

# Enter Epicycles

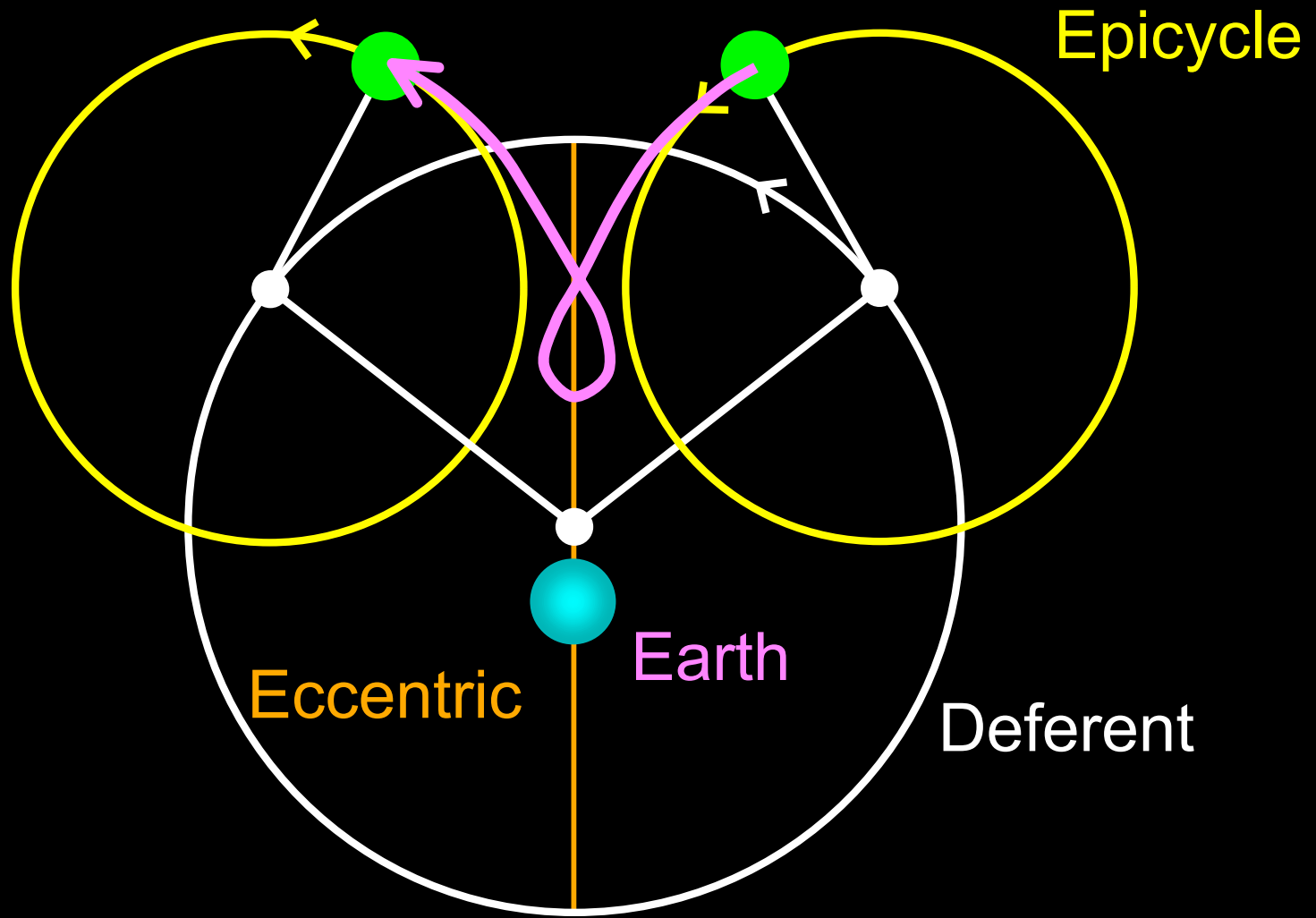


## Hipparchus of Nicaea (165-127 BC)

- 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*

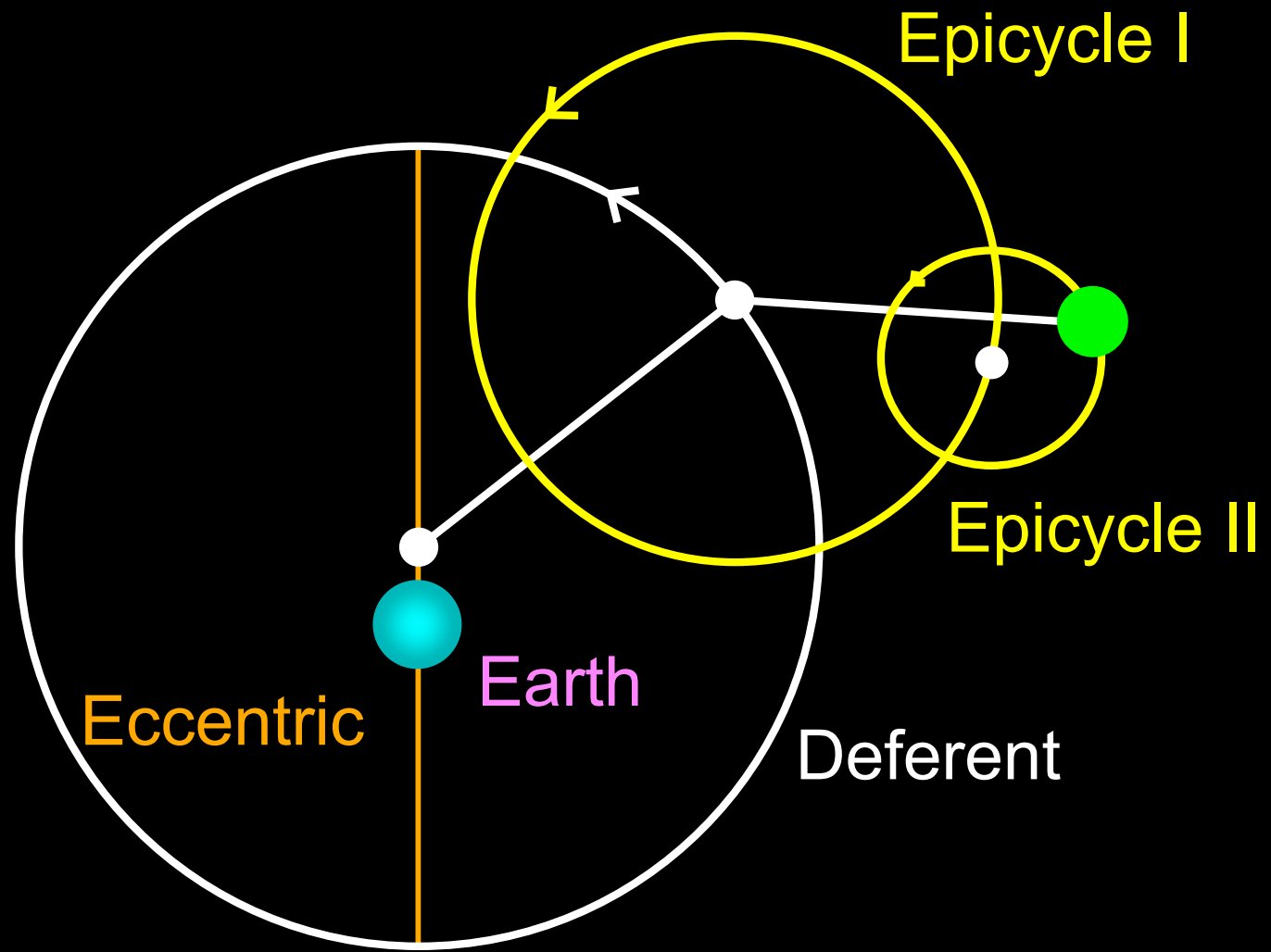


