On the DESI dynamical DE claim

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Big physical claims have been picked up by the world media.

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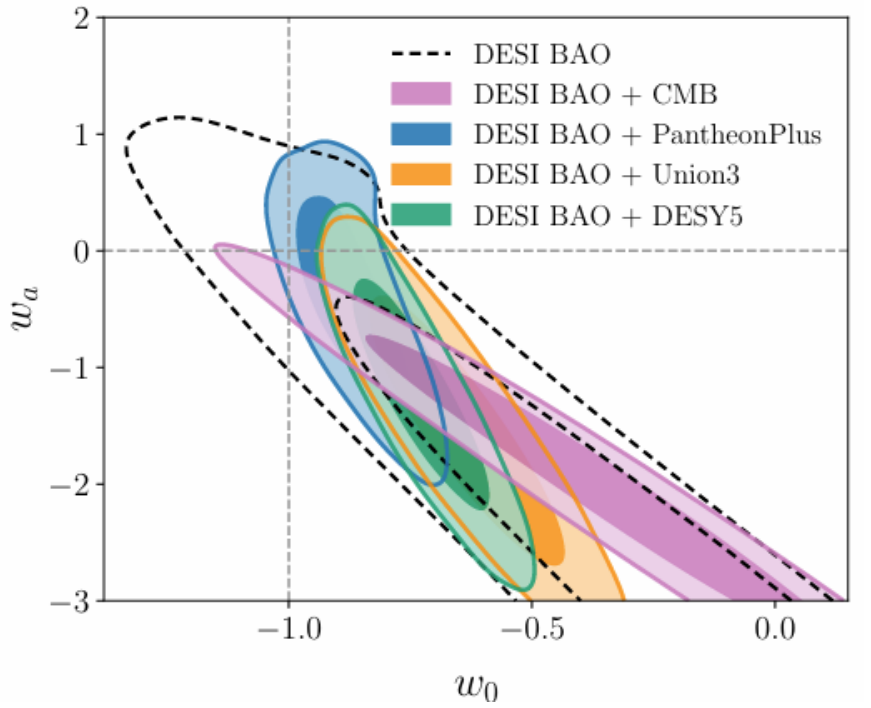
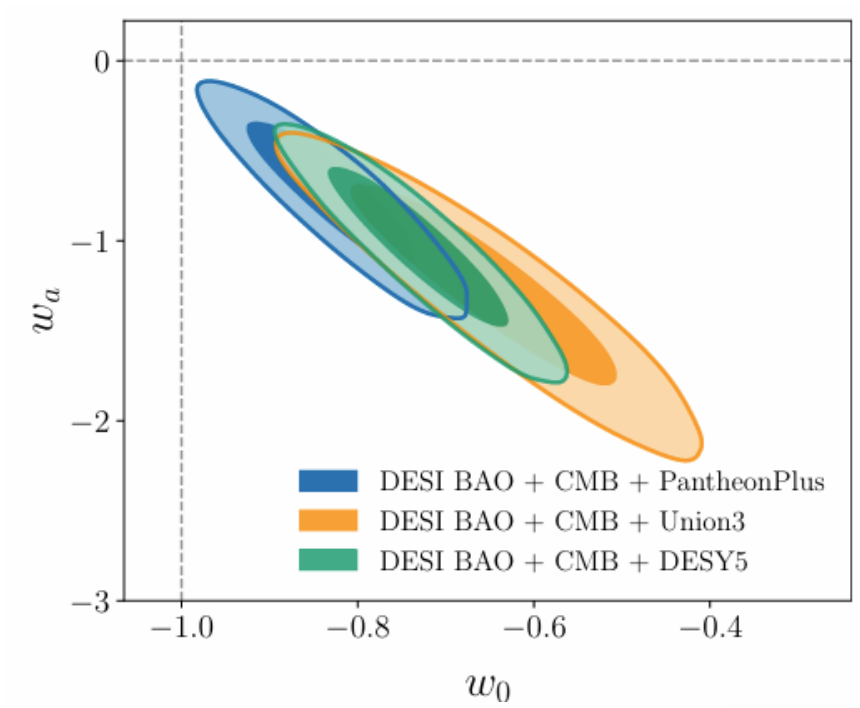
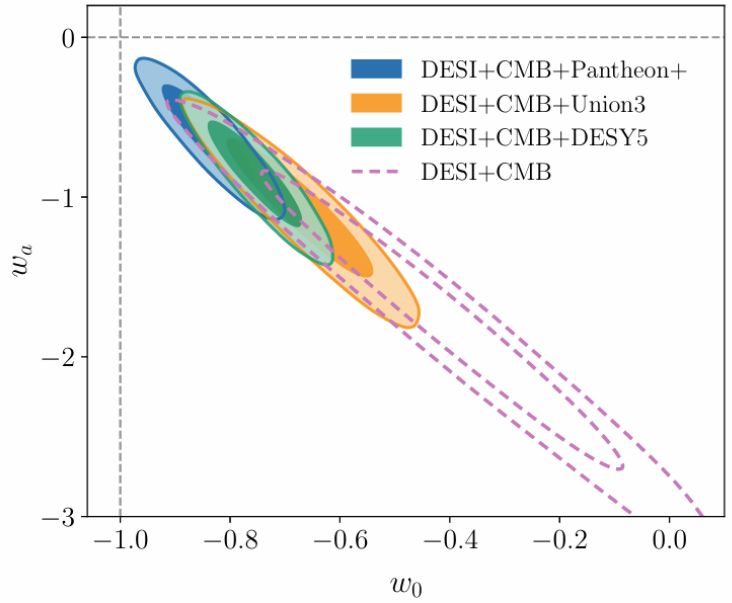


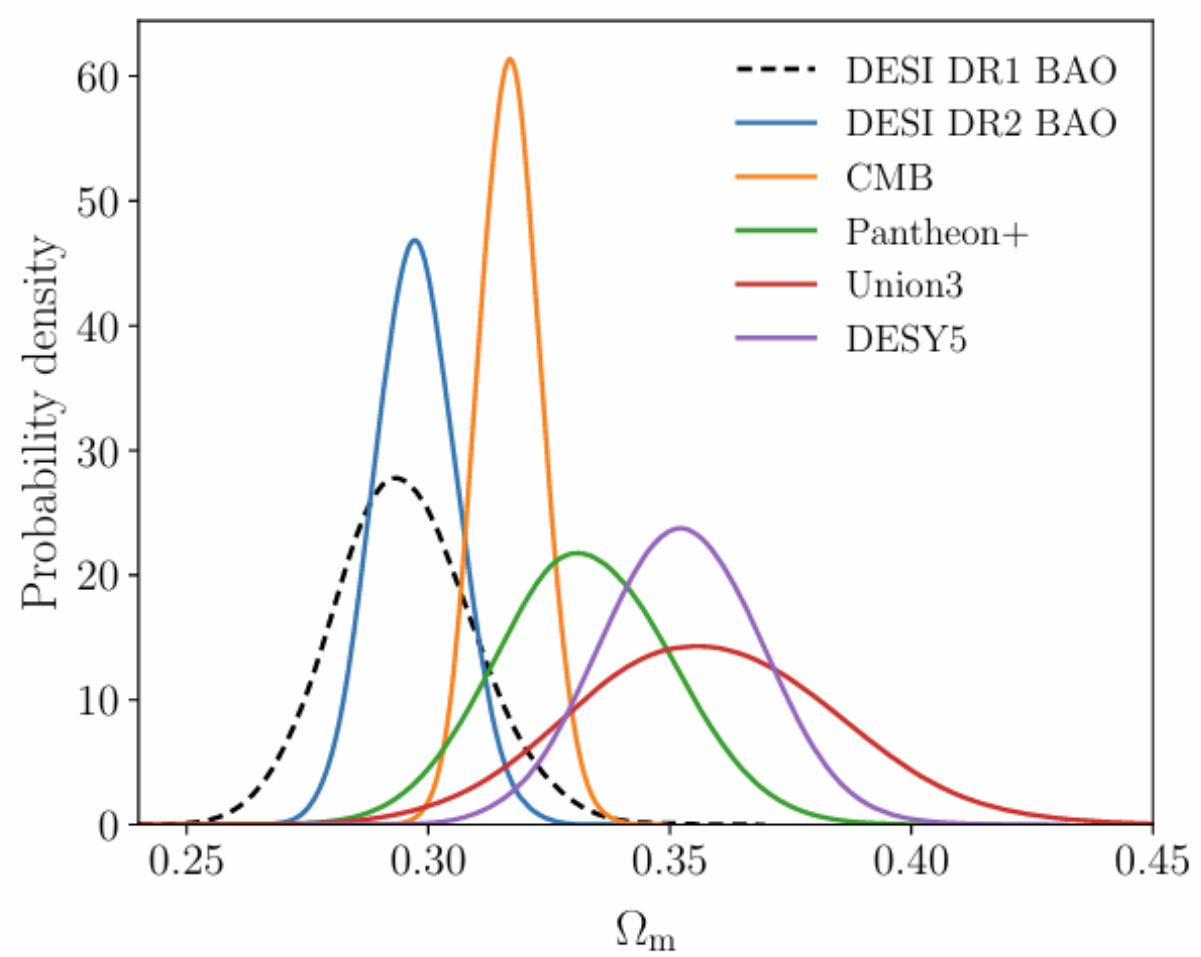


DESI Collaboration, 2404.03002 (DR1 BAO);
2503.14738 (DR2 BAO)



