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- 2D hologram
- 3D
- exists in real-life data

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b) mathematical spaces
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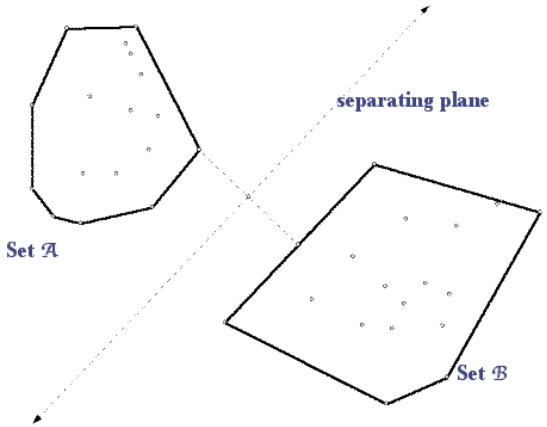

Number of Stars?

The Shape of Space

Hubble: Space Telescope Science Institute

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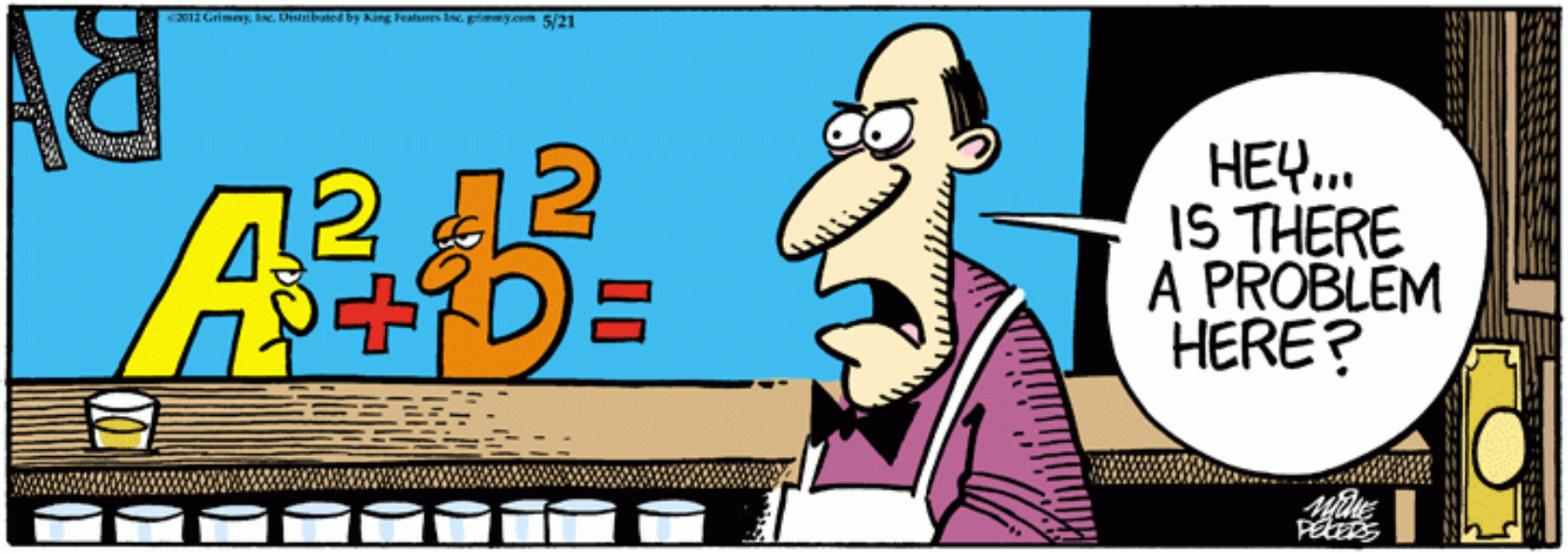
- finite number of stars...
- Critiques: convenience sampling, light takes times to reach us and changes the view, repeated star patterns?

Does the real universe have curves? shape?



Mike Peters `https://www.grimmy.com/comics.php?sel_dt=2012-05-21`

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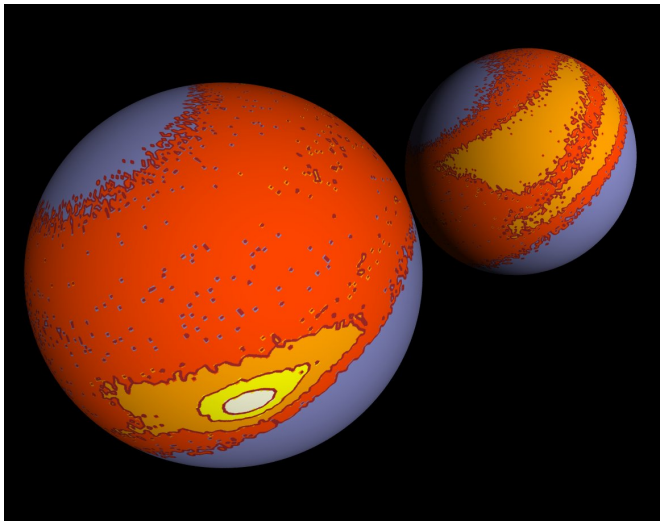
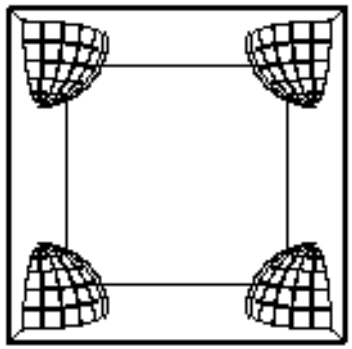


The overall shape of a protein... Shown are two views of the spherical histogram... for a large collection of protein structures. The statistical treatment of such data is in the realm of directional statistics. [Thomas Hamelryck]

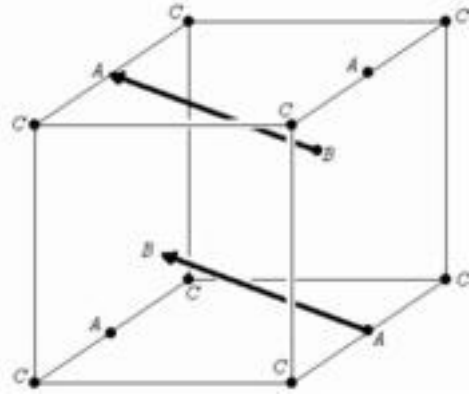
Applications: AI, biology, machine learning, statistics, and

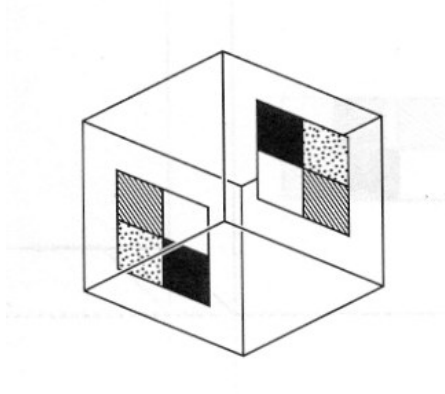
Is the universe finite and wraparound?

