# Putting it All Together:  The Ptolemaic System

**Claudius Ptolemy** (c. 90 - c. 168 CE)
• Librarian at Alexandria
• "The Great Treatise" & "The Almagest" (to the 12th Century)

## The Ptolemaic System: Objectives

**Wanted**: A Model to explain the observed apparent motions of the Sun, Moon, Planets, and the Celestial Sphere.

The Model should explain related phenomena such as the lunar phases, eclipses, and planetary brightness variation.

The Model should be capable of accurately predicting these phenomena. (When? Where? Details?)

The Model is geostatic, geocentric, and uses only uniform circular motions.
  (*cf.*, the Aristotelian doctrines and the Aristarchian heresy.)

# The Ptolemaic System

**Observations**
- The apparent rotation of the Celestial Sphere
- The annual motion of the Sun along the ecliptic
- The monthly motion of the Moon
  - The lunar phases and the synodic month
  - Lunar and Solar Eclipses
- The motions of the planets on the celestial sphere
  - Direct and retrograde motions
  - Planetary brightness variations
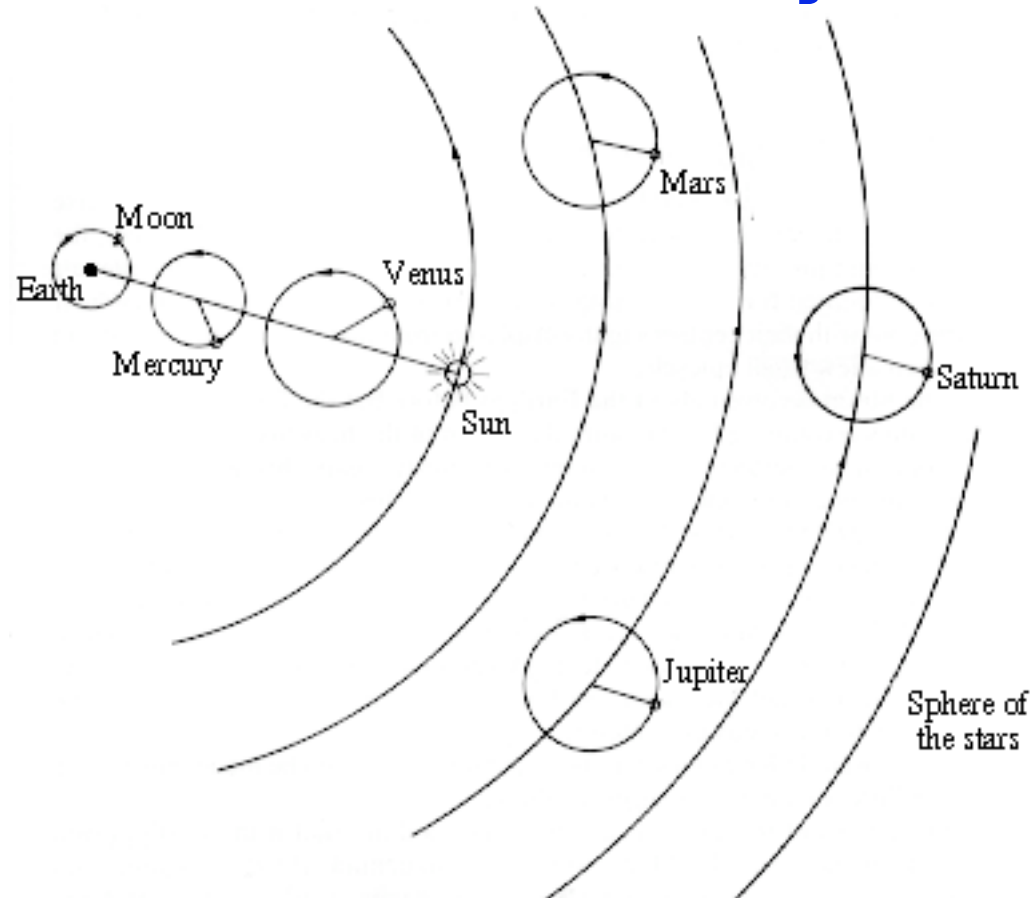  - Periodicities: The synodic periods

**Assumptions**
- A Geostatic cosmology (The Earth does not move.)
- Uniform Circular motions (It is a "perfect" universe.)