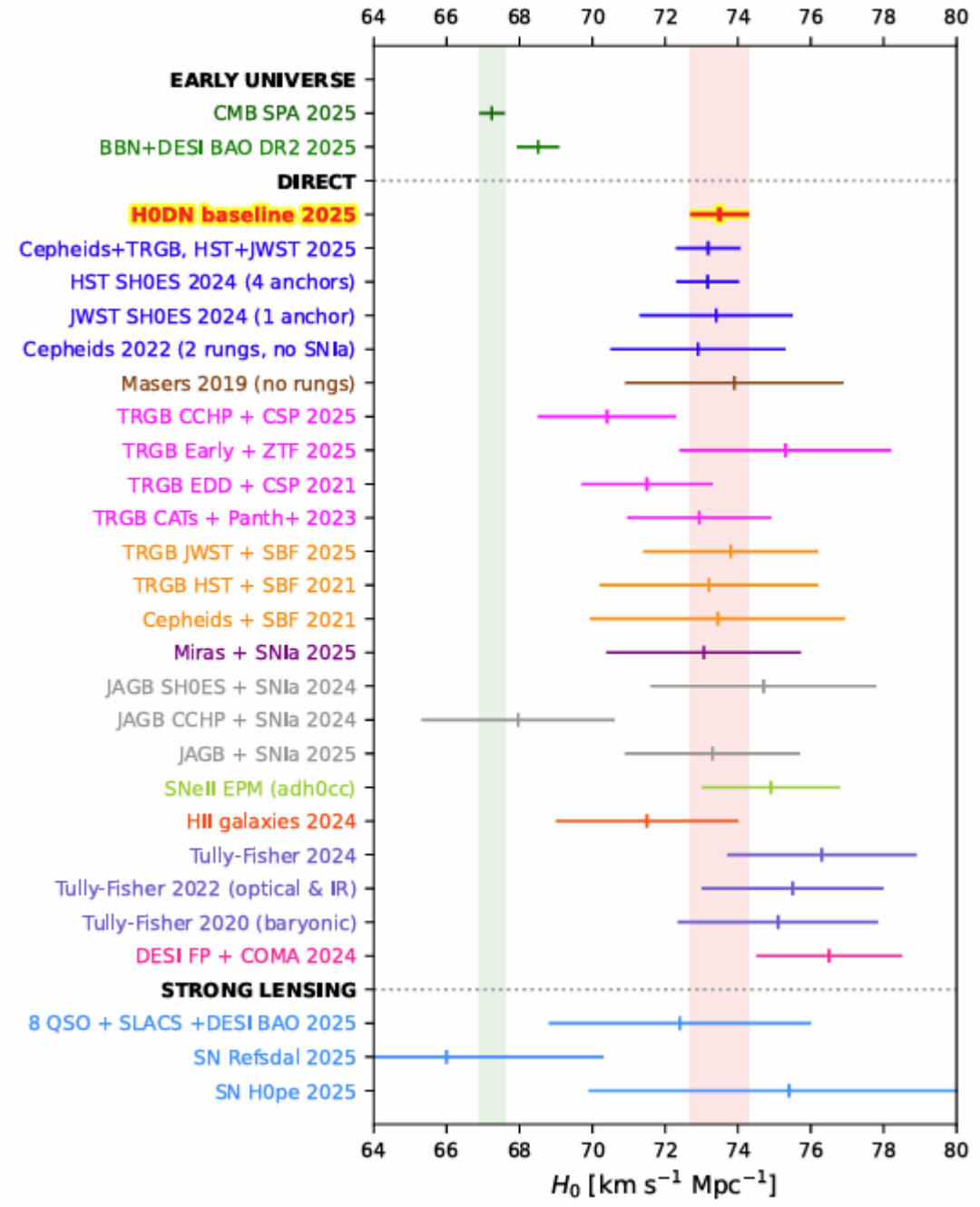
"Ω_m Tension" in (flat) ΛCDM.

DESI Collaboration, 2503.14738



However the dynamical DE claim is at odds with local H_0.

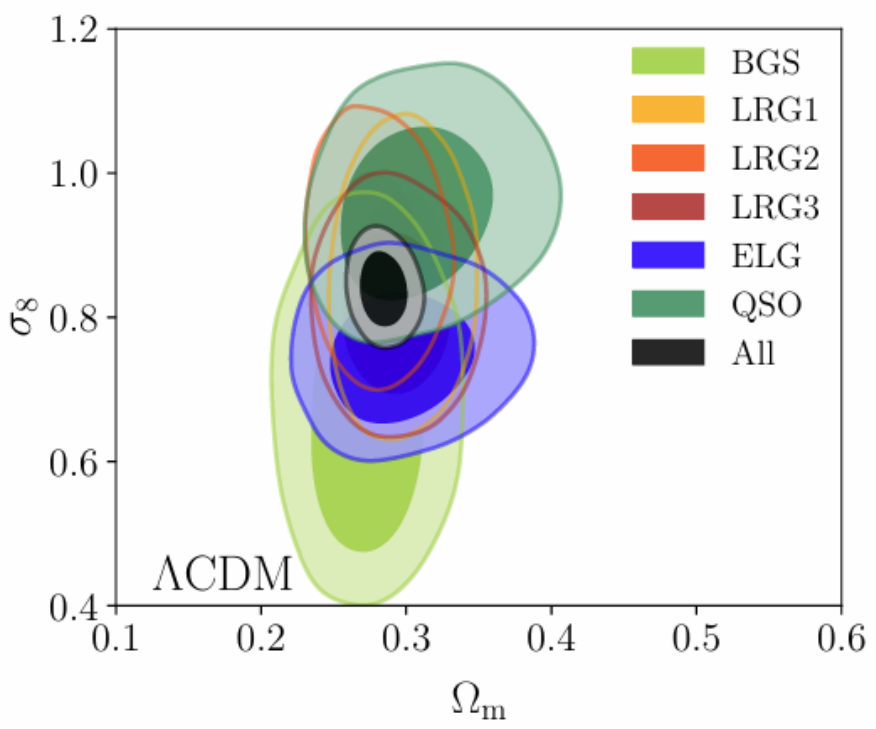
H0DN Collaboration, 2510.23823

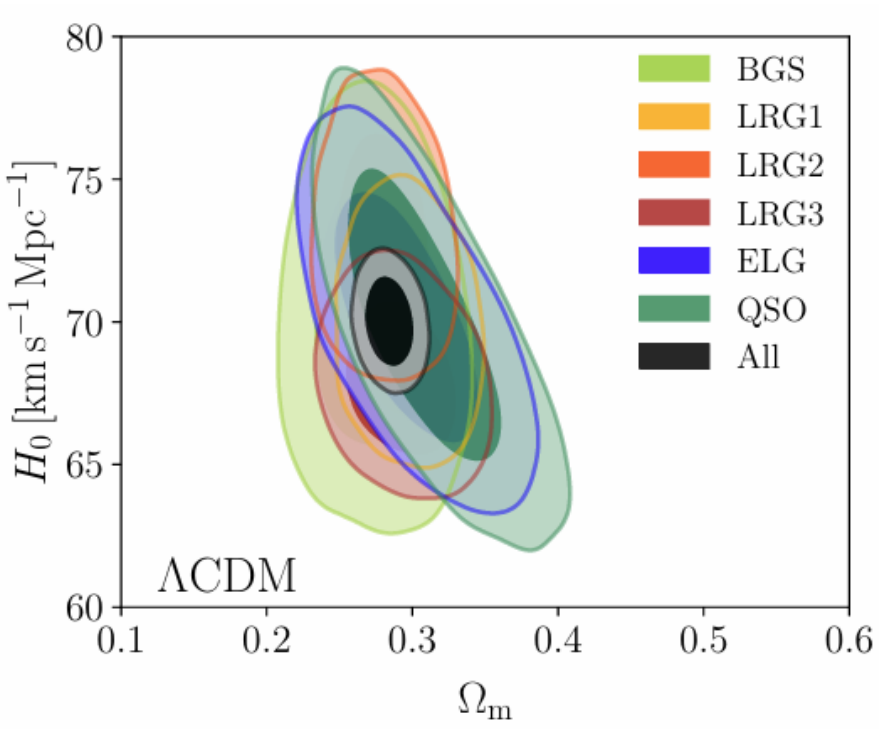


DESI also perform full-shape (FS) modelling analysis.

