The Copernican System

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

Motivation

- **Circumvent the complexities required of the Ptolemaic System**
- **Resolve the problem of planetary brightness variations**
- **Reconsider the heliocentric ideas of Aristarchus**

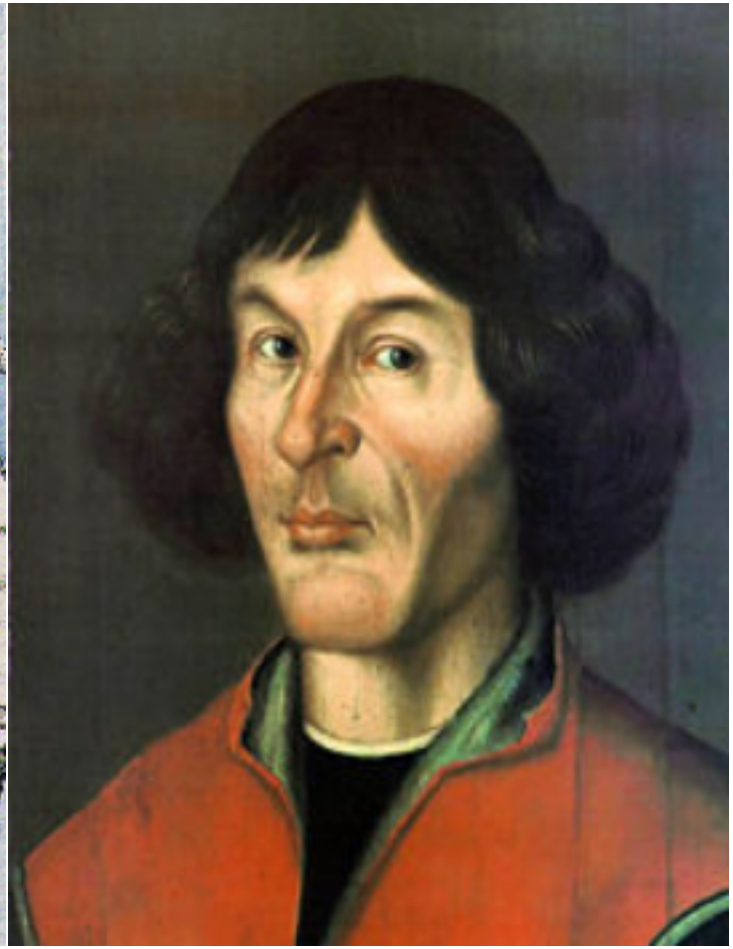
Methodology

- **Construct a heliocentric cosmology**
- **Allow the Earth to rotate about its axis as well**
- **Assume that motions are uniform and circular (*cf.* Aristotle)**

Results

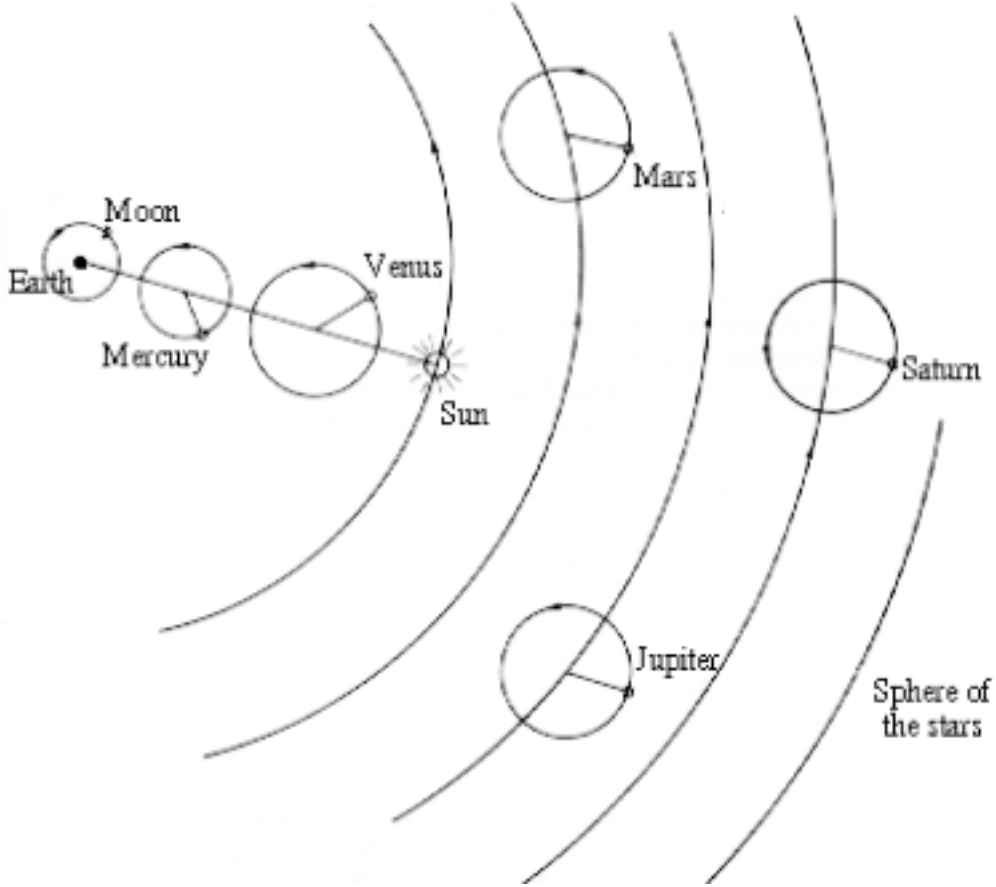
- **Basic planetary motions are explained without recourse to epicycles**
  (.. but epicycles were necessarily used for "fine tuning" the model)
- **A simpler system: Only one kind of planetary motion instead of three**
  (Ptolemy: Inferior planets, Superior Planets, and Earth)
- **The brightness variation problem was resolved in a simple way**
  (... assuming spherical planets shining by reflected sunlight.)

