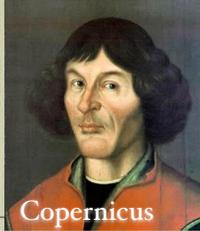


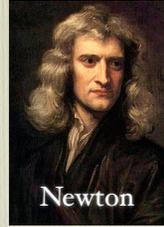
The Death of Astrology



Ptolemy



Copernicus



Newton



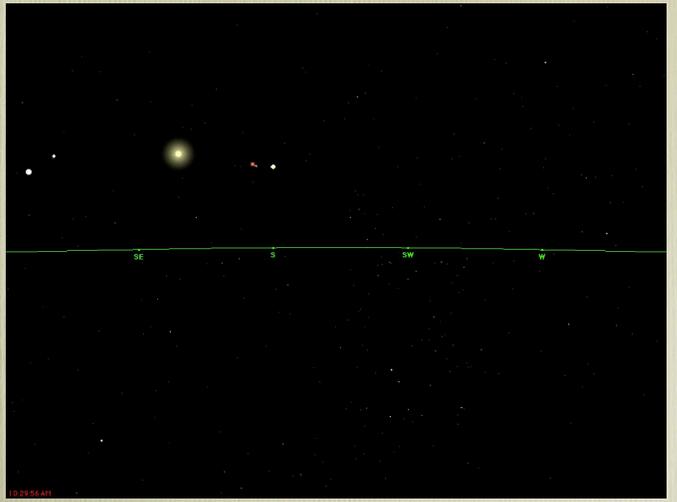
Kepler



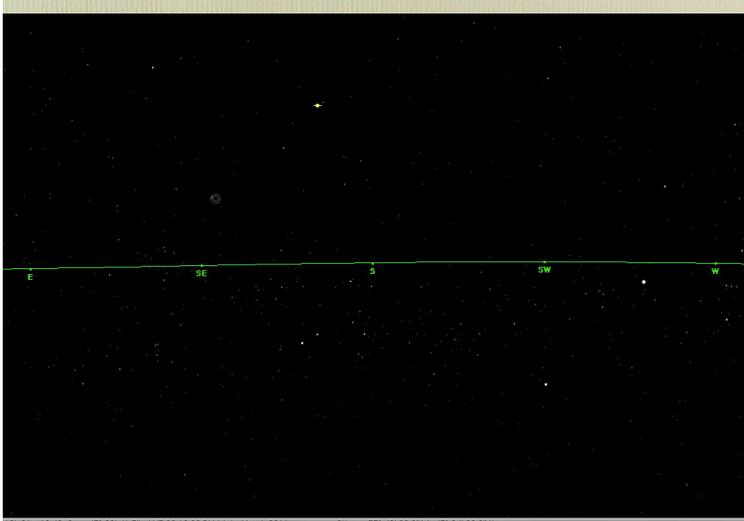
Galileo



Peter Watson, Dept. of Physics



Peter Watson

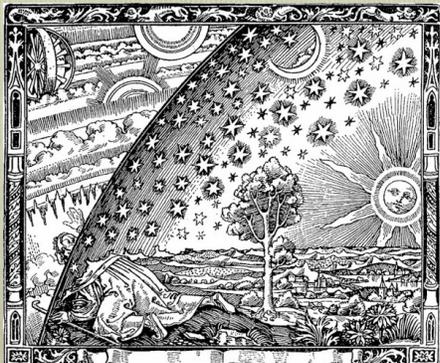


12h 01m 18.40s Dec: -45° 22' 41.3" LPT 09:18:08 PM Wed May 4, 2011 Ottawa 75° 42' 00.0" W 45° 24' 00.0" N

WHY?