Find no ΛCDM deviation in their data alone, which implies no dynamical DE.

DESI Collaboration, 2411.12021

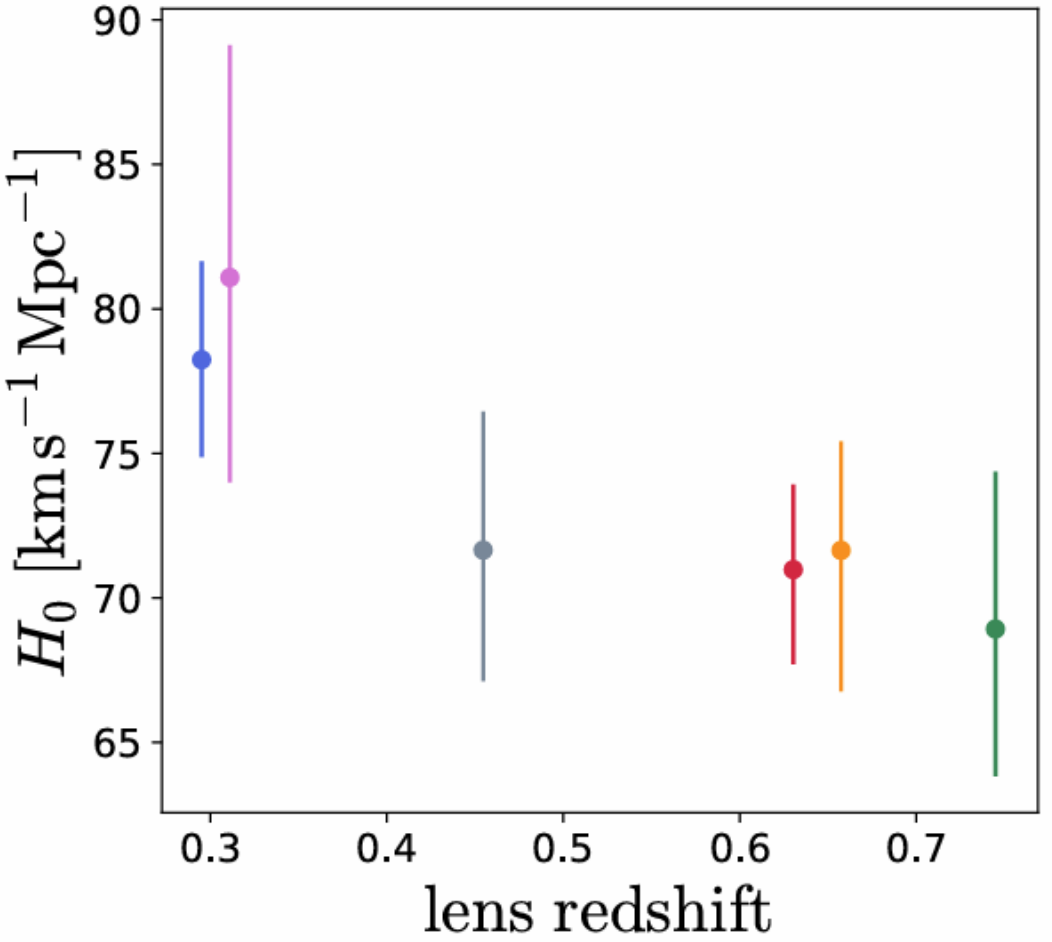




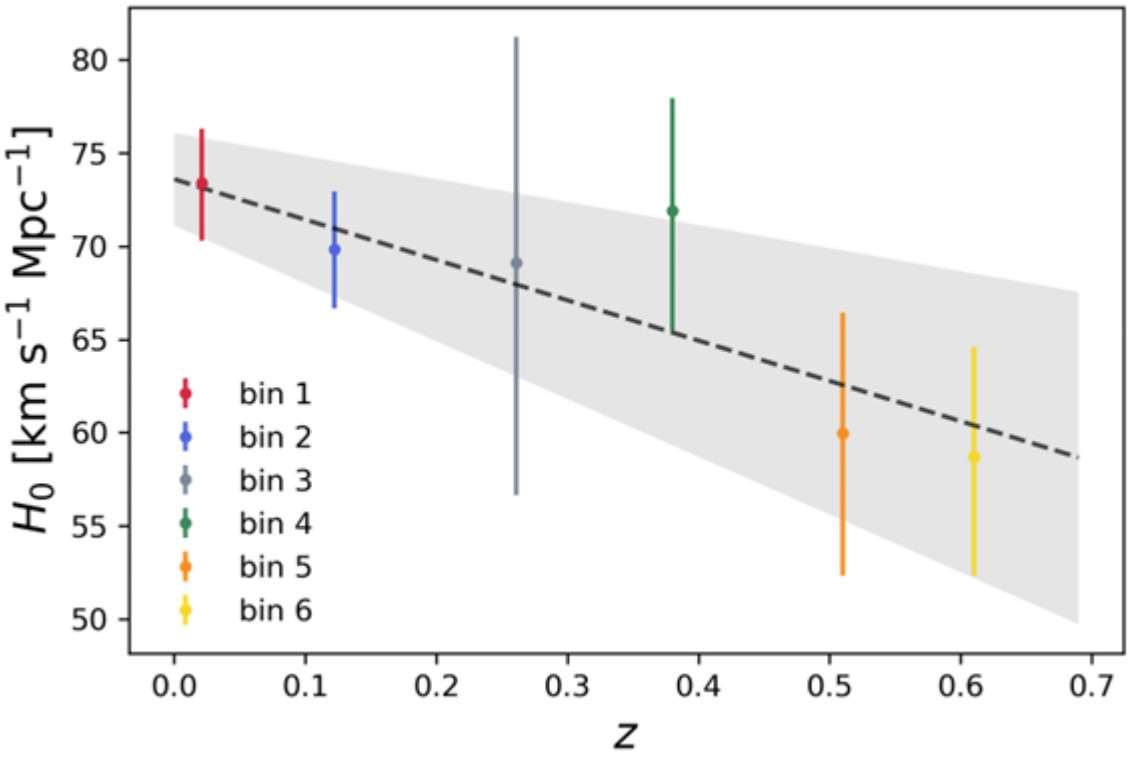
Where is this all going? Here is a simple (likely correct) claim.