Claudius Ptolemaeus
c. 83 - 168 CE



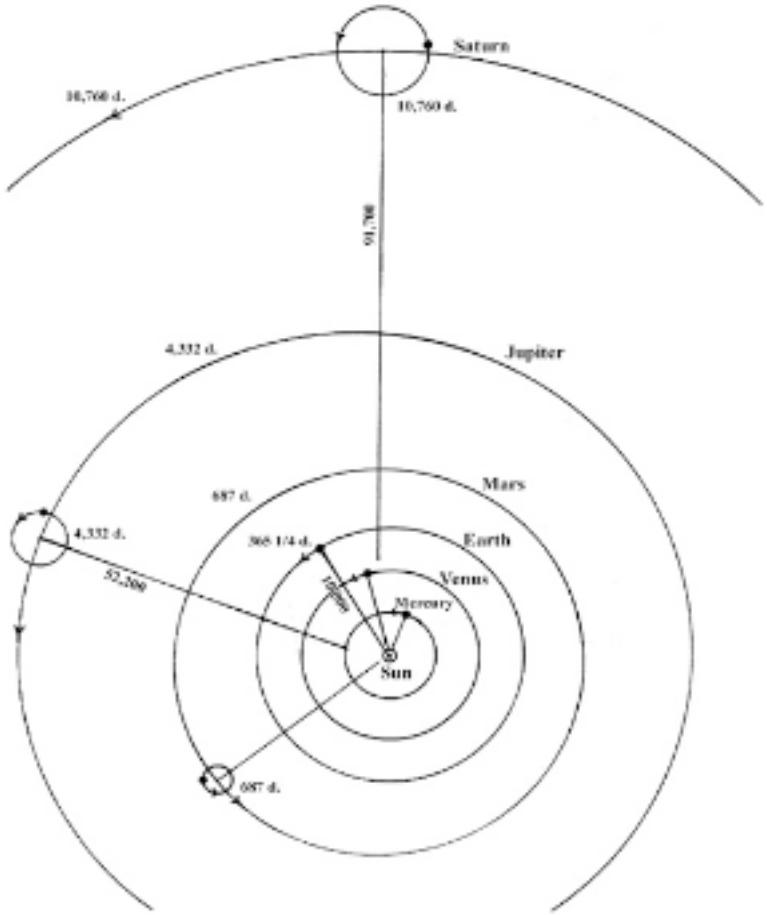
Nicolaus Copernicus
1473-1543 CE

Recollect: The Ptolemaic System



The **Celestial Sphere** rotates clockwise (westward) about the fixed **Earth** with a period of one sidereal day. The other objects depicted in the above figure (**Sun**, **Moon**, and **Planets**) generally move counterclockwise (eastward) with relative to that Celestial Sphere. Epicycles provide periodic retrograde motions for the planets. The Sun's period relative to the fixed stars of the celestial sphere is the sidereal year.

