No-Go Guide for the Hubble Tension

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·2012.08292 Do the observational data favor a local void?   PRD
·2102.02020 Chameleon dark energy can resolve the Hubble tension   PRD Letter
·2107.13286 No-go guide for the Hubble tension: Late-time solutions   PRD Letter
·2202.12214 No-go guide for the Hubble tension : matter perturbations under review

Rong-Gen Cai   Zong-Kuan Guo   Shao-Jiang Wang
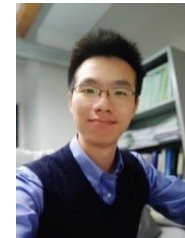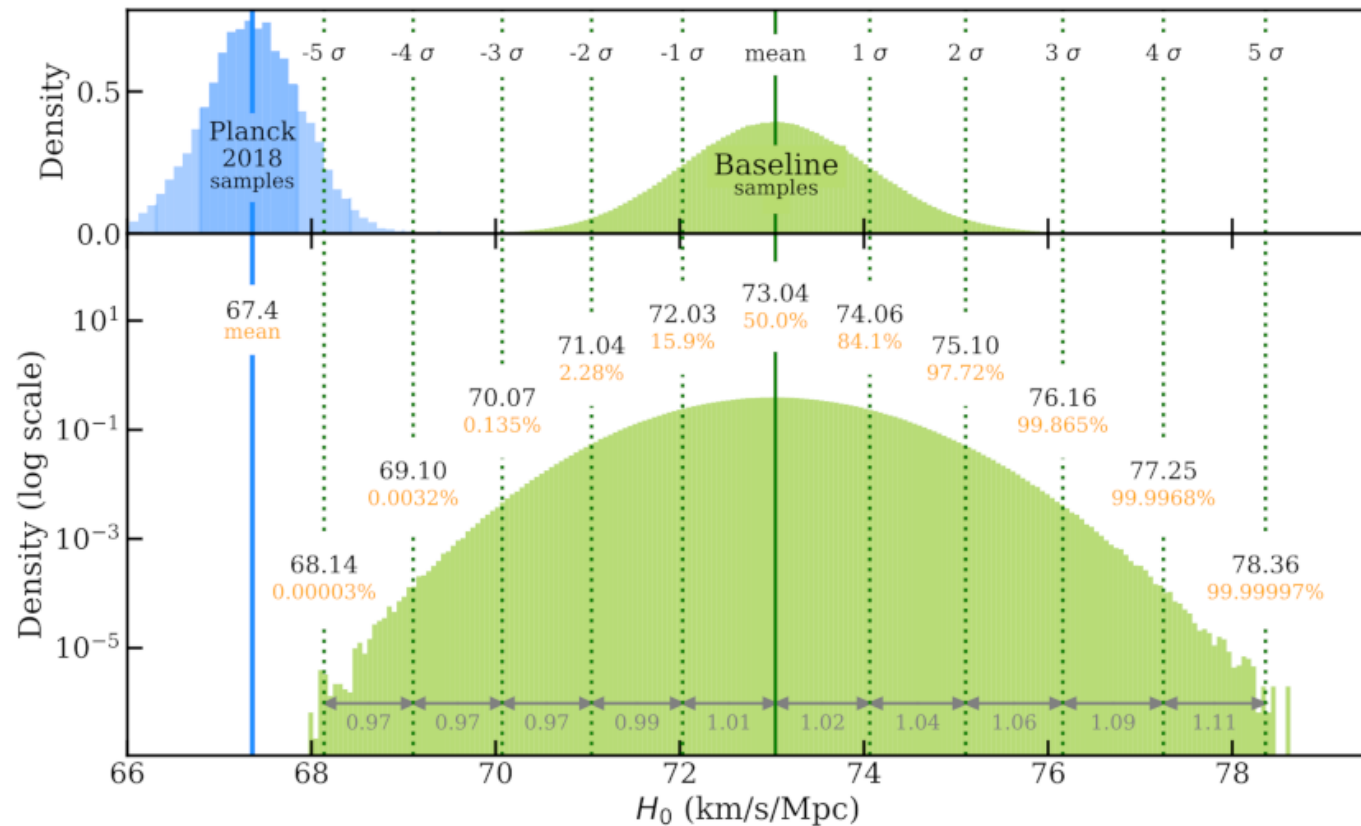
Li Li   Yong Zhou   Jia-Feng Ding

