The Geometry of our Universe?

- Pythagorean theorem? sum of the angles 180 degrees?
- What does our universe look like? Is it finite or infinite?
- My thesis in geometry differentiated spaces and examined how far away creatures can go away from each other in a space.

- Platonic solids: universe = dodecahedron
- Earth centered
- 19th century: elusive luminiferous ether
- Einstein theory of relativity - Riemann’s curved space
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Venus
Scientific & Mathematical Breakthroughs

- They require imaginative leaps
- Understanding what we are seeing is complicated by filters
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Nicolaus Copernicus (1473-1543): Heliocentric Model
Is our Universe Finite Without Edges?

- Klein bottle: 1882; Pac-Man 1980
- 3-torus with 96 stars
- An apartment in *Futurama: I, Roommate*
- *Portal* video game
Is our Universe Finite Without Edges?

- Klein bottle: 1882; Pac-Man 1980
- 3-torus with 96 stars
- An apartment in *Futurama: I, Roommate*
- *Portal* video game
- Looking for repeated star patterns—Critiques: light takes times to reach us and changes the view, recognize?
- Spherical dodecahedron
Angle Sum: Euclidean, Spherical, Hyperbolic or Other?

- Gauss: Hoher Hagen, Inselsberg, and Brocken
Angle Sum: Euclidean, Spherical, Hyperbolic or Other?

- Gauss: Hoher Hagen, Inselsberg, and Brocken

- Nikolai Lobachevsky: star Sirius
  \[ 180^\circ - \text{sum of the angles} = 3.727 \times 10^{-6} \text{ (should be } 10^{-8}) \]
Angle Sum: Euclidean, Spherical, Hyperbolic or Other?

- Gauss: Hoher Hagen, Inselsberg, and Brocken

- Nikolai Lobachevsky: star Sirius
  $180^\circ - \text{sum of the angles} = 3.727 \times 10^{-6}$ (should be $10^{-8}$)
  Euclidean $= 180^\circ$, spherical $> 180^\circ$, hyperbolic $< 180^\circ$

- Critiques: Experimental error, light rays bend with gravity, triangles too small
Is our Universe Expanding?

- Hubble redshift (1929) - distant galaxies are moving away from us faster
- Bicep2 telescope (2014) - big bang gravitational waves?
Supernova Experiments

Euclidean inverse square law: brightness \( \sim \frac{1}{\text{distance}^2} \)

Hyperbolic and spherical
Euclidean inverse square law: brightness $\sim \frac{1}{\text{distance}^2}$

Distant supernovae dimmer than expected in a coasting space

**Critiques:** Experimental error, no perfect model, not necessarily exploding at the same brightness
Density Experiments: WMAP & Planck

- Density equation
- Cosmic Microwave Background: small temperature fluctuations due to primordial plasma density
- Infinite Euclidean universe within .4%: missing fluctuations on large scale better fit a large spherical dodecahedral space [Weeks] or hyperbolic [Cowen]
- Critiques: difficulty agreeing on the meaning of the data, neutrino mass, dark energy, speed of light?
Shape of the Universe Web Search

Why "Critical Density" Could Determine the Fate of the Universe
io9 - by Esther Inglis-Arkell - Mar 24, 2014
That depends on the shape of the universe. And the shape of the universe depends on how many objects there are bending it out of shape, and ...

A Globe Can Help You Understand How Space Can Be Curved
io9 - by Esther Inglis-Arkell - 16 minutes ago
If you hangout among physicists long enough, you'll hear about curved space, higher dimensions, and the possibly weird shape of the universe ...

Scientists hope a billion-dollar laboratory in Guangdong could ...
South China Morning Post - Mar 25, 2014
It has been one of the missing pieces of the puzzle to understand the age and shape of the universe. “This is one of the key questions for the ...
Further Readings

- European Space Agency (2013), “Space Science: Planck.” http://www.esa.int/Our_Activities/Space_Science/Planck