The Hubble Tension

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Hubble's Law

- Edwin Hubble, 1929
- Cosmic Expansion
- Hubble Constant H_0

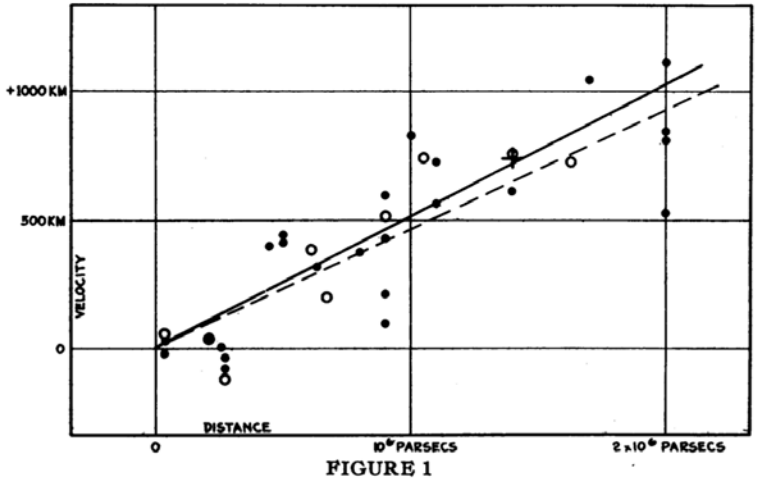


FIGURE 1

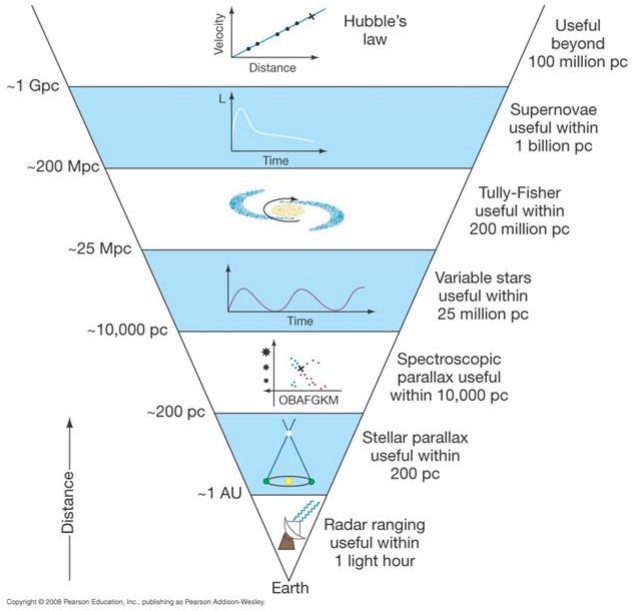
Velocity-Distance Relation among Extra-Galactic Nebulae.