Hubble Tension

Hubble tension is becoming a Hubble crisis at 5-sigma C.L. !

Credit: Riess et. al. 2112.04510

Hubble Solutions

Modify the cosmic sound horizon
- Changing expansion history
  - Dark radiation(s)
  - Early dark energy
- Changing recombination history
  - Primordial magnetic fields
  - Varying fundamental constants

Jedamzik, Pogosian and Zhao (2010.04158)
Nature.Communications.Physics 4(2021)123
"Why reducing the cosmic sound horizon alone can not fully resolve the Hubble tension"

$H_0 = 67.4 \pm 0.5\,\mathrm{km/s/Mpc}$

$H_0 = 73.04 \pm 1.04\,\mathrm{km/s/Mpc}$
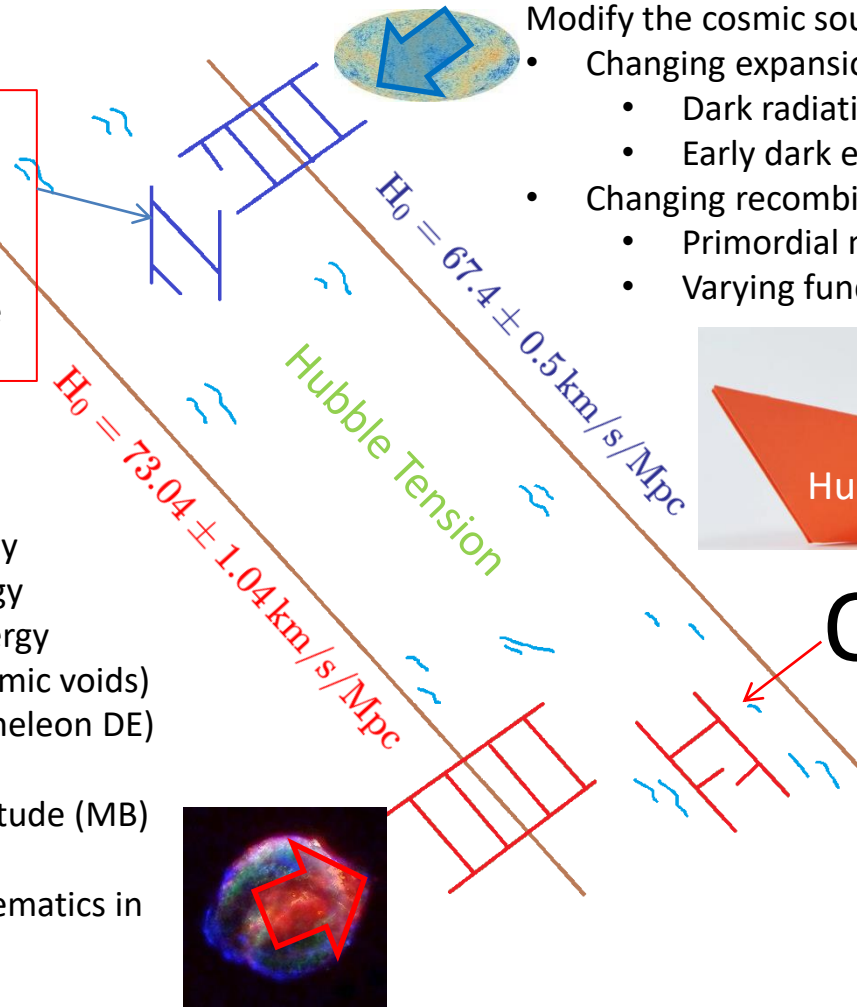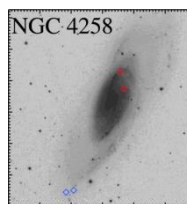
Hubble Tension

Hubble Diversity

Our Works!

