Cosmological Implications of the GWTC-3 Modified-Propagation Anomaly: Early-Anchor Recalibration, CMB-Lensing Refit, and Early-Universe H0 Inference Bias

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We project the GWTC-3 O3 modified-gravity propagation posterior into late- and early-universe inference tests using an updated Planck-facing calibration chain. The upstream O3 anomaly replication repository is archived on Zenodo (DOI: 10.5281/zenodo.18585598). A 60-restart Planck+MG global refit defines an updated early anchor, $H_0^{\rm Planck,MG} = 68.005$ (p50), $\Omega_m^{\rm Planck,MG} = 0.30643$ (p50), and $A_{\rm lens} = 1.0428$ (p50).

After rebasing late-time transfer sweeps to this anchor, the constrained anchor-relief posterior is $\mathcal{R}_{\rm anchor}^{\rm GR} = 0.1545$ (mean; p16/p50/p84 = 0.108/0.147/0.189). A 10-case robustness grid gives posterior-shift relief mean 0.5296 (p50 0.5125), while a joint SN+BAO+CC transfer model yields $\mathcal{R}_{\rm joint} = 0.8329$ (mean) but no Bayes preference for explicit transfer terms ($\log {\rm BF} = -0.533$).

For CMB lensing, direct CAMB propagation of MG draws still predicts baseline suppression at $L\sim100$ and $L\sim300$ (medians −15.29% and −9.49%). However, an MG-aware lensing refit recovers good fits (median $\chi^2 = 8.06$ vs Planck-reference 9.04; 100% of refit draws better than reference) with median $M_\star^2(z=0)/M_\star^2(z\gg1) \simeq 0.901$. Compressed-$\theta_\star$ inversions under GR assumptions bias inferred H_0 upward (mean $\Delta H_0 = +1.88$ km s^{-1} Mpc^{-1} for fixed Ω_m, or +4.55 for lensing-proxy Ω_m), indicating that early-universe inference assumptions can materially shift recovered expansion rates in this MG-conditioned scenario.

I. SCOPE AND FRAMING

This work treats the O3 modified-propagation signal phenomenologically: given the inferred posterior, what cosmological consequences follow? The O3 anomaly analysis and data products are archived on Zenodo [1]. We do not re-argue detection significance in this manuscript.

Modified GW propagation has been explored in theory-forward frameworks [14, 15]. Here, we use a data-driven posterior and update the pipeline to answer three questions in one chain:

1. How much late-time Hubble tension relief remains after recalibrating the early anchor?
2. Does Planck 2018 lensing necessarily reject this posterior, or can an MG-aware refit absorb the suppression?
3. How much can GR-based early-universe compression bias inferred H_0 if MG truth is assumed?

II. PIPELINE SUMMARY

Posterior draws are taken from `outputs/finalization/highpower_multistart_v2/M0_start101` and propagated through four linked stages:

1. **Global Planck+MG recalibration:** 60-restart multistart fit (`cpuset 0-59`) to establish updated early-anchor reference values.
2. **Late-time rebasing:** constrained/pilot transfer sweeps are rebased to the new Planck-like anchor and recompressed into a final relief posterior.
3. **CMB lensing forecasts:** baseline draw-level CAMB projection to Planck 2018 lensing bandpowers, followed by an MG-aware two-parameter lensing refit.
4. **Compressed early-universe inversion:** GR inversion of $\theta_\star = r_d/D_M(z_\star)$ under fixed-Ω_m and lensing-proxy-Ω_m assumptions.

These are targeted forecasts and refits, not a full MG TT/TE/EE perturbation-sector likelihood analysis.

III. RESULTS

A. Updated early anchor from the global Planck+MG fit

The 60-restart Planck+MG run completed all restarts with 5 converged minima and 55 max-evaluation exits. Using converged minima only, we obtain:

$$H_0^{\rm Planck,MG} = 68.005302 \text{ (p50)}, \quad \Omega_m^{\rm Planck,MG} = 0.30643039 \text{ (p50)}, \tag{1}$$

With local reference $H_0^{\rm local} = 73.0$, the baseline gap used in rebased relief calculations is

$$\Delta H_0^{\rm base} = \left| H_0^{\rm local} - H_0^{\rm Planck,MG} \right| = 4.994698. \tag{2}$$

B. Late-time relief after rebasing

After rebasing constrained transfer sweeps to the updated early anchor and applying Monte Carlo calibration:

$$\mathcal{R}^{\rm GR}_{\rm anchor} = 0.1545 \quad (\text{mean; p16/p50/p84} \; = 0.1085/0.1475/0.1891) \tag{3}$$

Independent robustness and joint-fit diagnostics are:

- 10-case robustness grid: posterior-shift relief mean 0.5296 (p50 0.5125, p84 0.5453), with zero failed cases.
- Joint SN+BAO+CC transfer fit: relief posterior mean 0.8329 (p50 0.8386), but

  $$\log \mathrm{BF}_{\rm transfer/no\text{-}transfer} = -0.533, \tag{4}$$

  so explicit transfer terms are not favored in this setup.