- The scientific approach to the examination of phenomena is a defence against the pure emotion of fear... This made for a kind of harmony and confidence. The sun came up about as often as it went down, in the long run...
- Tom Stoppard, *Rosencrantz and Guildenstern are Dead*
- By and large, it works

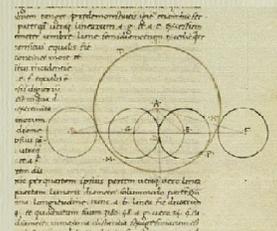
- Flammarion engraving (1888)
- (artist and origin unknown: probably combination of several old woodcuts/drawings)



Peter Watson

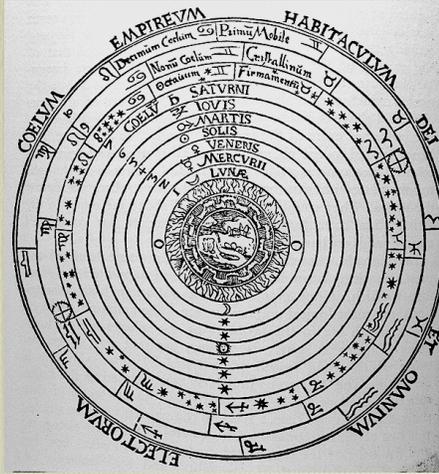
Ptolemy ~140 AD

- All of these ideas came together in the *Almagest* (13 Volumes on Astronomy)
- First real model of the universe
- Ptolemaic model



Peter Watson

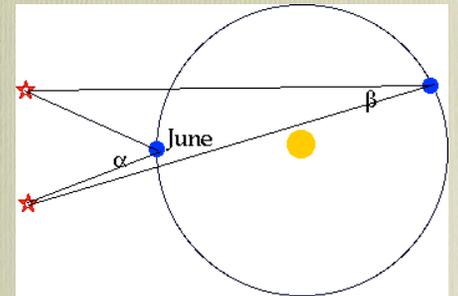
- Geocentric: Earth at the centre
- Moon, planets and the Sun in circular orbits
- Stars and crystal sphere beyond



Peter Watson

Why the earth must be stationary:

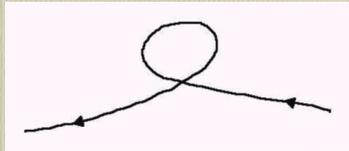
- Suppose that the earth revolved around the sun.
- Angle between two stars would change during year
- But it doesn't!



Peter Watson

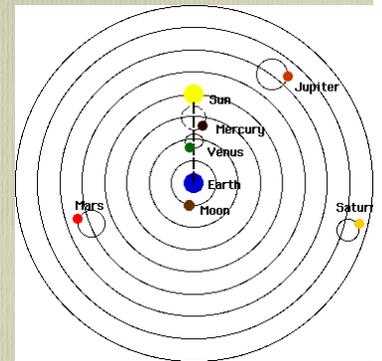
But

- Mercury and Venus never get far from sun.
- Retrograde Motion.
- Planets are always brightest when south at midnight



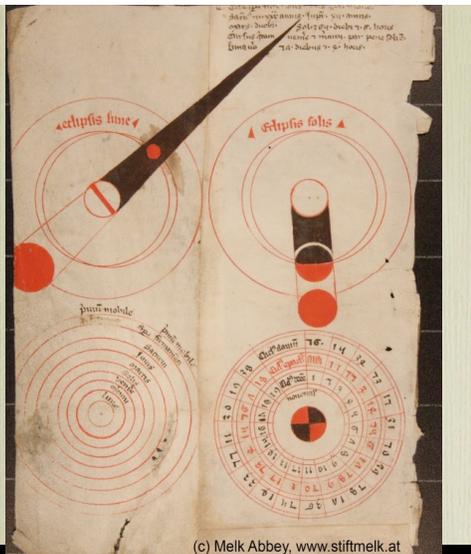
Peter Watson

- Lock orbits of Mercury and Venus to sun.
- Add epicycles: planets orbit about a point, which orbits about the earth.
- Earth is removed slightly to off-centre



