**Title:** A Cosmic Glitch in Gravity

**Speakers:** Yunfei (Robin) Wen

**Collection/Series:** 50 Years of Horndeski Gravity: Exploring Modified Gravity

**Date:** July 17, 2024 - 3:00 PM

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**Abstract:**

We present a model that modifies general relativity on cosmological scales, specifically by having a 'glitch' in the gravitational constant between the cosmological (super-horizon) and Newtonian (sub-horizon) regimes. This gives a single-parameter extension to the standard ΛCDM model, which is equivalent to adding a dark energy component, but where the energy density of this component can have either sign. Fitting to data from the Planck satellite, we find that negative contributions are, in fact, preferred. Additionally, we find that roughly one percent weaker superhorizon gravity can somewhat ease the Hubble and clustering tensions in a range of cosmological observations. Therefore, the extra parametric freedom offered by our model deserves further exploration, and we discuss how future observations may elucidate this potential cosmic glitch in gravity, through a four-fold reduction in statistical uncertainties.

# A Cosmic Glitch in Gravity

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With Niayesh Afshordi, Douglas Scott, and Lukas Hergt
Based on arxiv:2311.03028

# A Simple Phenomenological Model

Minimal deviations from GR on cosmological scales

$$H^2 = \frac{8\pi G_{\rm cosmo}}{3}\rho_{\rm tot} = \frac{8\pi G_{\rm N}}{3}\left[\rho_{\rm tot} + \left(1 - \frac{G_{\rm N}}{G_{\rm cosmo}}\right)\rho_{\rm crit}\right]$$

One-Parameter Extension from ΛCDM

$$\Omega_{\rm g} = \frac{\rho_{\rm DE} - \rho_\Lambda}{\rho_{\rm crit}} = 1 - \frac{G_{\rm N}}{G_{\rm cosmo}}$$

$$\frac{G_{\rm N}}{G_{\rm cosmo}} = 1 - \frac{3}{2}(\lambda - 1) = 1 - \frac{3}{2}c_2$$

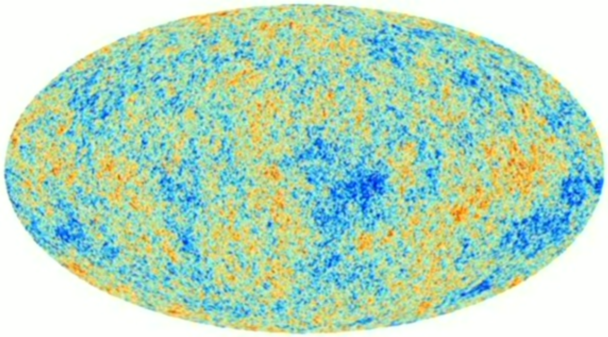
Hořava–Lifshitz     Einstein-aether

Similar to the early dark energy Model proposed by Doran and Robbers 2006

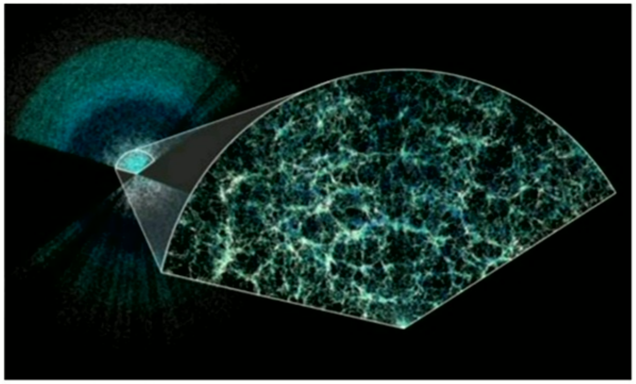
$$\rho_{\rm DE} = \rho_\Lambda + \Omega_{\rm g}\rho_{\rm crit}, \quad \text{where} \quad \rho_{\rm crit} = \frac{3H^2}{8\pi G_{\rm N}} \quad \text{and} \quad \rho_\Lambda = \frac{\Lambda}{8\pi G_{\rm N}}$$

Allowing $\Omega_{\rm g} < 0$ , named as the cosmic glitch in gravity (CGG)