- Euclidean 3-torus or other finite Euclidean universes



A sphere in a 3-torus.





A room in *Futurama: I, Roommate* or *Portal* video game

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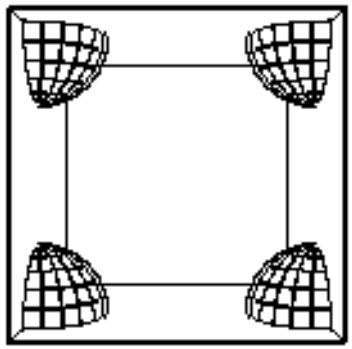

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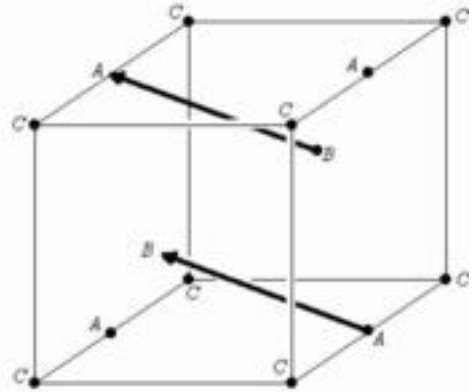
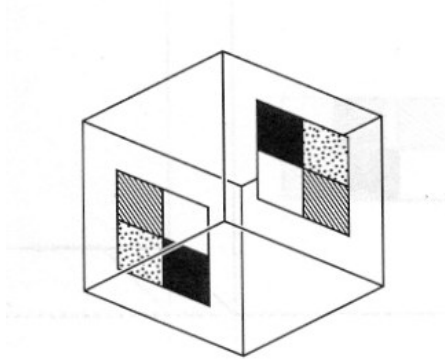
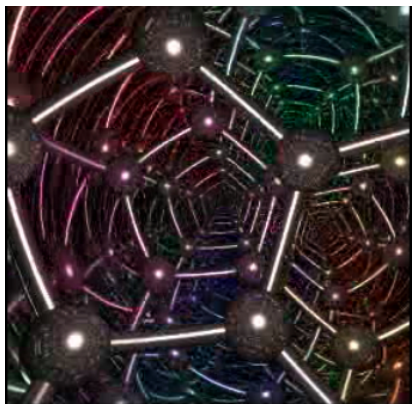




A room in *Futurama: I, Roommate* or *Portal* video game

- spherical dodecahedron



Paul Nylander: life from the inside

historically Platonic solids: universe = finite dodecahedron

- hyperbolic Weeks manifold

http://www.atheistrepublic.com/sites/default/files/styles/blog-featured-image/public/proof.jpg

Venus

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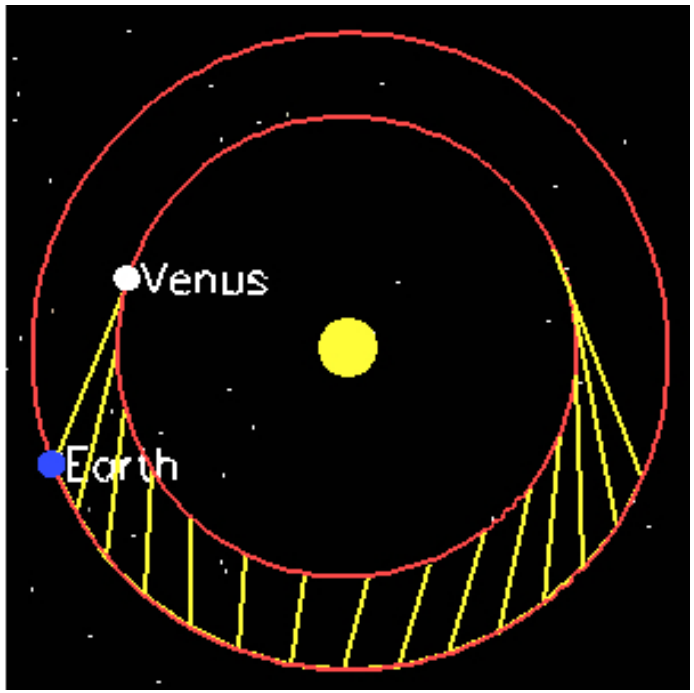
Scientific & Mathematical Breakthroughs

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

Nicolaus Copernicus (1473-1543): Heliocentric Model



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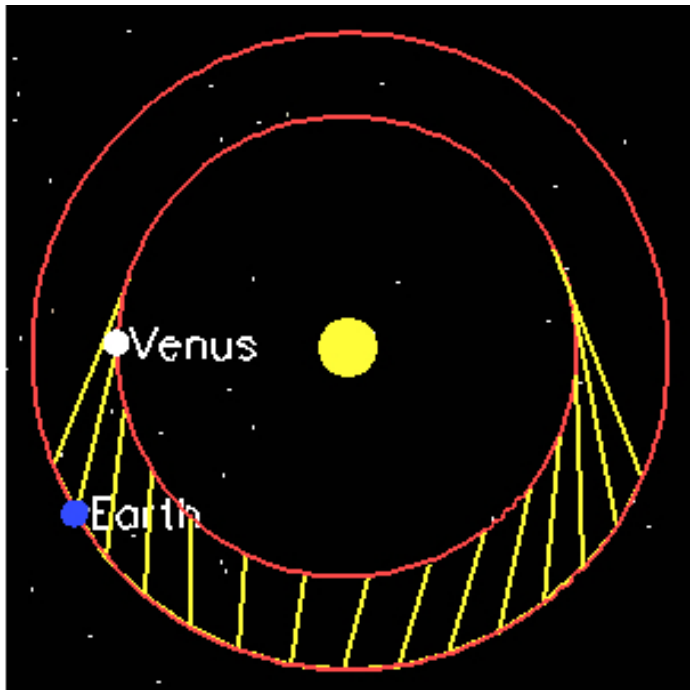

