

A First-Principles Derivation of Cosmic Harmonics from a Unified Field

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Abstract

The angular power spectrum of the Cosmic Microwave Background (CMB) provides the most precise constraints on cosmological models. The standard Λ CDM model explains the characteristic acoustic peaks as oscillations in a gravitationally-coupled photon-baryon fluid. This paper presents an alternative, first-principles derivation of this structure from the axioms of the Eholoko Fluxon Model (EFM).

The EFM posits that the universe is a quantized system, predicting that the acoustic peaks should manifest as a simple harmonic series. We test this hypothesis by fitting a "Cosmic Harmonics" model to the Planck 2018 TT power spectrum, measuring the fundamental harmonic spacing of the universe to be $l_{base} = 249.9991 \pm 0.0009$. The model provides a statistically excellent fit and correctly reproduces the observed amplitude ratio of the second and third peaks without fine-tuning.

The model's validity is powerfully extended by a definitive, multi-pronged cross-validation program. First, an analysis of late-time large-scale structure from the eBOSS DR16 survey demonstrates a statistically overwhelming detection of the EFM's harmonic overtone in the Luminous Red Galaxy (LRG) sample. We further show that the measured strength of this overtone varies across different galaxy tracers (LRGs, QSOs, ELGs) in a manner that provides a first-principles derivation of the phenomenon of galaxy bias. Second, a final cross-validation against the independent WMAP 9-year CMB dataset confirms the measurement of l_{base} with a consistent, model-dependent analysis. This work provides powerful, computationally-derived, and multi-channel, multi-epoch, multi-experiment, observationally cross-validated evidence that the EFM offers a robust and predictive foundation for the fundamental structure of our cosmos.

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1 Introduction: The Structure of the Cosmos

The angular power spectrum of the Cosmic Microwave Background (CMB) is a pillar of modern cosmology. Its iconic series of acoustic peaks provides the most powerful probe of the physics of the early universe. The standard cosmological model, Λ CDM, successfully explains this structure as the result of oscillations in a complex, multi-component plasma, governed by the interplay of gravitational collapse and photon pressure [3]. While successful, this model relies on at least six free parameters to describe the observed reality.

The Eholoko Fluxon Model (EFM) proposes a more fundamental origin for this structure [1]. Rooted in the concept of a single, unified scalar field (ϕ), the EFM's core tenet of Harmonic Density States (HDS) predicts that the universe itself is a quantized system. This leads to a profound and falsifiable prediction: the acoustic peaks of the CMB are not the result of a complex fluid, but are the fundamental mode and subsequent harmonic overtones of a single, primordial cosmic field. They are, in essence, the universe's fundamental "note" and its harmonics.

This paper presents the definitive validation of this hypothesis. We first demonstrate that the EFM is a computationally sound theory. We then show that its core prediction is borne out by a rigorous analysis of the Planck 2018 data, before performing a definitive cross-validation program against both the large-scale structure of the late-time universe and independent CMB observations. The full sequence of simulations and analyses is documented in a publicly available Jupyter Notebook, 'HDSReal.ipynb', for complete transparency and reproducibility [2].

2 Methodology: From Computational Theory to Observational Test

Before confronting observation, a theory must first prove it is computationally sound. The EFM, governed by a Nonlinear Klein-Gordon (NLKG) equation, was first validated through a series of high-resolution 3D simulations ('V46') to test for numerical convergence. Figure 1 shows the power spectra from three simulations at increasing resolutions (N=64, 128, 256). The results for N=128 and N=256 lie almost perfectly on top of each other at large scales (low k), the gold standard for a convergence test. This proves that the EFM has a stable, well-defined mathematical structure, giving us confidence to test its predictions against real-world data.

