

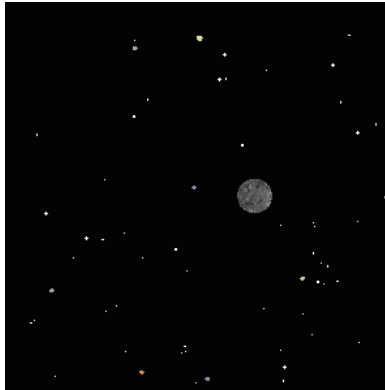
The Geometry of our Universe?

- 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



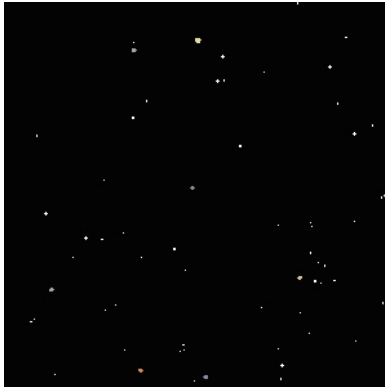
Venus



Venus



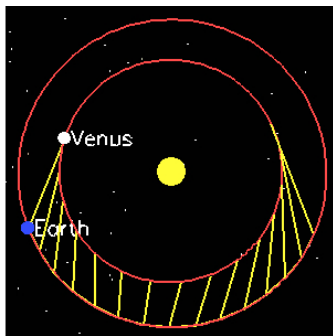
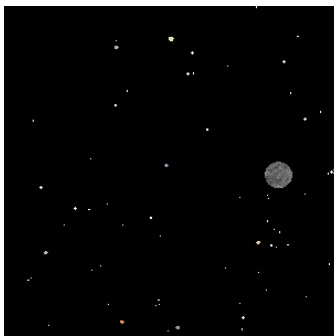
Venus



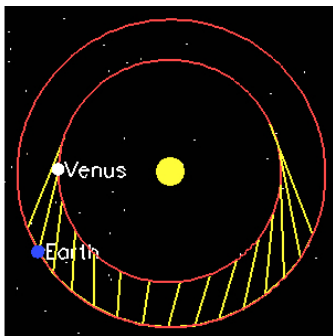
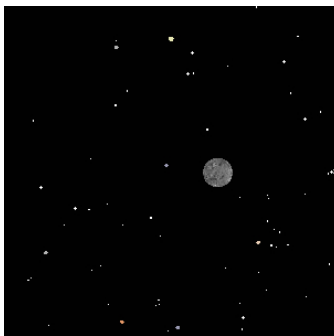
Scientific & Mathematical Breakthroughs

- They require imaginative leaps
- Understanding what we are seeing is complicated by filters

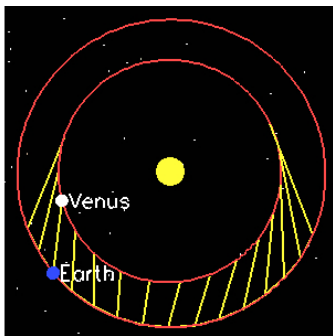
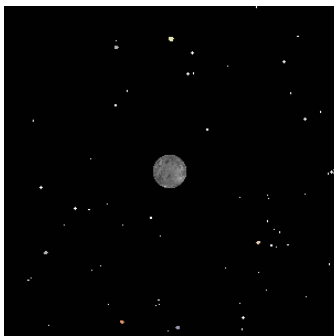
Nicolaus Copernicus (1473-1543): Heliocentric Model