The Copernican System



All motions in this figure, including those of the Earth, are circular and counterclockwise. or eastward.

(Only the “residual” epicycles associated with Mars, Jupiter, and Saturn are shown)

The Copernican System

Testing the Theory

The principal test of the Copernican System was in its successful prediction or explanation of planetary brightness variations.

However: That test rested on the assumption that the planets were spherical objects shining by reflected sunlight. This assumption was not testable in 1543.

But: Given this assumption the observed variations would falsify the Ptolemaic Model.

Other Predictions and Tests of the Copernican Theory

Direct Observation of Planetary Phases
(Only gibbous and full phases for superior planets, but all phases for inferior planets)
(See Galileo, *Sidereus Nuncius* 1610)

Direct detection of the Earth's Motions
Stellar Parallax (Bessel, 1838), **Aberration of Starlight** (Picard, 1680; Bradley, 1725), **Doppler Effect** (Stark, 1905?)

Note that any direct proof of significant Terrestrial motion also falsifies significant parts and precepts of Aristotelian physics.

Testing the Copernican Model

A "virtue" of the Copernican Model relative to the Ptolemaic Model is its greater simplicity (cf. Ockham's Razor)

• Retrograde motions are naturally explained - without recourse to epicycles
• There is only one kind of planetary motions rather than three types.
• Brightness variations understood in terms of known phenomena.

Problems

Theological and Political Issues

• Conflicts with Aristotelian Physics and Philosophy
• Aristotle and Church Doctrine: Thomas Aquinas (1224-1274)
• Contemporary Theology: Martin Luther (1483 -1546)

"However, as Holy Scripture tells us, so did Joshua bid the sun to stand still and not the earth" *[Reference is to Joshua 10:10–15]*

Shortcomings, Weaknesses, or Mistakes of the Copernical Model

• A fixed celestial sphere (*cf. Democritus)*
• A heliocentric and possibly heliostatic universe (*cf. Digges)*
• Unnecessary assumptions: Uniform Circular Motions (*cf. Kepler*)
... requiring in Hipparchus - style epicyclical motions for "minor" corrections.

....and there was some competition:

The Tychonic System

Tycho Brahe (1546 - 1601)

Tycho's and Observational Astronomy

- **Astrometry**: Positional Astronomy before the Telescope
(Positions and Parallaxes to 1 arc-minute accuracy; Timekeeping)

- **The Supernova of 11 November, 1572 (*De Stella Nova,* 1573)**
.....things do change in the celestial realm!

- **The Comet of 1577 ("Tycho's Comet")**
.....comets are astronomical objects!
..... smashing the crystaline spheres?

- **Attempts to measure parallaxes***
..... the Earth probably doesn't move!

*Note: The Earth's radius (6370 km) would subtend 1 arc minute at a distance of 22 million km. This is about 57 times the Moon's distance - and about 1/7 that of the Sun.)

The Tychonic System

The Tychonic System (1583)