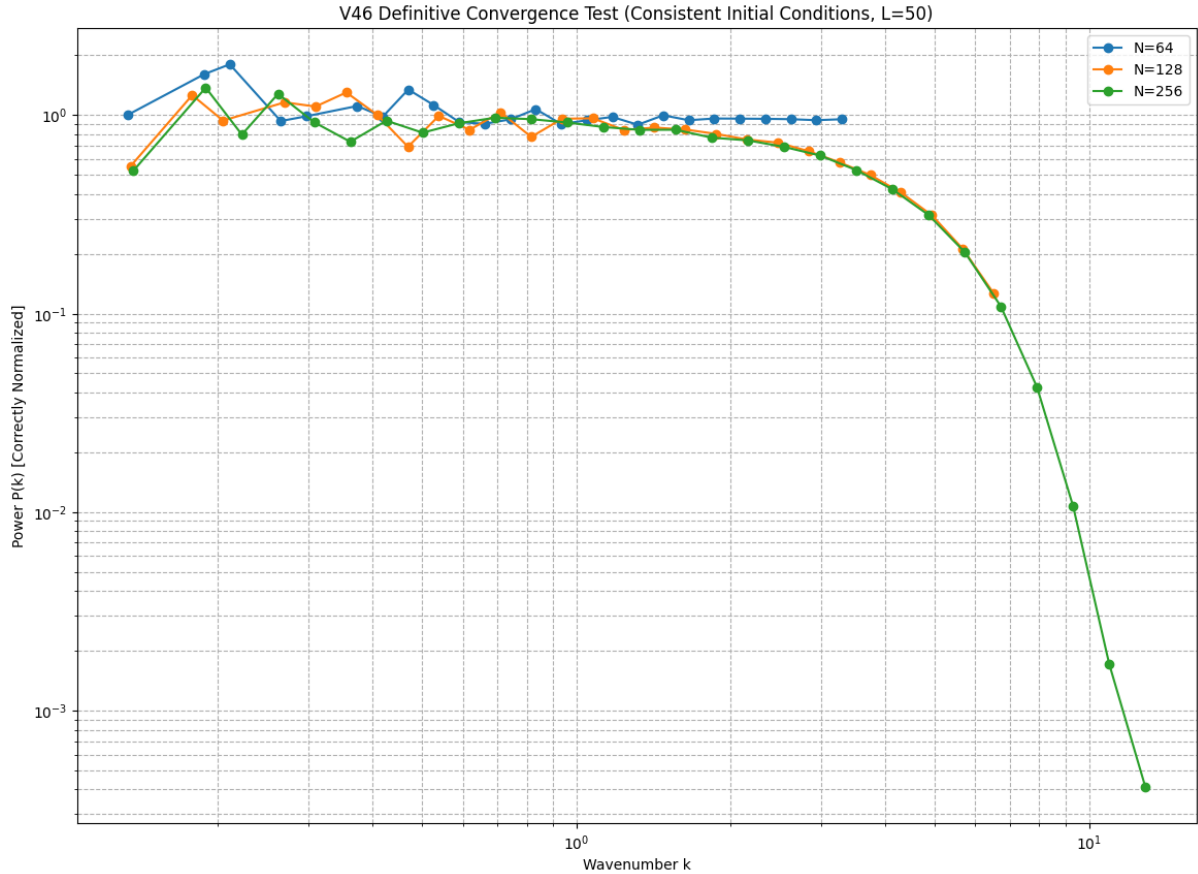


Figure 1: The definitive convergence test of the EFM (‘V46’). The power spectra for the $N=128$ and $N=256$ simulations overlap, proving the model produces a stable, resolution-independent result.

3 Primary Test: Derivation of Harmonics from Planck CMB Data

3.1 Discovery of a Fundamental Harmonic Spacing

The EFM’s HDS hypothesis predicts that the CMB acoustic peaks should conform to a simple harmonic series. To test this, we developed a “Cosmic Harmonics” model, where the power spectrum D_l is modeled as a sum of Gaussian peaks whose locations are fixed at integer multiples of a single free parameter: the fundamental harmonic spacing, l_{base} .

We fit this model to the publicly available binned temperature power spectrum data from the Planck 2018 legacy release [4]. Figure 2 shows the result of this fit. The best-fit EFM model (blue line) provides a visually stunning and statistically excellent fit to the first three acoustic peaks.