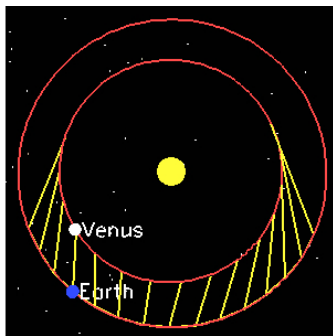
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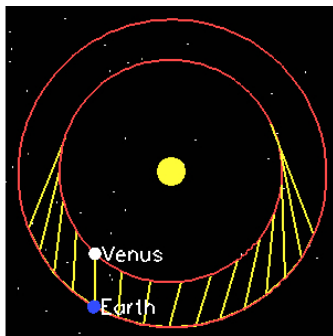
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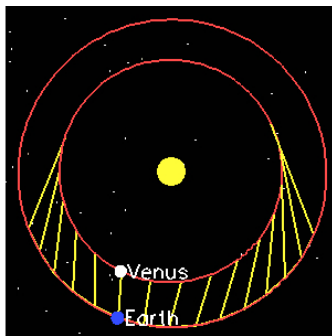
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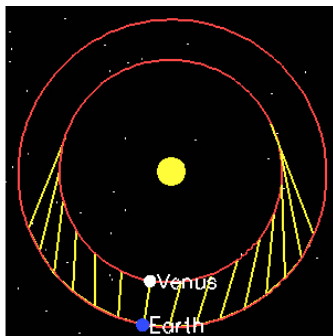
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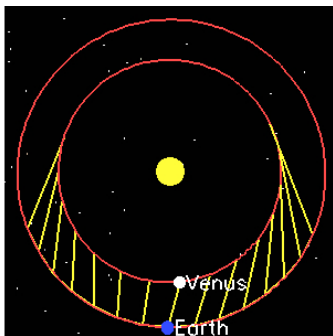
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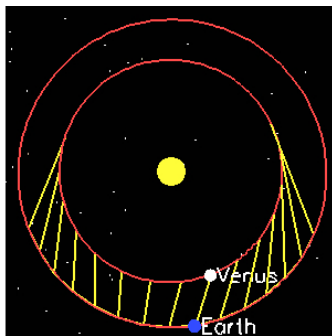
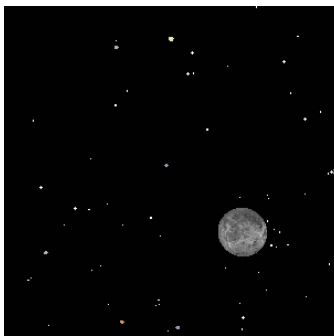
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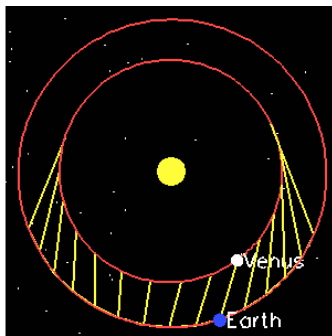
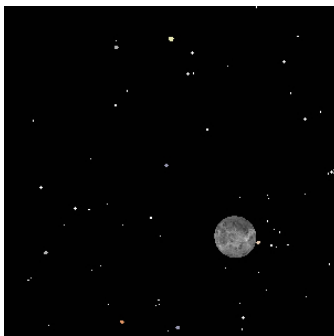
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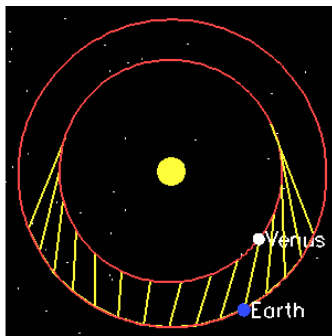
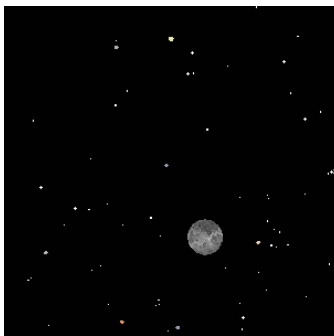
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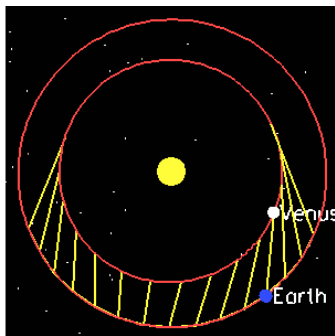
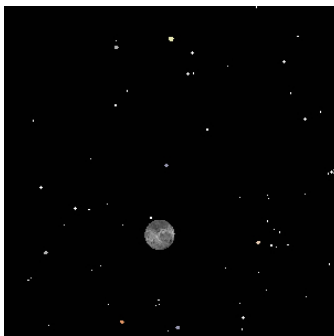
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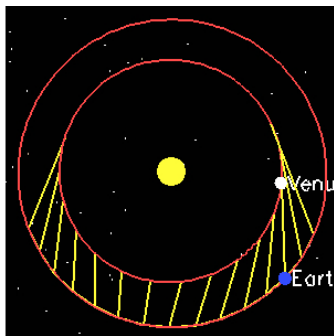
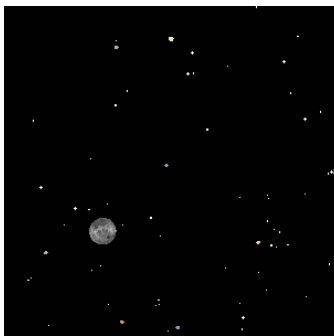
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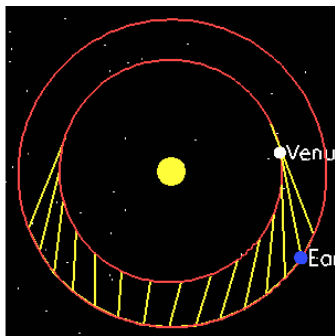
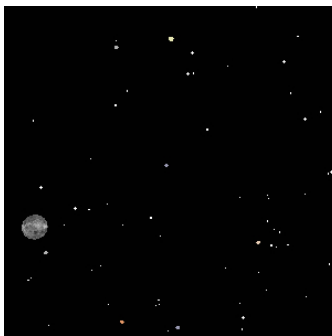
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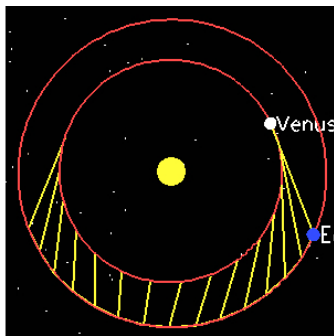
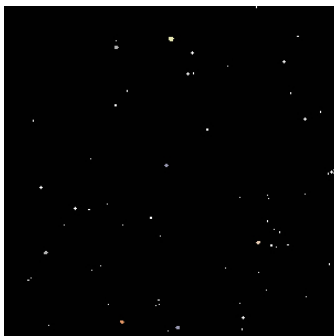
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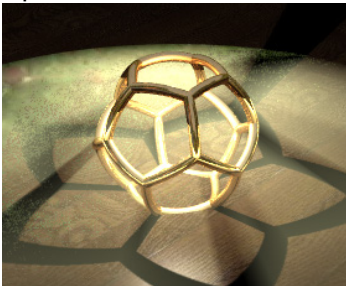


