The Prime Scalar Field

Cross-Dimensional Harmonic and Scalar Information in the Prime Sequence

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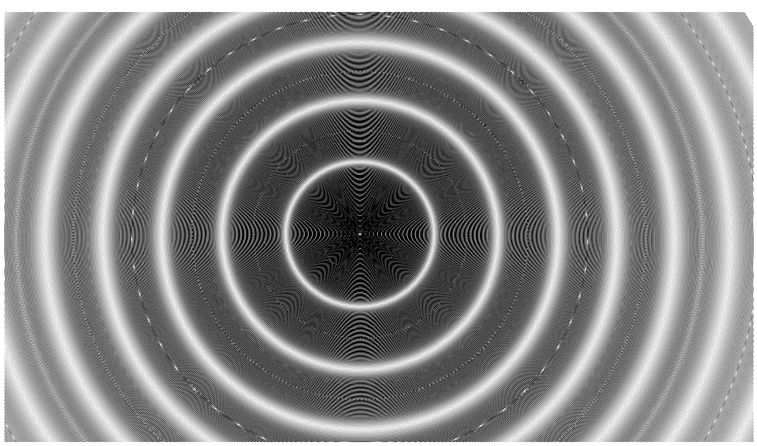
Abstract

Prime numbers, long regarded as pseudo-random, are shown here to encode a coherent cross-dimensional wave field. By mapping prime gaps into oscillatory forms, we demonstrate that patterns emerge naturally as a result of compression and expansion in prime spacings. These patterns work as information that scales infinitely, but also can transcend dimensionality, and can be transferable between 0D, 1D, 2D, or 3D information. When many prime-driven oscillations are superposed, these structures appear as interference patterns, which serve as a clear visualization of the underlying gap-encoded information. Building upon this, the propagation of the oscillations to form standing wave fields can additionally encode another carrier of limitless information. Fourier analysis of the prime sequence reveals harmonic peaks, while analysis of spherical and planar mappings display recurring nodal structures across scales up to 10^8 primes. We show that primes encode an unlimited, scalable wave field of discrete information, independent of their abstract definition as numbers. This suggests that while primes originate as a one-dimensional numerical sequence, the information they encode inherently holds data only translated in a 3D environment— fully representable as volumetric data within the wave field itself. The primes therefore act not only as generators of oscillatory forms, but as complete 3D information carriers embedded within a 0D or 1D domain.



1 Introduction

Prime numbers occupy a central role in mathematics, appearing pseudo-random yet essential to the structure of integers. Traditional approaches—the Prime Number Theorem, the Riemann Hypothesis, and analytic studies of the zeta function—have emphasized distributional properties and asymptotic density. Here, we propose a different interpretation: that primes act as encoders of an underlying wave field that can encode limitless discrete information.

The patterns are not caused by an external field, but are generated intrinsically by the prime gaps themselves. Regions of compression (small gaps) and expansion (large gaps) create oscillatory structures that, when visualized as waves, reveal a coherent field. Superposition of these oscillations produces interference-like patterns, which serve as a window into the structure already encoded by the prime sequence.

Here we show that primes, when interpreted as a wave field, exhibit two key structural features:

1. **Scalar recurrence** — nodal patterns repeat across scales, from small prime sets to hundreds of millions.

2. **Multi-resolution layering** — different oscillatory structures coexist simultaneously at different resolutions, with coarse nodal domains and fine-scale oscillations present in the same field.

Together, these properties reveal that primes encode not just a repeating structure, but a richly layered field of information analogous to harmonic overtones in acoustics or multi-scale decompositions in signal processing.

2 Methods

2.1 Prime gaps as oscillatory drivers

Let $\{p_n\}$ be the ordered sequence of primes. Define the prime gaps as

$$g_n = p_{n+1} - p_n.$$

We interpret each gap g_n as corresponding to a wavelength λ_n or frequency f_n:

$$f_n = \frac{1}{g_n}, \qquad \lambda_n = g_n.$$

This mapping produces a collection of oscillatory modes whose relative spacing is dictated directly by the distribution of prime gaps.