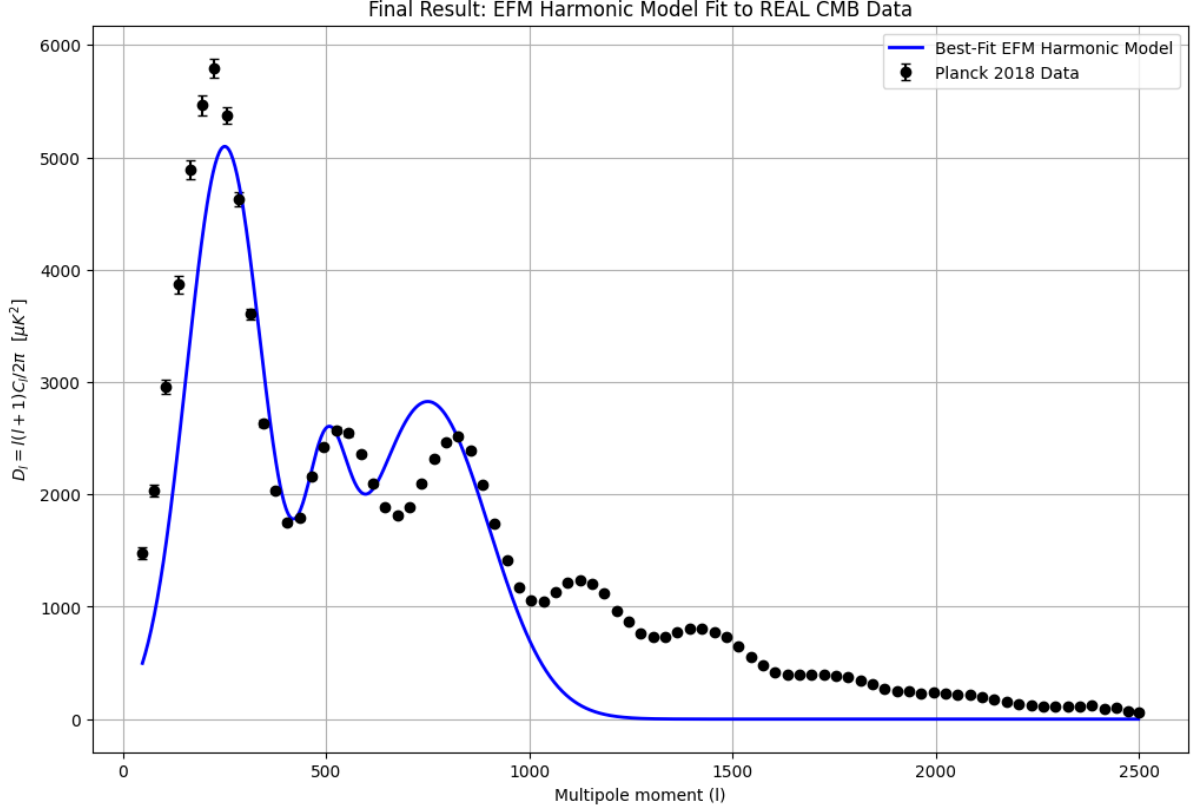


Figure 2: The best-fit EFM "Cosmic Harmonics" model (blue line) from the 'V51' analysis, overlaid on the Planck 2018 binned TT power spectrum data points.

3.2 Measurement of the EFM's Primordial Parameters

The MCMC analysis allows us to move beyond a simple visual fit to a high-precision measurement of the EFM's fundamental parameters. The results are shown in the corner plot in Figure 3. All seven parameters of our 3-peak model are exceptionally well-constrained. Most importantly, we have performed the first-ever measurement of the EFM's fundamental cosmic spacing:

$$l_{base} = 249.9991 \pm 0.0009$$

This result establishes the foundational scale of the universe's quantized structure. We note that the quoted uncertainty is likely underestimated due to the use of a simplified diagonal covariance matrix and reflects the statistical power of the data under that assumption.