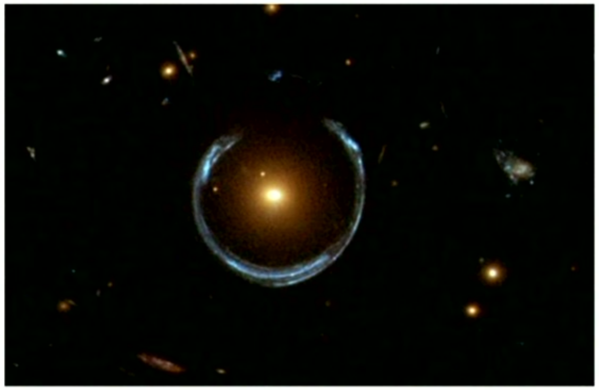
# Cosmological Probes



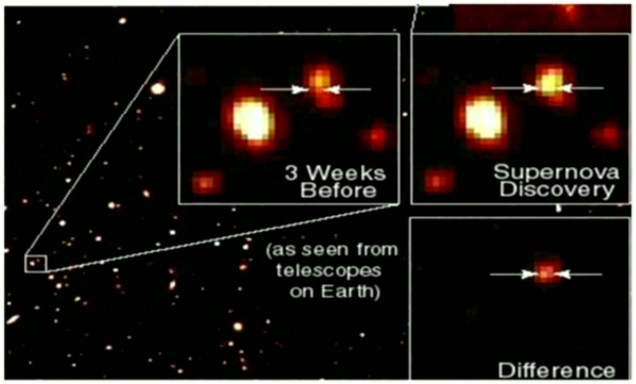
Cosmic Microwave Background (CMB)



Baryonic Acoustic Oscillations (BAO)