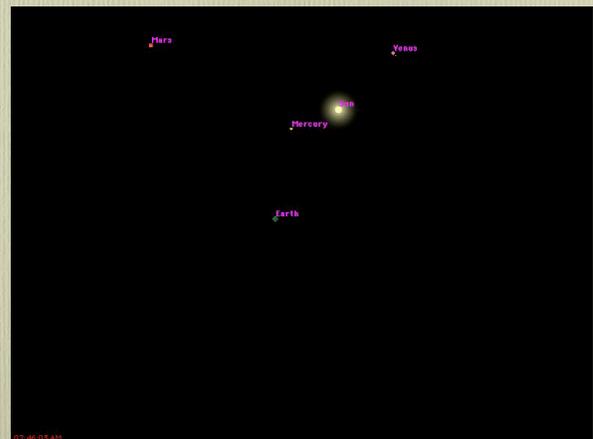
Peter Watson

- A medieval fragment (1490)



(c) Melk Abbey, www.stiftmelk.at

- And we can even get it to work!



Peter Watson

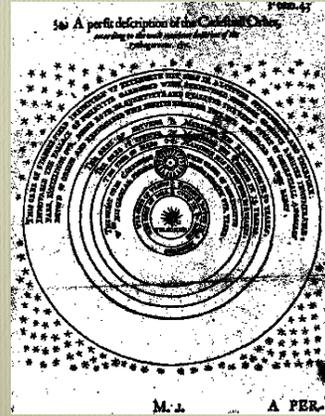
COPERNIKUS (1473-1543)



- Ptolemy's model now required 40 epicycles to work

Peter Watson

De revolutionibus orbium coelestium *The Book No One Read*

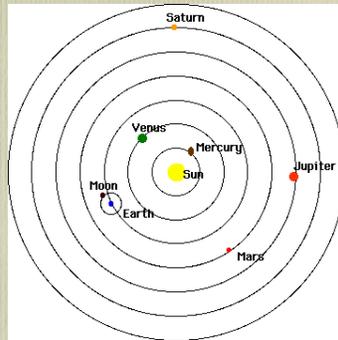


- A Heliocentric solar system.
- Still uses circular orbits, so still needs epicycles.

Peter Watson

- *Il sole no si muove* (The sun does not move)
Leonardo da Vinci

- Motion of Mercury & Venus "unlocked" from sun.
- No parallax because fixed stars are very far away
- So why do you believe in Copernicus?



Peter Watson

Reasons for asserting the earth is motionless:

1. David in Psalm 89: God has founded the earth and it shall not be moved.
2. Joshua bade the sun stand still-which would not be notable were it already at rest.
3. The earth is the heaviest element, therefore it more probably needs rest.
4. Everything loose on the earth seeks its rest on the earth, why should not the whole earth itself be at rest?

Peter Watson

4. We always see half of the heavens and the fixed stars also in a great half circle, which we could not see if the earth moved, and especially if it declined to the north and south...

5. A stone or an arrow shot straight up falls straight down. But if the earth turned under it, from west to east, it must fall west of its starting point.

6. In such revolutions houses and towers would fall in heaps.

7. High and low tide could not exist; the flying of birds and the swimming of fish would be hindered and all would be in a state of dizziness.

Peter Watson

Reasons for the belief that the earth is moved:

1. The sun, the most excellent, the greatest and the midmost star, rightly stands still like a king while all the other stars with the earth swing round it.
2. That you believe that the heavens revolve is due to ocular deception similar to that of a man on a ship leaving shore.
3. That when Joshua bade the sun stand still Moses wrote for the people in accordance with the popular misconception

Peter Watson

4. As the planets are each a special created thing in the heavens, so the earth is a similar creation and similarly revolves.

5. The sun fitly rests at the centre as the heart does in the middle of the human body.

6. Since the earth has in itself its especial centrum, a stone or an arrow falls freely out of the air again to its own centrum as do all earthly things.

7. The earth can move five miles in a second more readily than the sun can go forty miles in the same time.

Voight (1667). *Der Kurstgunstein Einfalt Mathematischer Paritäten* Erstes Hundert.