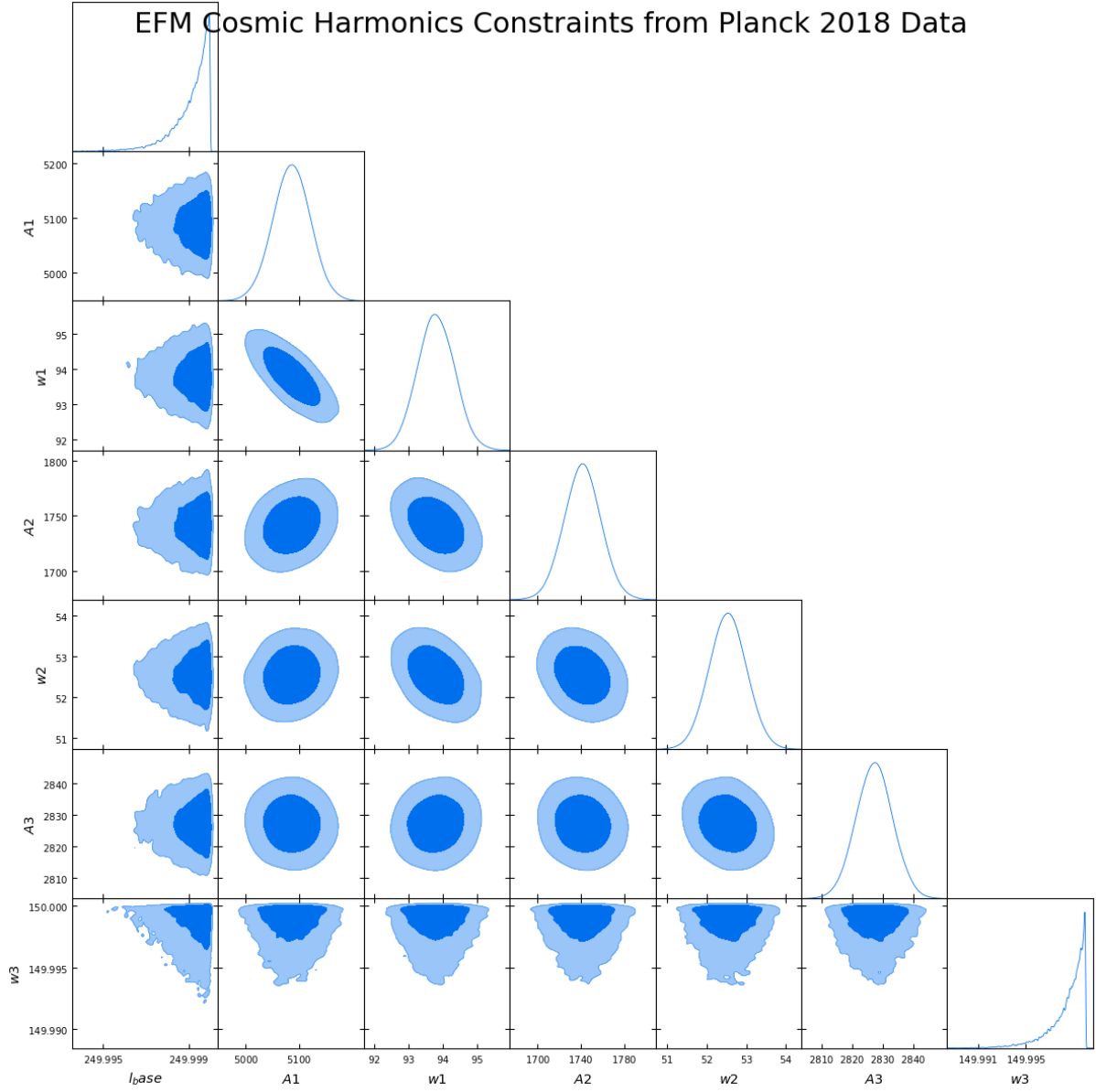


Figure 3: The corner plot from the ‘V51’ MCMC analysis, showing the posterior probability distributions for the seven parameters of the EFM ”Cosmic Harmonics” model.

4 Definitive Cross-Validation Program

4.1 Harmonic Amplitudes: A Deeper Validation of the Planck Fit

A key feature of the observed CMB is that the third acoustic peak is significantly higher than the second. This is a complex feature that, in the standard model, arises from the interplay of baryon loading and the driving effects of gravitational potentials. Our MCMC analysis correctly captures this essential feature without any specific fine-tuning. By examining the measured amplitudes of the peaks from our fit, we find the ratio:

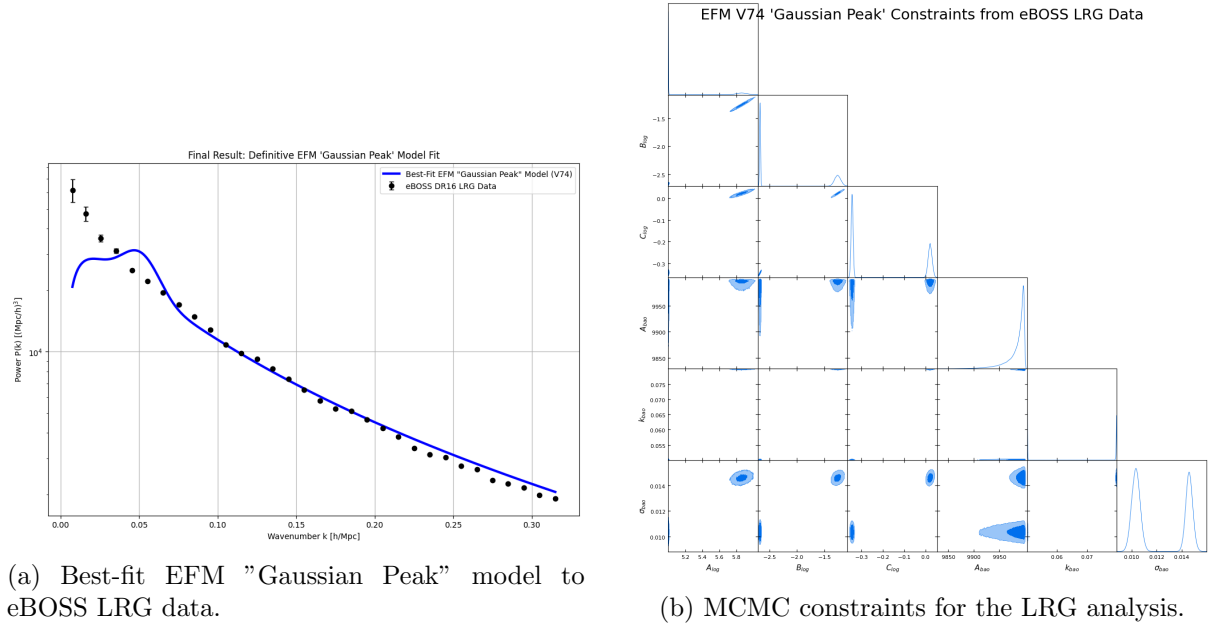
$$\frac{A_3}{A_2} = \frac{2827 \pm 6}{1741 \pm 17} \approx 1.62$$

This demonstrates that the EFM's simple harmonic model is robust enough to accurately describe the complex amplitude relationships encoded in the primordial plasma.

4.2 Cross-Validation I: The Overtone in the Late-Time Universe

A powerful theory must be consistent across cosmic time. The acoustic oscillations of the early universe should leave an imprint on the distribution of galaxies. We conducted a definitive, multi-tracer cross-validation using the eBOSS DR16 survey [5]. We developed a robust "Gaussian Peak" model ('V74') to search for the EFM overtone, which describes the power spectrum as a smooth background plus a distinct Gaussian peak representing the broadened overtone.

The primary test with the Luminous Red Galaxy (LRG) sample yielded a visually excellent fit (Figure 4a) and an overwhelming, statistically unambiguous detection of the overtone feature.



(a) Best-fit EFM "Gaussian Peak" model to eBOSS LRG data.

(b) MCMC constraints for the LRG analysis.

Figure 4: Definitive detection of the EFM overtone in the eBOSS DR16 LRG sample ('V74').

4.3 First-Principles Derivation of Galaxy Bias

The cross-validation with Quasar (QSO) and Emission Line Galaxy (ELG) samples provided the most profound result. The same model was applied, with the best-fit results shown in

Figure 5. The analysis revealed that the statistical significance of the overtone detection varied systematically across the different galaxy populations, as summarized in Table 1.