# Epicycles & Eccentrics

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 epicycles



# Claudius Ptolemais (Ptolemy - c. 150 AD)



Great Astronomer & Geographer of  
the late classical age

Wrote the *Mathematical Syntaxis*

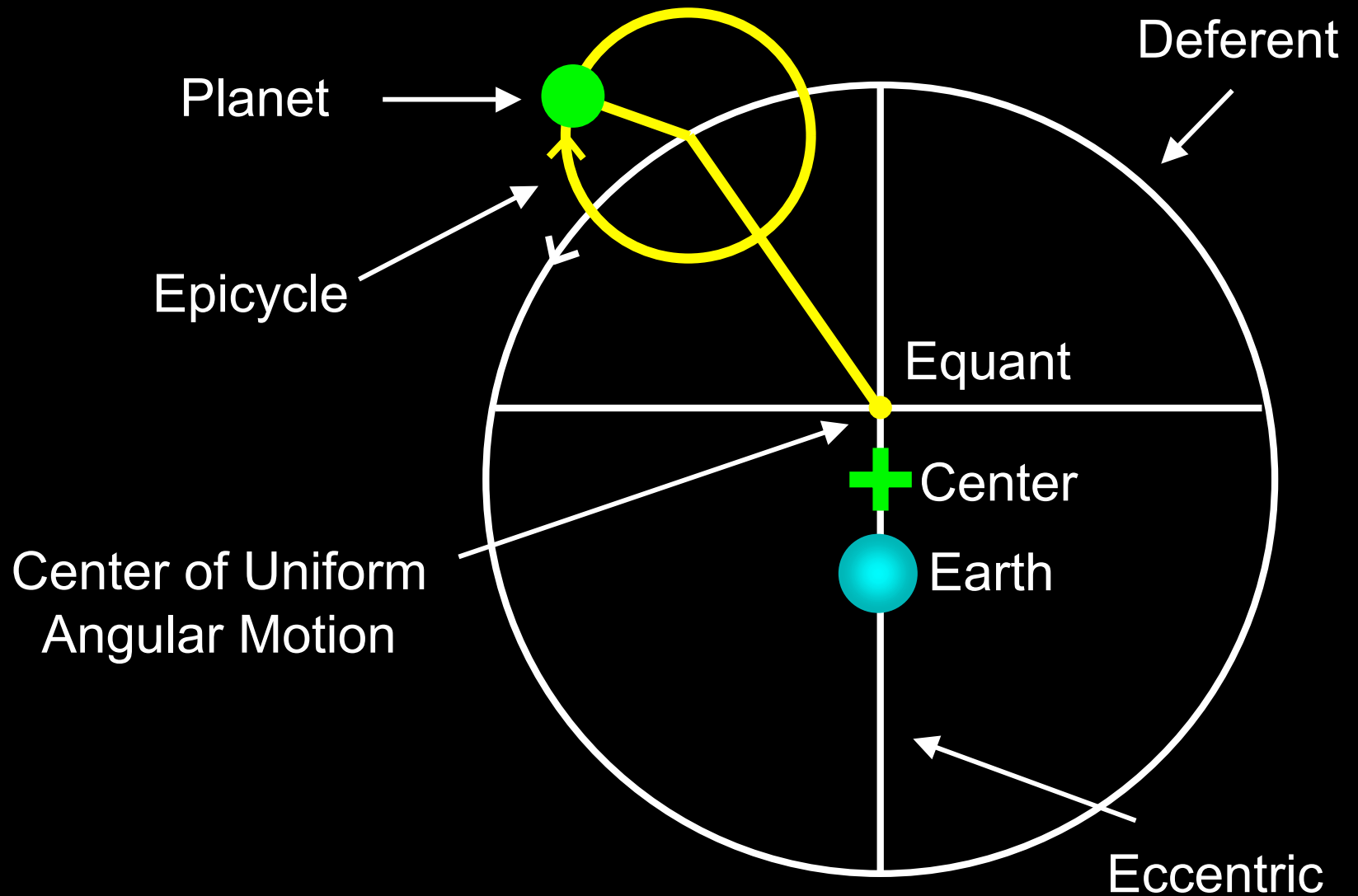
- Compilation of Mathematical & Astronomical knowledge of the time.
- The Arabs referred to this manuscript as “*Al Magest*,” literally “*The Greatest*”
- Today it retains this name as *The Almagest*

