# Tycho & Kepler

# Tycho Brahe – The Data Taker

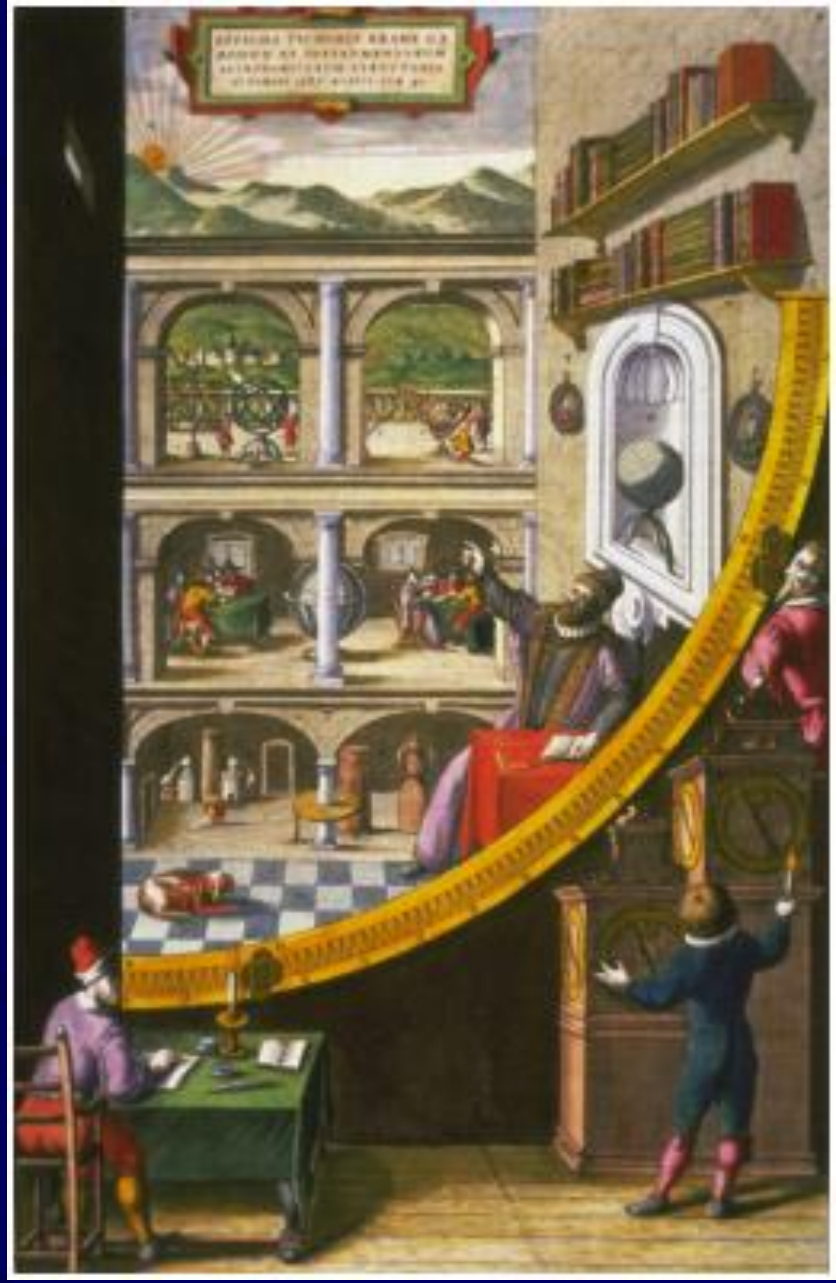
- Key question:
  **<u>Where</u>** are things?