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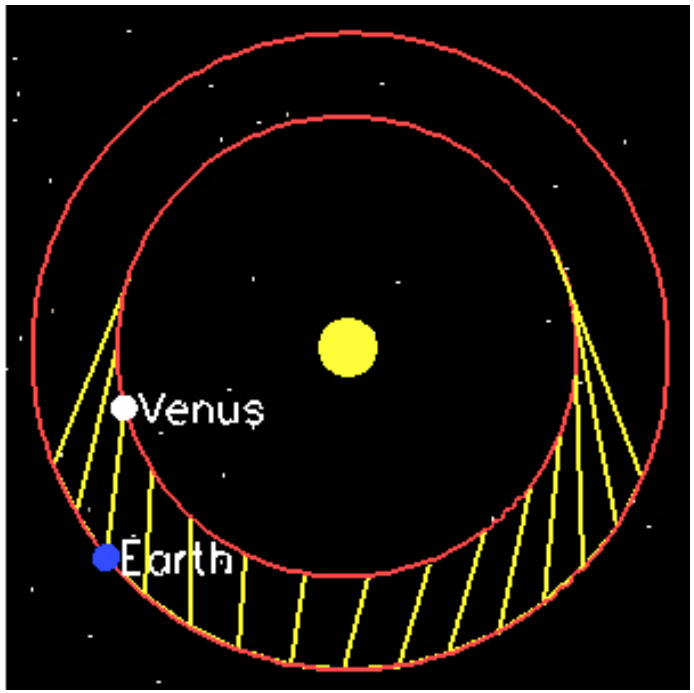

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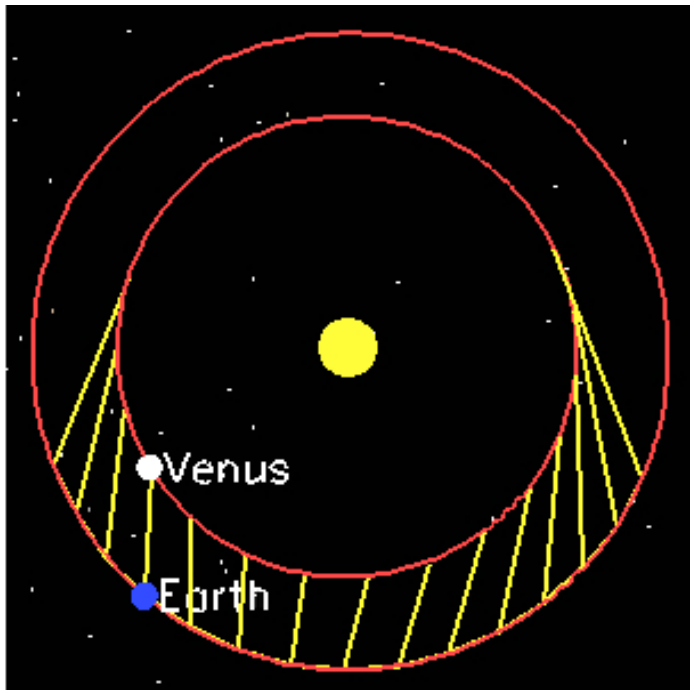

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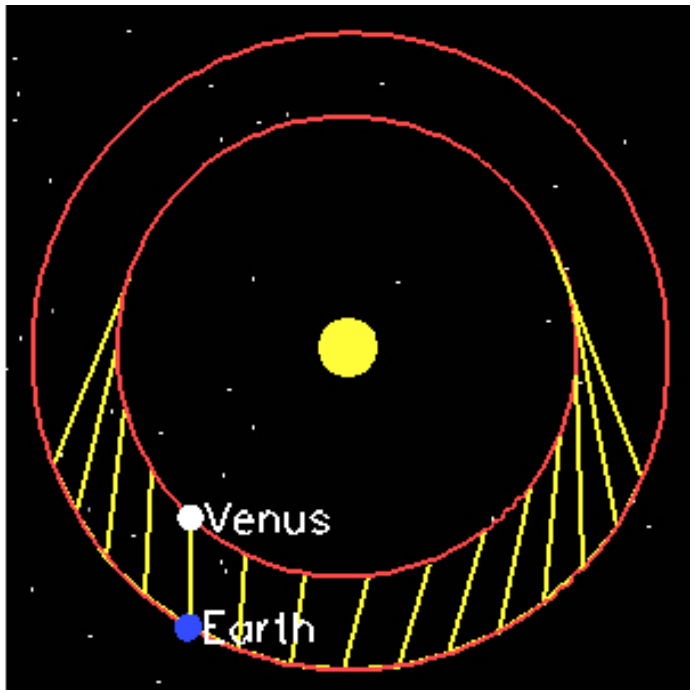

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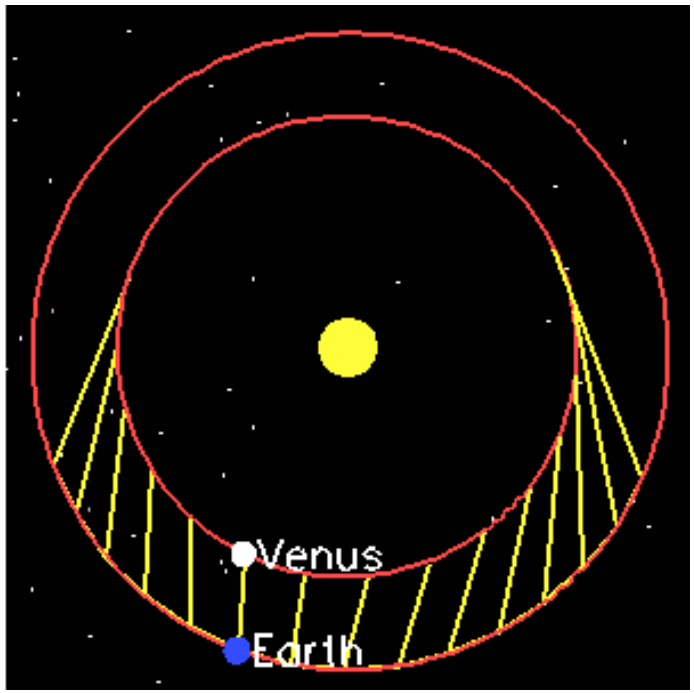