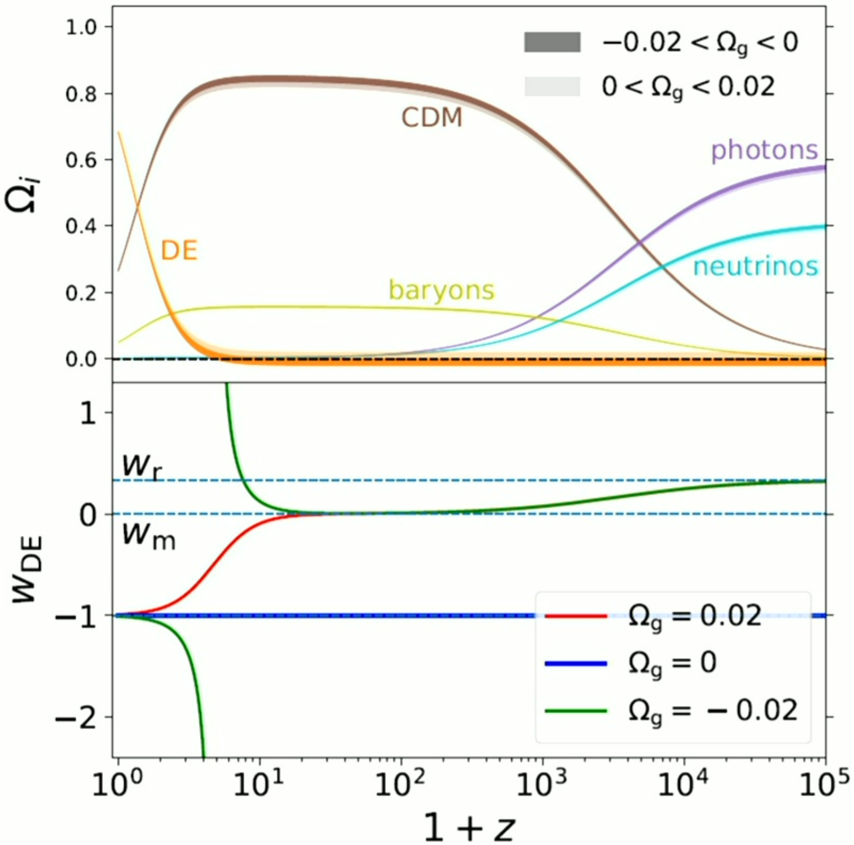


Weak Lensing/Cosmic Shear

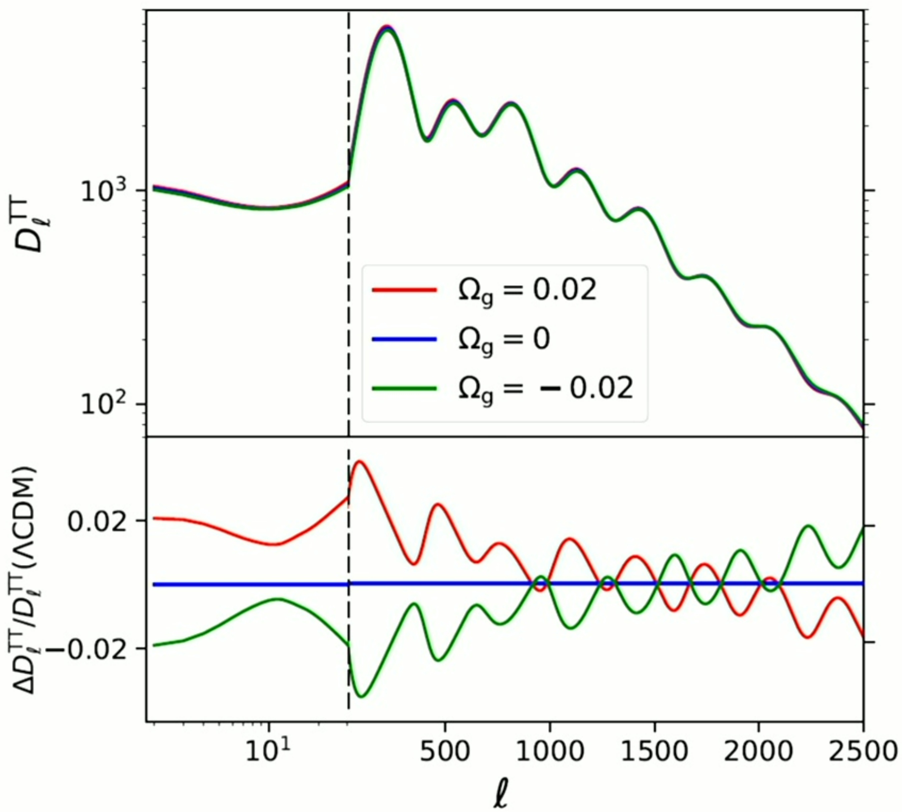



Supernovae (SNe)

