Status Update

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Data

BINGO

Simulation with thermal noise and foreground

21 cm map[1] + foreground map[2]

↓

Simulates the observed data

→

+ thermal noise[3]

↓

Simulates the instrumental contamination

→

foreground cleaning

↓

final simulation: data I used

CMB

Planck 2018

BAO

SDSS, SDSS III and 6dFGS

SNe Ia

Pantheon+

1) 21 cm map → cosmological 21-cm signal

- two-dimensional tomographic realizations
- 500 lognormal realizations

2) Foreground map → main sources contributing to the frequency range

- synchrotron and free-free emissions
- thermal dust and anomalous microwave emissions

3) Instrumental noise → contamination

- thermal (white) noise, taking into account the BINGO specifications
- apply a cut sky mask to the simulations

4) Foreground cleaning → remove the contribution

- blind method: no information on the foreground signal is used
- decompose the observations into different angular scales for different sky positions to estimate the emission contribution
- foreground is reconstructed

- 3 dark sector interaction models: https://arxiv.org/abs/2308.05807

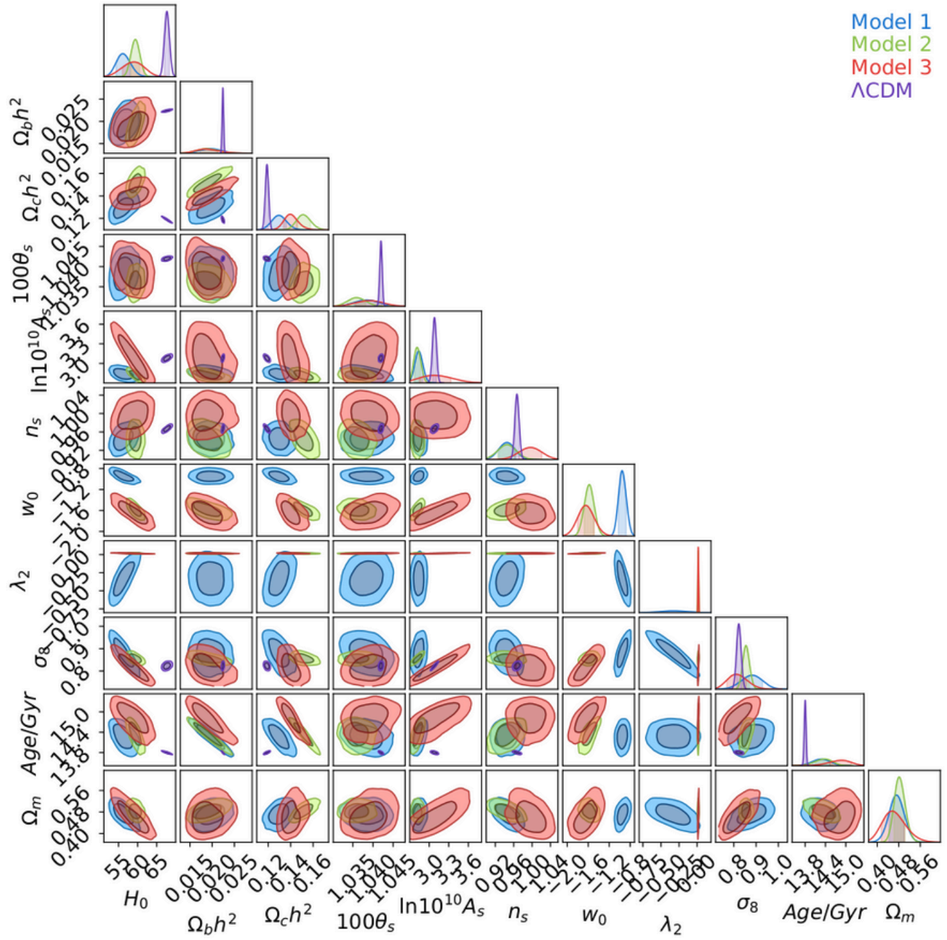
Parameter	Priors		
$\Omega_b h^2$	$[0.005, 0.04]$		
$\Omega_c h^2$	$[0.001, 0.5]$		
$100\theta_s$	$[1.03, 1.05]$		
$\ln(10^{10} A_s)$	$[2.7, 4.0]$		
n_s	$[0.9, 1.07]$		
	Model 1	Model 2	Model 3
w_0	$[-3.0, -0.3]$	$[-3.0, -1.0]$	$[-3.0, -1.0]$
$\lambda_{1(2)}$	$[-1.5, 1.5]$	$[0.0, 0.04]$	$[0.0, 0.04]$