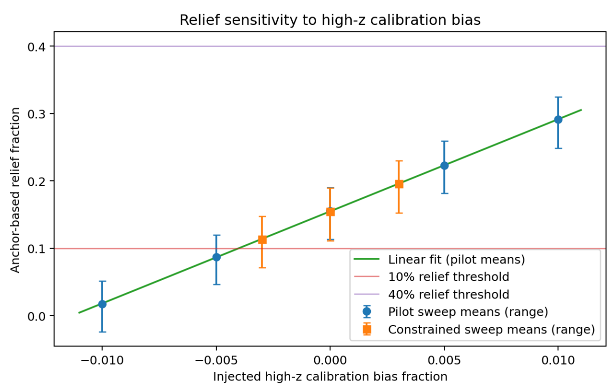

FIG. 1. Rebased relief sensitivity to high-z transfer bias from constrained and pilot sweeps. The final calibrated posterior is centered at $\mathcal{R}^{\rm GR}_{\rm anchor} \approx 0.15$.

C. CMB lensing: baseline suppression and MG-aware refit

Baseline draw-level CAMB projection against Planck 2018 lensing bandpowers (`consext8`, 64 draws) gives:

$$\left. \frac{C_L^{\phi\phi}(\mathrm{MG})}{C_L^{\phi\phi}(\mathrm{Planck\ ref})} \right|_{L\approx 106} = 0.847^{+0.091}_{-0.127}, \tag{5}$$

$$\left. \frac{C_L^{\phi\phi}(\mathrm{MG})}{C_L^{\phi\phi}(\mathrm{Planck\ ref})} \right|_{L\approx 286} = 0.905^{+0.068}_{-0.080}, \tag{6}$$

with median suppressions of -15.29% and -9.49%. The baseline fit quality is poor relative to the Planck-reference model:

$$\chi^2_{\rm MG,baseline}\ (\text{median}) = 51.77, \qquad \chi^2_{\rm Planck\ ref} = 9.04, \tag{7}$$

and only 3.1% of draws outperform the reference. A 32-draw cross-check from an independent posterior sample is more discrepant (-18.66% at $L \approx 106$, -11.29% at $L \approx 286$; $p_{\rm better} = 0$).

We then perform an MG-aware lensing refit (32 draws) with a phenomenological effective-$M_\star^2$ amplitude plus ℓ-tilt response. This removes the baseline mismatch:

$$\chi^2_{\rm MG\ refit}\ (\text{median}) = 8.06, \tag{8}$$

better than the Planck-reference $\chi^2 = 9.04$ in 100% of refit draws. The fitted median response corresponds to

$$\frac{M_\star^2(z=0)}{M_\star^2(z \gg 1)} \simeq 0.901 \tag{9}$$

(about a 9.9% drop), with small residual suppression at $L \approx 286$.

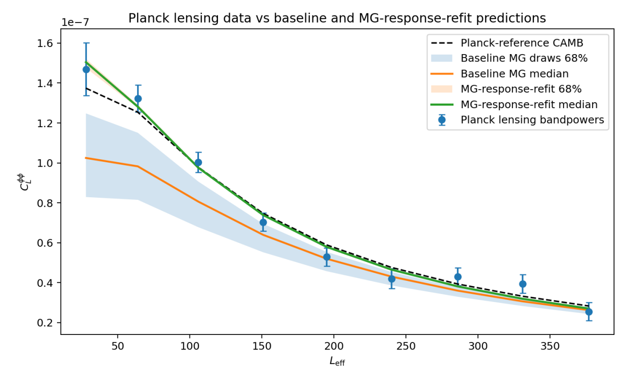

FIG. 2. Planck 2018 lensing bandpowers with baseline MG projection and MG-aware refit overlay. The refit absorbs the baseline suppression and restores near-reference fit quality.

D. Early-universe GR inversion biases inferred H_0 upward

Using the rebased early-anchor assumptions in compressed-$\theta_\star$ inversion:

- fixed $\Omega_m = \Omega_m^{\rm Planck,MG}$: $H_{0,\rm inferred}$ mean 72.394 (p50 73.170), with mean $\Delta H_0 = +1.876$ km s^{-1} Mpc^{-1} relative to draw-level truth;
- lensing-proxy Ω_m: $H_{0,\rm inferred}$ mean 75.065 (p50 75.226), with mean $\Delta H_0 = +4.547$ km s^{-1} Mpc^{-1}.