# Impacts on Cosmology

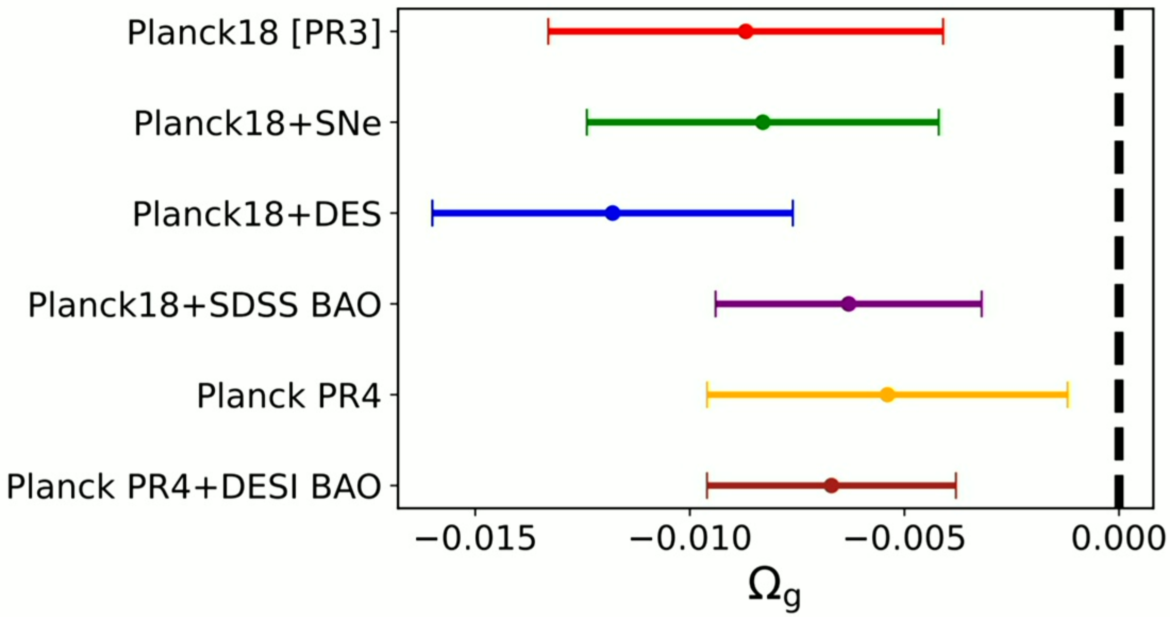



Background




CMB anisotropies power spectrum

# A Cosmic Glitch : Preference for Negative $\Omega_g$




Current constraint

$$\Omega_g = -0.0087 \pm 0.0046$$

Future CMB surveys constrain

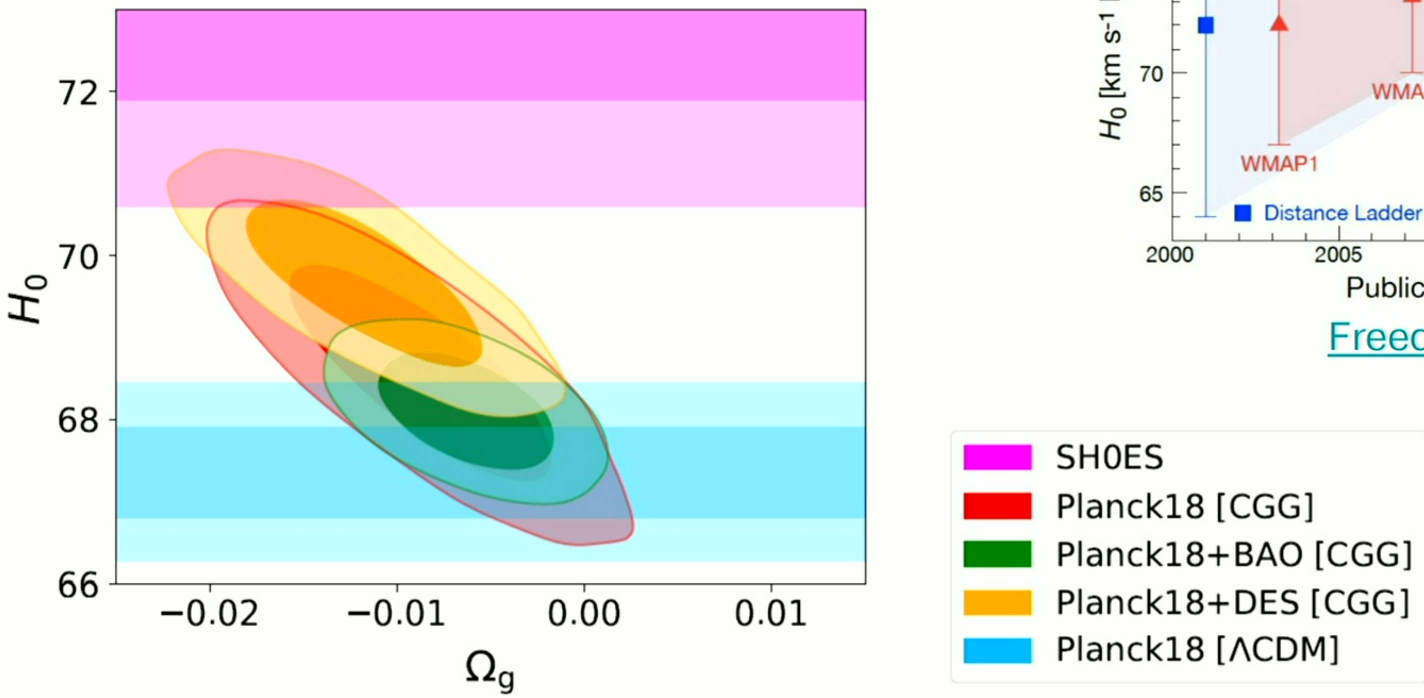
$$\sigma(\Omega_g) \approx 0.001$$

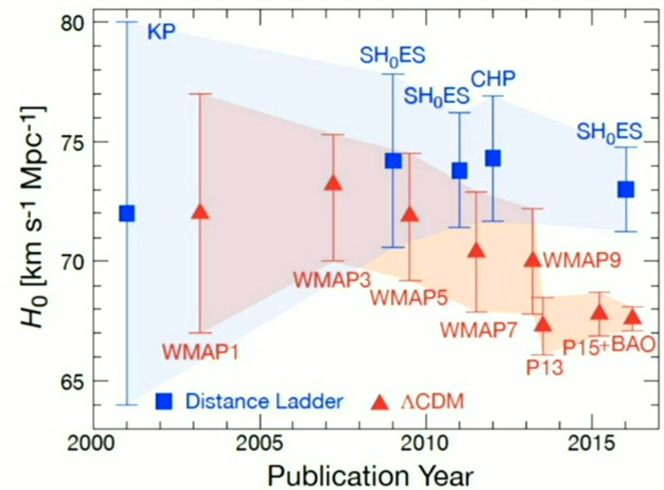
Future CMB and Euclid-like LSS surveys constrain

$$\sigma(\Omega_g) < 0.001$$

The evidence for the glitch ranges from 1.3 $\sigma$ to 2.8 $\sigma$ for the current data