Peter Watson

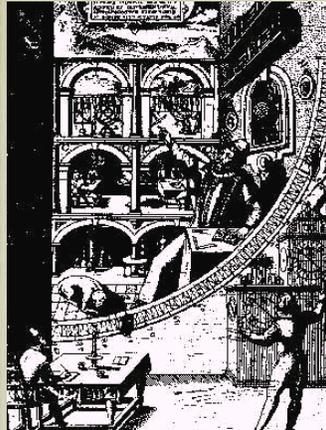
Tycho Brahe 1546-1601

Note the tin nose ...



Peter Watson

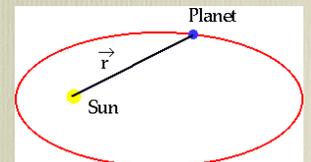
- Ruler of island of Hveen, off coast of Denmark.
- Constructed Uraniborg to measure position of planets and stars



Peter Watson

Kepler 1571-1627

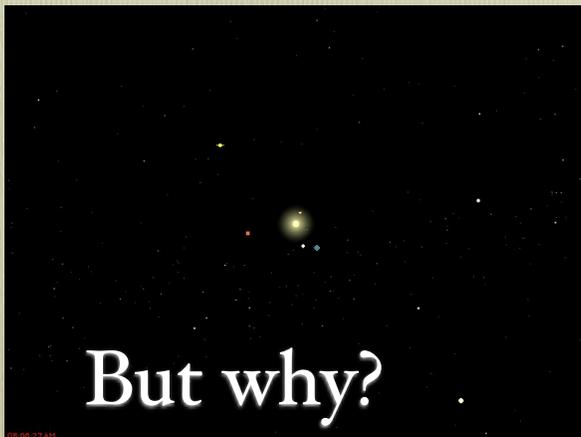
- Corresponded with Brahe
- “Acquired” records after his death: i.e. refused to give them up to his heirs



1. Planets move in ellipses
2. Planets move fastest when they are closest to the sun
3. Outer planets move slower

Peter Watson

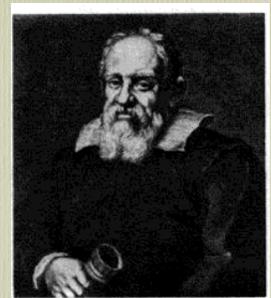
Makes the solar system so simple



00:00:27 AM

GALILEO (1564-1642)

- Lived in Pisa



Peter Watson

- Exploited (but didn't invent) telescope



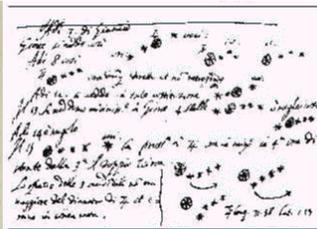
Peter Watson

- Moons of Jupiter: Jan 8th 1608

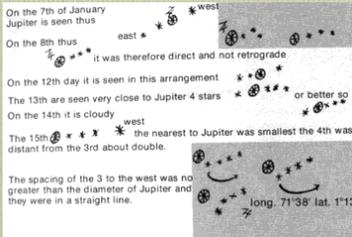


Peter Watson

This is his original notebook

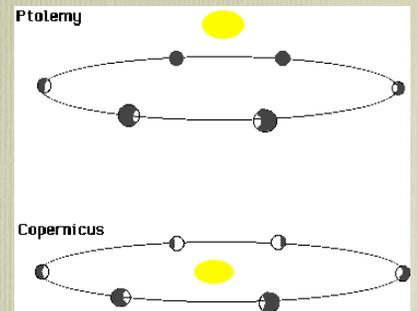
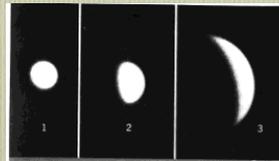


- and this is a translation.
- moons also discovered by a German astronomer, Marius (or Mayr). He gave them their names Io, Europa, Ganymede and Callisto.