- Catalogued positions of planets in Uraniborg and Prague
- Working without telescope
- Data ten times as accurate as before
- Died at banquet binge drinking

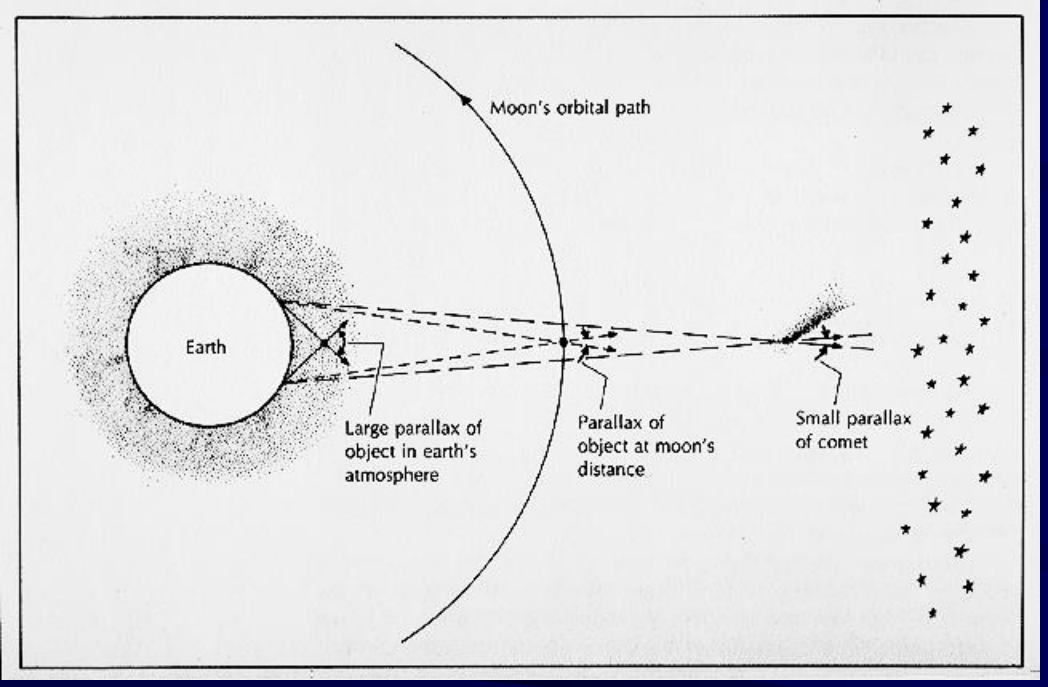
Tycho Brahe (1546–1601)

# Tycho Brahe

- collects detailed and accurate (1-2’ accuracy) observations of stellar and planetary positions over a period of 20 years
- His research costed 5-10% of Danish GNP
- shows that comets and novas are extralunar contrary to Aristotle
- Shows that stars can change (Supernova of 1572)
- Proves that comets are superlunar