$$v = H_0 D$$

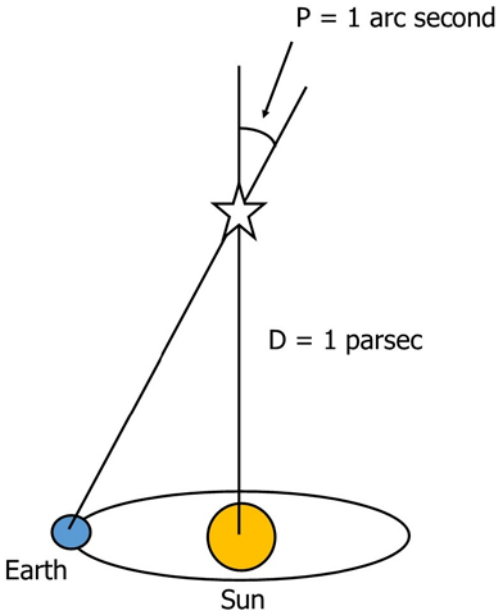
The "Late" Method

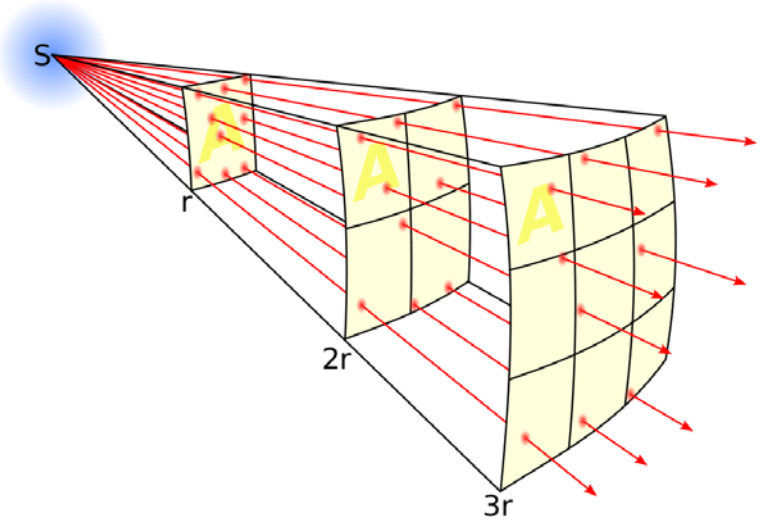
- Direct application of Hubble's Law
- Velocities determined by redshift
- Distance determined by Cosmic Distance Ladder
- $H_0 = 73.24 \pm 1.74$ km/s/Mpc

The "Cosmic Distance Ladder"