→ Barionic matter density
→ Dark matter density
→ BAO's angular size in the recombination sky
→ Primordial spectrum amplitude
→ Spectral index of the primordial space
→ Dark energy equation of state
→ Coupling constant

Model	Q	ω	λ
I	$3\,\lambda_2 H\,\rho_d$	$-1 < \omega < 0$	$\lambda_2 < 0$
II	$3\,\lambda_2 H\,\rho_d$	$\omega < -1$	$0 < \lambda_2 < -2\,\omega\,\Omega_c$
III	$3\,\lambda_1 H\,\rho_c$	$\omega < -1$	$0 < \lambda_1 < -\omega/4$

→ Depends on the dark energy
→ Depends on the dark energy
→ Depends on the dark matter

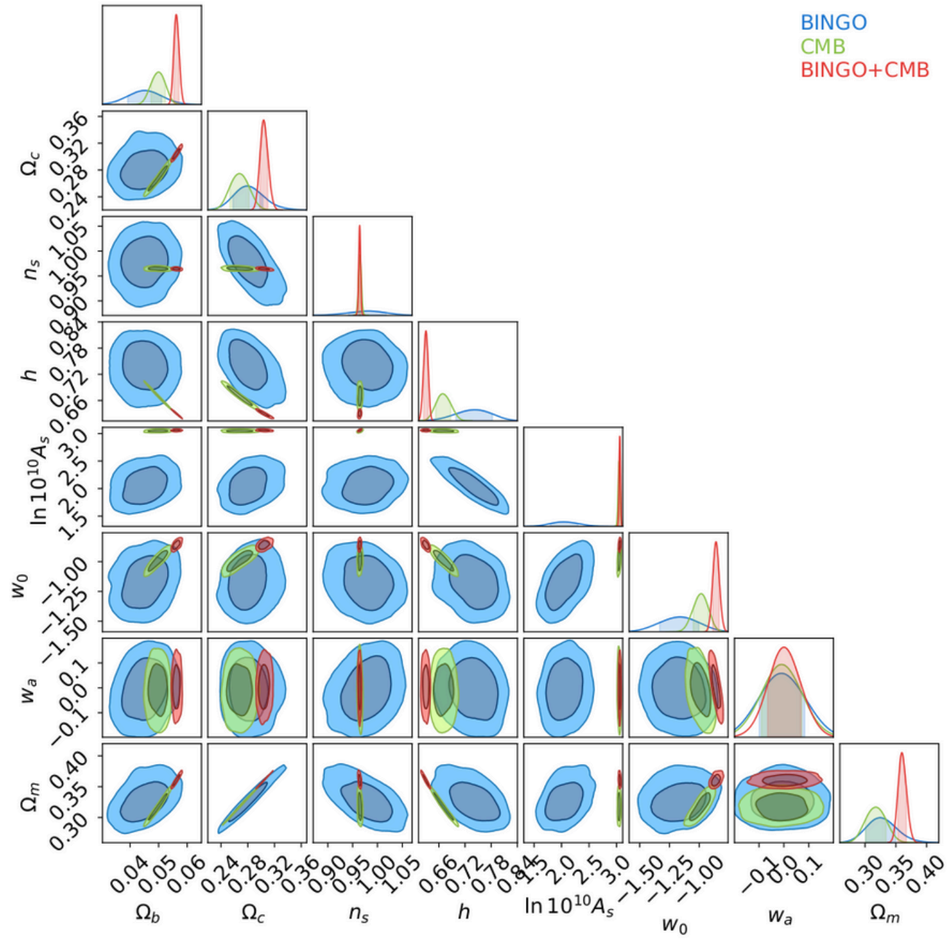
Results

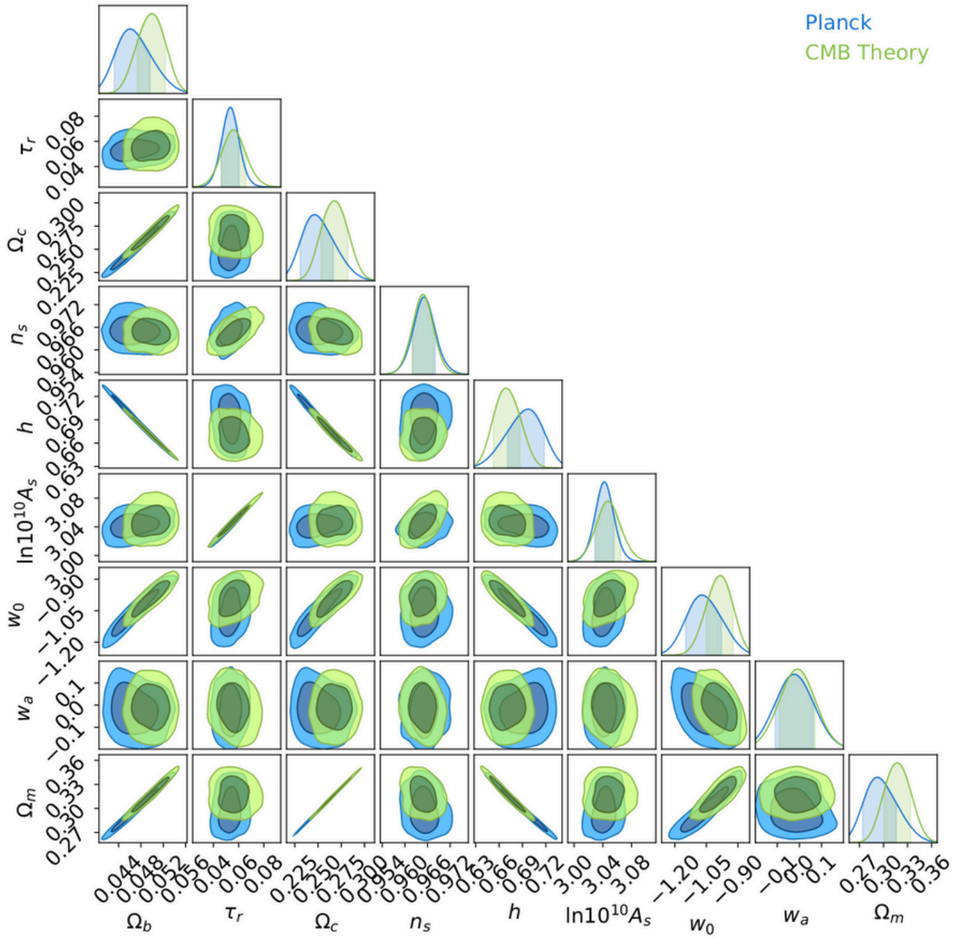


Cosmological parameters - BINGO

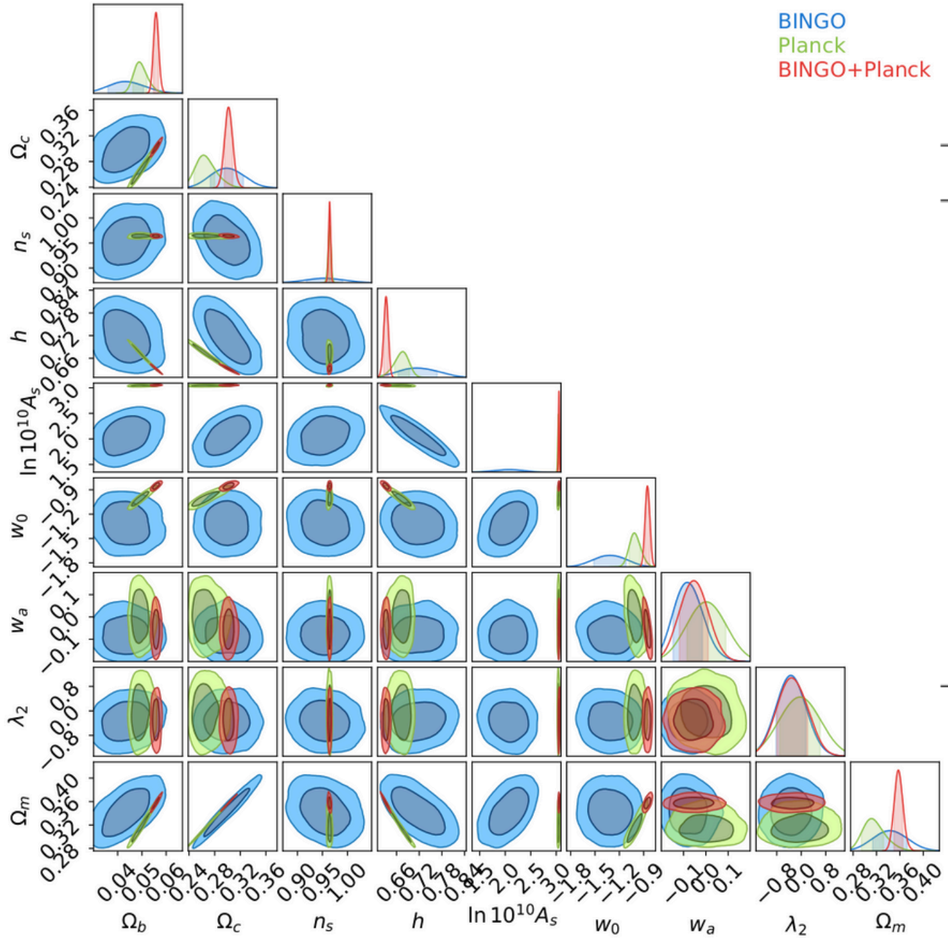
Parameter	Model ΛCDM	Model 1	Model 2	Model 3
$\Omega_b h^2$	0.0224 ± 0.0002	$0.0196^{+0.0024}_{-0.0023}$	$0.0187^{+0.0025}_{-0.0023}$	$0.0185^{+0.0028}_{-0.0024}$
$\Omega_c h^2$	$0.1189^{+0.0014}_{-0.0015}$	$0.1294^{+0.0067}_{-0.0064}$	$0.1510^{+0.0066}_{-0.0060}$	$0.1396^{+0.0065}_{-0.0060}$