2.2 Interference as visualization

Although the underlying driver is the gap structure, the natural mathematical representation is a superposition of oscillations. The wave field $F(x)$ may be written schematically as

$$F(x) = \sum_n A_n \cos\left(\frac{2\pi}{g_n} x + \phi_n\right),$$

with amplitudes A_n and phases ϕ_n. The nodal and antinodal regions visible in simulations correspond to interference between these modes, but fundamentally reflect the expansion/compression encoded in the gaps.

2.3 Dimensional encodings

The prime-driven field can be represented in multiple dimensional forms:

- **0D:** primes as discrete pulses or information
- **1D:** single wave information - integers in sequence
- **2D:** prime planar interference maps encoding 3D wave and nodal information.
- **3D:** Interference density as amplitudes - standing-wave spherical fields.

2.4 Spherical mapping and Legendre forms

The natural geometry for a global prime wave field is the sphere, which enforces isotropy and closure. This connects directly to spherical harmonics $Y_\ell^m(\theta, \phi)$, which are eigenfunctions of the Laplacian on the sphere:

$$\nabla^2 Y_\ell^m + \ell(\ell+1) Y_\ell^m = 0.$$

In particular, nodal structures seen in the spherical prime wavefield resemble the nodal lattices of $P_\ell(\cos\theta)$, the Legendre polynomials, which form the angular part of the harmonics. This suggests that the prime field can be decomposed into a weighted basis of spherical harmonic modes. However, this does not rule out other closed geometries, such as toroidal or ellipsoidal embeddings, which may encode similar periodic boundary conditions. Propagated waveforms require outer boundaries—these may be either linear (box-like) or circular, with the latter more naturally matching the isotropic symmetry of the observed nodal structures.

2.5 Fourier analysis of the prime sequence

To quantify the harmonic structure, we analyze the prime indicator sequence

$$\chi(n) = \begin{cases} 1, & \text{if } n \text{ is prime} \\ 0, & \text{otherwise,} \end{cases}$$

and its Fourier transform

$$\hat{\chi}(k) = \sum_{n=1}^{N} \chi(n)\, e^{-2\pi i k n/N}.$$

FFT spectra consistently show sharp peaks at recurring frequencies, revealing harmonic order within the prime distribution.

2.6 Periodicity and angular closure analysis

A further analysis was conducted on the prime-derived coordinates (X', Y') and Euclidean step sequence $D[n]$. Autocorrelation, power spectra, and phase-folding analyses revealed a recurring base period near $P \approx 2.34$, repeating across thousands of samples. When data were folded on this supercycle, discrete phase minima aligned coherently across multiple cycles, confirming stable internal periodicity.