# Alleviating Cosmological Tensions

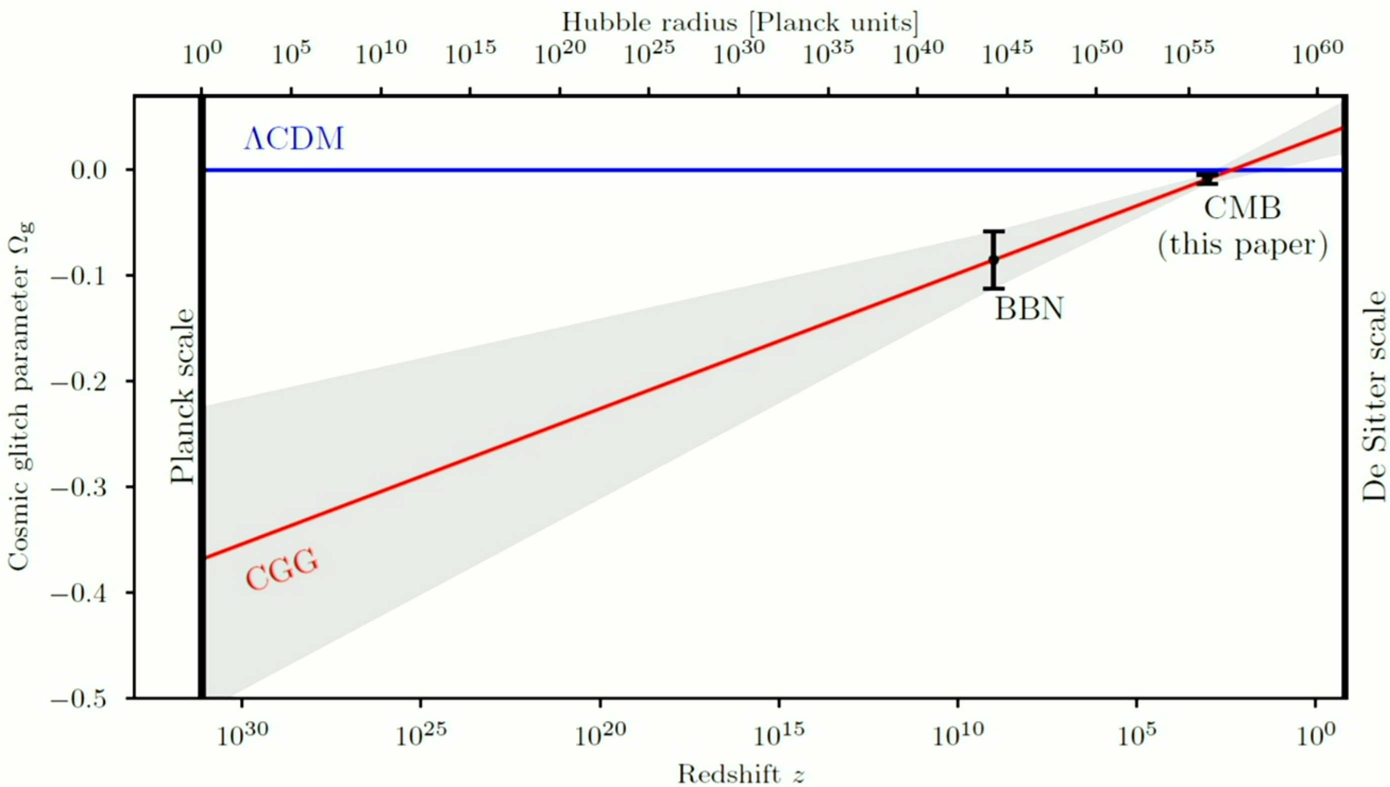



[Freedman 17]

Reduces the Hubble tension from 4.1$\sigma$ to 3.0$\sigma$

# Non-constant Glitch?




BBN measurement comes from helium abundance in low metallicity galaxies
([Kohri and Maeda 2022](#))

## Summary

- A cosmic glitch in gravity (CGG), i.e. a model in which gravity is different for super-horizon and sub-horizon scales
- Equivalent to an additional dark energy component tracking the critical density of the Universe
- Current data favors the super-horizon gravity to be ~ 1% weaker at around 2 $\sigma$
- Alleviates both the Hubble tension and the clustering tension
- Future cosmological data will significantly tighten the constraint on CGG

