New Ideas from Astronomy and Cosmology

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Session 2**

Agenda
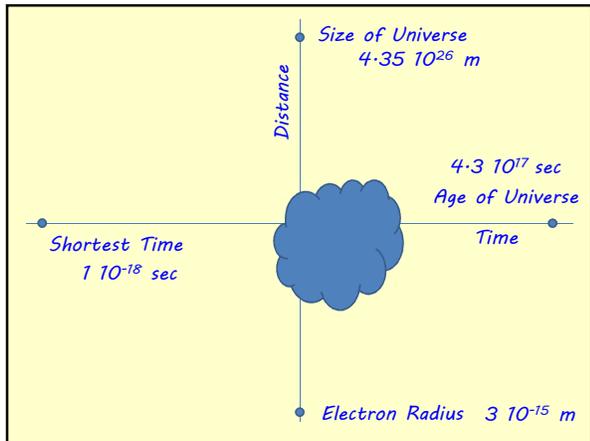
Introduction
   Space, Time and Matter ☑
   Early views of the cosmos
   Important Ideas from Classical Physics

Two 20th Century revolutions in Physics
   Relativity
   Quantum Theory

Interwoven with Ideas from Astronomy and Cosmology

Size of Universe
$4.35 \ 10^{26}$ m

Distance

$4.3 \ 10^{17}$ sec
Age of Universe

Shortest Time
$1 \ 10^{-18}$ sec

Time

Electron Radius $3 \ 10^{-15}$ m

We all have an intuitive understanding of the meaning of
   Space, Time and Matter.
Our understanding of these ideas comes from what we observe.

Part of the universe exists beyond our direct perception of it.

To understand the universe we must overcome the prejudice of our intuition.

Early ideas of the universe focused on two concepts
Finite vs. Infinite

	Finite	Infinite
Space	Finite in extent	Infinite in extent
Time	Began and will end	No beginning and no end
Matter	Atoms (digital)	Continuous (analog)

Pythagoras of Samos
(c. 570-c. 495 BC) was an Ionian Greek philosopher, mathematician, and mystic.
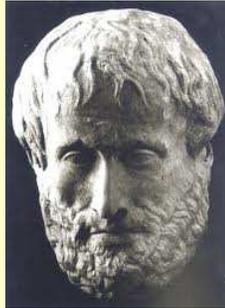
He began to understand music by observing that harmonic tone were produced by plucked strings whose lengths were in simple ratios.

"What we observe we can understand."

Aristotle
(384 BC – 322 BC)
Greek philosopher

Intuitive thinker – problems can be solved within one's mind
- *heavy objects fall faster*
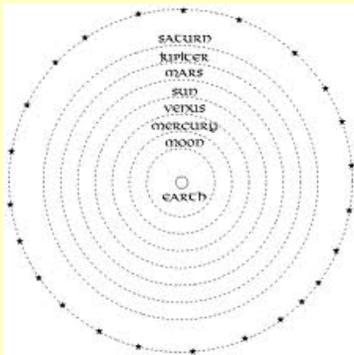- *motion requires force*
- *non-rotating earth*

Hipparchus (c. 190 BC – c. 120 BC) Greek astronomer & mathematician; founder of trigonometry.
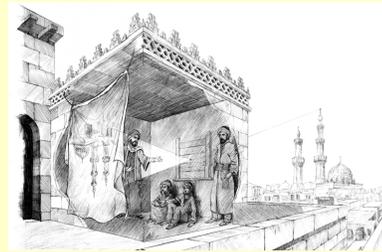
Geo-centric model of the early universe

Claudius Ptolemy (c. AD 90 – c. AD 168), a Roman citizen of Egypt who wrote in Greek.

The Early (Geo-centric) Universe

## A Brief Look at Islamic Science

Alhazen:
An Arab or Persian physicist born in A.D. 965 in what is now the port city of Basra in modern-day Iraq.

Al-Jahiz:
An early proponent of evolutionary biology, he wrote of food chains and environmental determinism in his seven-volume Book of Animals in the ninth century.

Al-Jazari:
An Iraqi genius—Abu al-Iz Ibn Ismail ibn al-Razaz al-Jazari, or al-Jazari—laid out construction plans in A.D. 1206 for some 50 mechanical devices, such as the "Elephant Clock" recreated here in this computer-rendered image.
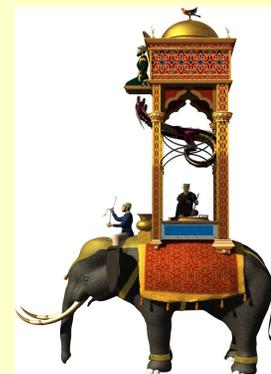
Al-Khwarizmi:
Considered by some the inventor of algebra, Abu Abdallah Muhammad ibn Musa al-Khwarizmi was a Persian mathematician working at the House of Wisdom in Baghdad in the ninth century. In fact, the very name of this form of math is derived from the Arabic al-jabr, meaning "restoring".