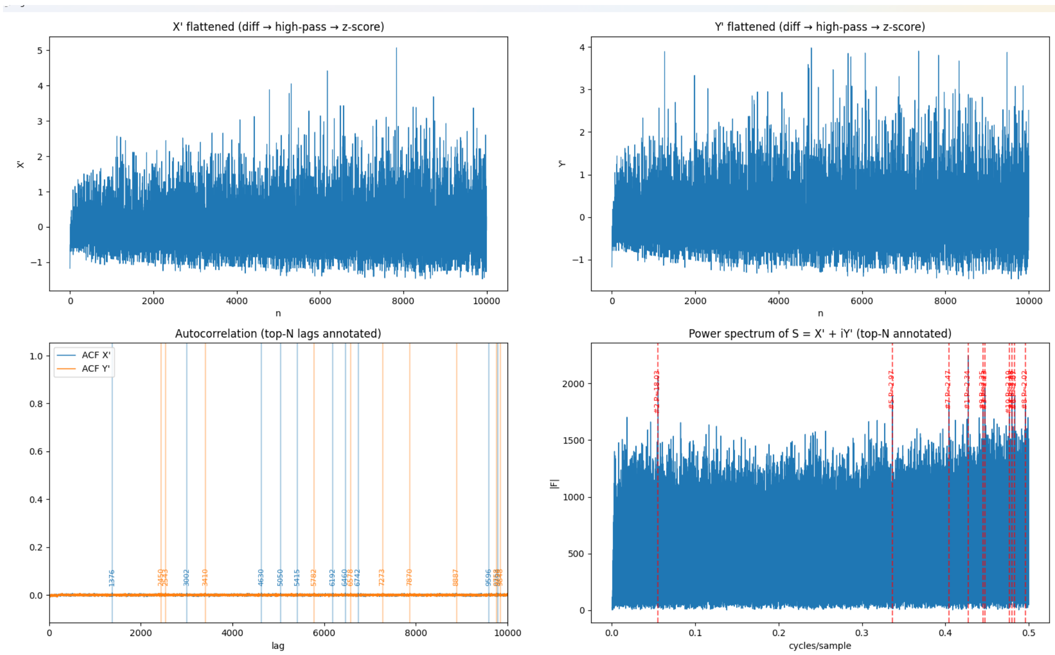


Figure 1: Autocorrelation and FFT spectra of detrended prime triplet data showing distinct periodic peaks (P ≈ 2.34). These peaks indicate stable recurring frequencies intrinsic to the prime field.

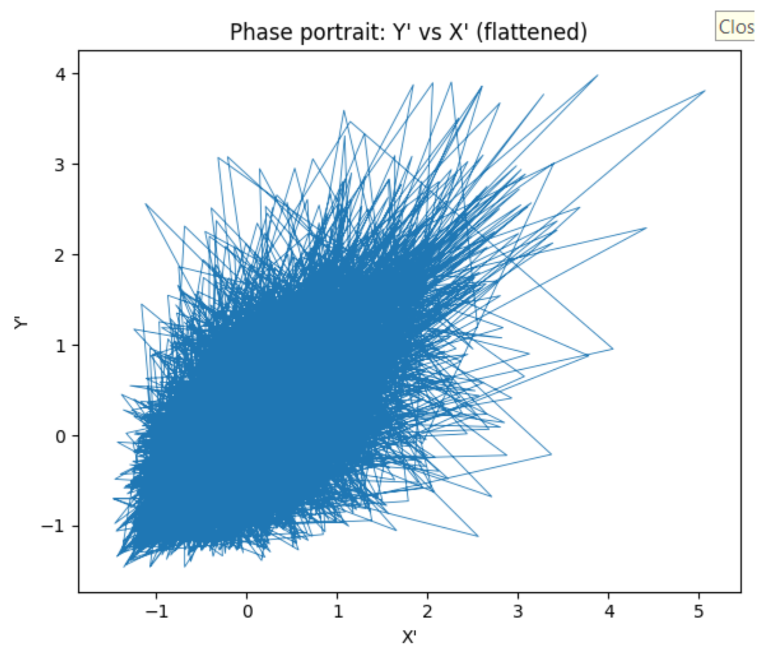


Figure 2: Phase-folded prime triplet data (P ≈ 2.34) showing recurrent discrete phase minima across cycles. Phase quantization supports the view that the prime field favors closed angular domains.

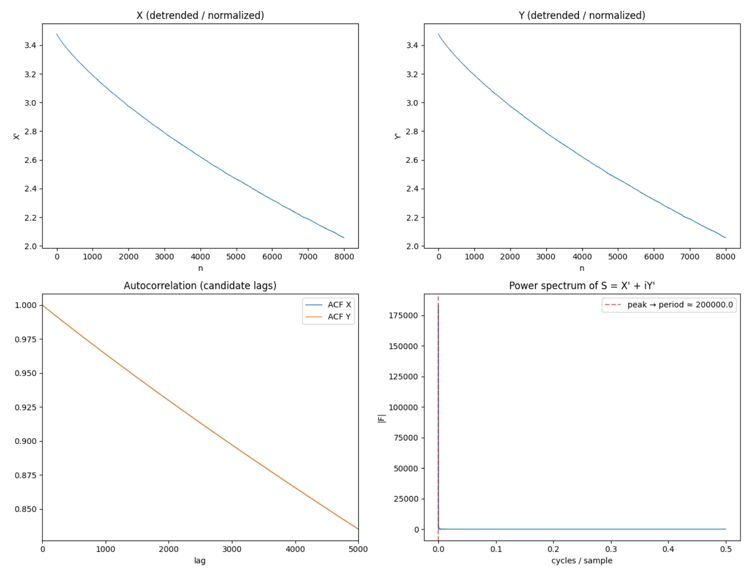


Figure 3: Phase portrait of Y' vs X' showing coherent elliptical clustering rather than random scatter, indicating cross-axis phase locking and isotropy consistent with circular or spherical embedding.