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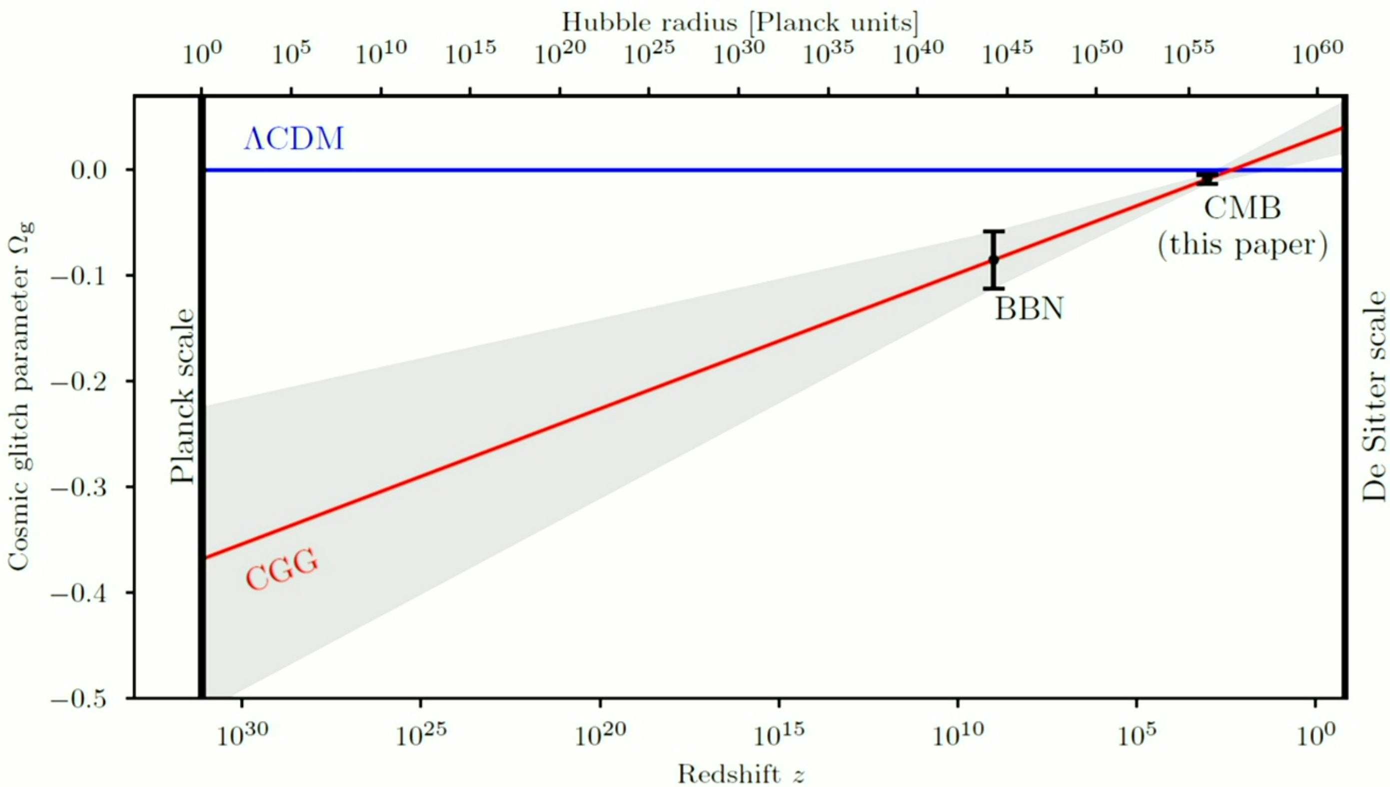


BBN measurement comes from helium abundance in low metallicity galaxies (Kohri and Maeda 2022)