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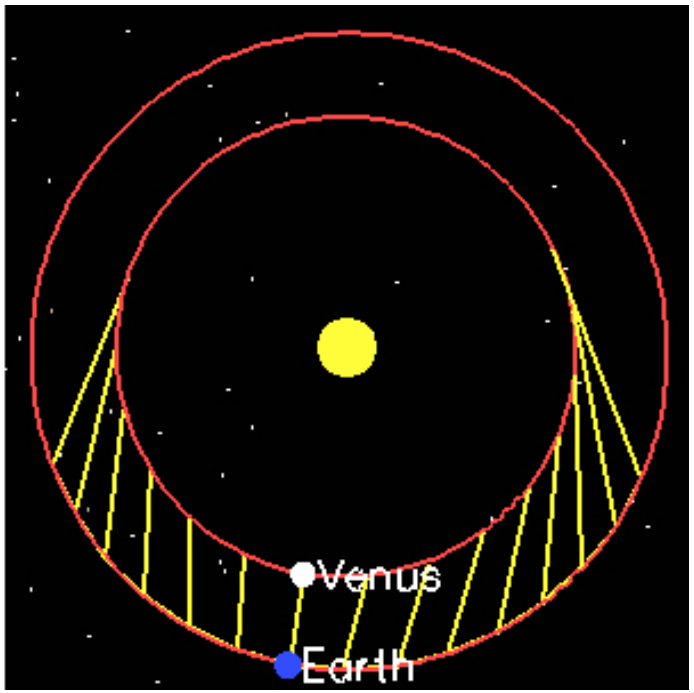

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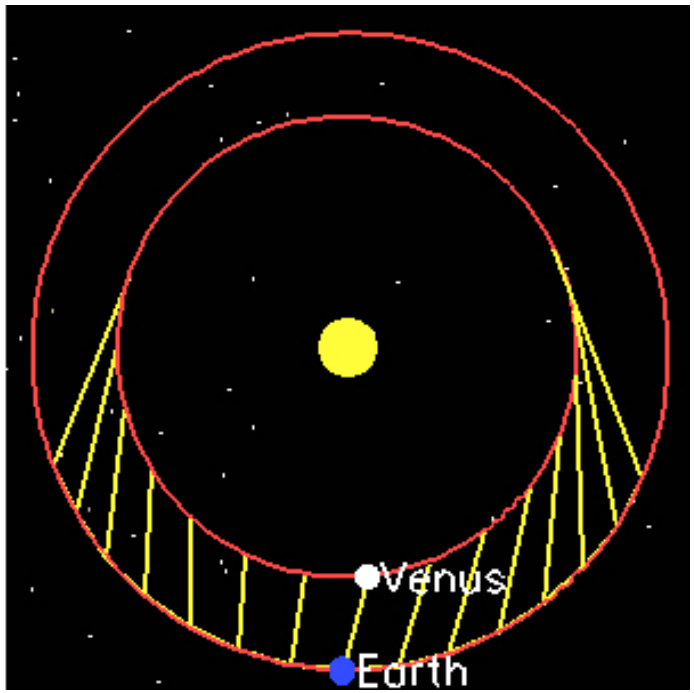

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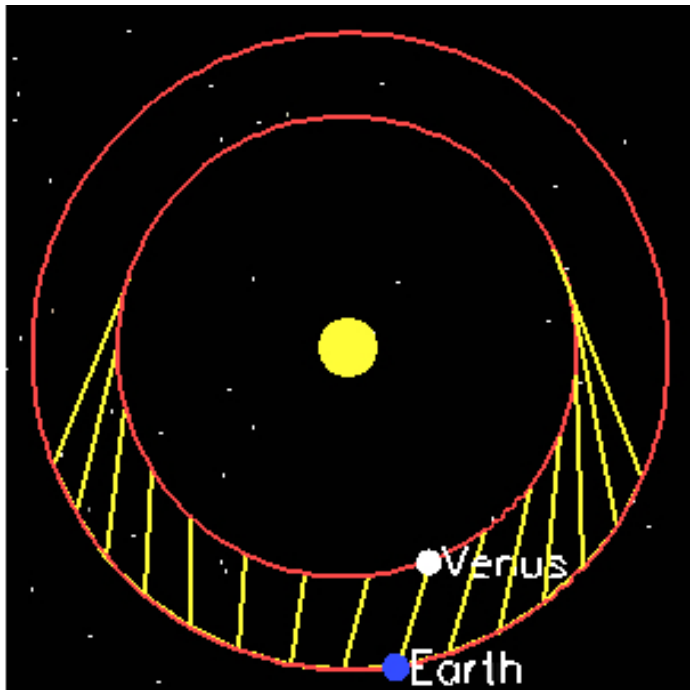

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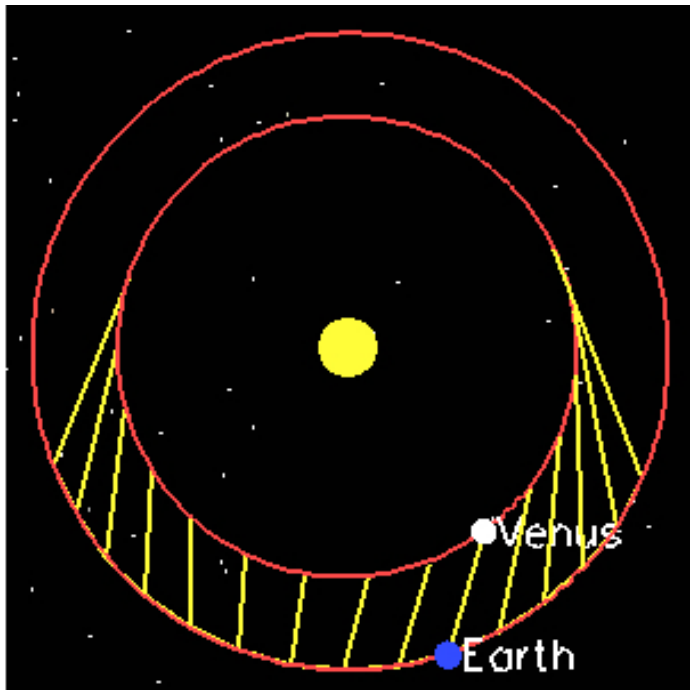