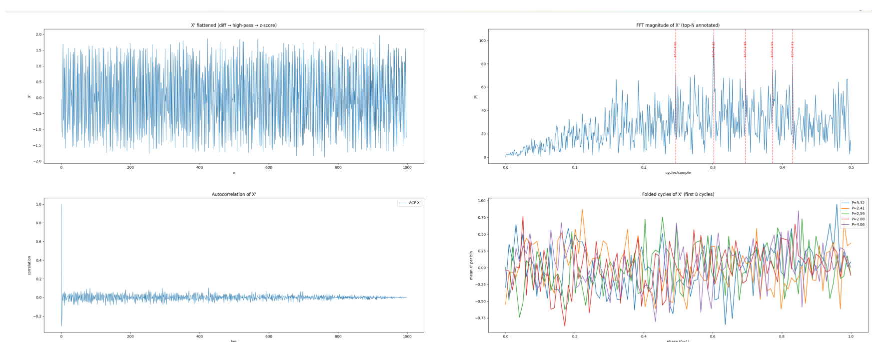


Figure 4: Polar projection of the prime field using supercycle phase as angular coordinate and amplitude radius $= |X', Y'|$. The isotropic closure suggests spherical or toroidal field mapping.

These combined results imply that the prime field exhibits inherent angular closure and isotropy, aligning naturally with circular or spherical boundary conditions. While not conclusive, these findings support the interpretation that primes encode a field optimized for closed geometries rather than open linear domains.

3 Results

3.1 FFT harmonic peaks

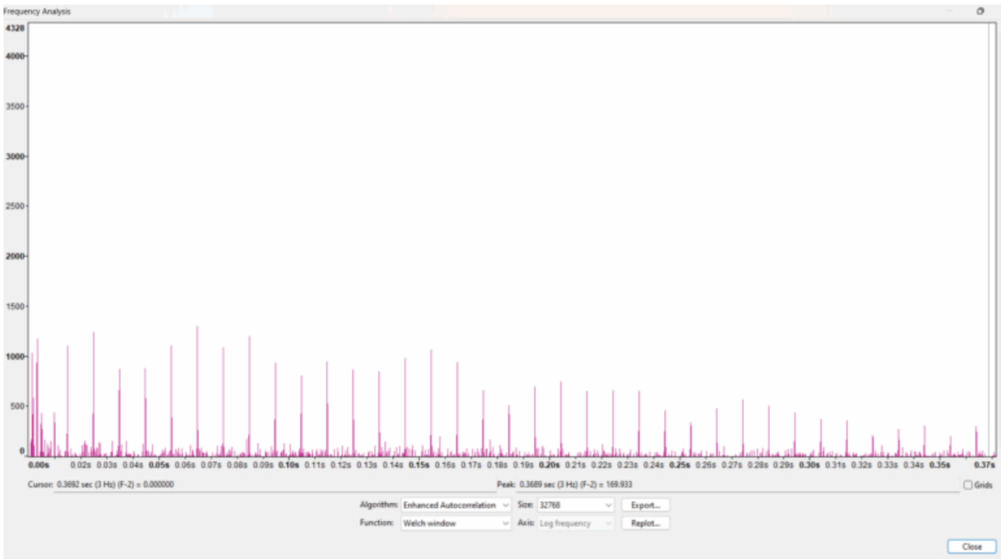


Figure 5: FFT spectrum of the prime sequence showing harmonic-like spikes.