Peter Watson

- The final nail in the coffin of Ptolemaic model: the phases of Venus



Peter Watson

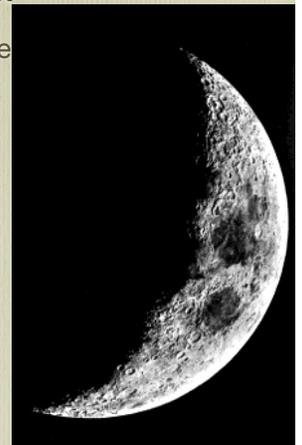
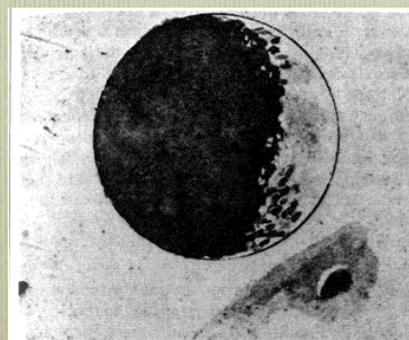
Except he wanted to keep it a secret!

- "Haec immatura a me iam frustra leguntur o.y."
- "These are at present too young to be read by me"
- "Cynthiae figuras aemulatur mater amorum"
- "The mother of love (Venus) imitates the shape of Cynthia (the Moon)"

Peter Watson

Mountains of Moon.

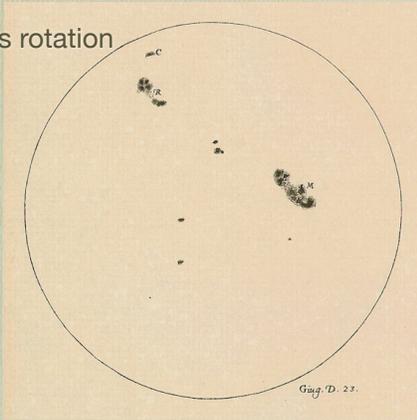
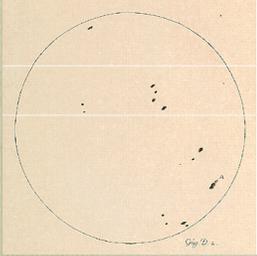
Showed heavenly bodies "Imperfect"
can see shadows changing on edge of craters



Peter Watson

Sunspots 1612

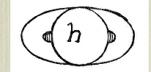
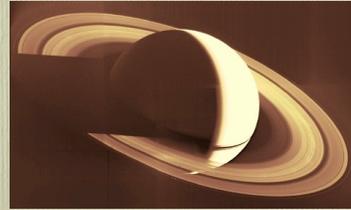
- Allowed period of sun's rotation to be measured.
- ~ 29 days



Peter Watson

Rings of Saturn

Galileo could never figure out what they were!
He thought that the planet had "handles".



Peter Watson

The greatest discovery Galileo never made

For a week in 1612, Neptune was in the field of his telescope when he was observing Jupiter, and he even notes that it seemed to be a moving star

- But then it got cloudy!
- And it took 250 years to find Neptune!

10:48:17 AM

Peter Watson

A final note: the most famous quote
Epur si muove (And yet it does move)
was made by Giordano Bruno before he was burnt at the stake in 1600

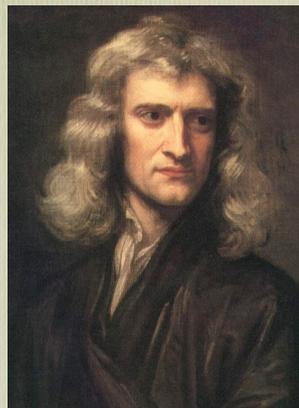
So the Ptolemaic model was **A Failure**

But a failure that lasted 1400 years!