**Approaches**
- The offsets and epicycles introduced by Hipparchus
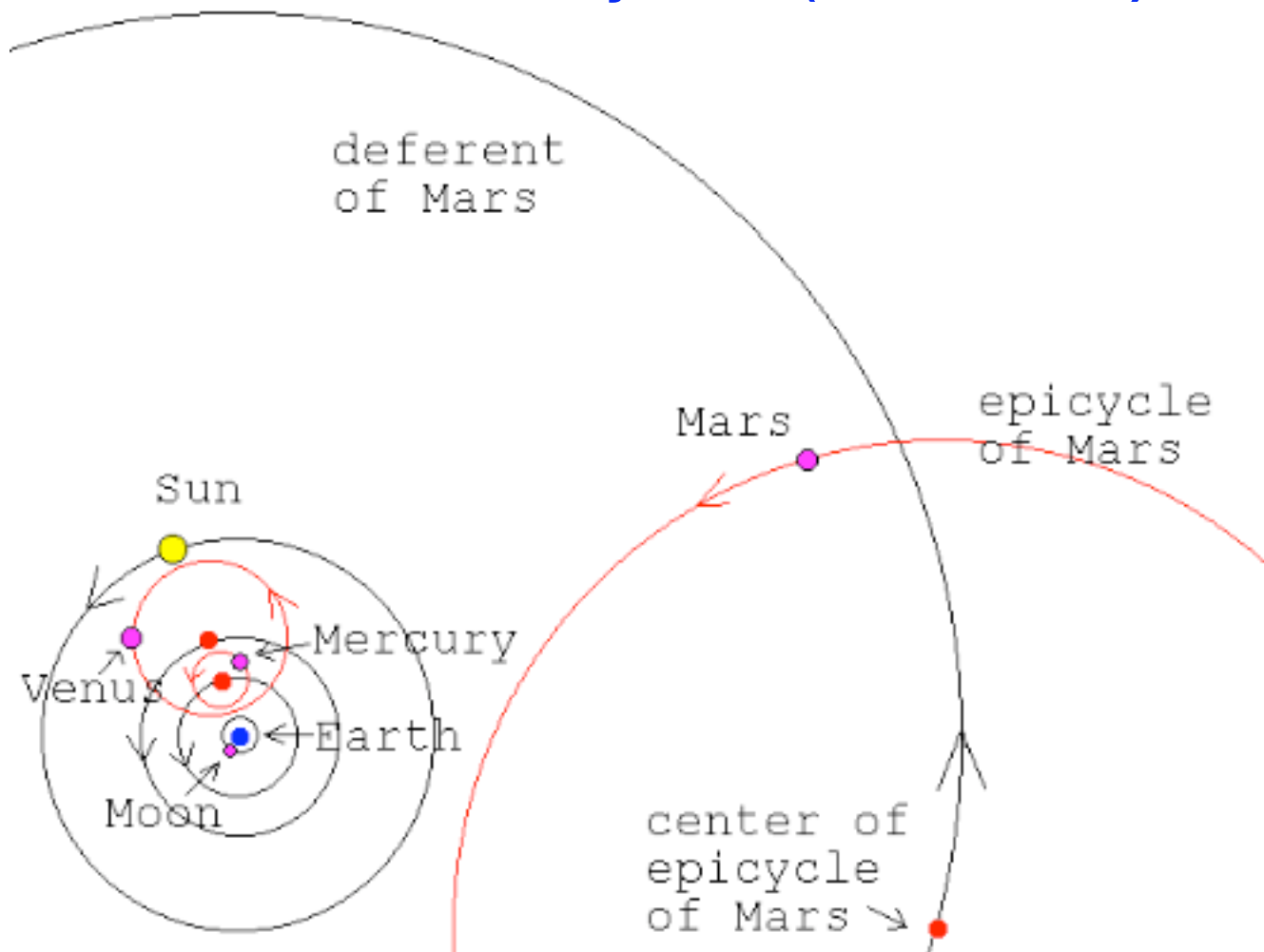
# The Ptolemaic System