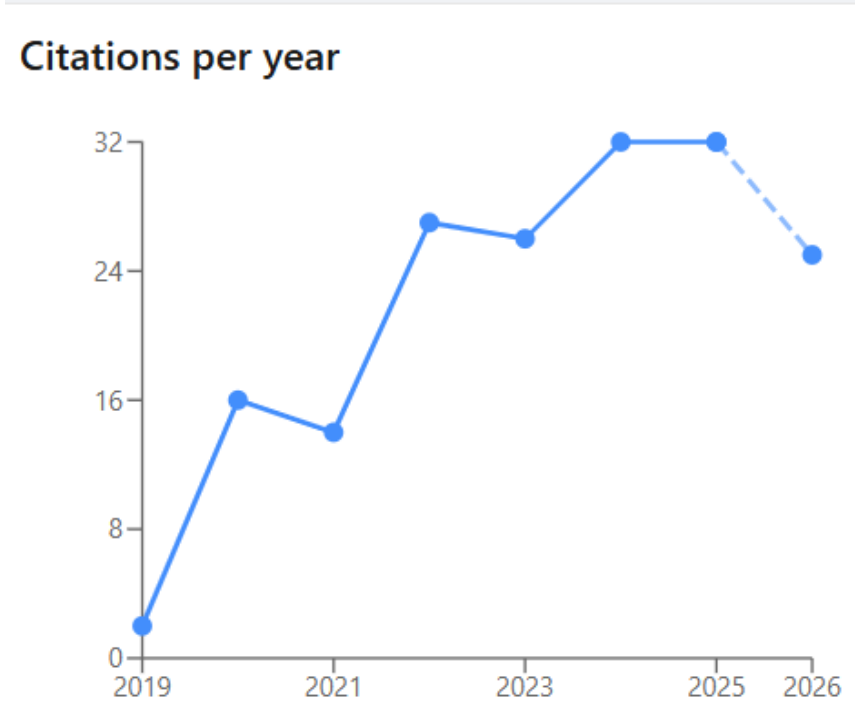
In science, dynamical models break down when model fitting parameters pick up time (redshift) dependence.

A key implication of H_0 tension is a broken ΛCDM model



H0LiCOW/TDCOSMO Collaboration, 1907.04869





Krishnan, ÓC, Ruchika, Sen, Sheikh-Jabbari, 2002.06044

Inspired by TDCOMSO but idea picked up by other groups.

We provided a physical interpretation not based on systematics, *cf.* TDCOSMO.

$$H^2 = \frac{\rho}{3},$$
$$(1+z)\frac{H'}{H} = \frac{3(\rho+p)}{2\rho} := \frac{3}{2}(1+w_{\rm eff}),$$

$$H_0 = H(z)\exp\left(-\frac{3}{2}\int_0^z \frac{1+w_{\rm eff}(z')}{1+z'}\mathrm{d}z'\right)$$

Basically, missing physics in ΛCDM can manifest as redshift-dependent H_0 in FLRW.

Krishnan, ÓC, Sheikh-Jabbari, Yang, 2011.02858

Later groups interpret $H_0(z)$ largely decoupled from the rest of the cosmological model.

However, H_0 is correlated with all other parameters when one fits data.

In the ΛCDM late Universe, this begins with Ω_m at the background level where H_0 and Ω_m are negatively correlated.

In 2022 at CQuEST we wrote 2 papers claiming that the ΛCDM parameter Ω_m is non-constant and increases with redshift.

ÓC, Sheikh-Jabbari et al. 2203.10558, 2206.11447

Note, in FLRW $H(z) = H_0 E(z)$, so H_0 is a non-dynamical overall scale.

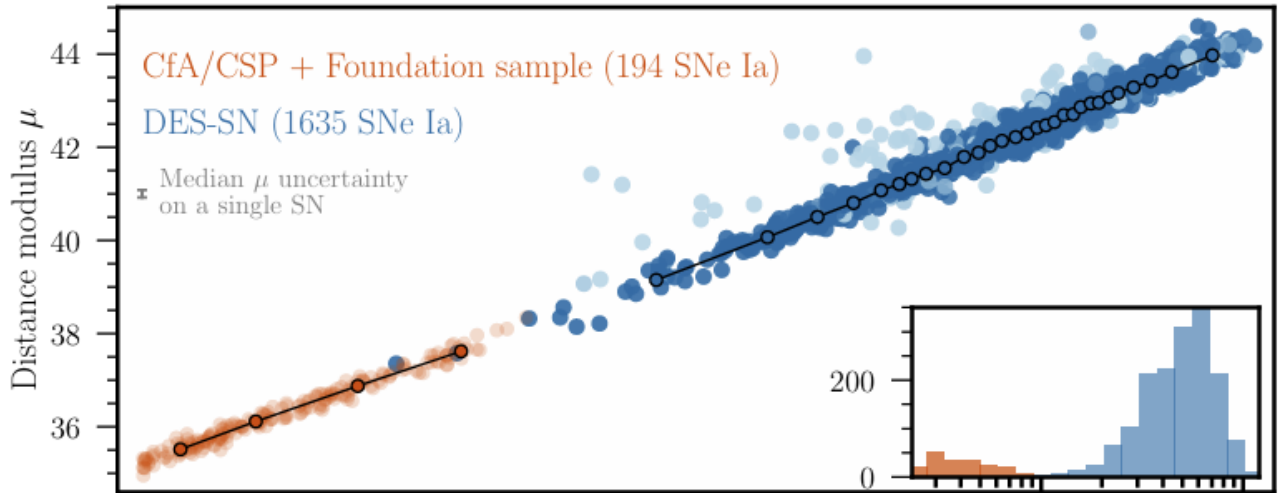
Our work predates DESI but differs in that DESI only document discrepancies between datasets, especially DESI and CMB.

Our claim is evolution happens throughout datasets. Easy to show that one implies the other.

In traditional Bayesian approach, parameters are constant by assumption.

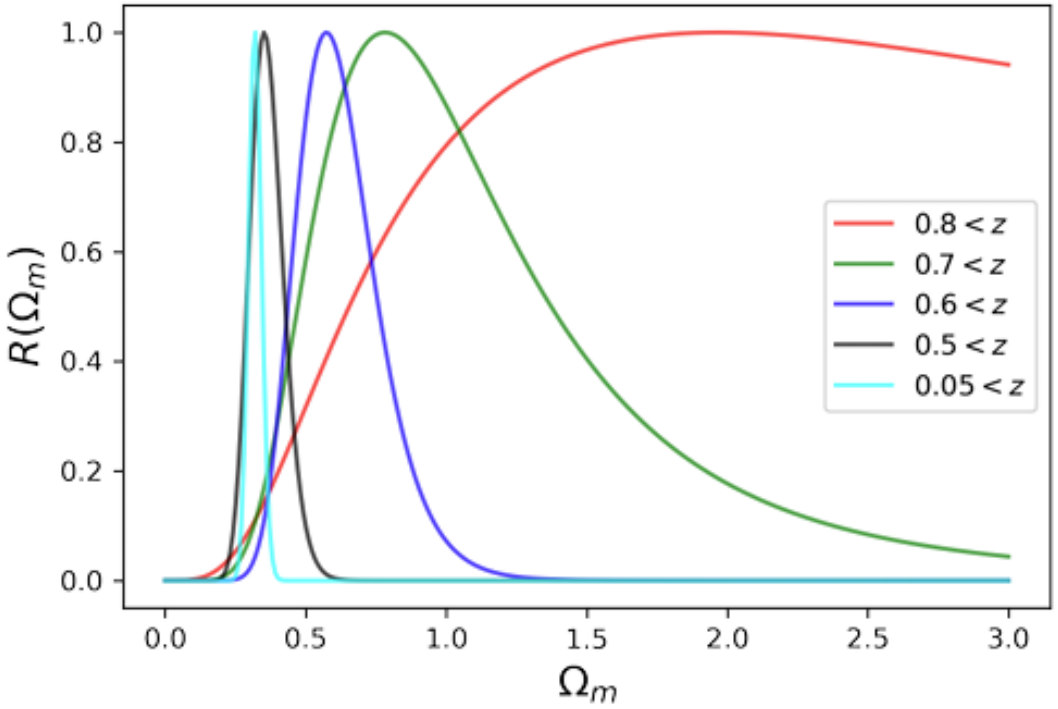
Here, the assumption is replaced by a testable hypothesis.

