The Copernican Revolution

The Earth moves and Science is no longer common sense

Nicholas Copernicus

- 1473-1543
- Studied medicine at University of Crakow
  - Discovered math and astronomy.
- Continued studies at Bologna, Padua, eventually took degree in Canon Law at University of Ferrara.
- Appointed Canon of Cathedral of Frombork (Frauenberg).

Copernicus' interests

- A “Renaissance Man”
- Mathematics, astronomy, medicine, law, mysticism, Hermeticism
- Viewed astronomy as a central subject for understanding nature.
  - Viewed mathematics as central to astronomy

The Julian calendar

- The Julian Calendar, introduced in 45 BCE, was a great improvement over previous calendars, but by the 16th century, it was registering 10 days ahead of the astronomical events it should have tracked.
  - The Julian Calendar had 365 days per year and one extra "leap day" every 4 years.

Copernicus' Task

- The Julian calendar was associated with Ptolemy.
- Copernicus believed that Ptolemy's system was at fault and need a (perhaps minor) correction.
  - E.g. Mars' orbit intersects orbit of Sun.

On the Revolutions of the Heavenly Spheres

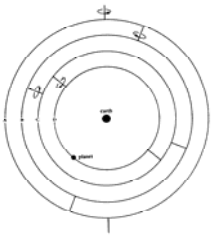
- Studied astronomy over 30 years, culminating in publication of *On the Revolutions* in 1543
  - **Remember this date: 1543**. It marks the beginning of the Scientific Revolution.
  - This the fourth date to be remembered. It is the same year as the publication of Vesalius' *On the Fabric of the Human Body*.

The conflicting views of ancient philosophy

- Plato: the Forms (e.g. mathematics) were reality.
- Aristotle: the Forms only describe an underlying physical reality.
- This led to conflicting interpretations in astronomy
  - In particular, the problem of the planets.

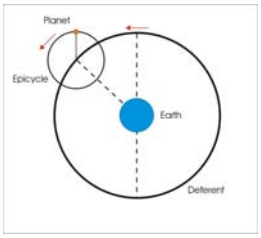
Solutions to the problem of the planets

- Aristotelian:
  - The spheres of Eudoxus
  - The superlunar realm is filled with crystalline shells.
    - A physical reality
  - Poor accuracy



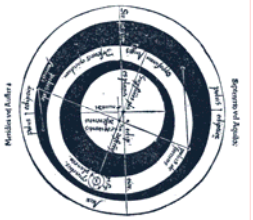
Solutions to the problem of the planets

- Platonic:
  - The Ptolemy Epicycle/Deferent system
    - A formal mathematical system only
  - No physical meaning



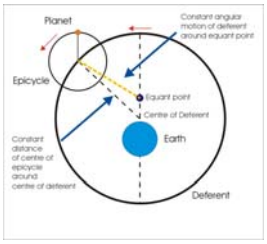
Medieval reconciliation of Aristotle and Plato

- Epicycles *and* concentric spheres.
- Epicycles like ball bearings running in carved out channels.
- Ptolemaic mathematical analysis, with a physical interpretation.



The Problem of the Equant

- Physically impossible to rotate evenly around a point not at the geometric centre.
- Could dispense with the equant if planets revolved around sun (while sun revolved around the stationary Earth).



The Problem of Mars' Orbit

- Mars' orbit would cut into orbit of Sun around Earth.
- Solution: Leave the Sun stationary and make the Earth move.

The Copernican System

- The Earth is a planet, circling the Sun.
- The Moon is not a planet, but a satellite circling the Earth.
- The "Fixed" stars truly are fixed, not just fixed to the celestial sphere.
- The Equant point is not required.

The Three Motions of the Earth

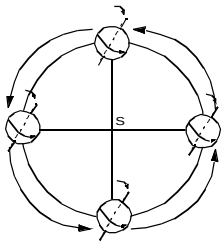
- 1. Daily rotation on its axis
  - Replaces the movement of the celestial sphere.
  - Though counter-intuitive, Copernicus argued that it was simpler for the relatively small Earth to turn on its axis every day from west to east than for the gigantic heavens to make a complete revolution from east to west daily.