- **Motivated by the failure to observe a stellar parallax.**

- **Theological motivations (Aristotle again!)**

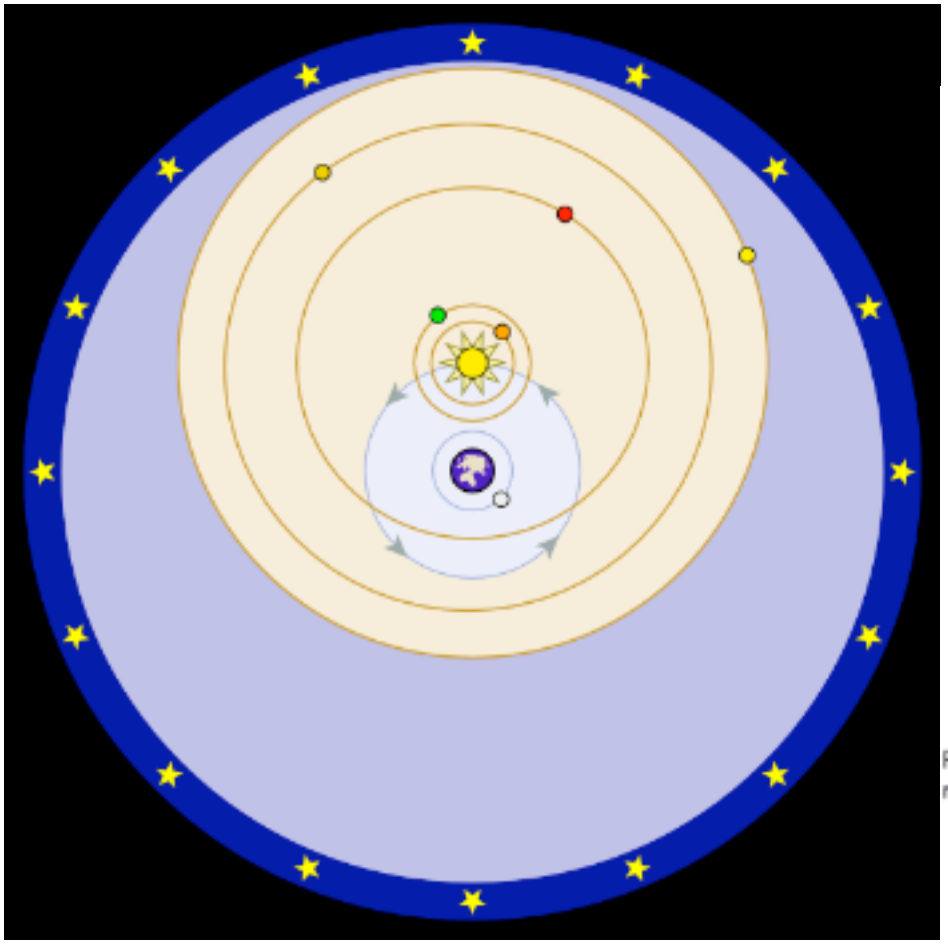
- **The Moon, Sun, and Celestial Sphere move about the central Earth (as in the Geocentric Ptolemaic System)**

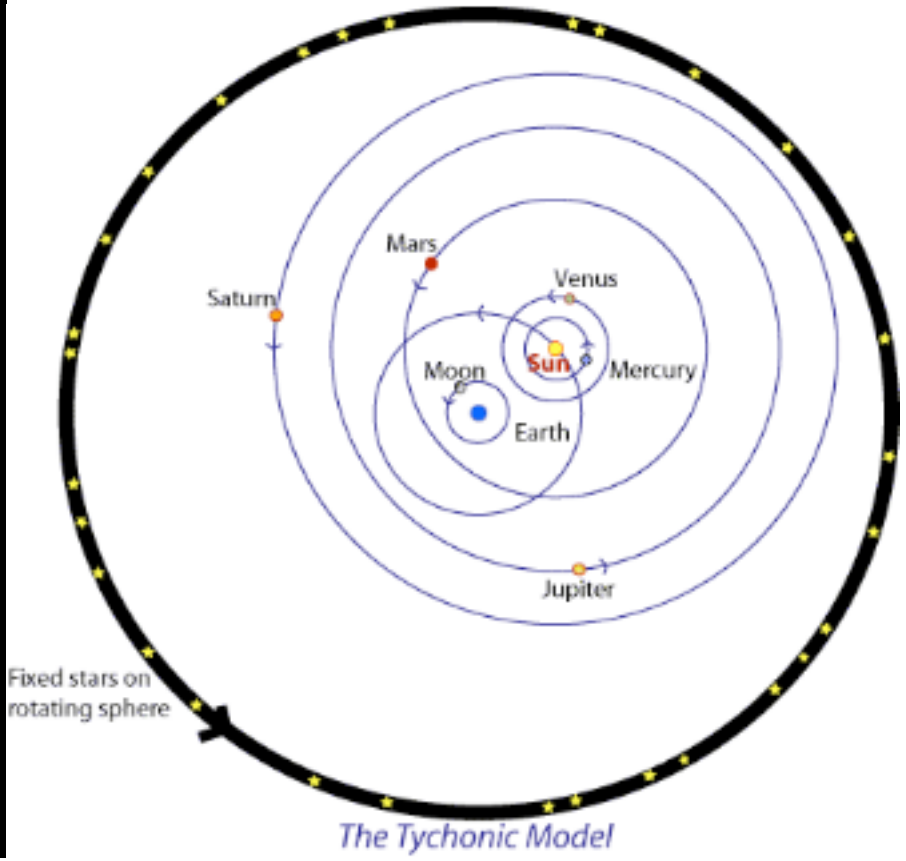
- **The other Planets orbit the Sun (as in the Heliocentric Copernican System)**