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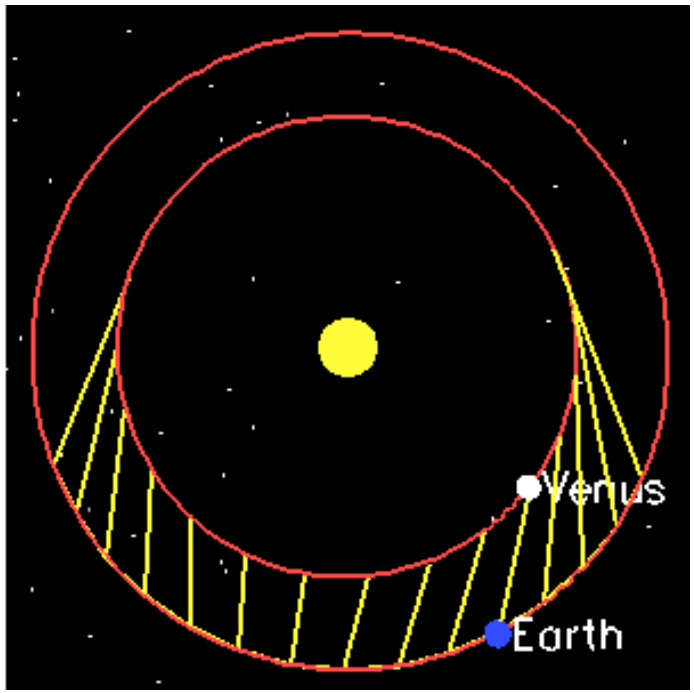

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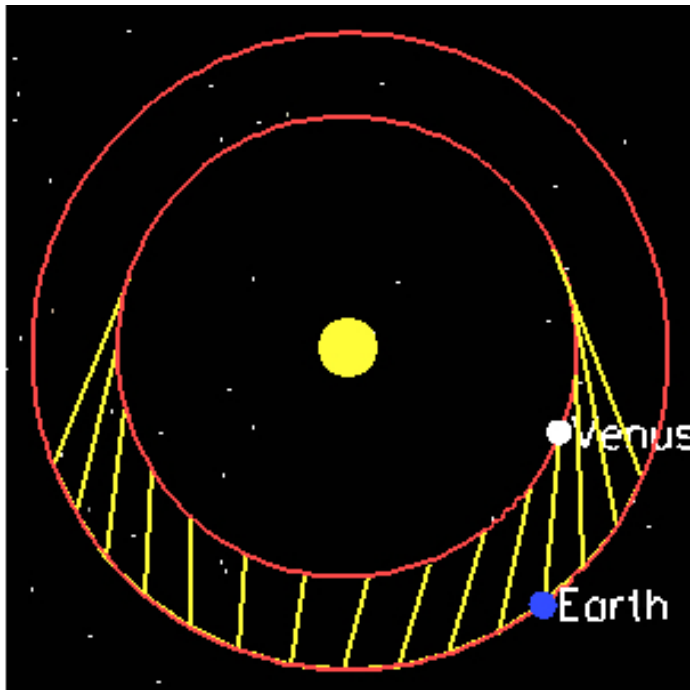

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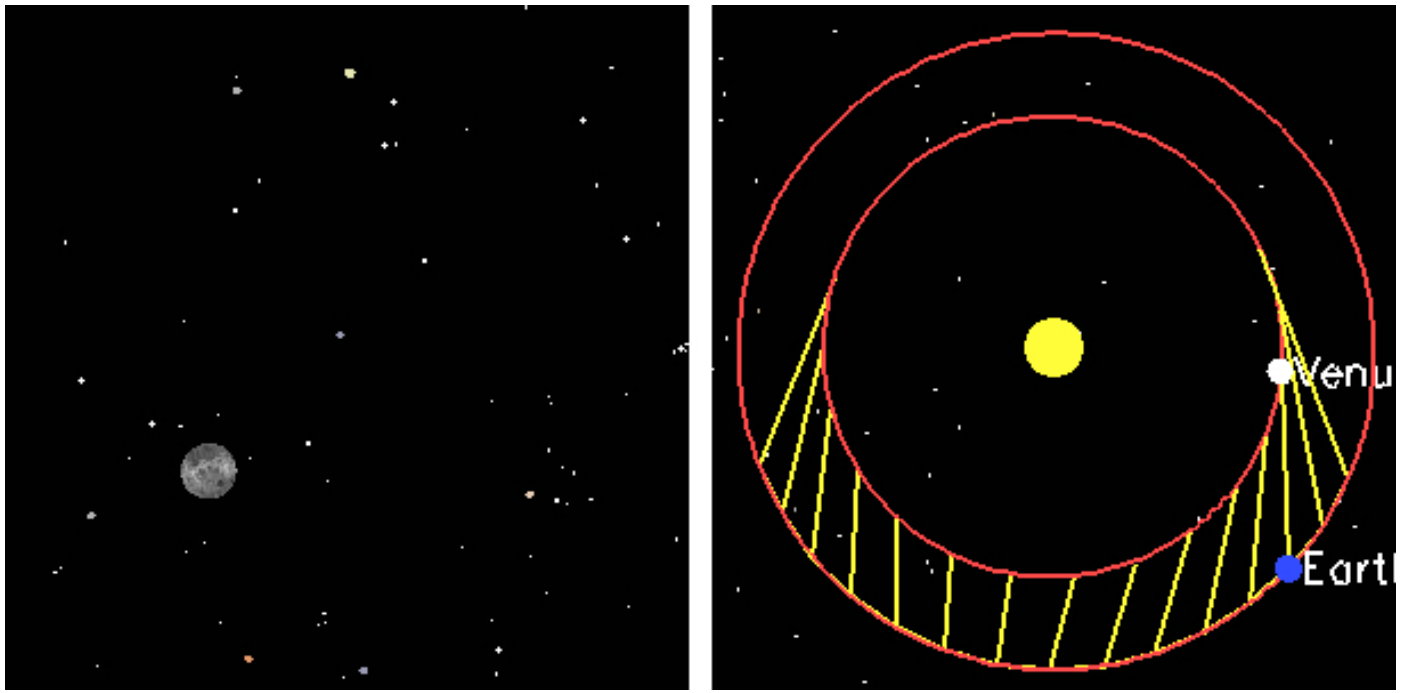