The Three Motions of the Earth

- 2. Annual revolution around the Sun.
  - Accounts for retrograde motion of the planets—makes them an optical illusion.

The Three Motions of the Earth

- 3. Rotation of Earth's North-South axis, once a year, around an axis perpendicular to the ecliptic.
  - Provides the seasons, and incidentally accounts for the precession of the equinoxes.



The Calendar and the Church

- For the Christian Church, it was vitally important to know what day it was.
- The segments of the church year required different prayers, different rituals, and different celebrations.
  - E.g. Easter is the first Sunday after the first full moon after the vernal equinox.

The Council of Trent

- The Council of Trent was set up in 1545 to deal with the Protestant threat to Catholicism.
- It also undertook to repair the calendar.
- The Council used Copernicus' new system to reform and reset the calendar.

The Gregorian Calendar

- In 1582, Pope Gregory adopted a new calendar to replace the Julian calendar.
- The Gregorian calendar, which we use today, has 365 days per year, with one extra day every fourth year.
  - But not if the year is a century year.
  - Unless it is divisible by 400.
  - Hence it adds 100-3=97 days every 400 years – three less than the Julian calendar.

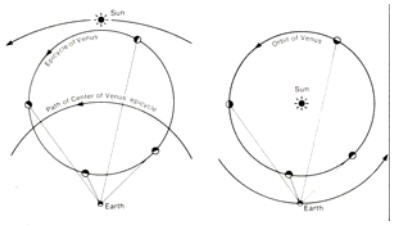
Copernicus' Style of Argument

- *Pythagorean/Platonic*
  - Mathematics is for mathematicians.
  - The reality is in the mathematical elegance; other considerations secondary.
  - Secretive and/of uninterested in the riff-raff of popular opinion.
- *Ad hoc* argument
  - Solutions to problems found by logic without supporting evidence.

Problems Remaining in Copernicus

- 1. The moving Earth.
  - Why can we not detect the motion of the Earth, which is very fast at the surface?
  - Why do the clouds not all rush off to the west as the Earth spins toward the East?
  - Why is there not always a strong East wind?

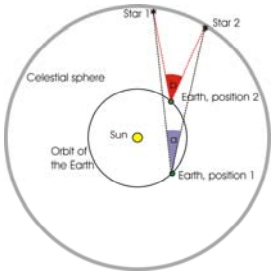
Problems Remaining in Copernicus



- 2. *Phases of Venus*
  - If Venus is sometimes on the same side of the sun as the Earth and sometimes across from the sun, it should appear different at different times. It should show phases, like the moon

Problems Remaining in Copernicus

- 3. *Stellar parallax*
  - Because the Earth moves around the sun, it gets sometimes closer and sometimes farther from certain stars.
  - The Earth at position 1 is farther from stars 1 and 2 than at position 2.
  - The angle between the stars at *a* should be smaller than the angle at *b*



Copernicus' *ad hoc* answers

- 1. We don't notice movement because the Earth carries everything around with it (the air, the clouds, ourselves).
- 2. Venus does not show phases because it has its own light (like the Sun and the stars).
- 3. We do not see stellar parallax because the entire orbit of the Earth around the Sun is as a point compared to the size of the celestial sphere.

It does not matter if it is true….

- The "Calculating Device“ viewpoint.
  - Typical of the way Phythagorean/Platonic conceptions are presented to the public.
    - That they are really just convenient fictions.
  - For example, the preface to *On the Revolutions* by Andreas Osiander.

From Osiander’s Preface

- There have already been widespread reports about the novel hypotheses of this work, which declares that the earth moves whereas the sun is at rest in the center of the universe…. [I]t is the duty of an astronomer to compose the history of the celestial motions through careful and expert study. Then he must conceive and devise the causes of these motions or hypotheses about them. Since he cannot in any way attain to the true causes, he will adopt whatever suppositions enable the motions to be computed correctly from the principles of geometry for the future as well as for the past…. For these hypotheses need not be true nor even probable. On the contrary, if they provide a calculus consistent with the observations, that alone is enough.

The Copernican system

- An illustration from *On the Revolutions.*
  - Note the similarity to Ptolemy’s system.