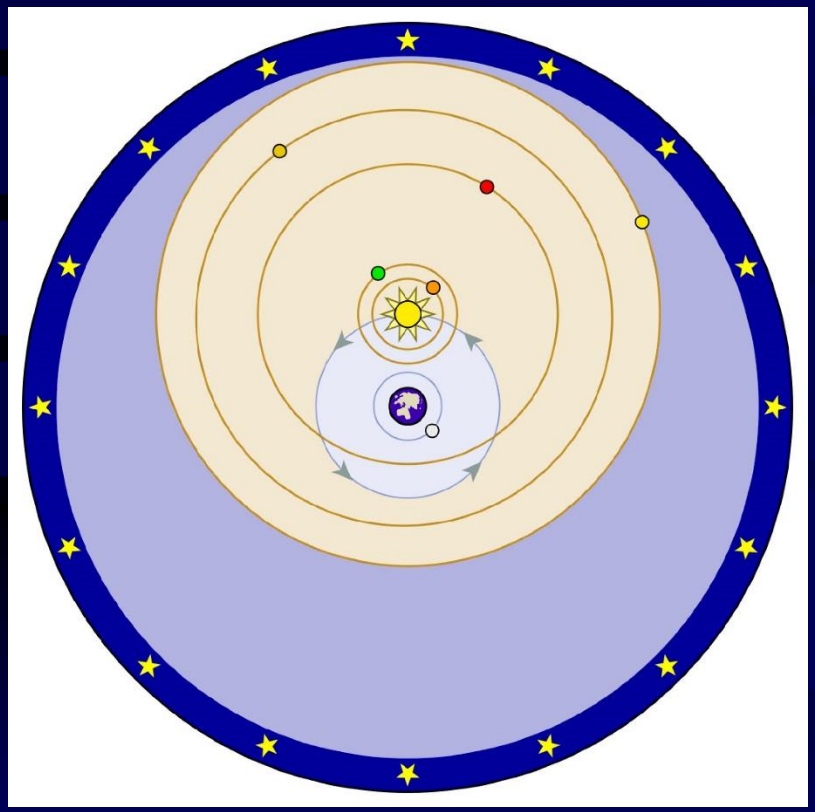
Tycho Brahe observing




# Measuring distances with the Parallax

- The closer an object is, the more shifted it appears with respect to the fixed stars from different points on Earth
- Tycho measures parallax zero for Great Comet of 1577 and the Supernova of 1572
- The objects must be beyond the moon: Change without circular motion → Contradicts Aristotle!

# Tycho's Hybrid Solar System Model



- Sun orbits earth
- Planets orbit sun
- Reaps Copernican benefits while being psychologically rewarding like Ptolemy

# Johannes Kepler–The Phenomenologist

- Key question:

**How** are things happening?

Major Works:

- Harmonices Mundi (1619)
- Rudolphian Tables (1612)
- Astronomia Nova (1609)
- Dioptrice

- Kepler vs Tycho Video

Johannes Kepler (1571–1630)