$100\theta_s$	1.0420 ± 0.0003	$1.0384^{+0.0030}_{-0.0031}$	1.0359 ± 0.0022	$1.0392^{+0.0033}_{-0.0035}$
$\ln 10^{10} A_s$	3.080 ± 0.029	$2.838^{+0.061}_{-0.059}$	$2.814^{+0.055}_{-0.051}$	$3.07^{+0.26}_{-0.23}$
n_s	0.967 ± 0.005	$0.945^{+0.017}_{-0.018}$	0.946 ± 0.020	$0.997^{+0.24}_{-0.25}$
w_0	-	$-0.953^{+0.075}_{-0.071}$	$-1.58^{+0.09}_{-0.10}$	-1.65 ± 0.16
$\lambda_{(1,2)}$	-	-0.33 ± 0.18	$0.0156^{+0.0050}_{-0.0049}$	$0.0161^{+0.0047}_{-0.0045}$
H_0	67.7 ± 0.7	$56.1^{+1.9}_{-1.8}$	$59.4^{+1.1}_{-1.2}$	$59.1^{+2.6}_{-3.1}$
σ_8	$0.822^{+0.11}_{-0.10}$	$0.883^{+0.045}_{-0.049}$	$0.854^{+0.016}_{-0.015}$	$0.810^{+0.047}_{-0.041}$
Age/Gyr	13.80 ± 0.03	$14.28^{+0.25}_{-0.27}$	$14.37^{+0.24}_{-0.27}$	$14.87^{+0.29}_{-0.35}$
Ω_m	-	$0.471^{+0.029}_{-0.027}$	$0.482^{+0.021}_{-0.020}$	$0.455^{+0.047}_{-0.40}$

Compatibility test between simulations – Chevallier–Polarski–Linder model





Compatibility test between the simulation and real data – CPL model