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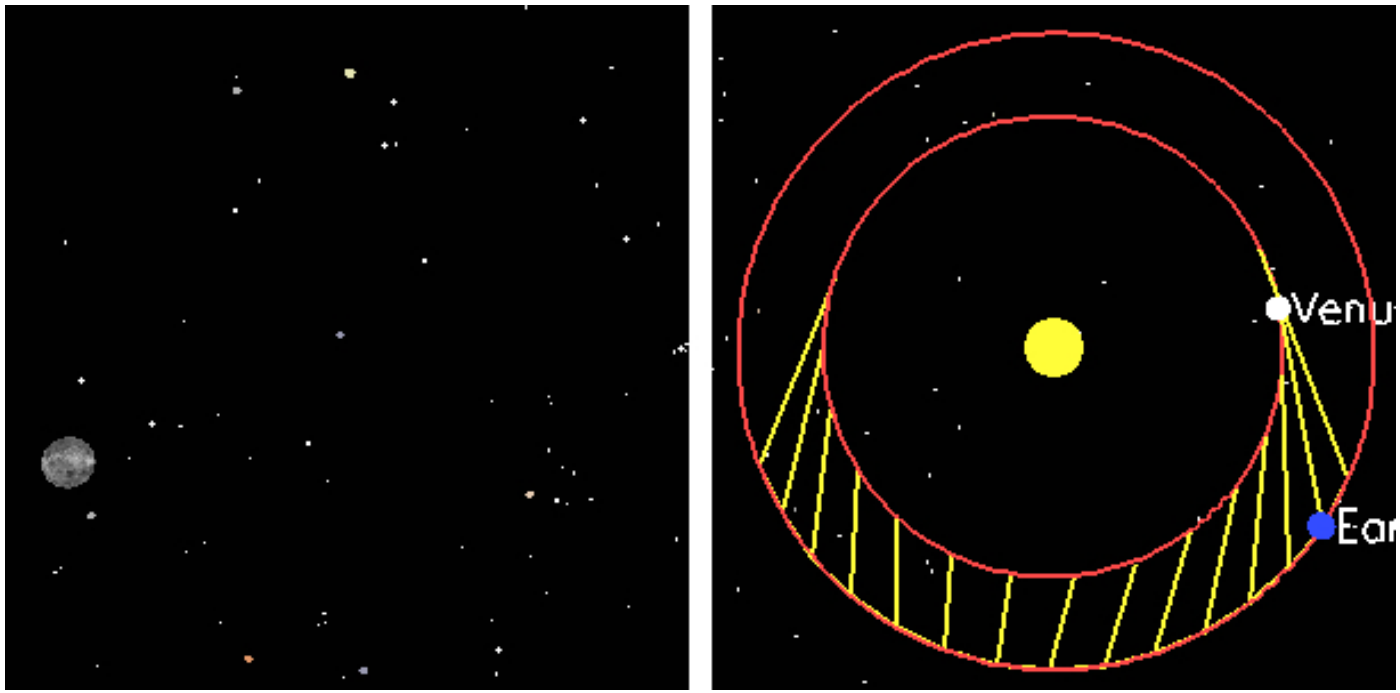

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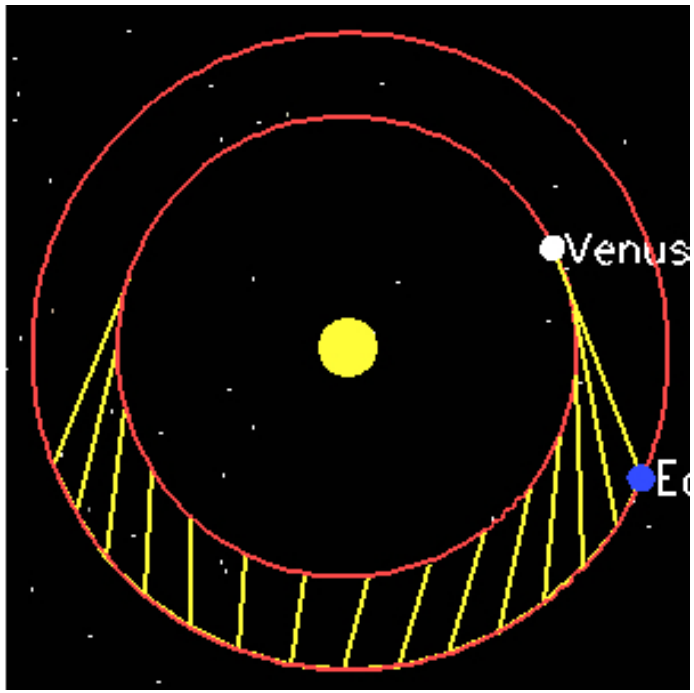