3.2 2D Interference

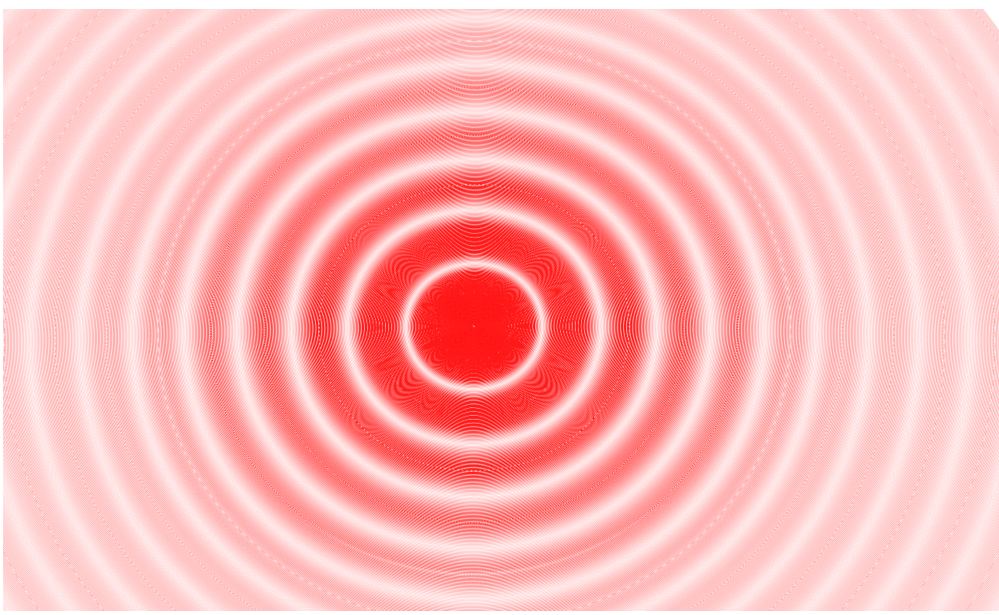


Figure 6: Prime puddle: 2D interference field from distributed stacks within the same boundary. Nodes and concentric structures emerge, reflecting prime gap expansion and compression.

3.3 Scalar recurrence and layered resolutions

The prime wave field exhibits not only recurrence of patterns across increasing scales, but also simultaneous layering of structures at different resolutions. At coarse resolution, broad nodal zones and low-frequency oscillations dominate; at finer resolution, high-frequency oscillations and small-scale nodes emerge within the same field. This demonstrates that the prime wave field is inherently multi-scale: different layers of information coexist, rather than replacing one another.

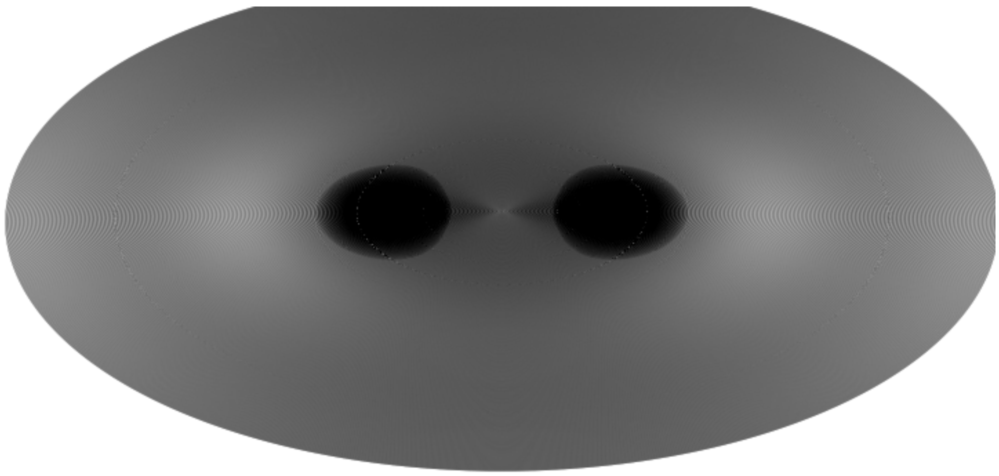


Figure 7: Filtered low-frequency pass of the prime wave field. Large-scale structure is revealed, while most finer oscillations are suppressed.