Parameter	Theoretical	CMB - Planck	BINGO	CMB + BINGO
Ω_b	0.0493	$0.0460^{+0.0036}_{-0.0028}$	$0.0473^{+0.0080}_{-0.0076}$	0.0558 ± 0.0011
Ω_c	0.2645	$0.246^{+0.020}_{-0.016}$	$0.292^{+0.031}_{-0.030}$	$0.302^{+0.007}_{-0.006}$
τ_r	0.0544	$0.0534^{+0.0071}_{-0.0070}$	-	$0.0574^{+0.0047}_{-0.0046}$
n_s	0.9649	$0.9650^{+0.0030}_{-0.0029}$	$0.958^{+0.0038}_{-0.0042}$	0.9643 ± 0.0020
h	0.6736	$0.697^{+0.021}_{-0.027}$	$0.740^{+0.048}_{-0.050}$	0.632 ± 0.006
$\ln 10^{10} A_s$	3.044	$3.042^{+0.014}_{-0.013}$	$1.99^{+0.027}_{-0.024}$	3.051 ± 0.009
w_0	-1.0	$-1.07^{+0.09}_{-0.08}$	$-1.31^{+0.02}_{-0.01}$	-0.85 ± 0.03
w_a	0.0	$-0.024^{+0.087}_{-0.085}$	$-0.036^{+0.086}_{-0.084}$	$-0.054^{+0.063}_{-0.065}$
Ω_m	-	$0.292^{+0.024}_{-0.018}$	$0.336^{+0.037}_{-0.034}$	0.358 ± 0.008

Next Steps

- Use new simulation for BINGO;
- Combine BINGO simulation with other data (CMB, BAO and SNe Ia) for the three interaction models.

Thank you!

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