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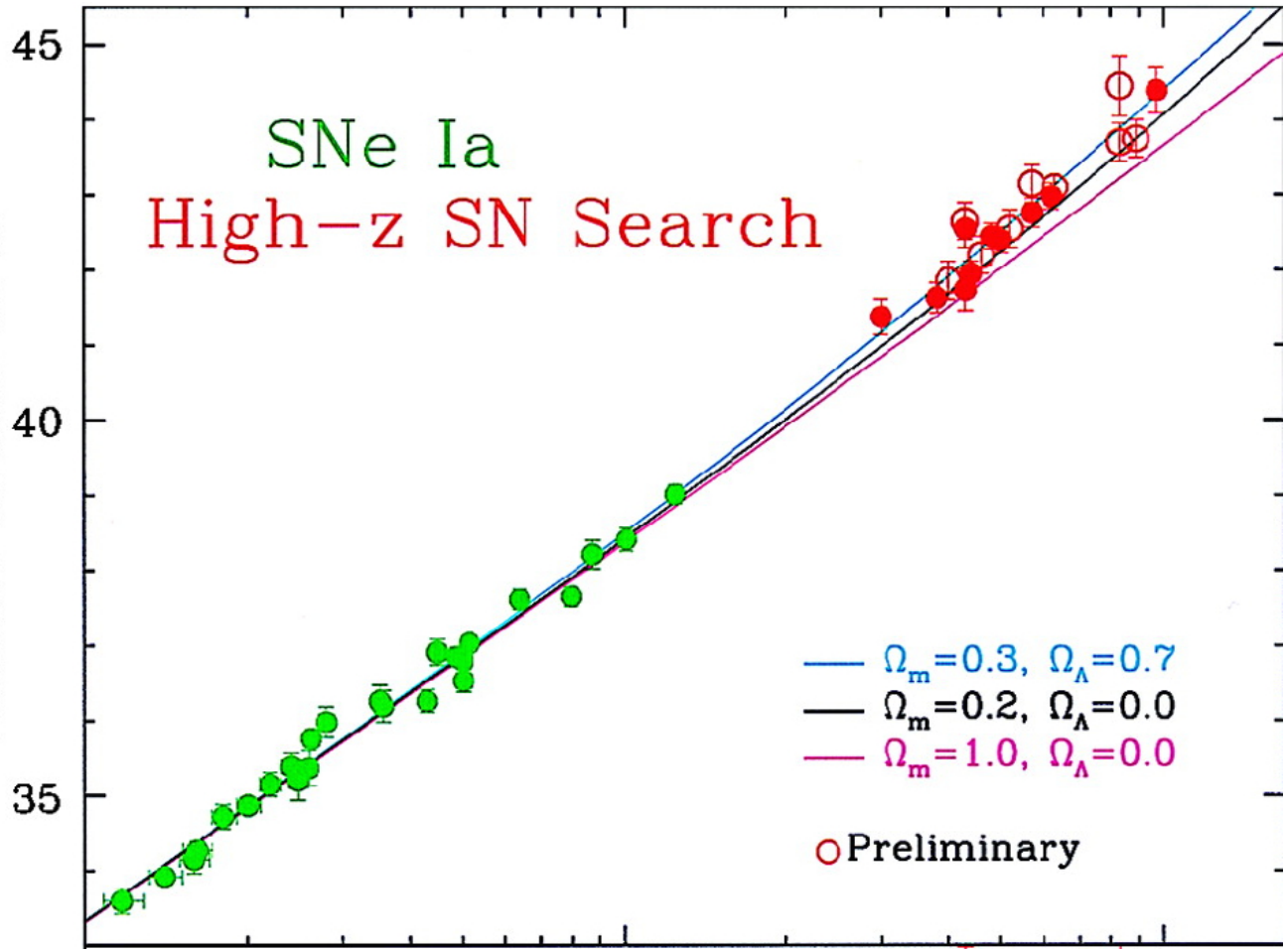
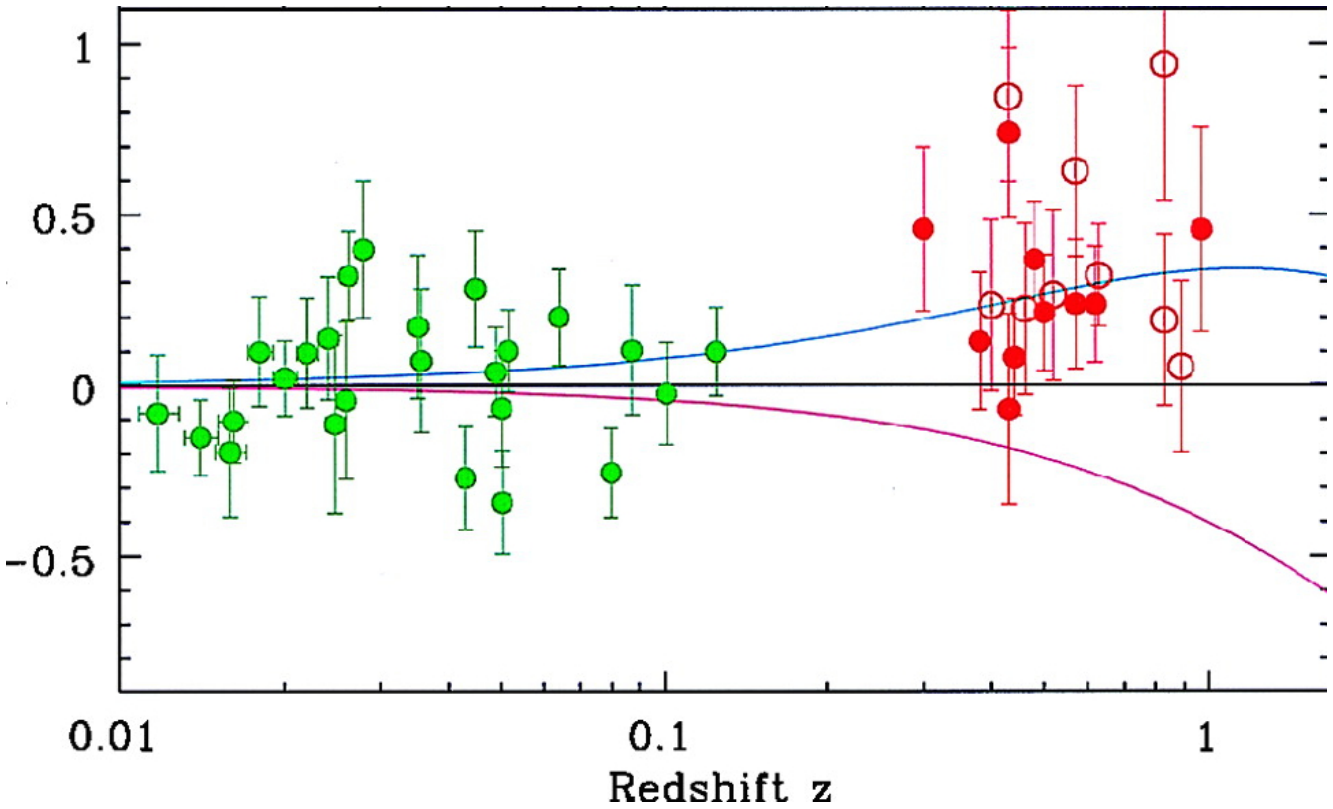
Diverse Experiments? Supernova Experiments