Some Fun Bits of History

Tycho's elk,Tycho's nose and Tycho's bladder
Tycho and Astrology
Tycho and Johannes Kepler
and
The Tychonic System and the Decrees of 1616

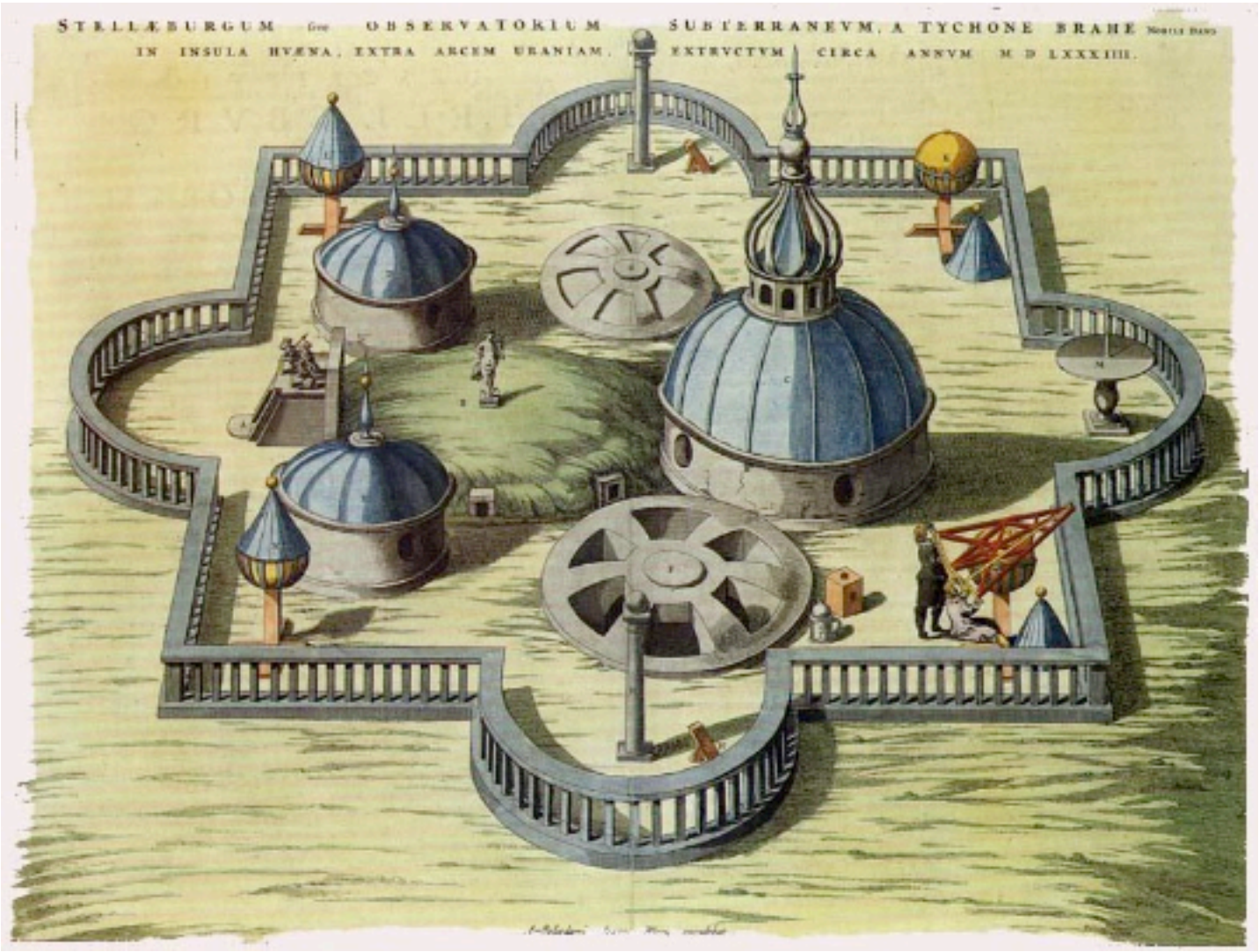
The Tychonic System





The Tychonic Model

The requisite epicycles are not shown. This system retains the essential Geostatic feature of the Ptolemaic System (hence no stellar parallax is expected) while correctly predicting planetary brightness (and phase) variations. (Images stolen from *Wikipedia*)



Tycho's Observatory: Stjerneborg on the Island of Hven

Tycho Brahe (1546-1601)