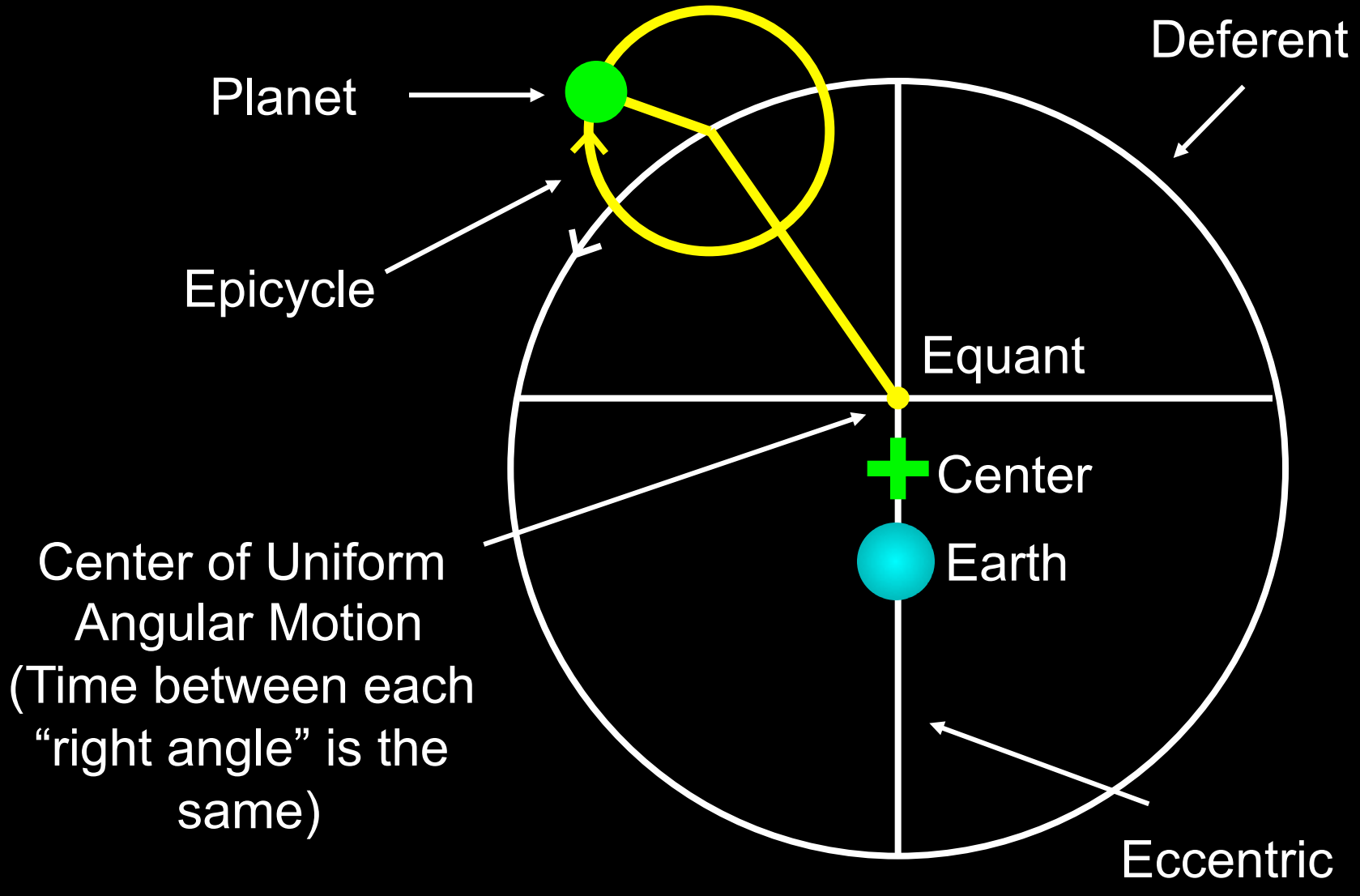
- Compilation of Mathematical & Astronomical knowledge of the time.
- The Arabs referred to this manuscript as "*Al Magest,*" literally *"The Greatest"*
- Today it retains this name as *The Almagest*