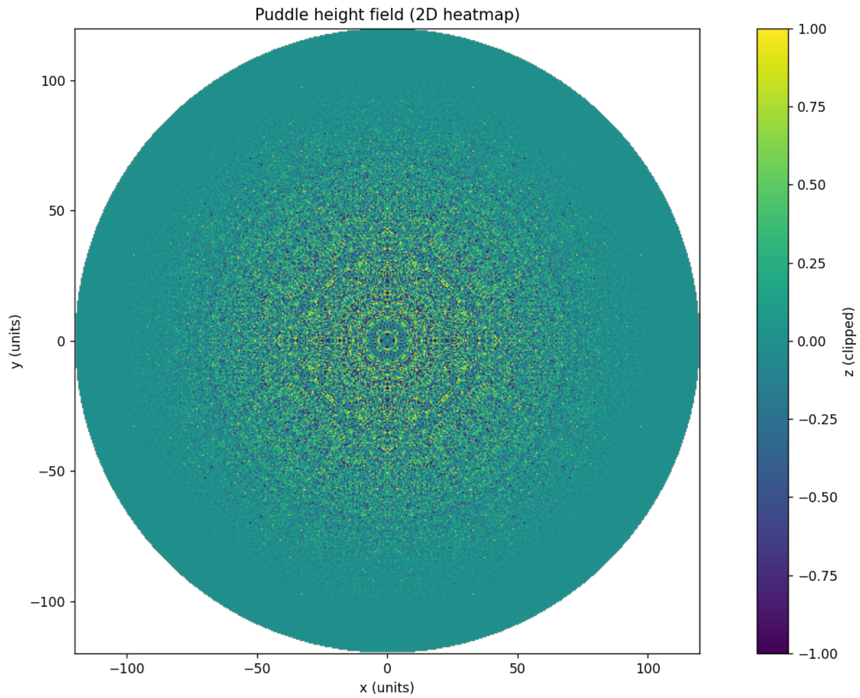


Figure 8: Density heatmap showing simultaneous multi-scale layering of nodes and patterns. Different resolutions coexist within the same field.

3.4 Low-frequency nodes and standing waves

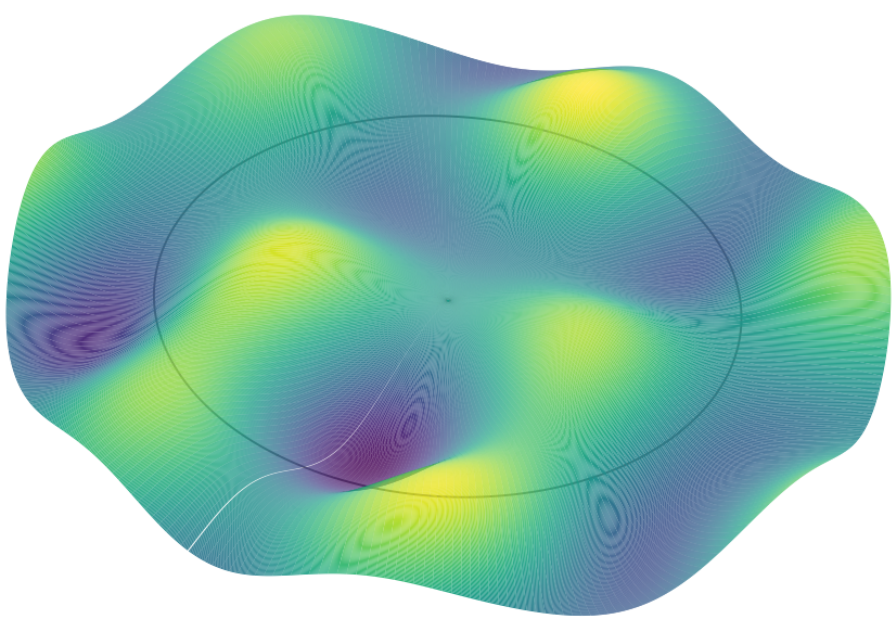


Figure 9: Low-frequency standing-wave view of a prime field propagation with low pass filtering. Distinct nodes emerge, repeating at different scales, highlighting scalar and fractal-like recurrence.