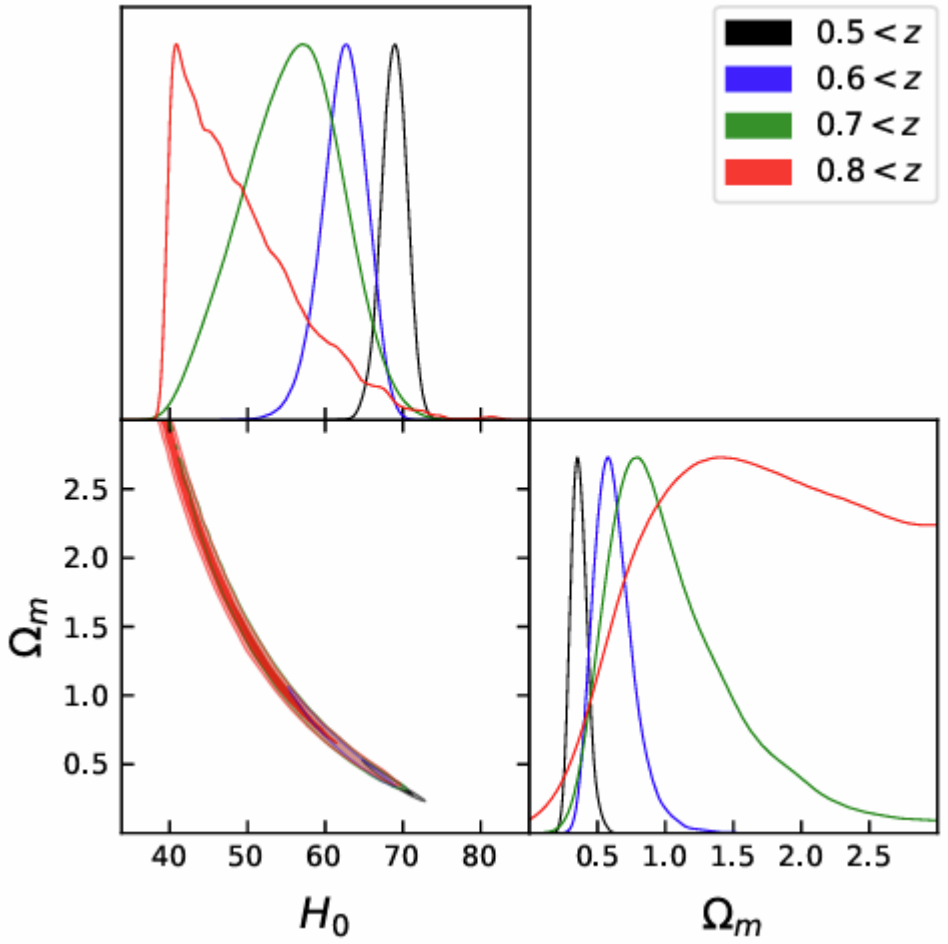
Community focus on dynamical DE.



	Ω_M	Ω_K	w_0	w_a
DES-SN5YR (no external priors)				
Flat-ΛCDM	0.352 ± 0.017	-	-	-
ΛCDM	$0.291^{+0.063}_{-0.065}$	0.16 ± 0.16	-	-
Flat-wCDM	$0.264^{+0.074}_{-0.096}$	-	$-0.80^{+0.14}_{-0.16}$	-
Flat-w_0w_aCDM	$0.495^{+0.033}_{-0.043}$	-	$-0.36^{+0.36}_{-0.30}$	$-8.8^{+3.7}_{-4.5}$

DES Collaboration, 2401.02929



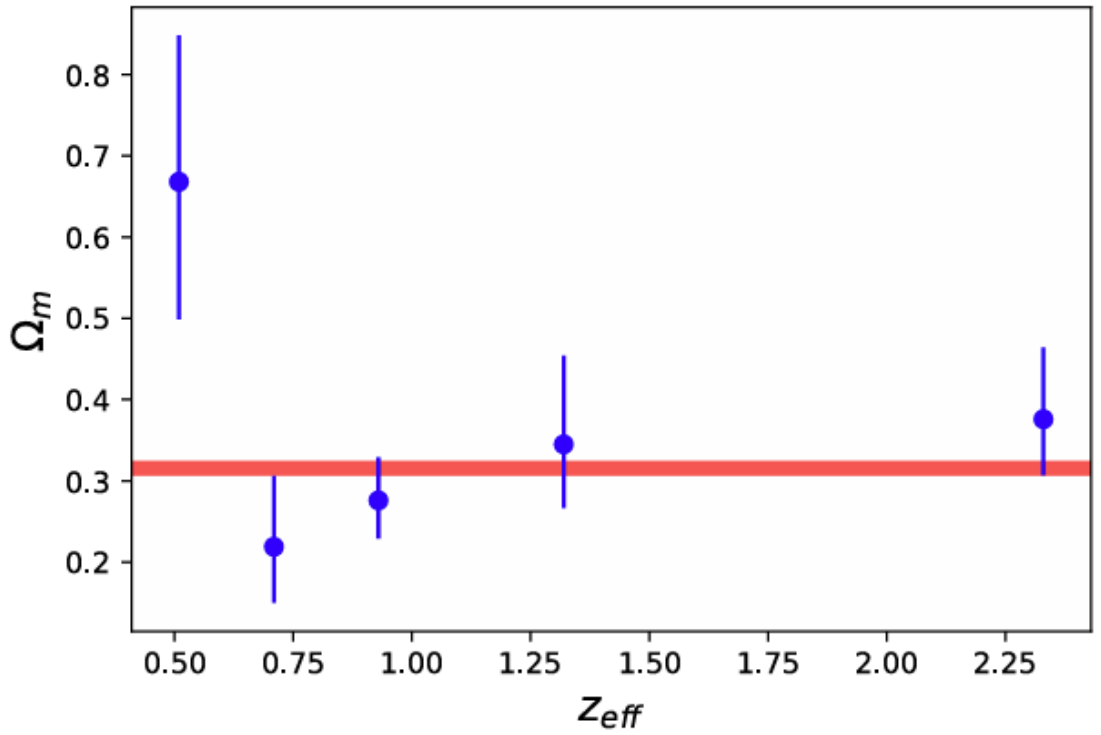


ÓC, Pourojaghi, Sheikh-Jabbari, 2406.06389

Need to see same increasing Ω_m trend in all data, including DESI.

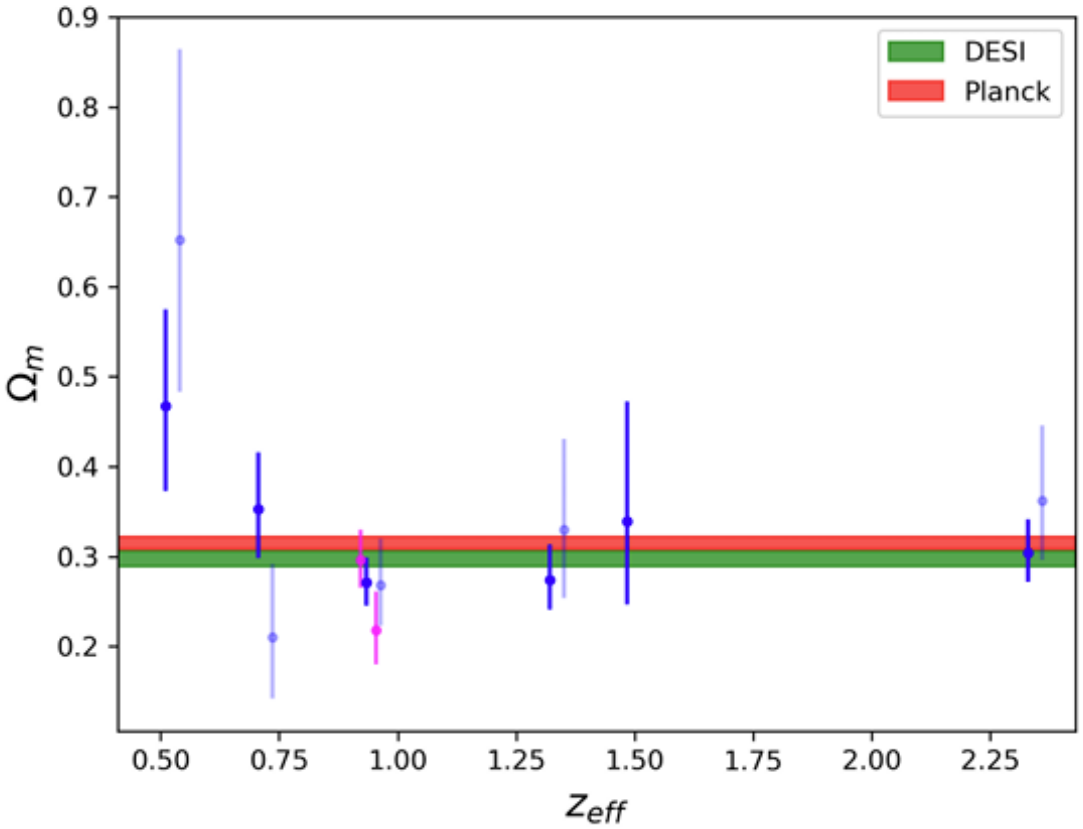
Apparent statistical fluctuation in LRG1 (and LRG2).