The Equant

Ptolemy introduced the Equant to account for observed changes in a planet's speed as it moved around the Earth

- Epicycle still moves about the center of the Deferent, but...
- Uniform *circular motion* about the center of the deferent is replaced by uniform *angular motion* about an off-center equant point

Ptolemy's Geocentric Model



Components of Ptolemy's Model

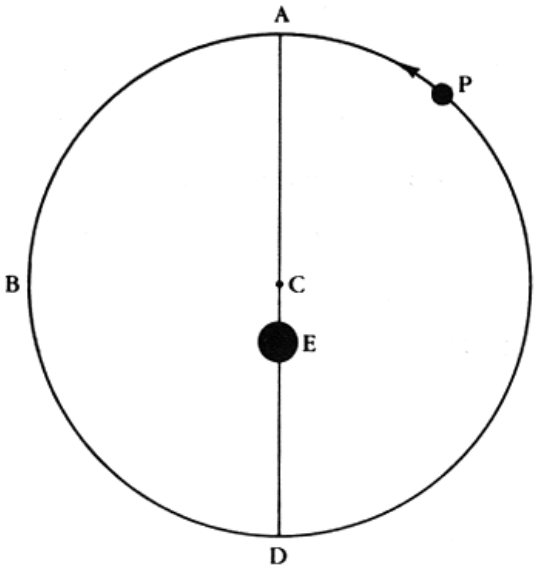
Eccentric: Moved the Earth off the center of the deferent to account for non-uniform motion (Hipparchus)

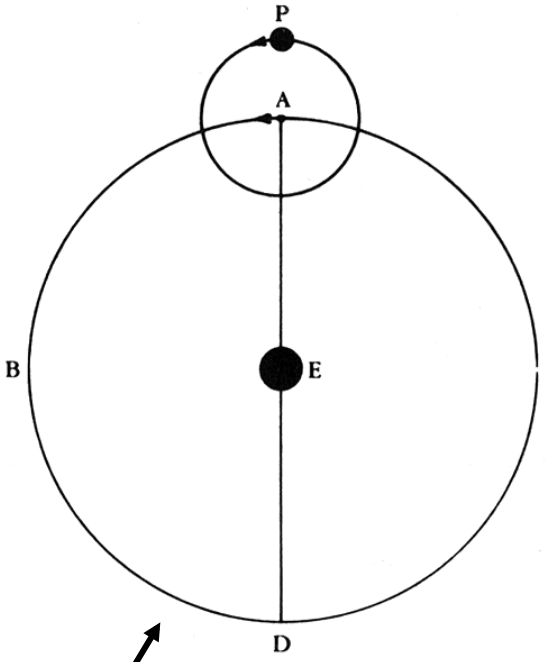
Epicycle: With eccentric, produce retrograde motion and explain brightness changes of superior planets (Hipparchus)

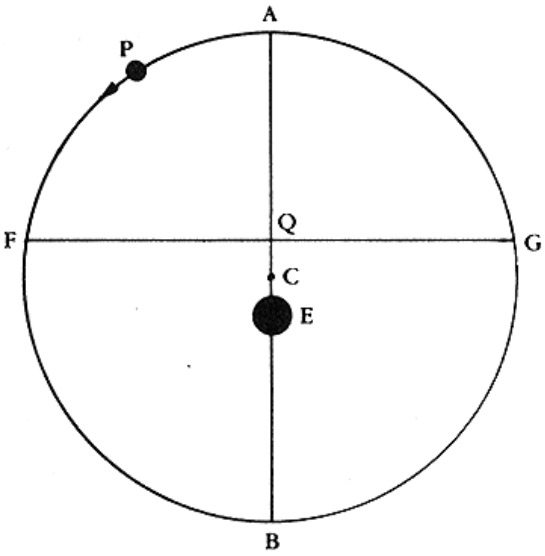
Equant: Uniform angular motion (no longer uniform circular motion) and no longer centered on the deferent. Introduced by Ptolemy to account for observed changes in speed

All of these concepts were merged together by Ptolemy to match the motions of the planets *but the Earth is no longer at the center*!

Eccentric Epicycle Equant







Q is the center of motion,
C is the center of the circle

The Deferent is the larger circle