Fatima al-Fihri:
It wasn't just Muslim men. The oldest continuously operating university in the world—Al-Qarawiyyin founded in Fès, Morocco, in 859—was founded by a merchant's daughter: Fatima al-Fihri.

Nicolaus Copernicus *a Polish astronomer (1473 – 1543) and the first person to formulate a comprehensive heliocentric cosmology.*

1 – recognized that the earth rotated

2- Copernicus Principle: "There is no preferred position in the cosmos."

Tyco Brahe (1546 – 1601), a Danish astronomer used the best features of Copernicus and Ptolemy to publish the most accurate measurements of planetary motion.
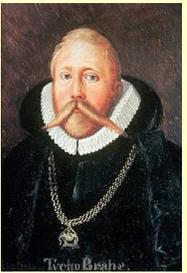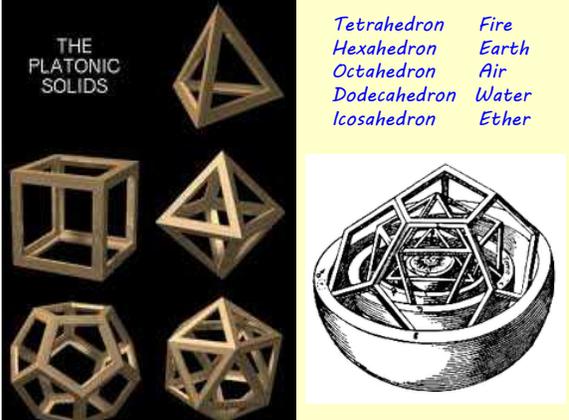
Johannes Kepler (1571 – 1630) was a German astronomer, mathematician.and a bit of a mystic.
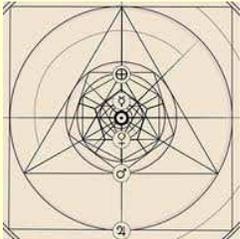
Kepler knew the 5 Platonic solids.

THE PLATONIC SOLIDS

Tetrahedron	*Fire*
Hexahedron	*Earth*
Octahedron	*Air*
Dodecahedron	*Water*
Icosahedron	*Ether*

Sphere > Cube > Sphere >Tetra > Sphere > Dodeca > Sphere > Icosa > Sphere > Octa > Sphere

Harmonices Mundi

Kepler published his results in

Mysterium Cosmographicum,

in 1596 and later in 1621. The full title was

Forerunner of the Cosmological Essays, Which Contains the Secret of the Universe; on the Marvelous Proportion of the Celestial Spheres, and on the True and Particular Causes of the Number, Magnitude, and Periodic Motions of the Heavens; Established by Means of the Five Regular Geometric Solids

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Eventually Kepler got it right – despite the wrong reasons

Kepler's laws
The orbit of every planet is an ellipse with the Sun at one of the two foci.

A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.

The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit.
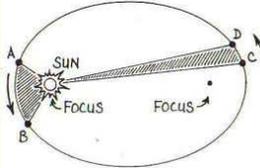
Up to this point we had correctly figured out:
Heliocentric solar system
Orbital shape and periods

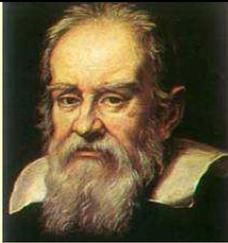**But the underlying reasoning was flimsy at best.**

Next comes science to sharpen up the logic.

Galileo Galilee (1564 – 1642) "Father of Experimental Science"

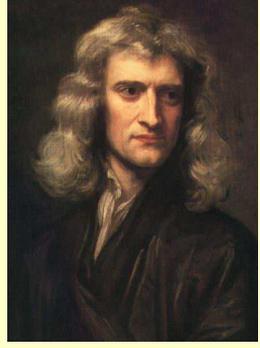Introduced systematic experimentation as a prerequisite for explanation.

Perfected the telescope and found the moons of Jupiter

Extensive study of motion and force.

Isaac Newton (1643 – 1727)

1) Calculus –

2) Laws of Motion

3) Law of Gravitation

The Big Ideas

1. Pythagoras – What we observe we can understand.
But no one said it would be easy!

2. Anonymous –Heliocentric solar system.

3. Copernicus – There is no preferred place in the cosmos.
This implies that the laws of the universe are the same everywhere.

4. Galileo – Father of Experimental Science

5. Isaac Newton – Calculus, Laws of Motion, Laws of Gravity