- Changing expansion history
  - Phantom dark energy
  - Interacting dark energy
  - Underdensities (cosmic voids)
  - Overdensities (chameleon DE)
- A astronphysical problem
  - The absolute magnitude (MB) tension
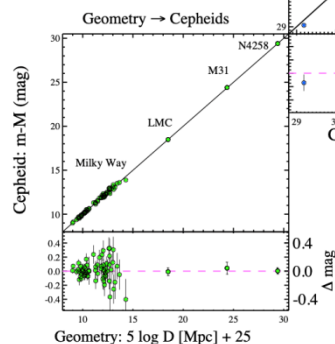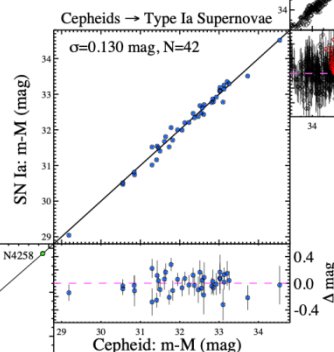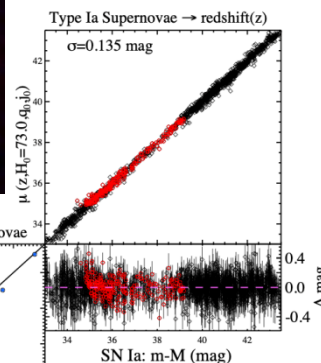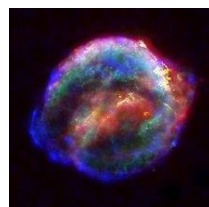 - Consider other systematics in observation

Distance Ladder

$$\mu = m - M_B = \log \frac{D_L}{10\text{pc}} = \log \frac{c}{H_0} + \frac{d_L}{10\text{pc}}$$

Distance Ladder
=
Cepheids + SNe
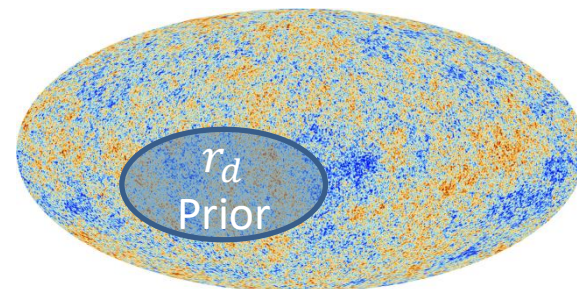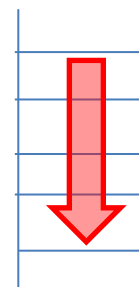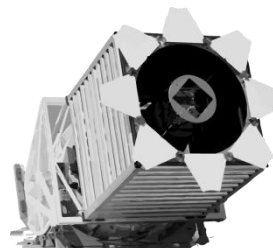

Type Ia Supernovae → redshift(z)
σ=0.135 mag

Cepheids → Type Ia Supernovae
σ=0.130 mag, N=42
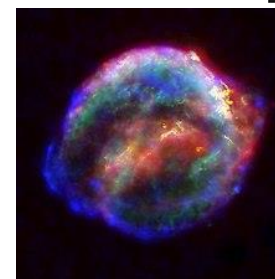
Geometry → Cepheids