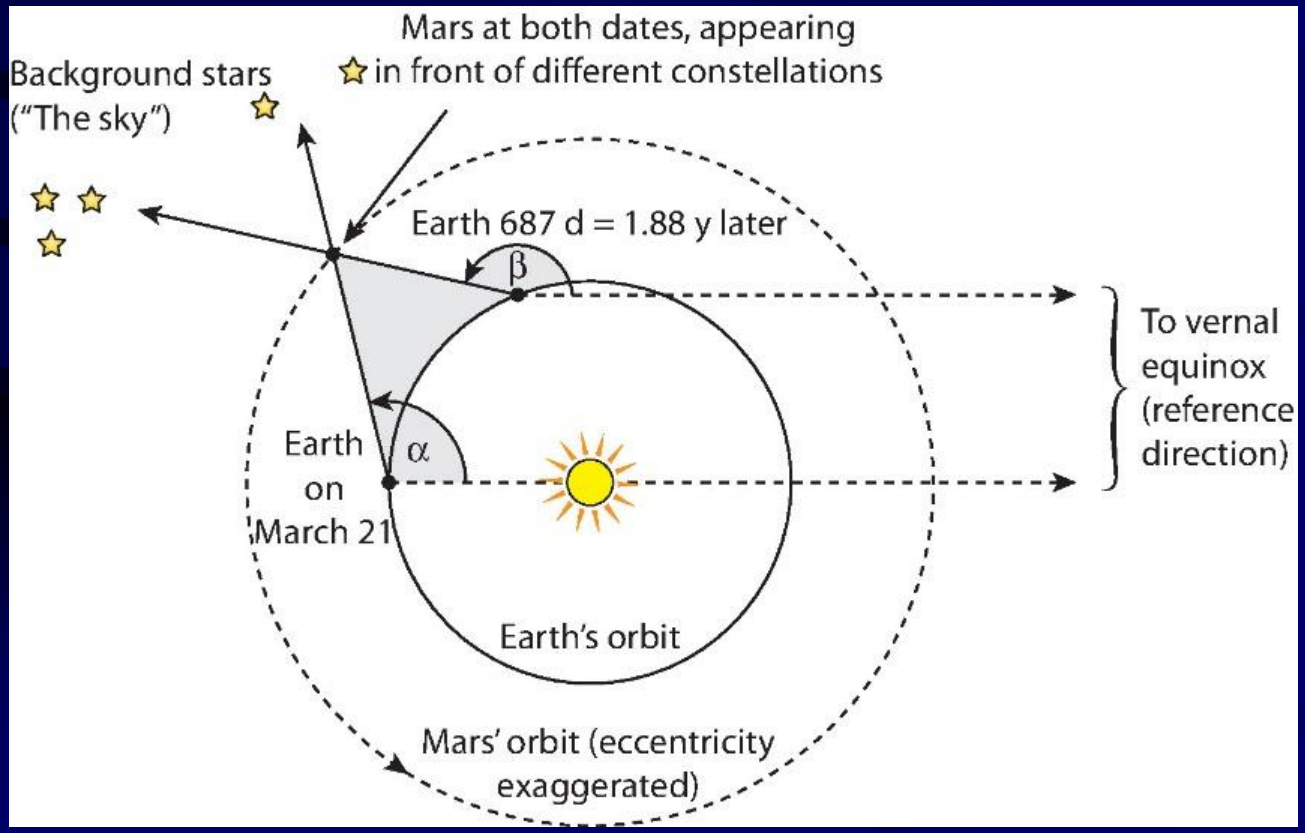
# Kepler's Beginnings

- Astrologer and Mystic
- Tried to find "music in the skies"
- Tried to explain distances of the 6 known planets by spheres resting on the 5 mathematical bodies

➔ **pre-scientific**

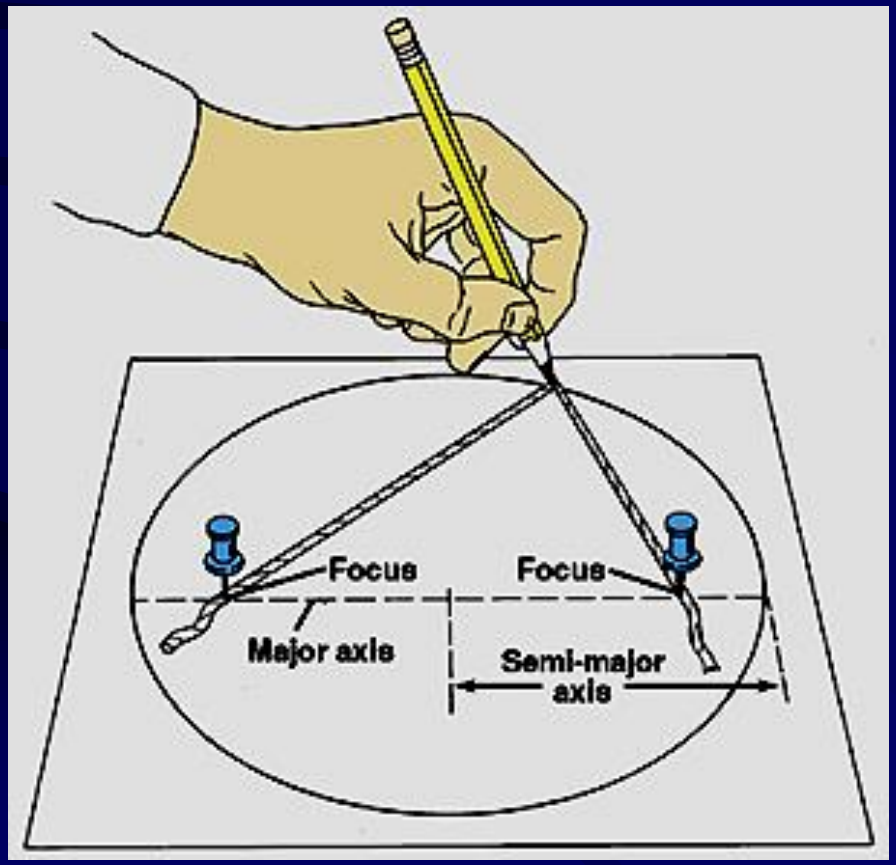

# Kepler's Construction of the Orbit of Mars

- War with Mars: Orbit is not circular!