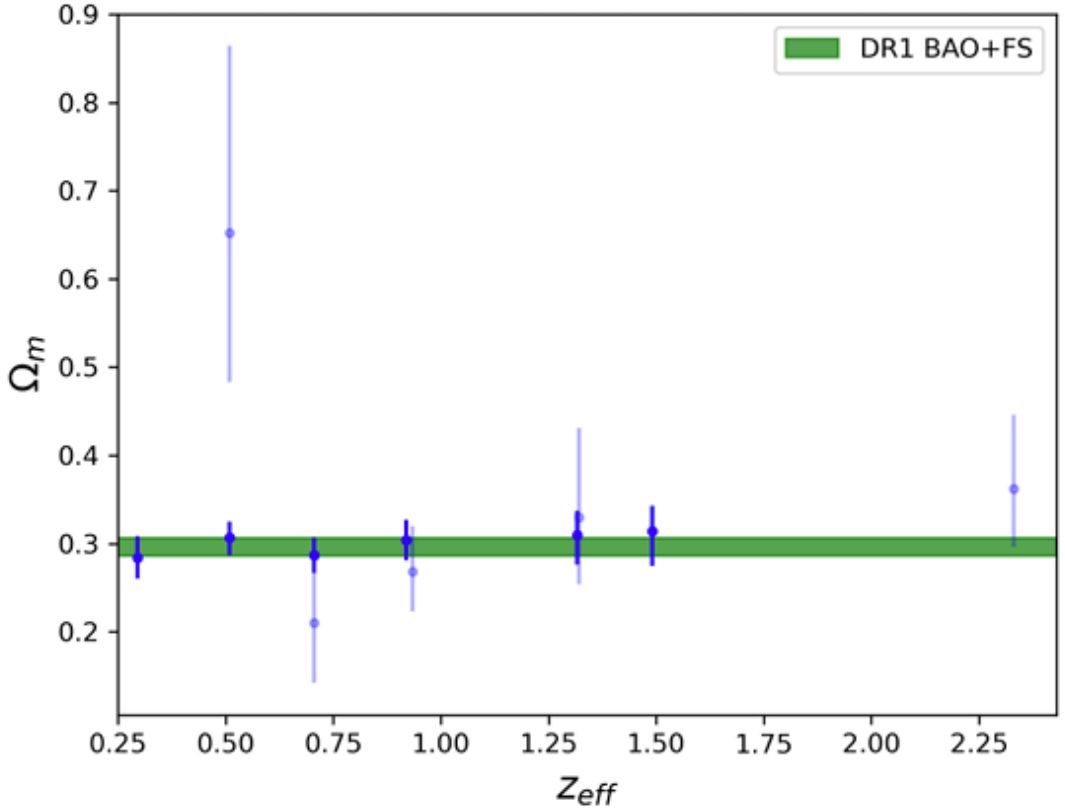
$$\frac{D_M/r_d}{D_H/r_d} = E(z)\int_0^z \frac{1}{E(z')}\mathrm{d}z'$$



ÓC et al., 2404.08633

Repeat with DESI DR2 BAO. BAO and FS modelling must converge.





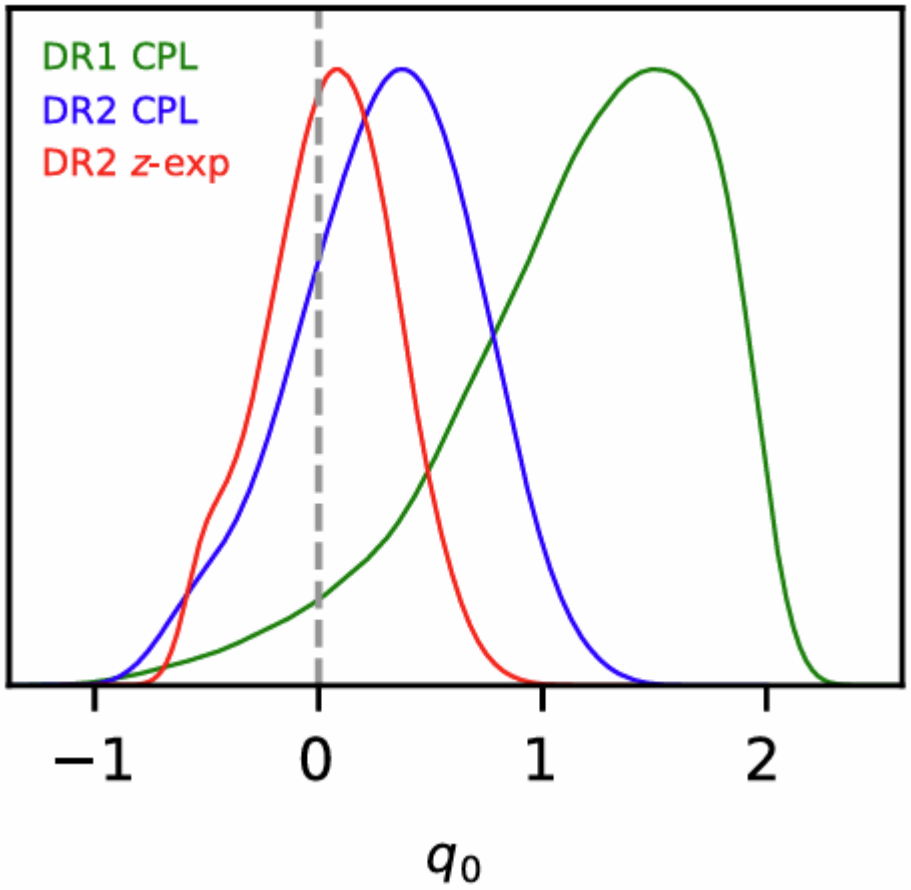
ÓC, Pourojaghi, Sheikh-Jabbari, Lin, 2504.04417

We were the first group to explicitly highlight q_0 sign problem.

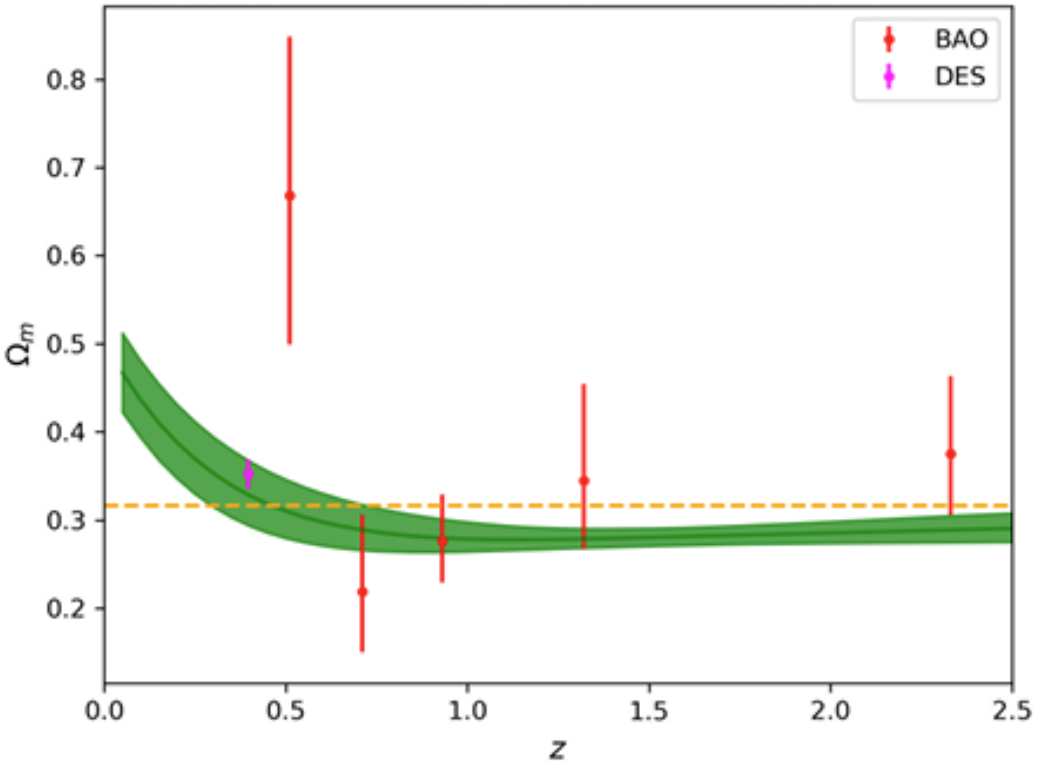
Later work at Yonsei (Young-Wook Lee et al.) recalibrates SNe to claim consistent $q_0 > 0$ result in SNe.