NGC 4258

Cepheids

CMB prior

r_d Prior

BAO Data

SDSS Experiments
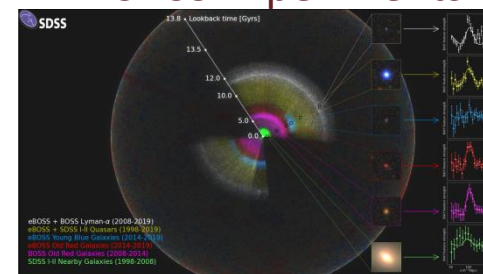
SNe + CMB prior
=
Inverse Distance Ladder

Credit: Riess et. al. 2112.04510

Our Late-time No-Go

No Priors

More General

H_0
M_B
Ω_m

H_0
r_d
Ω_m

Pantheon

BAO

Break Degeneracy

$Hz(z)$
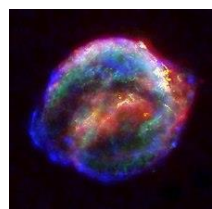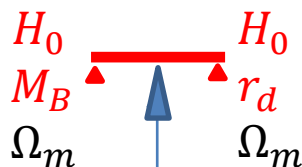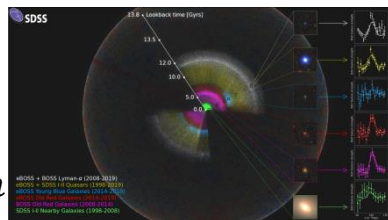
$$\frac{H}{H_0} = 1 + \frac{2}{3}\left(1 - \eta\frac{H_0 t}{P_{\mathrm{age}}}\right)\left(\frac{1}{H_0 t} - \frac{1}{P_{\mathrm{age}}}\right) \qquad P_{\mathrm{age}} \equiv H_0 t_0$$
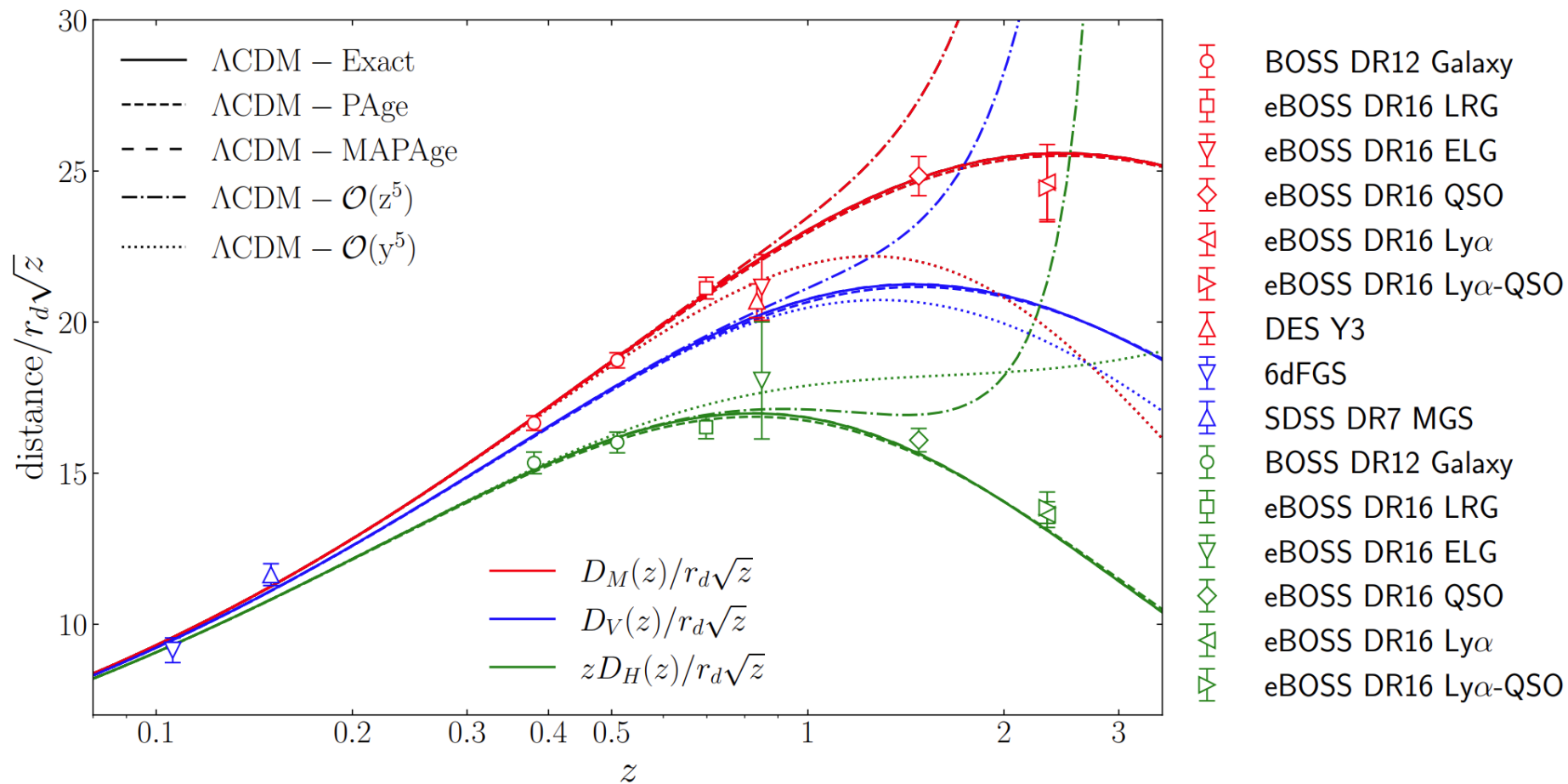
Zhiqi Huang 2020 ApJL 892:L28

