

Selected Topics in History of Science

Some history of astronomy and calendar

Lecture 2

7 March 2024

Astronomy – highly sophisticated an allowing mathematization

- Subject matter: Sun, Moon, planets, stars
- Stable and simple – compared to physics, biology, chemistry
- Early observations: Bronze Age – images of the Sun and the Moon, perhaps also some stars
- Evidence: Stonehenge – principal axis in the direction of sunrise at summer solstice (winter s.; vernal / spring and autumn equinox)
- (churches in Europe: altar facing East)

Astronomy in Babylonia

- Pattern of celestial omens (bad signs): harvest, epidemic, ...
- By 2000 BCE („before Christian era“) - established (pre-astrology)
- Social function of astronomy in Babylonia – stability in taking and keeping the records (clay tablets – copied, when broken)
- Observations by temple astronomers – visible to the naked eye
 - „re-emergence“ of Venus (not too close to the Sun)
 - „retrograde“ motion of Jupiter
- Sophisticated prediction of planetary motions: 300 BCE

Astronomy in Ancient Greece

- Recorded in literature, e.g. Homer
- Constellations: Orion, the Great Bear (Velký vůz), Pleiades
- Lunar eclipse: observation that the Earth's shadow is round, hence Earth is a sphere (Aristotle, *On the Heavens*, 350 BCE)
- Measuring the circumference of the Earth: 72 thousand kilometers, but given in stadia (now: 40 thousand km), Eudoxos of Cnidus
- Eratosthenes: measuring the the circumference of the Earth at summer solstice (Aswan / Syene and Alexandria): 45 thousand km

<https://www.nagwa.com/en/videos/287108723870/>

Ancient observations: studying the planets

Planets known from

Ancient times:

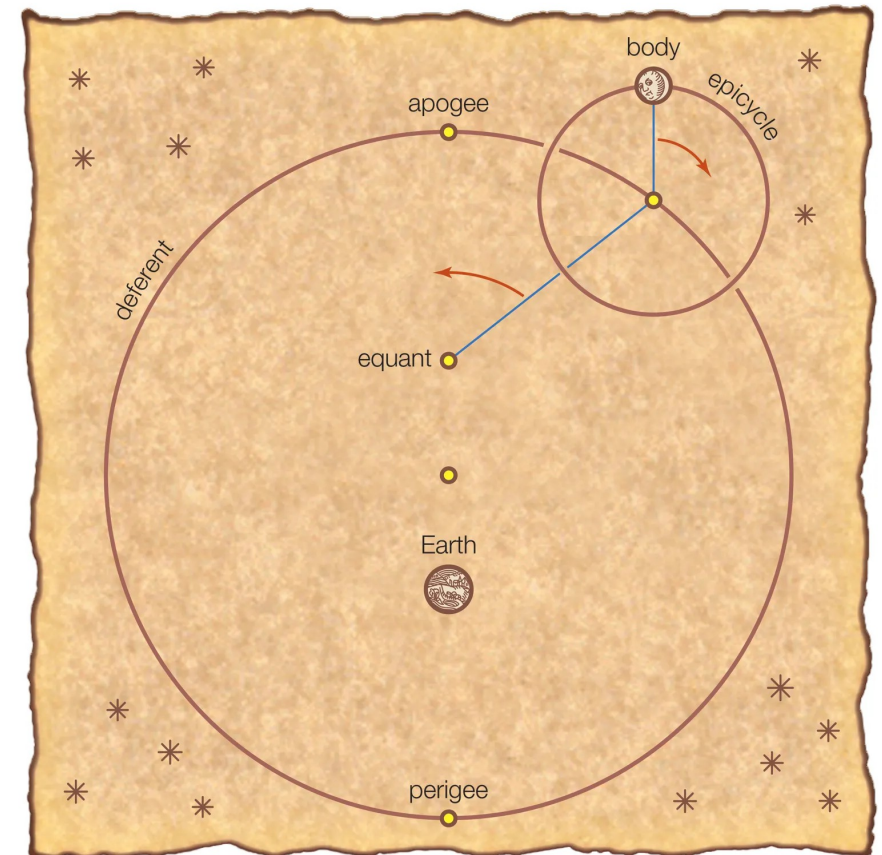
- Mercury
- Venus
- Mars
- Jupiter
- Saturn

discovered since the 18th century:

- Uranus: 1781
- Neptune: 1846
- Pluto: 1930 (until 2006)

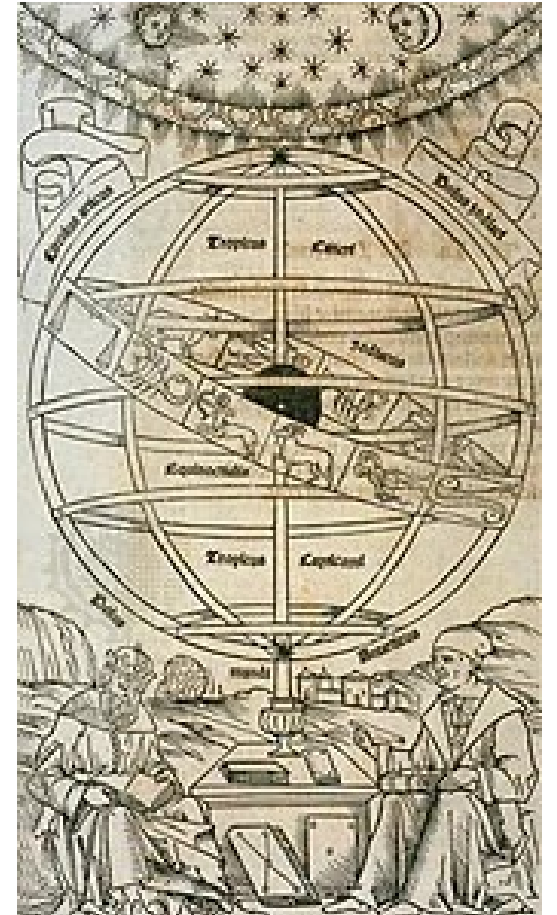
Claudius Ptolemaeus, *Almagest* (2nd c. BCE)