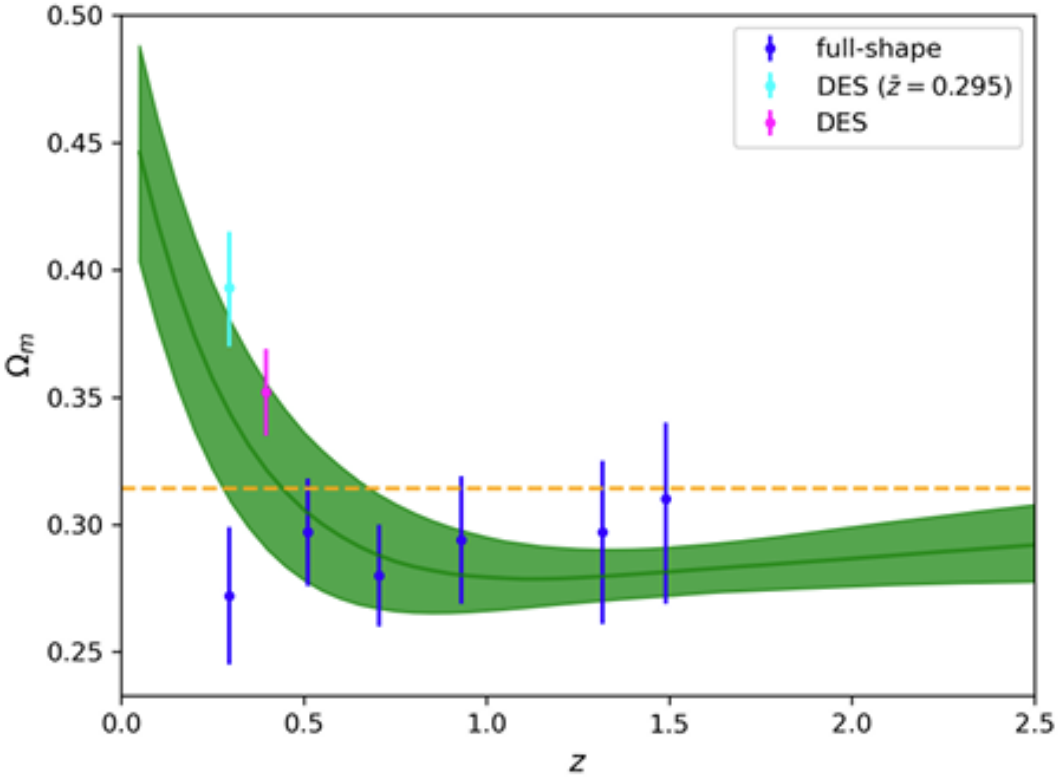
$$q_0 = \frac{1}{2}\left[1 + 3w_0(1 - \Omega_m)\right] < 0$$

ÓC, Pourojaghi, Sheikh-Jabbari, Lin, 2504.04417



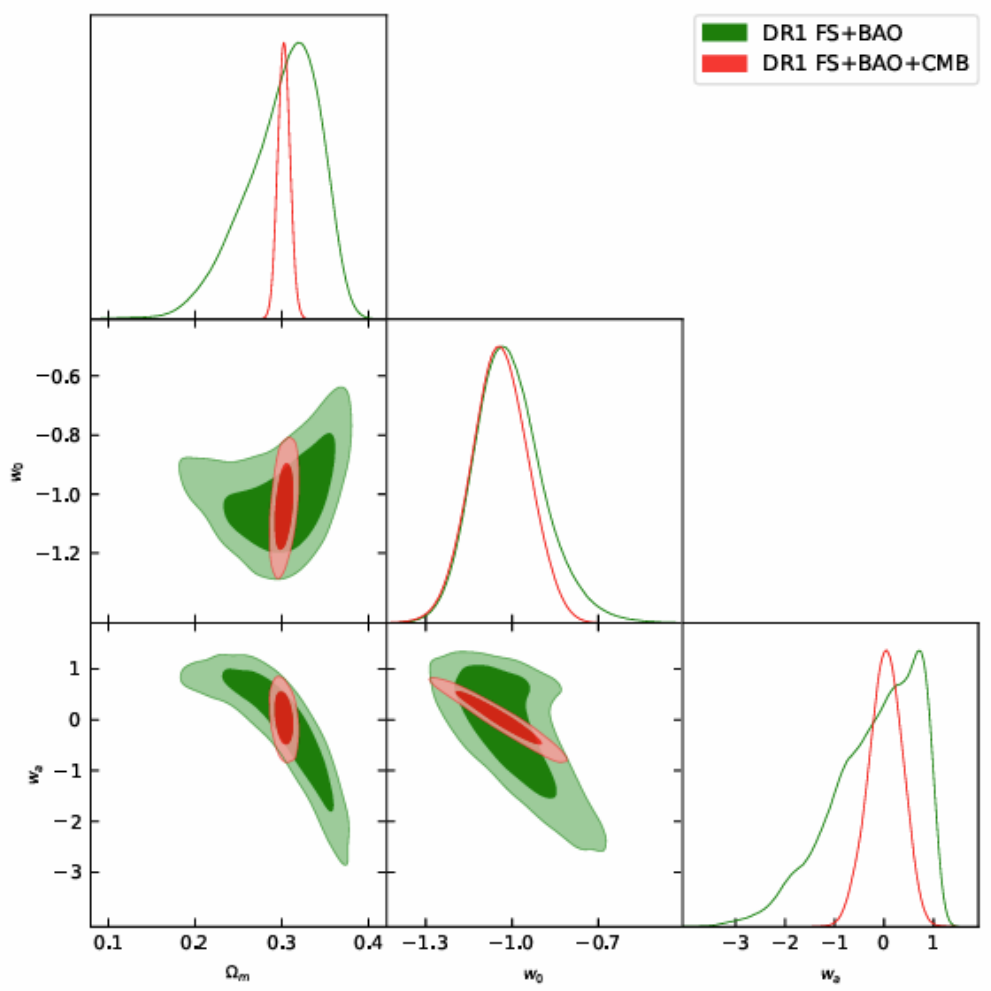
Can map the CPL w_0w_aCDM model back into flat ΛCDM.

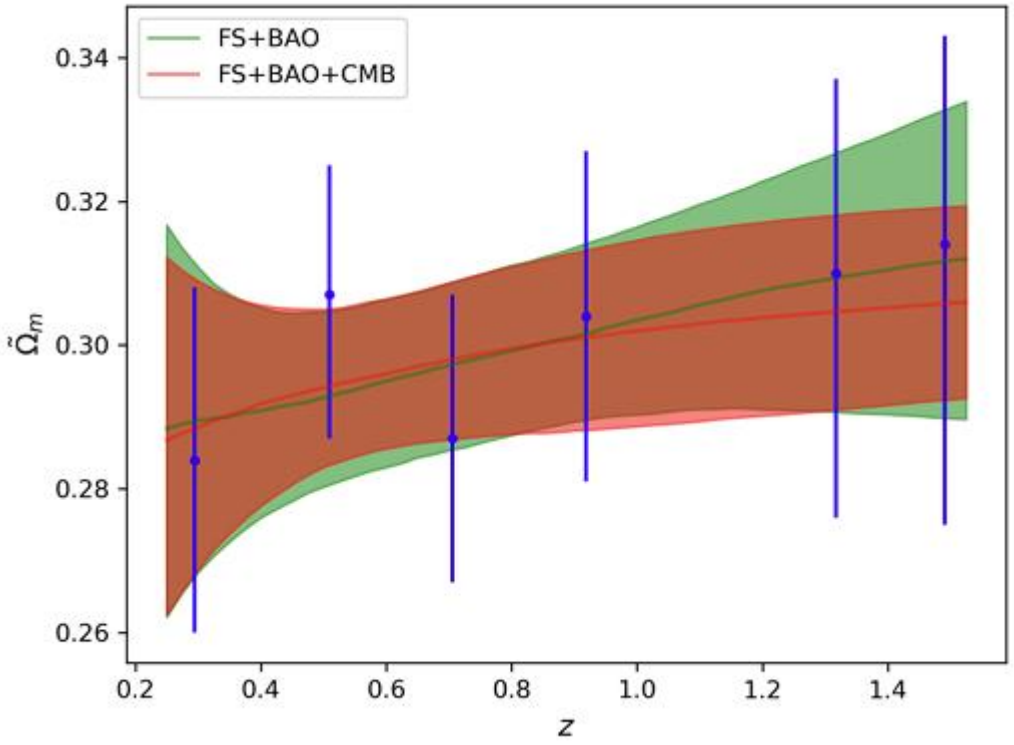




ÓC & Sheikh-Jabbari, 2412.12905

With same mapping one can fit DESI FS modelling constraints through flat ΛCDM to the CPL model.