**For Inferior Planets (Mercury Venus)**
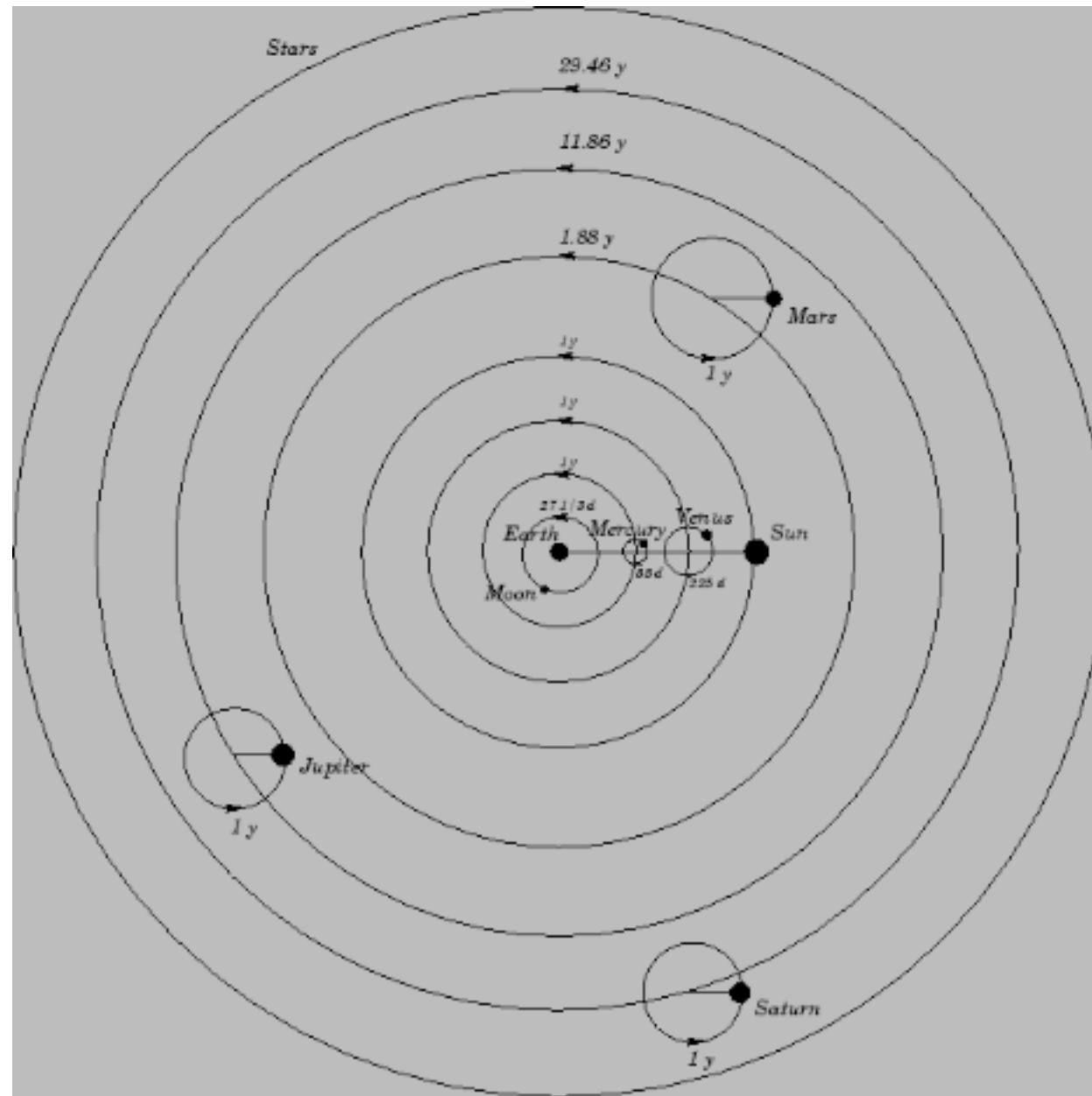Deferent Period is 1 Year; Epicyclic period is the Synodic Period

**For Superior Planets (Mars, Jupiter, Saturn)**
Deferent Period is the Synodic period; Epicyclic Period is 1 year

# The Ptolemaic System ("To Scale")

deferent
of Mars

Mars

epicycle
of Mars

Sun

Mercury

Venus

Earth

Moon

center of
epicycle
of Mars

Note: Indicated motions are with respect to the Celestial Sphere

**AGAIN:**

# Problems with the Ptolemaic System

## Recollect the assumptions
- The Earth doesn't move ("geostatic")
- The Earth is at the center of the universe ("geocentric")
- All motions are circular (... or combinations thereof)
- All motions are uniform (... *i.e.*, of constant speed)

## The Problems
- Complexity: Three different kinds of planets
- Complexity: Deferents, Epicycles, Equants, Tilts,..)
- Difficulty in giving accurate long-term predictions
   (....resolved by increasing complexity?)

- The problem of Brightness Variations
 (Are the planets spheres shining by reflected Sunlight?)

   ....but the Ptolemaic System was the only game in town!

# The Brightness Problem

• Superior Planets (Mars, Jupiter, Saturn) should be brightest at conjunction, faintest at opposition
- but the opposite is observed!

• Inferior Planets (Mercury, Venus) should be brightest at maximum elongation (broadest crescent) and fade toward superior conjunction ("new")
- but they actually brighten!

But does this falsify the Ptolemaic System?

# The Dark Ages
## (Roughly 400 CE to 1000 CE)

### The Classical Universe: The Ptolemaic System
**Geostatic & Geocentric**
**Limited Predictive & Explanatory Power**

### The Alexandrian Library (330 BCE - 415 CE)
**Bishop Theophilus (and 392 CE)**
**Saint Cyril (Bishop of Alexandria) and Hypathia (37 0- 415 CE)**

### "Evolution" of the Ptolemaic Model
**Astronomy in the Arabic World**
**The Lengthening Time Basis**
**Increasing Complexity**

### The Renaissance
**(~1300 to ~1500)**
**The Late Middle Ages to the Reformation**

# Next: The Copernican Revolution
## ("The Earth Moves")

**Nicolas Copernicus (1473-1543)**
*De Revolutionibus Orbium Coelestium (1543)*
["On the Revolutions of the Celestial Spheres"]

**Various Theological and Political Issues**
**• Aristotle and the "Aristarcian Heresy"**
**• Conflicts with Aristotelian Physics and Philosophy**
**• Aristotle and Church Doctrine: Thomas Aquinas (1224-1274)**
**• Contemporary Theology: Martin Luther (1483-1546)**
**"Joshua commanded the <u>Sun</u> to stand still, not the earth."**