Cosmic chronometers (CC)

$w_0 - \Omega_m$ $\Delta - z_c$ $\Omega_k - \mathrm{CPL} - \mathrm{CDM}$ $w_{\mathrm{CPL}}(a) = w_0 + w_a(1-a)$

$w_0 - \Omega_k$ Δ

$\Omega_m - \Omega_k$ z_c $q_0 = \frac{1}{2}\left(1 - \Omega_k + 3w_0(1 - \Omega_k - \Omega_m)\right)$

$w_0 - w_a$

w_0

w_a

Ω_k

Ω_m

oLCDM

wCDM

owCDM

PDE

George Efstathiou
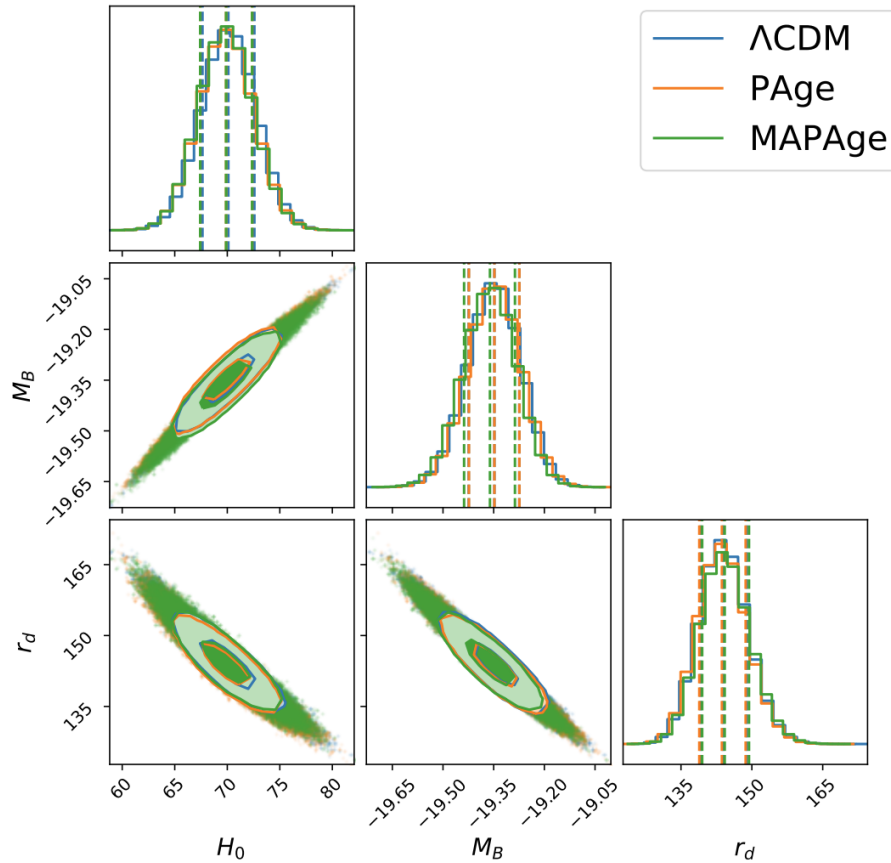(2103.08723) "To
H0 or not to H0 ?"