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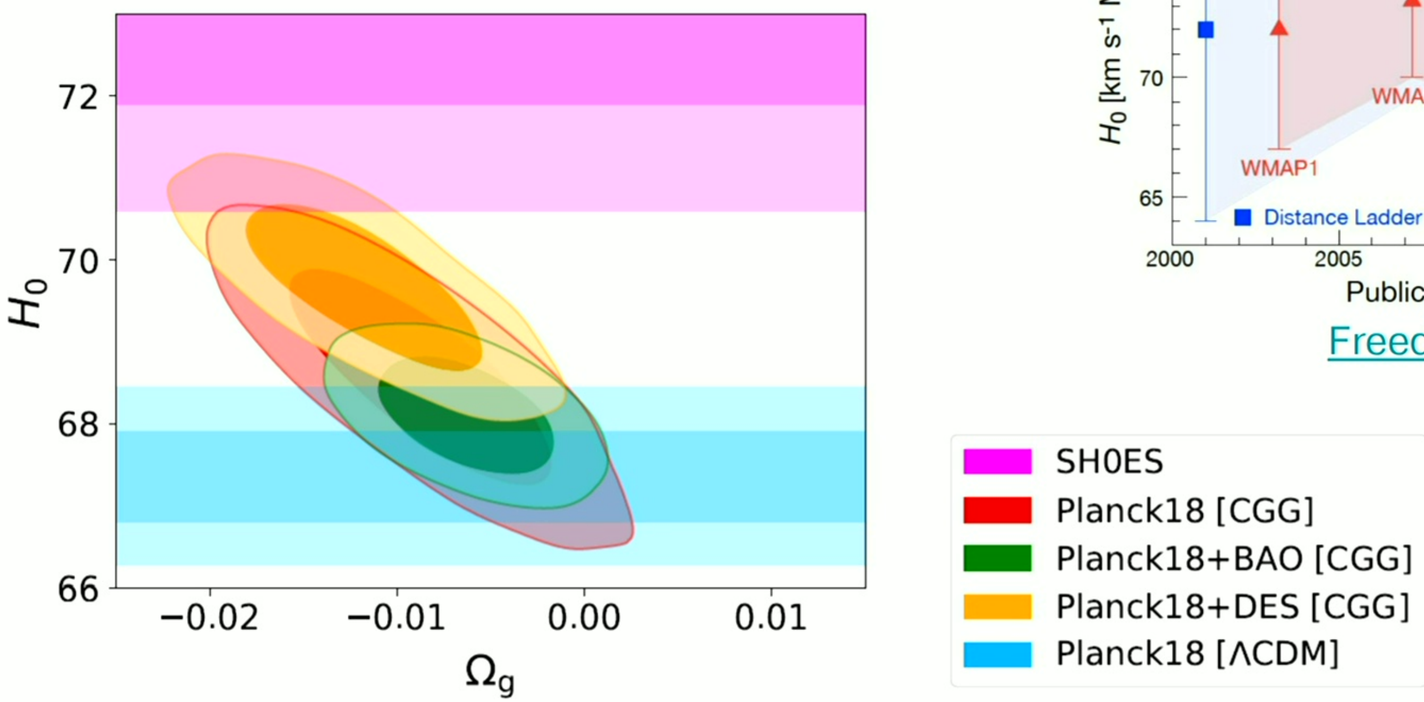


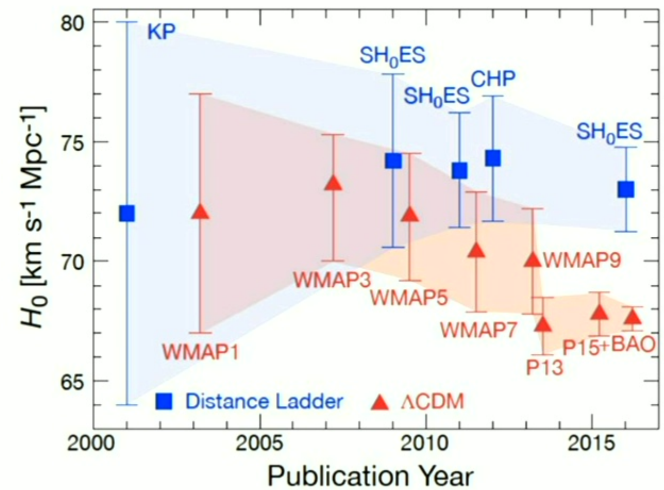


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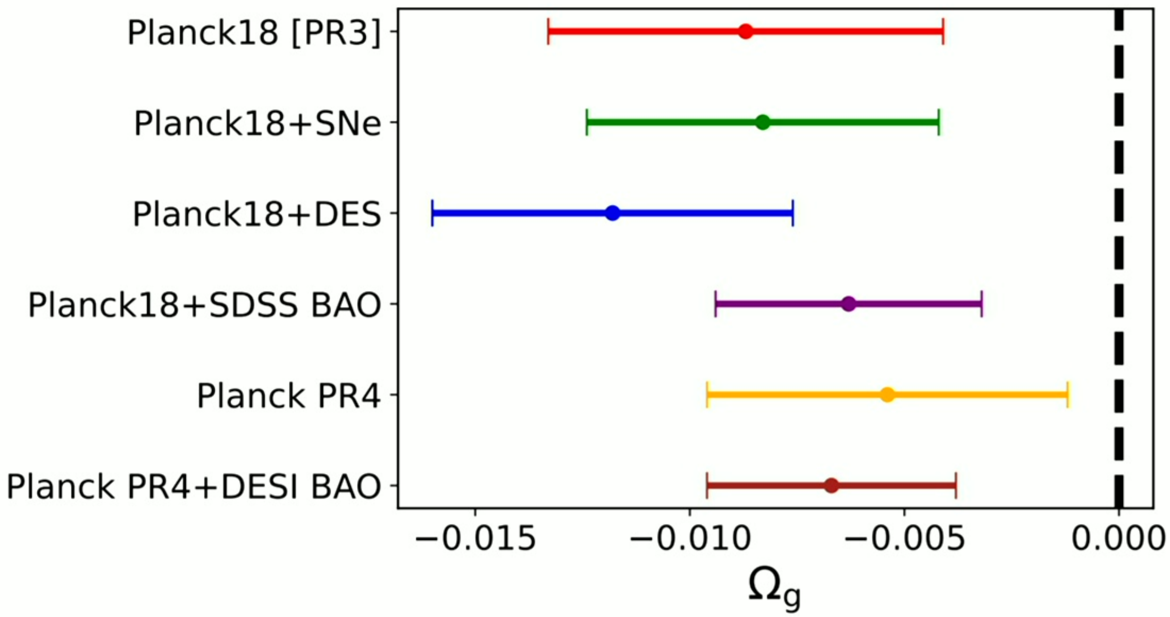