# 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)

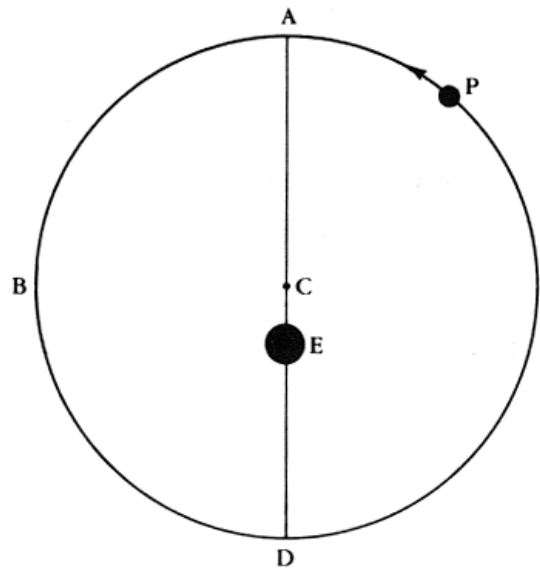
**Epicycle:** With eccentric, produce retrograde motion and explain brightness changes of superior planets (Hipparchus)

**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

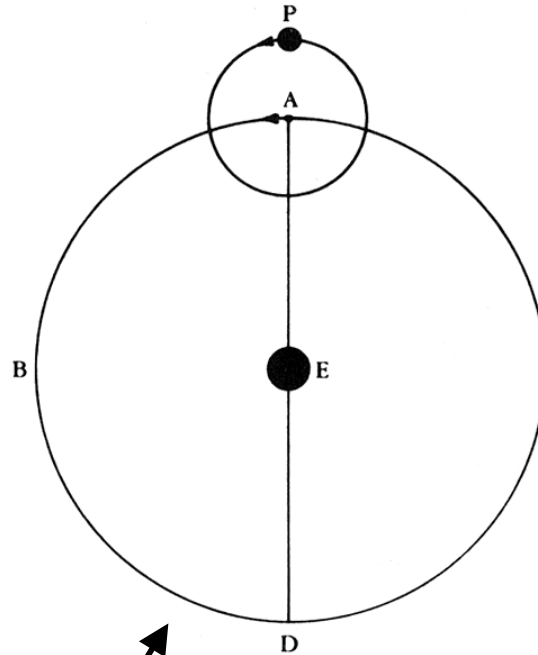
**All of these concepts were merged together by Ptolemy to match the motions of the planets  
*but the Earth is no longer at the center!***