Is our Universe Finite Without Edges?

- 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
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- 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?

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

Angle Sum: Euclidean, Spherical, Hyperbolic or Other?

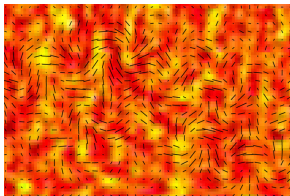
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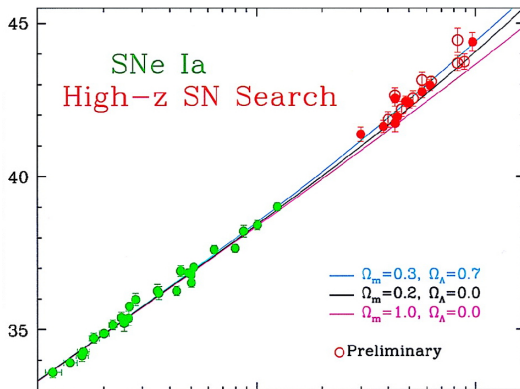
- Nikolai Lobachevsky: star Sirius
 180° – sum of the angles = 3.727×10^{-6} (should be 10^{-8})
 Euclidean = 180° , spherical $> 180^\circ$, hyperbolic $< 180^\circ$
- **Critiques:** Experimental error, light rays bend with gravity, triangles too small

Is our Universe Expanding?

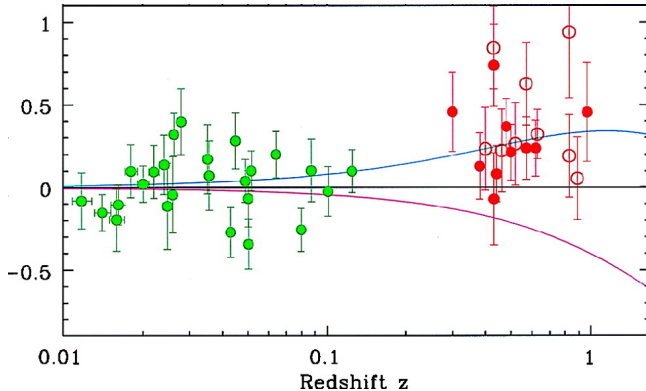
- Hubble redshift (1929) - distant galaxies are moving away from us faster
- Bicep2 telescope (2014) - big bang gravitational waves?



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

- Cowen, Ron (2013), "Universe may be curved, not flat: Anomalies in relic radiation could contradict the evidence for a level cosmos." Nature.
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