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



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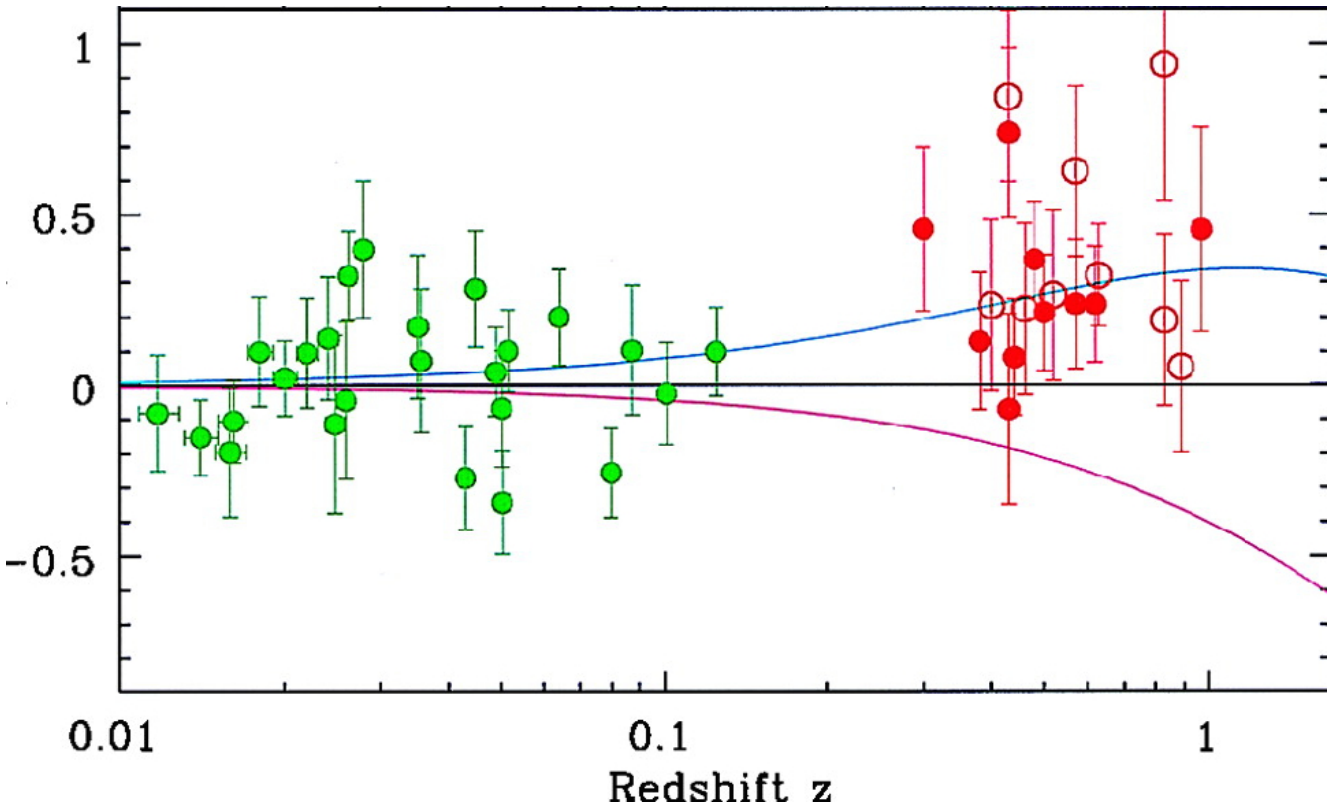

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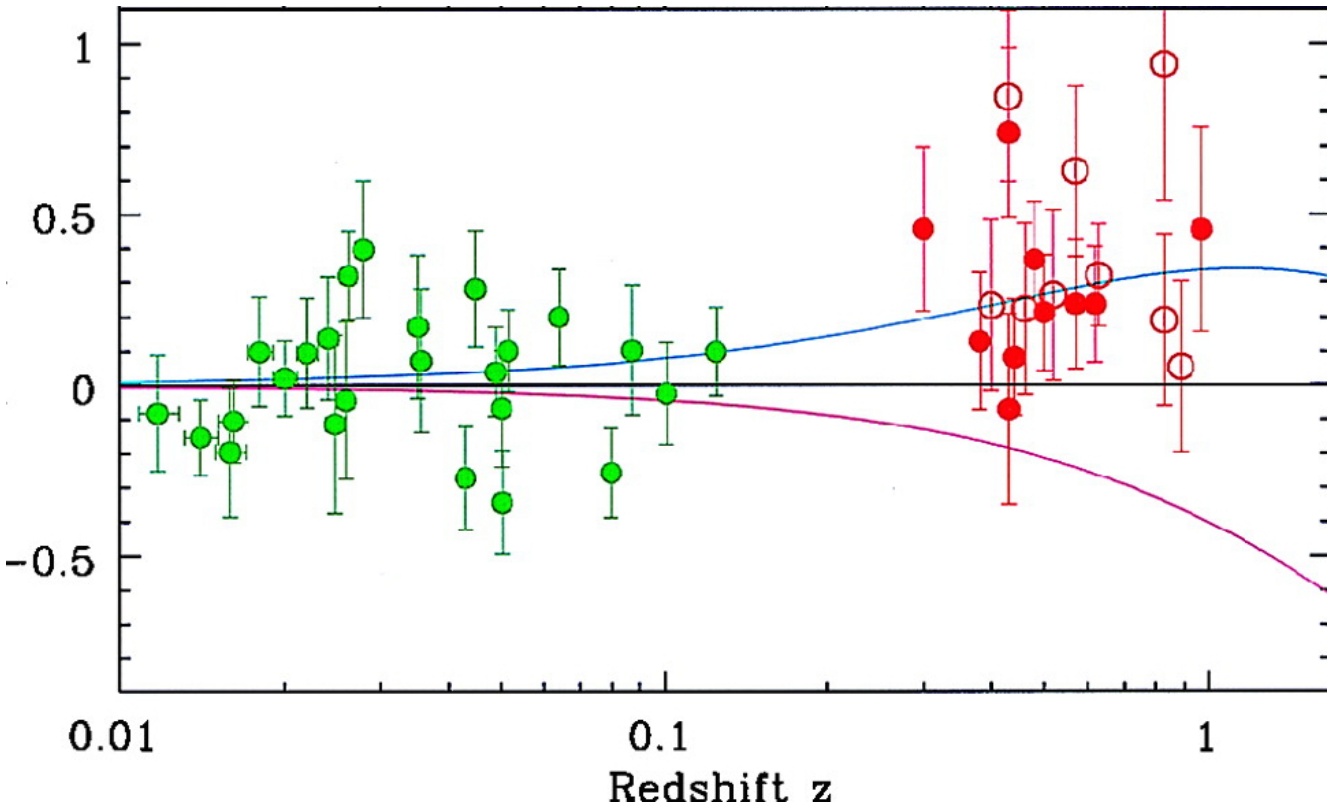

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Critiques: Experimental error, no perfect model, not necessarily exploding at the same brightness

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- Critiques: convenience samples, observable, experimental error, difficulty agreeing on the meaning of the data, neutrino mass, dark energy, speed of light?

Wilkinson Microwave Anisotropy Probe (WMAP)