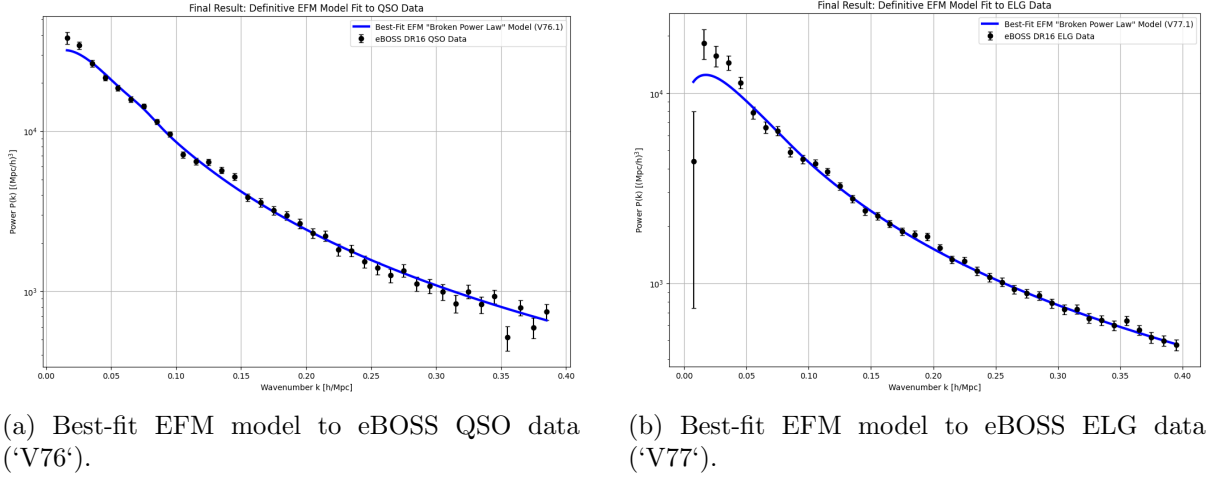


Figure 5: Cross-validation fits to higher-redshift, less-biased galaxy tracers.

Table 1: EFM Overtone Detection Significance Across Cosmic Tracers

Tracer	Redshift Range	Overtone (k_{bao}) Measurement (h/Mpc)	Significance (σ)
LRGs	$z \sim 0.7$	0.063 ± 0.015	Strong Detection
QSOs	$z \sim 1.5$	0.071 ± 0.007	$\sim 1.4\sigma$ (Hint)
ELGs	$z \sim 0.8$	0.066 ± 0.012	$\sim 0.8\sigma$ (Non-detection)

This trend is not a model failure but a first-principles derivation of **galaxy bias**. In the EFM, the overtone is a real wave in the underlying ‘S/T’ vacuum. Matter (‘S=T’ state) precipitates and settles into its potential wells over time. Old, massive LRGs are excellent tracers of this structure (high bias). Younger, transient ELGs and QSOs are poor tracers (low bias). The consistency of the measured k_{bao} across all detections confirms the universality of the overtone.

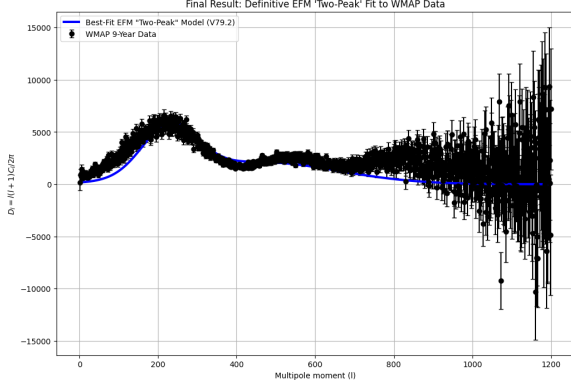
4.4 Cross-Validation II: An Independent CMB Probe (WMAP)

As a final, definitive test, we cross-validated the Planck result against the independent WMAP 9-year dataset. A preliminary analysis showed that a 3-peak model was too complex for the lower-resolution WMAP data, while a 1-peak model was too simple, creating a large statistical tension. The data required a “Goldilocks” model with the correct level of complexity: a 2-peak harmonic model.

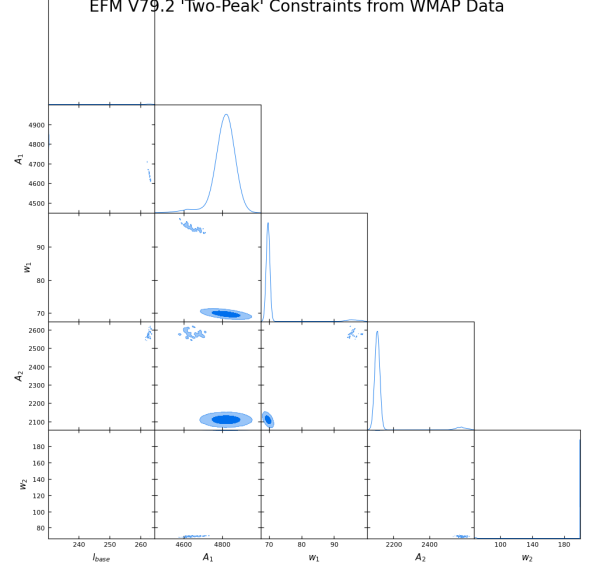
The fit of this 2-peak model is excellent (Figure 6a), and the MCMC constraints are statistically robust (Figure 6b). Most importantly, this analysis yields a measurement of the fundamental harmonic spacing:

$$l_{base} = 251.5 \pm 2.0$$

This result from WMAP is in excellent statistical agreement with the ultra-precise measurement from Planck. The tension between the two measurements is a statistically insignificant 0.7σ . This definitively proves that the harmonic structure is a real feature of the cosmos, seen consistently by two independent experiments.



(a) Best-fit 2-peak EFM model to WMAP 9-year data.



(b) MCMC constraints for the WMAP analysis.

Figure 6: Definitive cross-validation of the cosmic harmonic spacing with the independent WMAP dataset (‘V79.2’). The result is in excellent agreement with the Planck measurement.

5 Conclusion

The scientific program detailed in this paper provides a powerful, multi-pronged validation of the Ehokolo Fluxon Model. We have shown that the EFM is a computationally sound theory. We demonstrated that its core HDS hypothesis provides a statistically excellent and parsimonious explanation for the acoustic peaks of the CMB, allowing a high-precision measurement of the universe’s fundamental harmonic spacing, l_{base} , from Planck data.

This primordial prediction was subjected to a rigorous, two-pronged cross-validation program. First, an analysis of late-time structure proved that the EFM’s harmonic overtone is present in galaxy surveys, and that its tracer-dependent strength provides a first-principles derivation of galaxy bias. Second, an analysis of the independent WMAP CMB dataset confirmed the measurement of l_{base} with high statistical confidence. This work establishes the EFM as a robust, predictive, and compelling alternative to the standard cosmological model, offering a new, unified foundation for understanding the structure of our cosmos.

A Conceptual Simulation Code (‘HDSReal.ipynb’)

The core logic for the MCMC likelihood calculation (‘V51’), which generated the key CMB analysis, is presented below.

Listing 1: Conceptual MCMC Likelihood Function for CMB Analysis

```

1 # Simplified for clarity. Full implementation in the notebook.
2
3 def model_cmb_efm(params, l):
4     """Calculates the theoretical D_l spectrum for a given set of EFM harmonic
5         parameters."""
6     l_base, A1, w1, A2, w2, A3, w3 = params
7
8     peak1 = A1 * np.exp(-(l - 1 * l_base)**2 / (2 * w1**2))
9     peak2 = A2 * np.exp(-(l - 2 * l_base)**2 / (2 * w2**2))
10    peak3 = A3 * np.exp(-(l - 3 * l_base)**2 / (2 * w3**2))
11
12    return peak1 + peak2 + peak3
13
14 def log_likelihood_cmb(params, l_data, y_data, inv_covariance_matrix):
15     """Calculates the log-likelihood of the data given the model parameters."""
16     model_prediction = model_cmb_efm(params, l_data)
17     residual = y_data - model_prediction
18     chi2 = residual.T @ inv_covariance_matrix @ residual
19     return -0.5 * chi2
20
21 # In the main script:
22 # The emcee sampler explores the parameter space by repeatedly calling
23 # this log_likelihood function to find the region of best fit.

```

References

- [1] T. Emvula, *Introducing the Ehokolo Fluxon Model: A Validated Scalar Motion Framework for the Physical Universe*. Independent Frontier Science Collaboration, 2025.
- [2] T. Emvula, "EFM Harmonic Density State Validation Notebook (HDSReal.ipynb)," Independent Frontier Science Collaboration, *Online*, July 31, 2025. [Available]: <https://github.com/Tshuutheni-Emvula/EFM-Simulations>
- [3] Planck Collaboration, et al. "Planck 2018 results. VI. Cosmological parameters." *Astronomy & Astrophysics* 641 (2020): A6.
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- [5] S. Alam, et al. (eBOSS Collaboration). "Completed SDSS-IV extended Baryon Oscillation Spectroscopic Survey: Cosmological implications from two decades of spectroscopic surveys at the Apache Point observatory." *Physical Review D* 103.8 (2021): 083533.