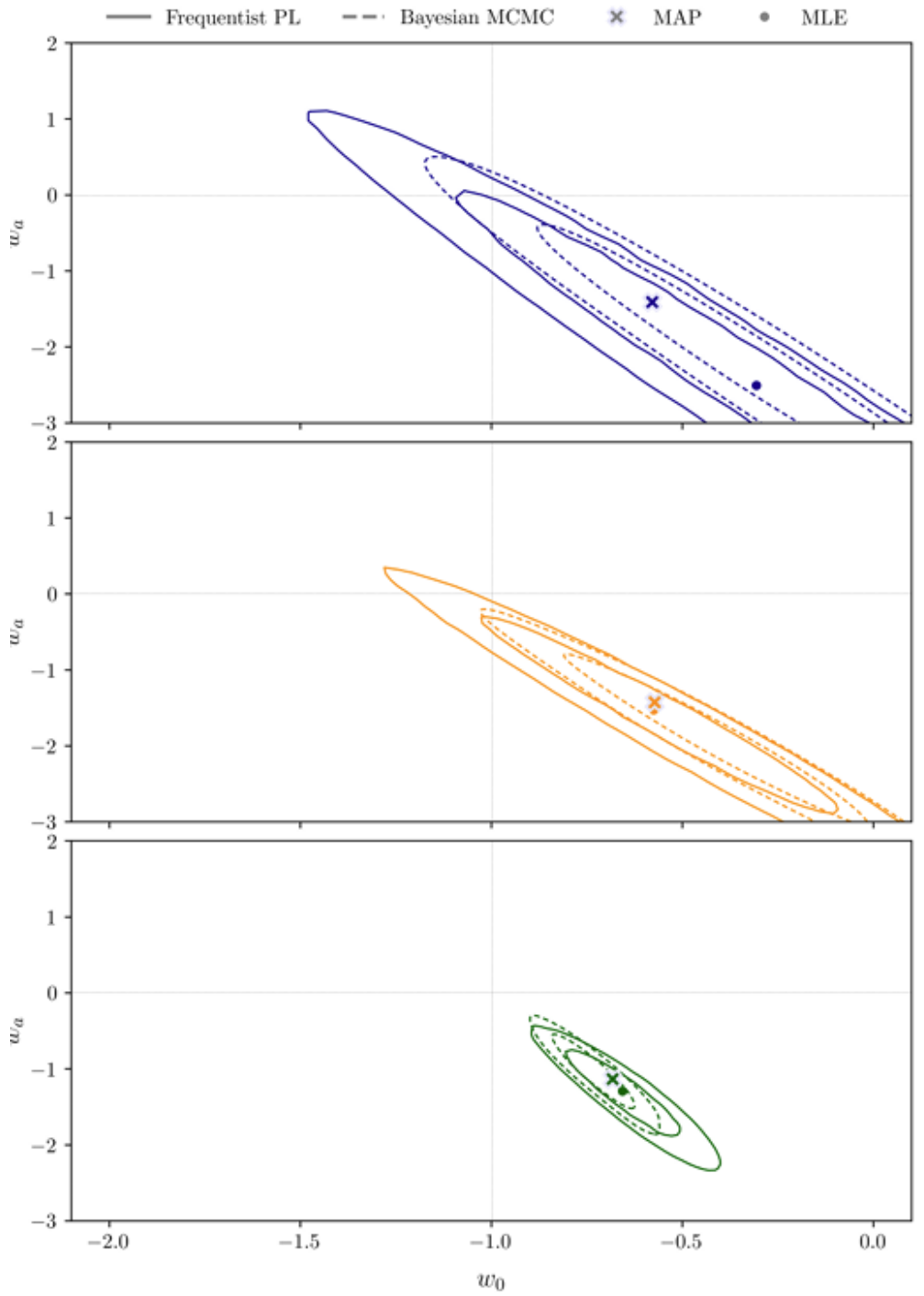
ÓC, Pourojaghi, Sheikh-Jabbari, 2505.19029

Real problem here is dynamical DE should be seen independently in datasets.

If not seen in DESI data alone, it is hard to accept claim.

DESI FS modelling confronted to CPL exhibited projection effects. Problem just solved by DESI.

DESI Collaboration, 2607.02498.



Let's return to H_0 tension - a better established anomaly.

Analytically (no data) one can argue that w(z) > -1 correlates with lower H_0 relative to ΛCDM provided $\Omega_m h^2$ is anchored at high redshift.

$$X(z) = \exp\left(3\int_0^z \frac{1+w(z')}{1+z'}\mathrm{d}z'\right) \qquad H(z)^2 = H_0^2(1-\Omega_m)X(z) + H_0^2\Omega_m(1+z)^3$$

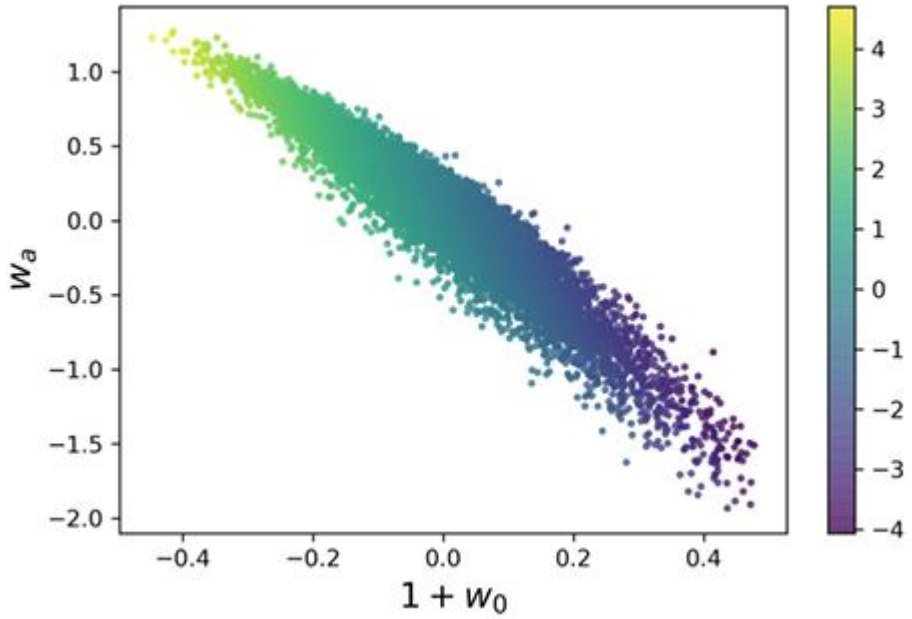
ÓC, Pourojaghi, Sheikh-Jabbari, Lin, 2504.04417

When 1+w(z) changes sign (phantom crossing), one needs to resort to data.

In 2022, we showed that $w_0 > -1$ typically correlates with lower H_0 relative to ΛCDM across mock DESI forecast datasets.

Turns out that DESI is a typical realisation of the data.

Lee, Lee, ÓC, Sheikh-Jabbari, Thakur, 2202.03906.



Summary

Either the ΛCDM cosmological parameters are constant (tensions are due to systematics) or they are not (missing physics).

Our group developed these ideas starting with H_0 through Ω_m to S_8 (not discussed). Non-trivial to establish in independent datasets.

DESI has reported a dynamical DE deviation, which makes H_0 tension worse (physics?), and also an "Ω_m Tension" between datasets.

The "Ω_m Tension" is less general than the increasing Ω_m trend we claimed 2 years prior to DESI in CQUeST papers.