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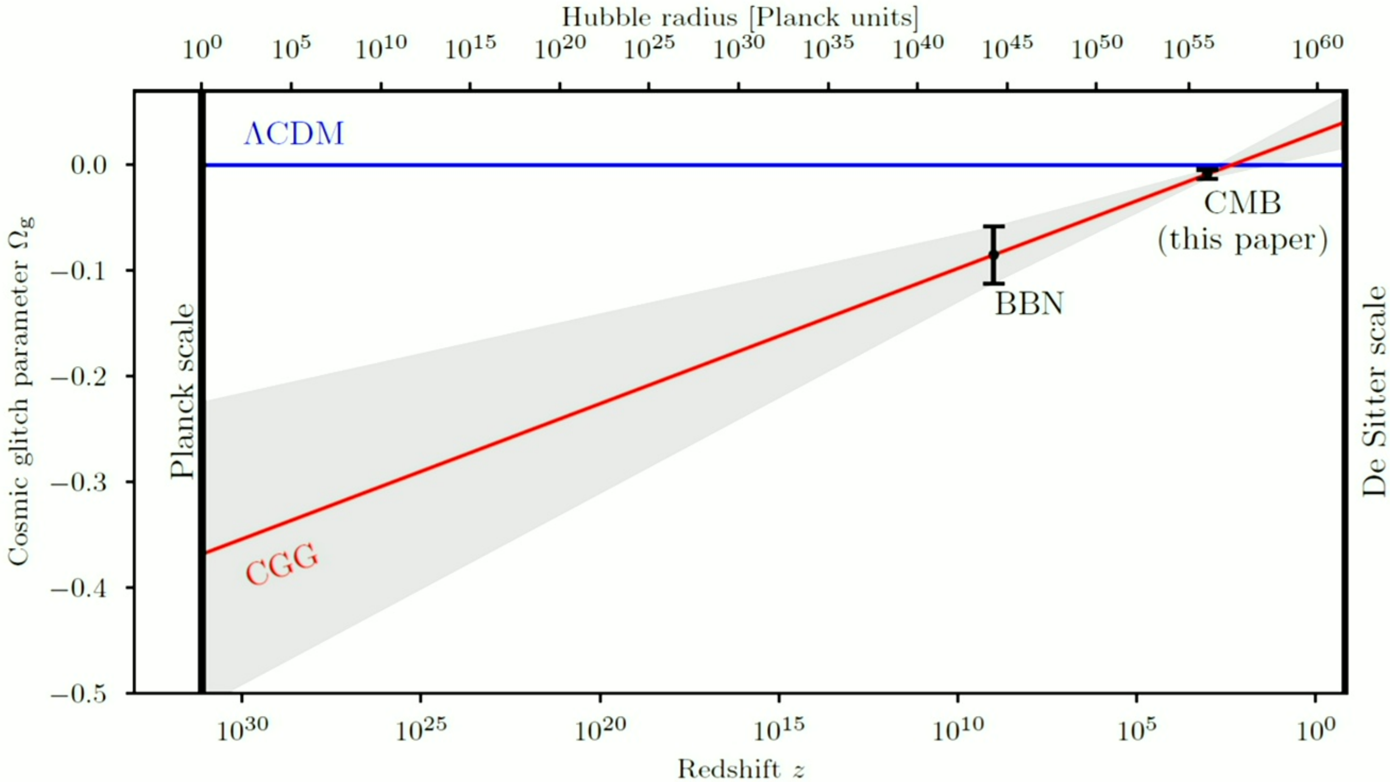


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