Peter Watson

Newton

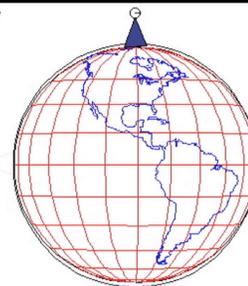
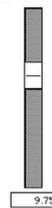
- 1642-1727
- Born the day of Galileo's death



Peter Watson

Universal Gravitation

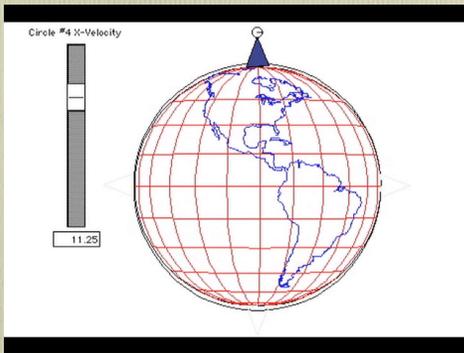
Circle #4 X-Velocity



- How does the moon stay up?
- By falling!

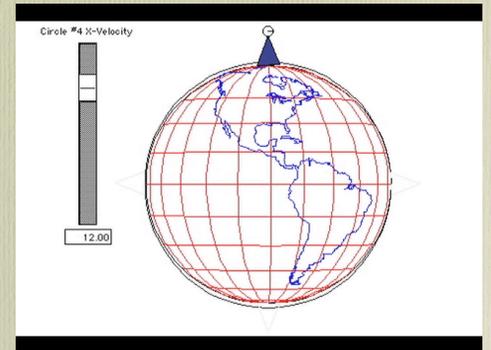
Peter Watson

- Faster



Peter Watson

- and faster

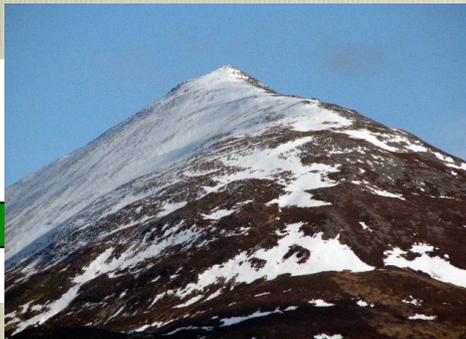
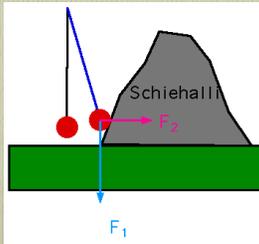


Peter Watson

- The extra step is to realise that any two bodies in the universe attract each other

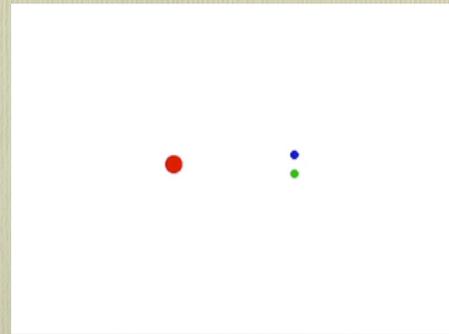
Even mountains!

- First measurement was done with Schiehallion



Peter Watson

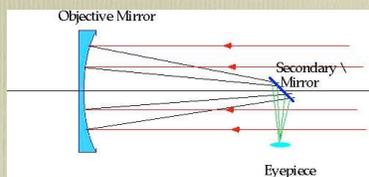
Explains Kepler's laws



Peter Watson

Newton's other contribution: understanding light

- the reflecting telescope
- precursor of all modern telescopes



Peter Watson

and splitting up light into its constituent colours



Peter Watson

We'll skip forward to 1960

Why 1960?

1. Systematic observations (needed writing, Babylon 1500 BC)
- Model for the universe (needed observations, Ptolemy 100 AD)
- Collecting light (needed clear glass, telescope, Galileo, 1605 AD)
- Fundamental Physics (needed calculus, Newton, 1666)
- Saving light (needed chemistry, photography, Daguerre 1860)
- Synthesizing the ideas (needed computers, 1945)
- Extending the spectrum (needed radar: Jansky radio-telescopes, 1955)
- Escaping the atmosphere (needed satellites, 1956)



Acknowledgements

- Astronomy Picture of the Day (APOD)
- Wikisource
- Simulations: Voyager (Carina software), Interactive Physics
- British Museum, Royal Society, Museo Galileo
- Notes will be posted at www.physics.carleton.ca/~watson/

Next; On to 1960: Leaving Earth Behind