- geocentric model: the Sun, the Moon, and all planets orbit a stationary Earth
- heavenly bodies must move in the most perfect possible fashion – circles
- retain such motion and still explain the erratic apparent paths of the bodies: shift the centre of each body's orbit (deferent) from Earth—accounting for the body's apogee and perigee—and add a second orbital motion (epicycle) to explain retrograde motion.



Regiomontanus, 1496, *Epitome*

- Johannes Müller von Königsberg (1436-1476)
- Cardinal Bessarion asked R.'s teacher Peuerbach to remedy the problems in the translation of *Almagest* by George of Trebizond (1450)
- Regiomontanus finished the work 1462 (print: 1496)
- An alternative to Ptolemy's model of the orbits of Mercury and Venus – the „geometric key“ for Nicolaus Copernicus (1473-1543) to reorient planetary motions around the Sun (not the Earth)



Calendar and its reforms

- Solar calendar: in step with the seasons
- Lunar calendar: movable religious feasts (Easter etc.)
- Roman republican calendar: probably only 10 months / 304 days
- Martius, Aprilis, Maius, Juniiue, Quintilis, Sextilis, September, October, November, December (M, A, M, J, 5, 6, 7, 8, 9, 10)
- Adding January and February (7th c. BCE, changed 5th c. BCE)
- Continuing confusion; Julian calendar: 46 BCE (Julius Caesar)
- Tropical year: 365 and $\frac{1}{4}$ of a day – nowadays: leap year

Further calendar reforms

- Julian calendar: 365.25 days, but correct value: 365.242199
- error 11 minutes 14 seconds per year → $\frac{3}{4}$ of a day in 100 years, and by 1545, the vernal equinox (20 or 21 March) was 10 days later
- 1572: Pope Gregory XIII agreed to the proposal of Christopher Clavius (1537-1612)
- 24 February 1582: bull issued determining that 5 October became 15 October that year; accepting 365.2422 days
- Introduction of a leap year: every 4 years, but not in the years divisible by 100, unless divisible by 400 (1900 not, 2000 leap)

Adoption of Gregorian calendar

- Draft of the bull: an astronomer and scientist, Christopher Clavius, who also introduced decimal comma
- Accepted by Kepler and Brahe (science)
- Accepted by Catholics – issued by Pope
- Not accepted by Protestants; only gradually
- Jacob Bernoulli: born late December 1654, or early January 1655
- All of Europe eventually accepted, Russia only in 1918
 - (Great October Revolution – 7 November 1917)

Johannes Kepler (1571-1630) astronomer

Laws of planetary motions:

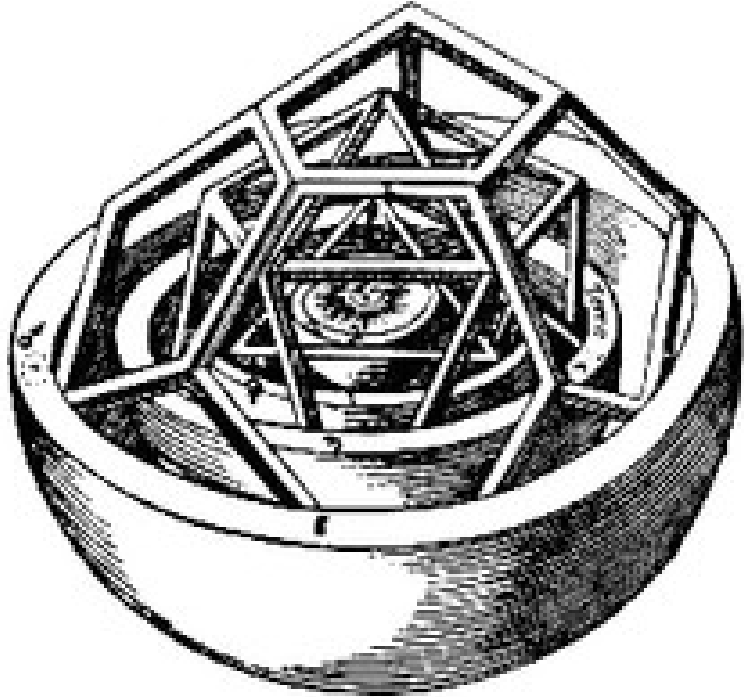
- Planets move in elliptic orbits
- „area law“
- „harmonic law“

made his living as an astrologer

- Snowflakes
- Tycho Brahe



Mysterium Cosmographicum



Five regular solids:

- Tetrahedron (4 triangles)
- Cube (6 squares)
- Octahedron (8 triangles)
- Dodecahedron (12 pentagons)
- Icosahedron (20 triangles)

What do we want to achieve?

Harmony – easy model

- four or five elements;
- everything in small numbers
- ...

Another take on cosmology

- Spheres
- „cloud nine“
- Heaven beyond these spheres

Predictions

- regularities
- occurring again
- predicting eclipses (lunar / solar)

Going beyond the sphere

