

# RENAISSANCE ASTRONOMY

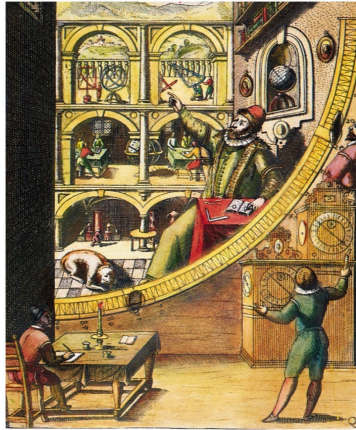


## Questions

Just because there is a new theory, should I accept it?

Which comes first – a new Theory or new Data?

# Tycho Brahe



## Tycho Brahe

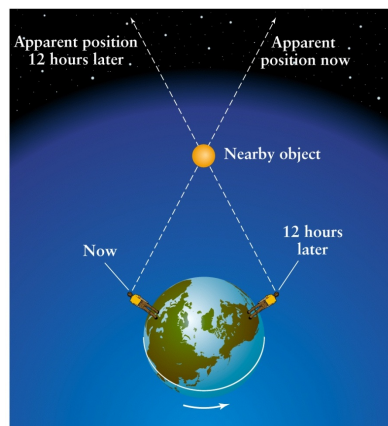
[1546 - 1601]

Tycho worked for the Danish King Frederick II, who built him an observatory on the Baltic island of Hveen. There he spent 20 years obtaining **accurate pre-telescopic** astronomical observations of stars and planets. Tycho was both arrogant and extravagant. He had a “falling out” with the new King Christian IV, so he left Denmark for Prague. [Tycho lost his nose in a duel.]

## Observations by Tycho Brahe

A. Comets were thought to be *atmospheric vapors*, but no **parallax** (**triangulation**) angle was observed for a bright one seen during 1577.

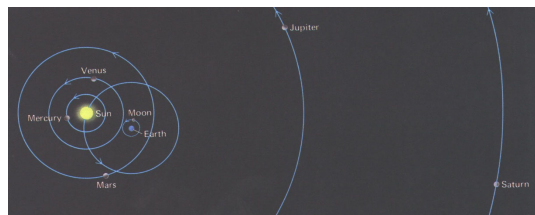
Tycho concluded that the comet was 3 times the Moon's distance and that it revolved around the Sun.



## Observations by Tycho Brahe

- B. Observed a supernova.
- C. Obtained 1-arcminute accuracy of stellar and planetary positions.
- D. Obtained continuous records of the Sun, Moon, and planets.

He also developed a Cosmological Model, but only he believed in it.



# Johannes Kepler



## Johannes Kepler

[1571 - 1630, Germany]

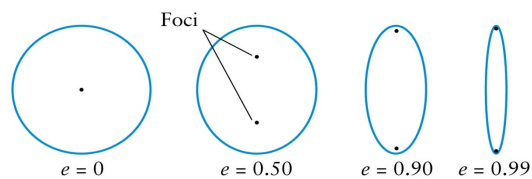
Learned the Copernican heliocentric hypothesis. He was a mathematics and astronomy teacher at Graz, Austria, but the power of the Catholic Church forced him (a Protestant) to leave.

He became an assistant to Tycho, who wanted Kepler to develop a theory to describe planetary motion, but he never gave Kepler full access to the necessary data. After Tycho's death, Kepler got it all.

# Orbit of Mars

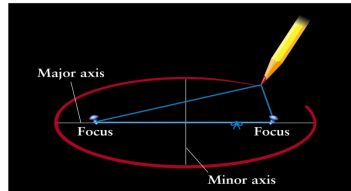
First he tried circles, equants, ovals, etc. Finally, after years, he tried an ellipse. Found that the orbit of Mars is an ellipse with the Sun at a focus.

The sum of the distances to the two foci is always constant for all points on the ellipse. Ellipses are described by their **semi-major axis** and by their **eccentricity**.  $e = (\Delta \text{ foci} / \text{major axis})$

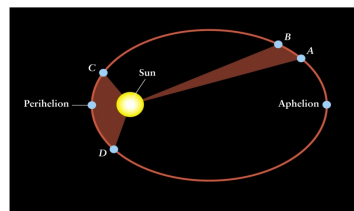


# Kepler's Three Laws

1. All planets have elliptical orbits with the Sun at a focus (conic sections).



2. Law of Equal Areas: Equal areas are swept out in equal time intervals.



# Kepler's Three Laws

3. Harmonic Law (published in *The Harmony of the Worlds*):

$$P^2 = k a^3,$$

where  $k = 1$  if  $P$  is in earth years and  $a$  is in AUs.

Planet	Sidereal period $P$ (years)	Semimajor axis $a$ (AU)	$P^2$	$a^3$
Mercury	0.24	0.39	0.06	0.06
Venus	0.61	0.72	0.37	0.37
Earth	1.00	1.00	1.00	1.00
Mars	1.88	1.52	3.53	3.51
Jupiter	11.86	5.20	140.7	140.6
Saturn	29.46	9.54	867.9	868.3
Uranus	84.01	19.19	7,058	7,067
Neptune	64.79	30.06	27,160	27,160
Pluto	248.54	39.53	61,770	61,770