Relative to the recalibrated early anchor $H_0^{\rm Planck,MG} = 68.005$, the posterior medians shift by approximately:

$$\Delta H_0^{\rm truth} \approx +2.39, \quad \Delta H_0^{\rm fixed\ inversion} \approx +5.16, \quad \Delta H_0^{\rm lensing\ inversion} \approx \tag{10}$$

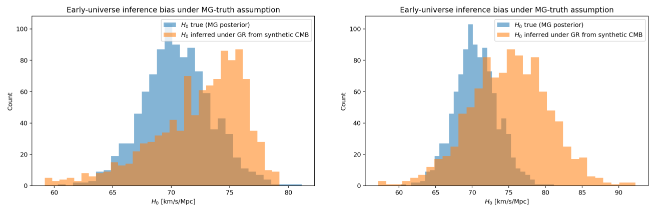

FIG. 3. Draw-level H_0 truth versus GR-inferred H_0 under compressed-$\theta_\star$ inversion with fixed-Ω_m (left) and lensing-proxy-Ω_m (right). Both assumptions bias inferred H_0 upward, with larger shift in the lensing-proxy case.

IV. INTERPRETATION

The updated pipeline supports three conclusions.

First, recalibrating the Planck-like early anchor materially lowers the constrained anchor-relief estimate (now centered near ~ 0.15), while robustness-grid and joint-transfer diagnostics still indicate that meaningful upward H_0 shifts are available in broader transfer-conditioned settings.

Second, baseline CAMB propagation of the O3 MG posterior predicts lensing suppression, but this does not by itself imply exclusion once MG-aware response freedom is included: the phenomenological refit reaches χ^2 comparable to or better than the Planck-reference model.

Third, if MG truth holds while early-universe compression is interpreted under GR assumptions, inferred H_0 can be biased high by order $+2$ to $+5$ km s^{-1} Mpc^{-1} relative to posterior truth, and by up to $\sim +7$ km s^{-1} Mpc^{-1} relative to the recalibrated Planck-like anchor median.

Within this study scope, the largest systematic lever is not only late-time transfer, but also model-assumption bias in early-universe inference compression.

REPRODUCIBILITY

Core scripts used in this follow-up are:

- `scripts/run_planck_global_mg_refit_multistart.py`
- `scripts/rebase_bias_transfer_sweep_to_planck_ref.py`
- `scripts/run_hubble_tension_final_relief_posterior.py`
- `scripts/run_hubble_tension_mg_forecast_robustness_grid.py`
- `scripts/run_joint_transfer_bias_fit.py`
- `scripts/run_hubble_tension_cmb_forecast.py`
- `scripts/run_hubble_tension_mg_lensing_refit.py`
- `scripts/run_hubble_tension_early_universe_bias.py`

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DATA AVAILABILITY AND DOIS

The follow-up uses posterior products from the O3 anomaly pipeline and public cosmology datasets. Data provenance and DOIs are:

- O3 modified-gravity tension anomaly repository (Zenodo): DOI 10.5281/zenodo.18585598.
- O3 search-sensitivity injection data used in upstream calibration (Zenodo): DOI 10.5281/zenodo.7890437.
- GWTC-3 catalog paper: DOI 10.1103/PhysRevX.13.041039.
- Pantheon+ cosmology constraints: DOI 10.3847/1538-4357/ac8e04.
- SH0ES local-H_0 reference: DOI 10.3847/2041-8213/ac5c5b.
- SDSS DR12 BOSS consensus BAO (source of `sdss_DR12Consensus_bao.dat`): DOI 10.1093/mnras/stx721.
- eBOSS DR16 cosmological compilation (source class for `sdss_DR16_LRG_BAO_DMDH.dat`): DOI 10.1103/PhysRevD.103.083533.
- DESI 2024 BAO cosmological constraints (source class for `desi_2024_gaussian_bao_ALL_GCcomb_mean.txt`): DOI 10.1088/1475-7516/2025/02/021.
- Cosmic-chronometer compilation components used in `Hz_BC03_all.dat`: DOIs 10.1088/1475-7516/2012/08/006, 10.1103/PhysRevD.71.123001, and 10.1088/1475-7516/2010/02/008.
- Planck 2018 cosmological-parameter and lensing references: DOIs 10.1051/0004-6361/201833910 and 10.1051/0004-6361/201833886.

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