P_{age}

η
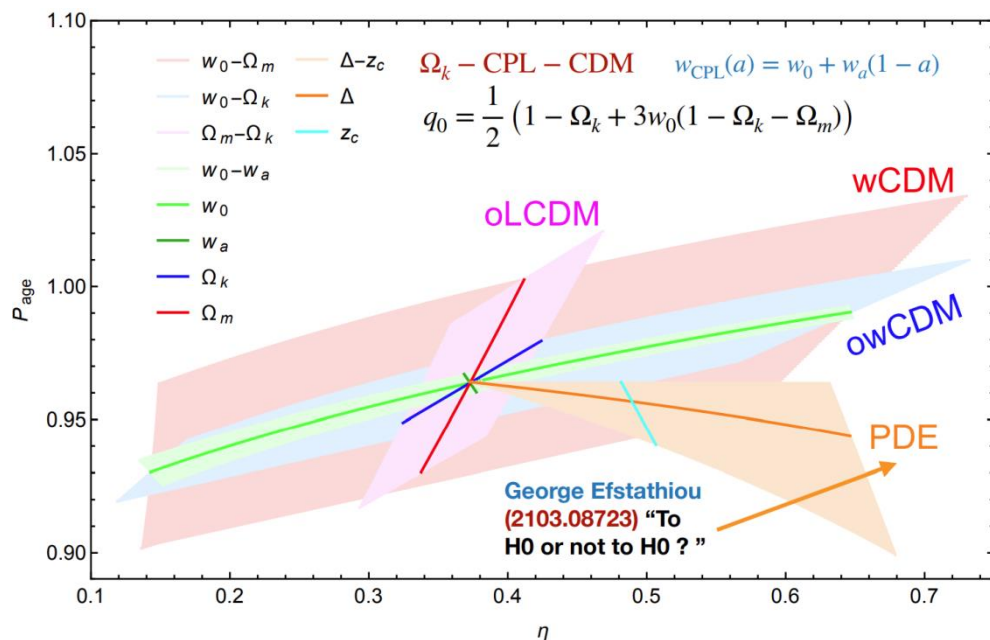
Better late-time model parametrization