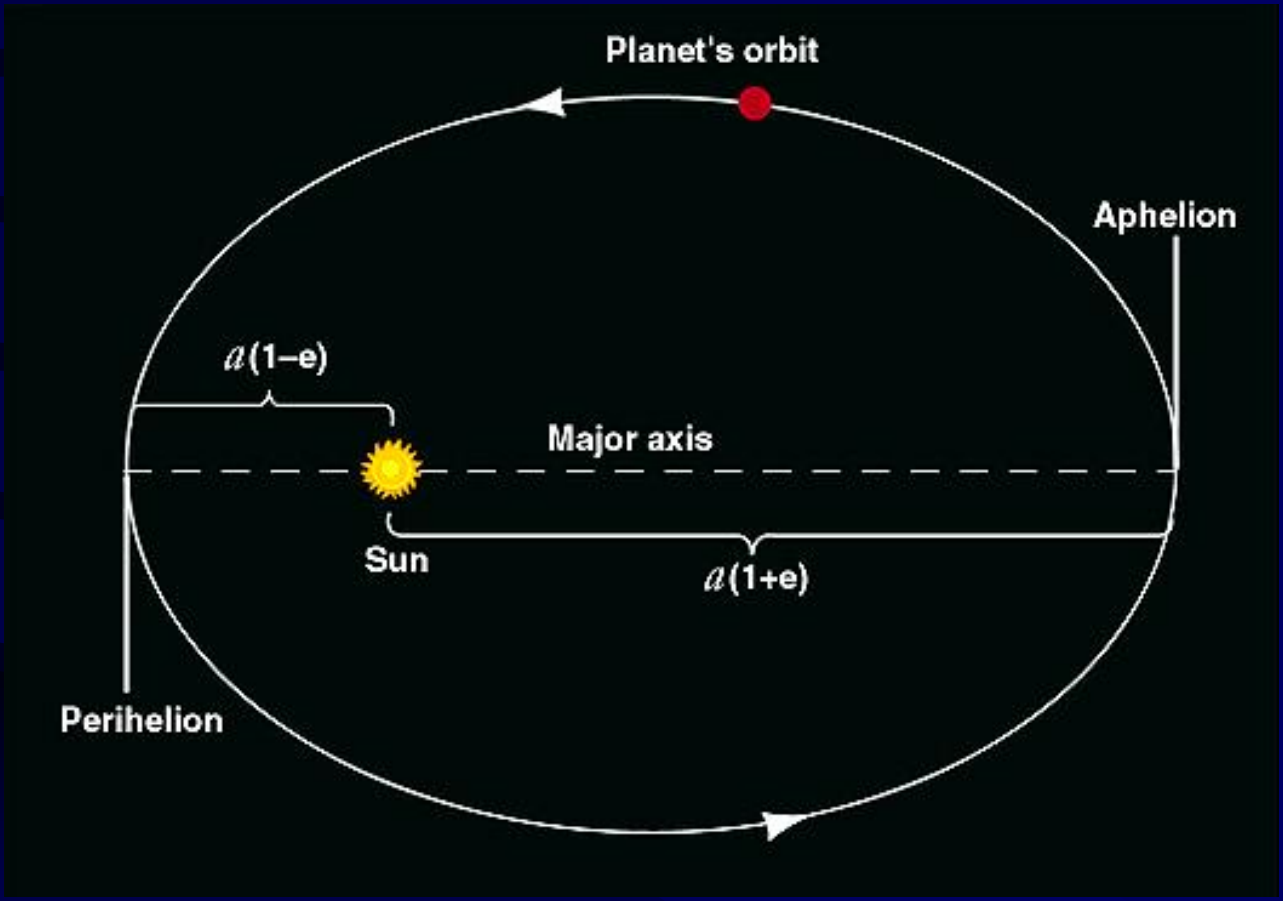


# Kepler's First Law: Orbit Shape

The orbits of the planets are ellipses, with the Sun at one focus



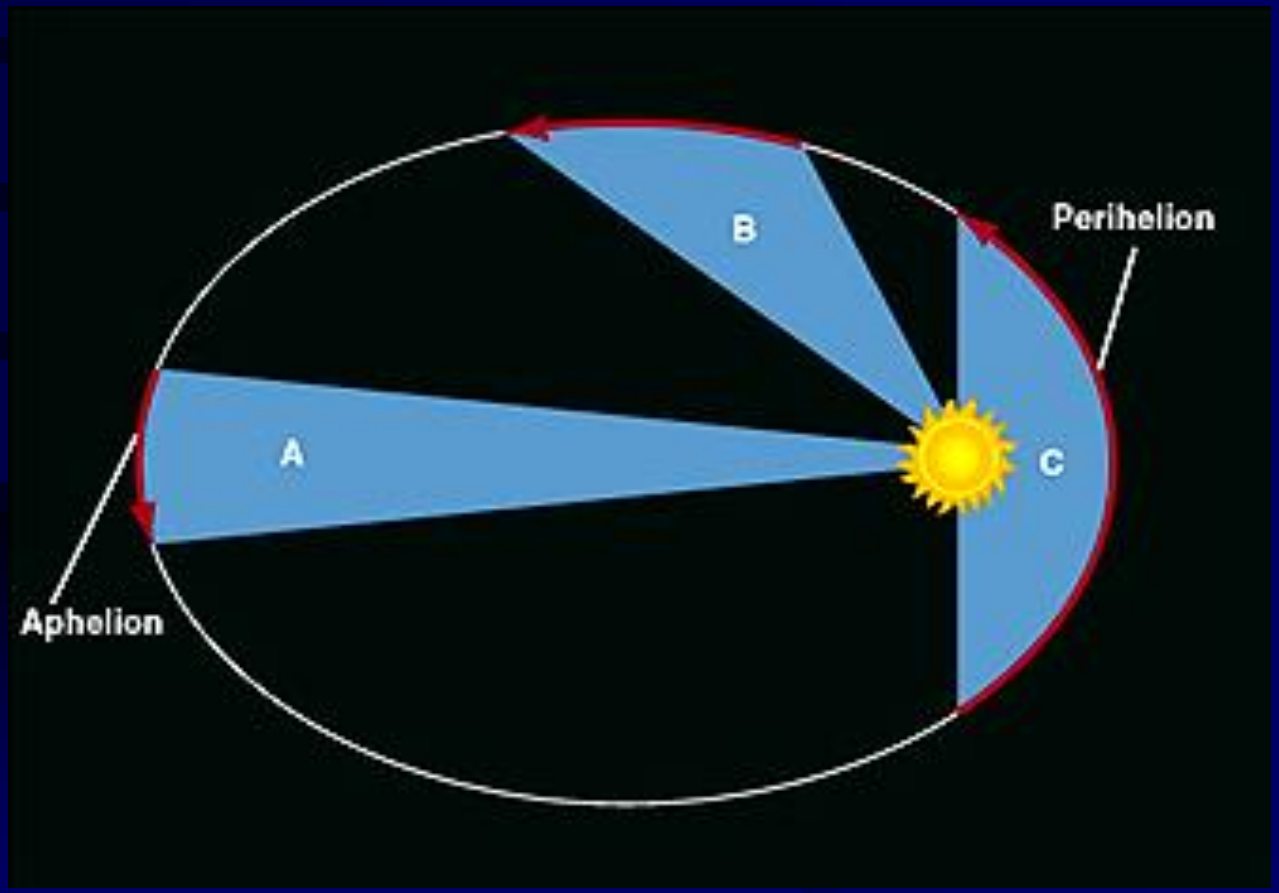
# Ellipses




$a$ = “semimajor axis”; e = “eccentricity”

# Kepler's Second Law: Motion in Time

An imaginary line connecting the Sun to any planet sweeps out equal areas of the ellipse in equal times



# Kepler's Third Law: Relating Orbits

The square of a planet's orbital period is proportional to the cube of its orbital semi-major axis:

$$P^2 \propto a^3$$

**Jupiter:** $5^3 / 12^2 = 125/144 \sim 1$

| | **a** | **P** | | |
|---|---|---|---|---|
| Planet | Semi-Major Axis | Orbital Period | Eccentricity | $P^2/a^3$ |
| Mercury | 0.387 | 0.241 | 0.206 | 1.002 |
| Venus | 0.723 | 0.615 | 0.007 | 1.001 |
| Earth | 1.000 | 1.000 | 0.017 | 1.000 |
| Mars | 1.524 | 1.881 | 0.093 | 1.000 |
| Jupiter | 5.203 | 11.86 | 0.048 | 0.999 |
| Saturn | 9.539 | 29.46 | 0.056 | 1.000 |
| Uranus | 19.19 | 84.01 | 0.046 | 0.999 |
| Neptune | 30.06 | 164.8 | 0.010 | 1.000 |
| Pluto | 39.53 | 248.6 | 0.248 | 1.001 |
| | **(A.U.)** | **(Earth years)** | | |