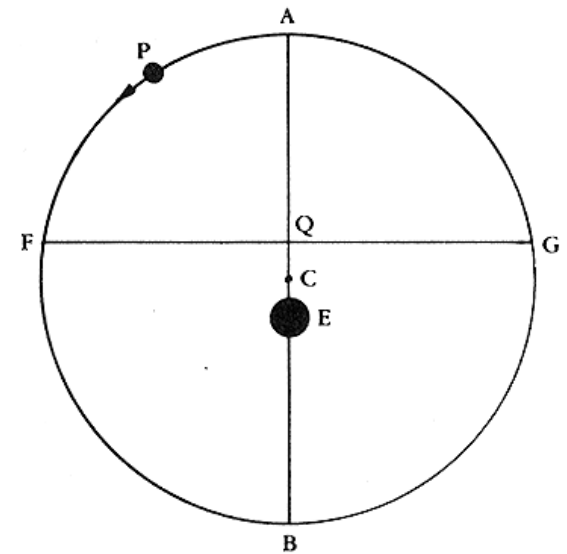
# Eccentric



# Epicycle



# Equant



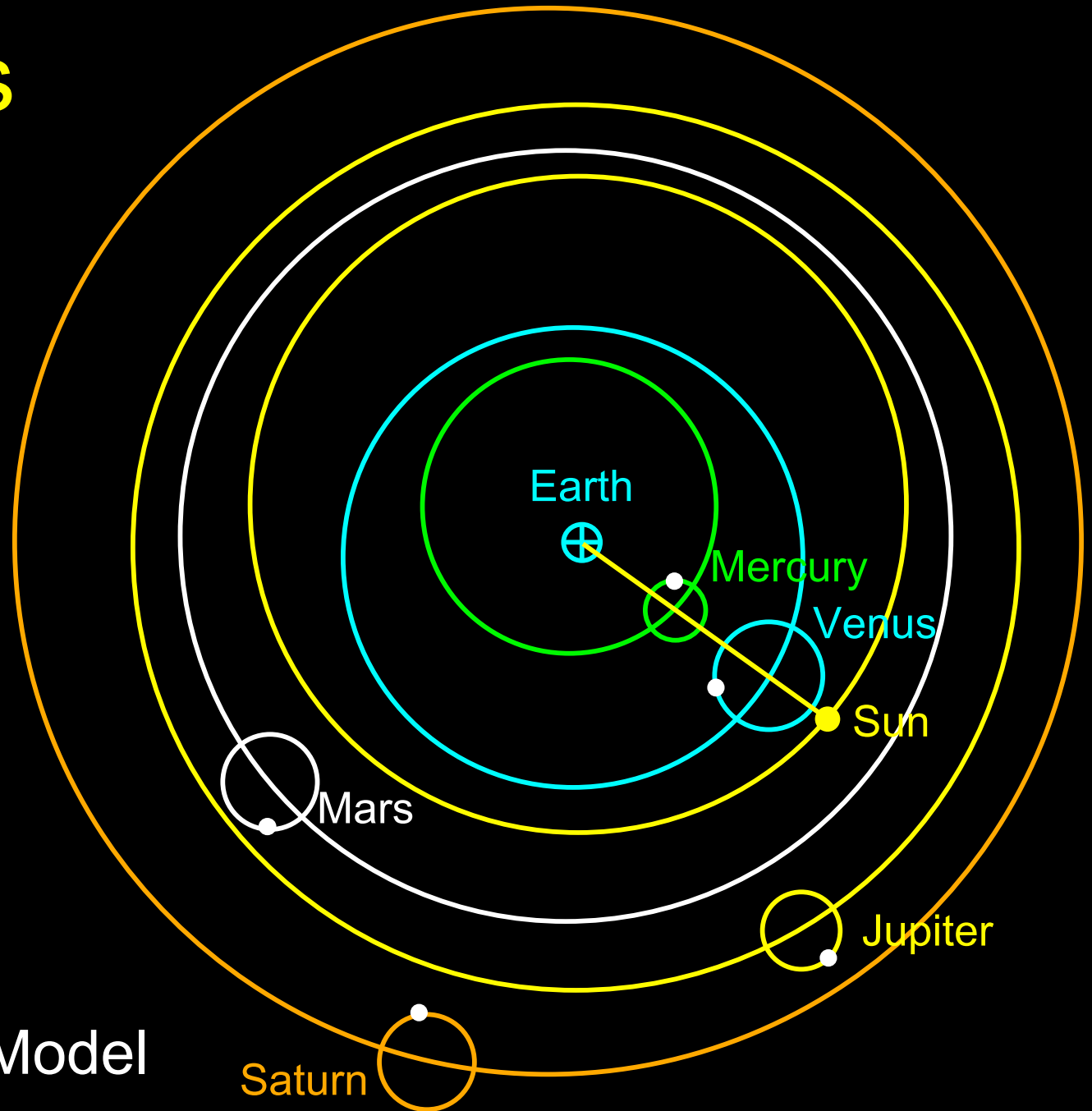
Q is the center of motion,  
C is the center of the circle

The Deferent is the larger circle

# Ptolemy's Model

It worked,  
Sort of.

But when it didn't,  
when it slipped,  
they just re-tuned the  
deferants & equants.



A *Geocentric* Model