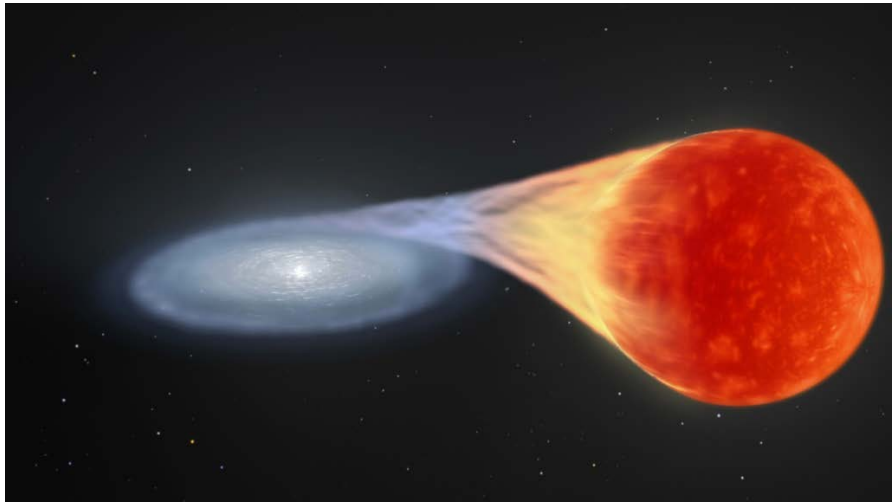
The Distance Ladder





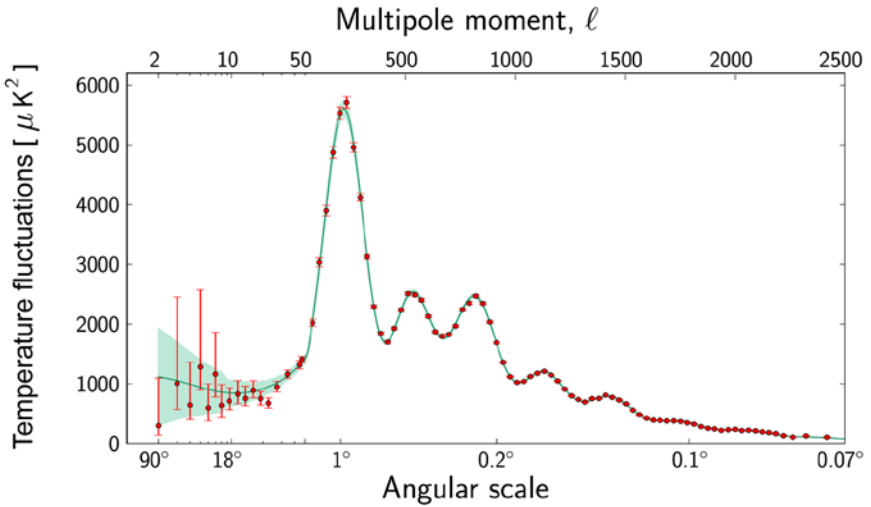
Type IA Supernovae

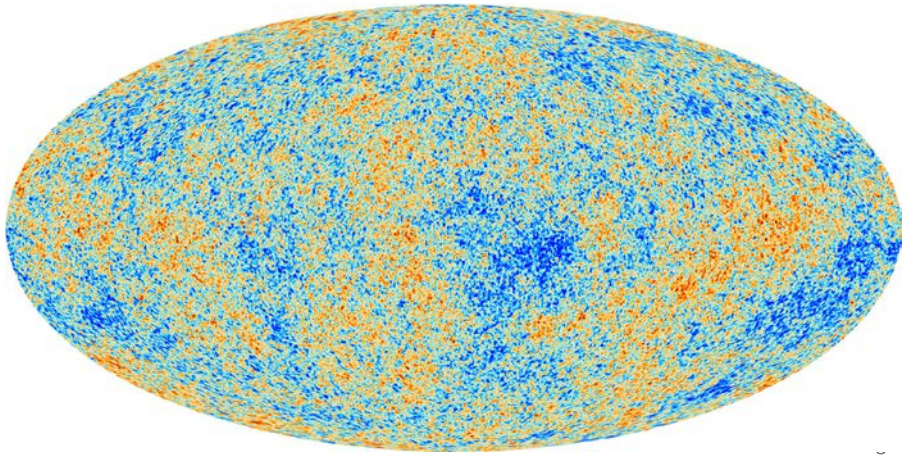
- Accretion of mass onto white dwarf stars
- Occurs at reliable mass threshold
- Provides a reliable luminosity
- Great Standard Candles



The “Early” Method

- Based on ΛCDM Model
- CMB Temperature Fluctuations vs Angular Scale
- Curve fitting gives H_0
- Planck data
- $H_0 = 67.4 \pm 0.5$ km/s/Mpc



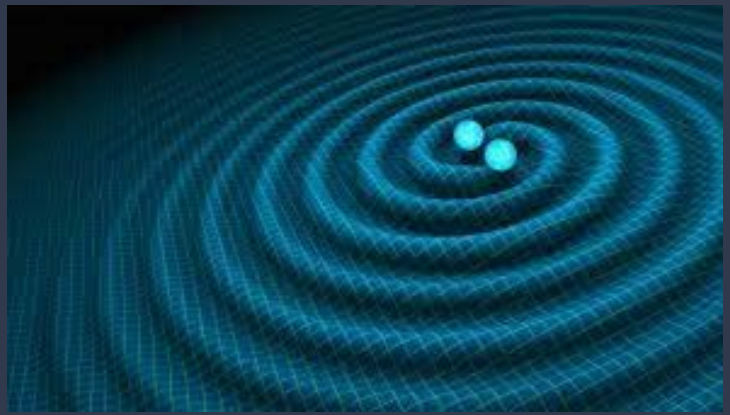


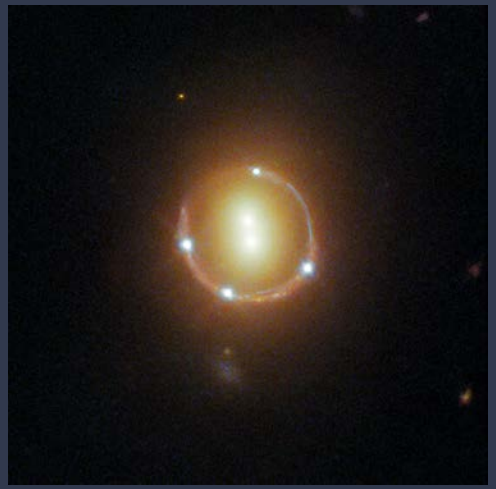
Experimental vs Theoretical Resolutions

- These results can not be reconciled with current uncertainties
- New methods are needed for measuring H_0
- The ΛCDM model may fail!

Experimental vs Theoretical Resolutions

- Systematic error appears unlikely
- Multimessenger astronomy may provide alternative measurements
- Gravitational Lensing can constrain H_0 as well





Summary

- The Hubble Tension is a discrepancy between values of H_0 for different experimental methods
- The resolution will require either new physics or expose deficiencies in observational methodologies
- New areas of astronomy may provide alternative measurements that guide us toward a solution

The End

Sources

1. https://iopscience.iop.org/article/10.1088/1361-6382/ac086d
2. https://vickyscowcroft.github.io/PH40112_rmd/ch-obs-techs-cmb.html
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