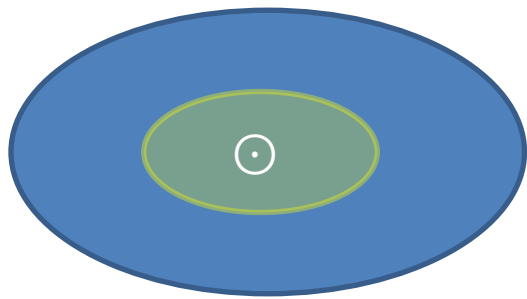# No Evidence Beyond LCDM at Late-time
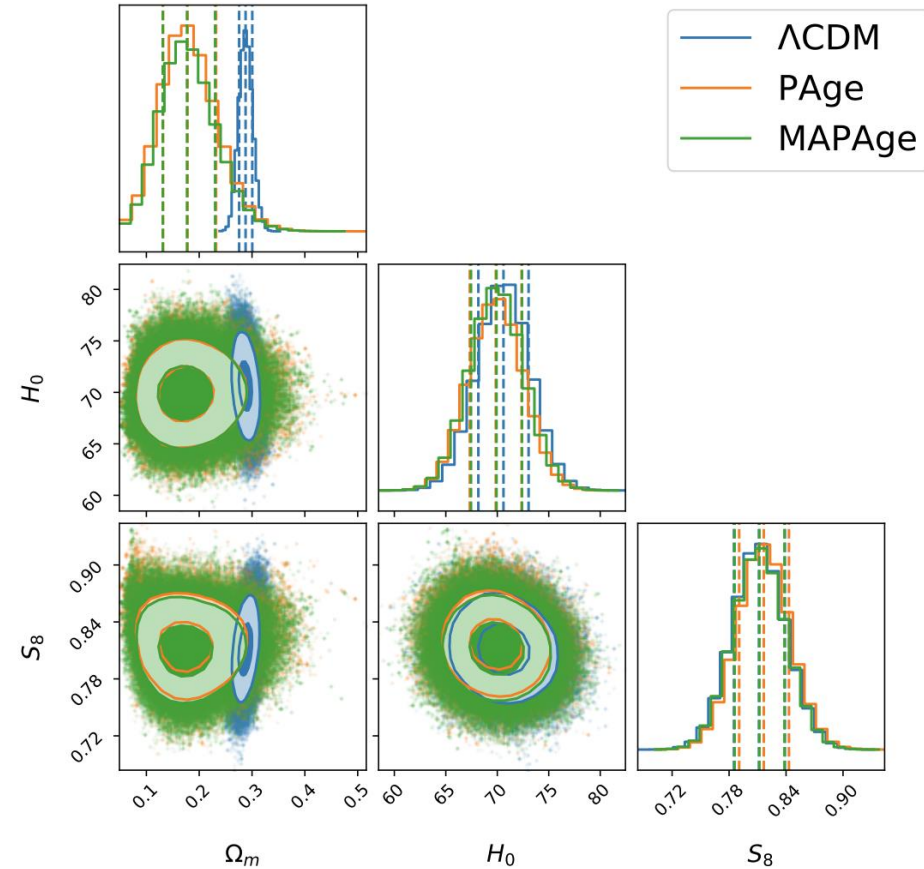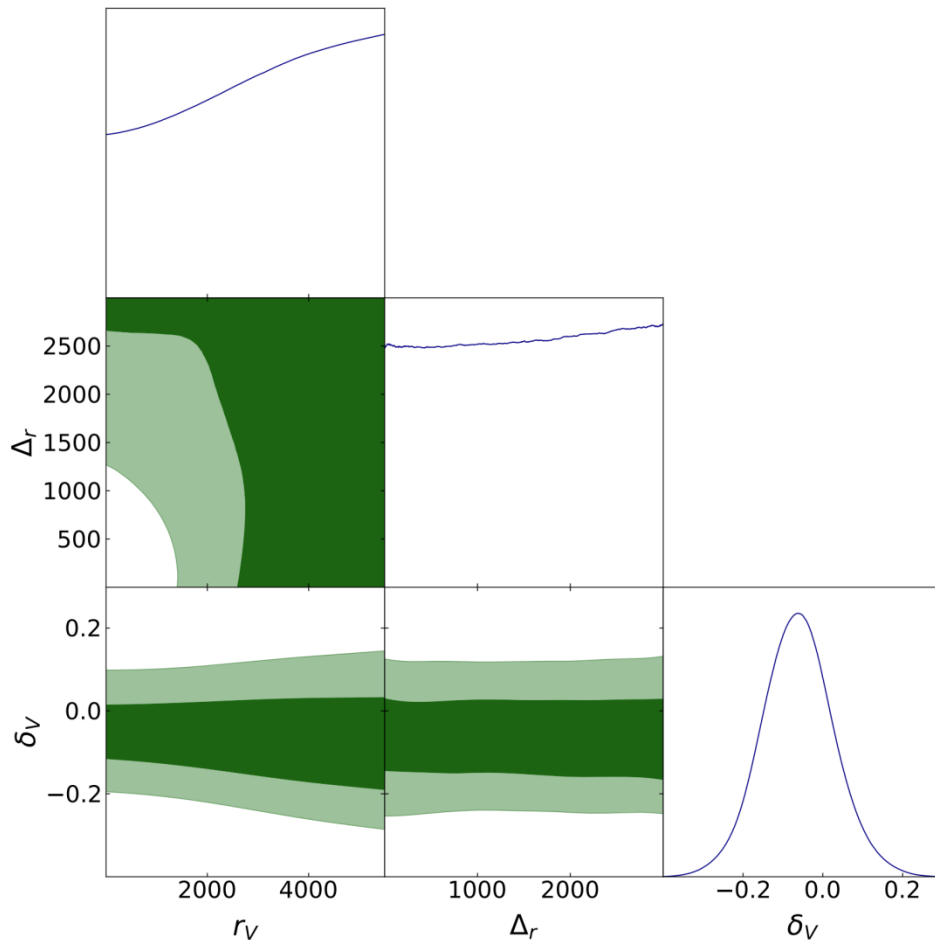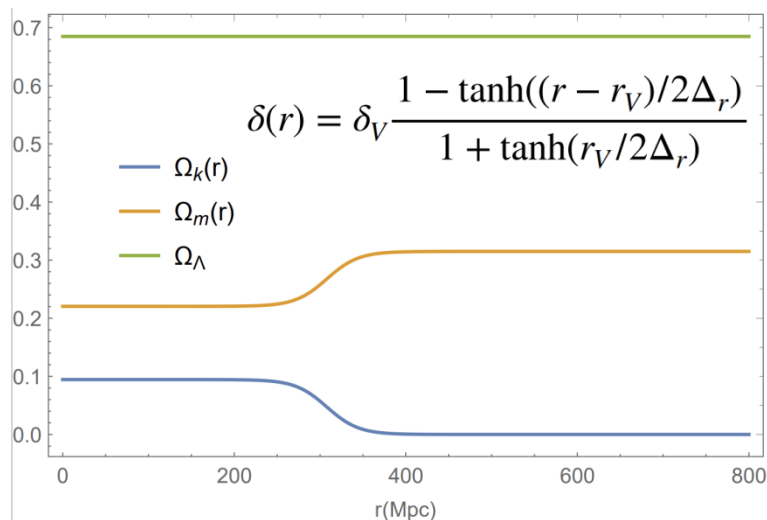
No Evidence for a Large Local Void

Pantheon SNe data with GBH profile in ΛLTB model

$$H^2(r,t)$$
$$= H_0^2(r)\left[\Omega_M(r)\left(\frac{R_0(r)}{R(r,t)}\right)^3 + \Omega_k(r)\left(\frac{R_0(r)}{R(r,t)}\right)^2 + \Omega_\Lambda(r)\right]$$

$$\delta(r) = \delta_V \frac{1 - \tanh((r - r_V)/2\Delta_r)}{1 + \tanh(r_V/2\Delta_r)}$$

- $\Omega_k(r)$
- $\Omega_m(r)$
- Ω_Λ

Conclusion

- Hubble tension might be a smoking gun for new physics but we don't find it up to now;

- Local homogeneous solutions might not the key for resolving the Hubble tension;

- Local inhomogeneous solution with GBH profile in ΛLTB model might not resolve the Hubble Tension;

- Chameleon dark energy with Hubble Diversity scenario? ----- maybe.

Thanks for your listening!