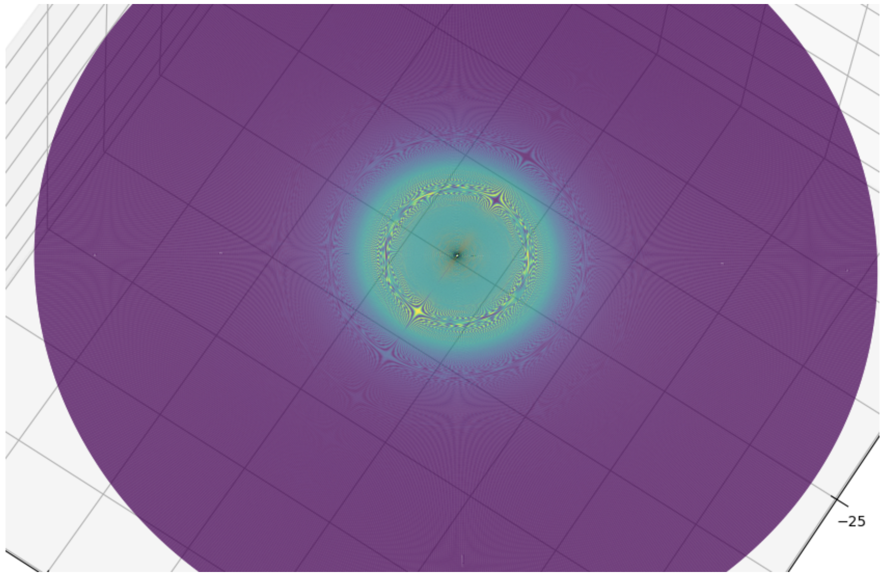


Figure 10: Nodes in the prime wave field. These nodal intersections provide discrete anchoring points across scales, revealing the self-similarity of the prime field.

3.5 Spherical wave field embeddings

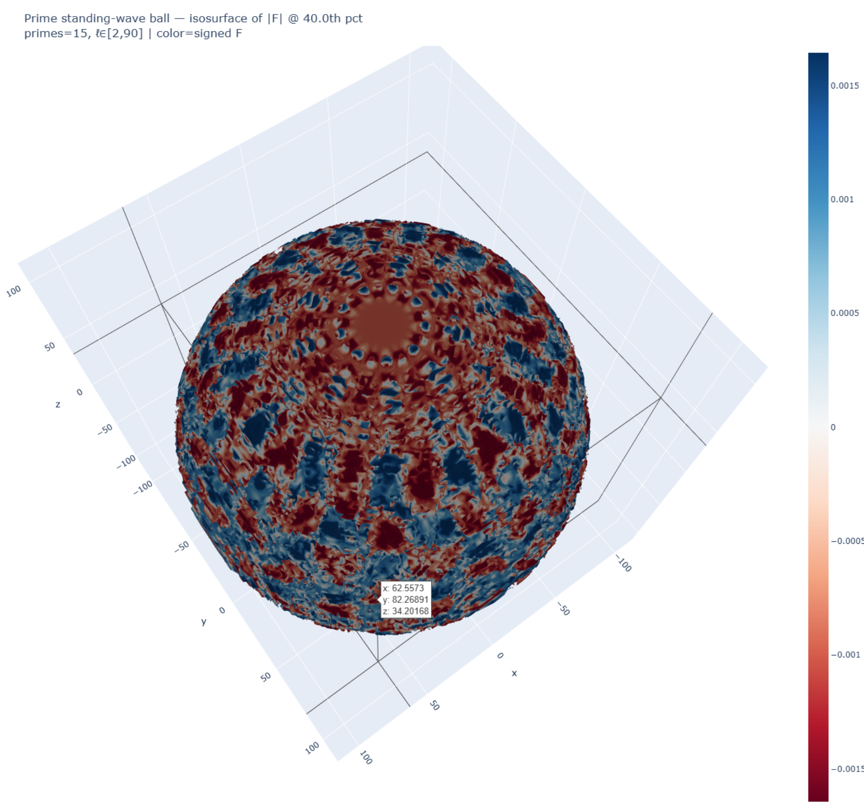


Figure 11: Prime wave field mapped to a spherical shell. Isosurface reveals nodal lattices consistent with spherical harmonics and Legendre forms.

3.6 Discrete boundary encoding

Although within the same boundary, Prime Waves and their individual frequencies will never align. This creates an infinite discrete informational reservoir. There are two exceptions to this in the field, where the boundaries meet and halfway through the sequence, always opposite polarity; where oscillations align to all-positive or all-negative values. These themselves work as discrete units of information, given there is only one of each. Such boundaries act as markers, emphasizing that primes encode information not only in oscillatory overlap but in their discrete constraints.

4 Discussion

The results support a dual interpretation: prime gaps as the generator of oscillatory modes, and interference as the visualization of those modes. This makes the prime wavefield both mathematically grounded and intuitively accessible.

Scalar recurrence—the persistence of nodal forms at increasing scales—suggests fractal-like behavior and supports the interpretation of primes as an endless information reservoir.

On top of the information, this field acts as a platform for cross dimensionality, from a natural number set; 0 dimensional. This set can be interpreted as 2D or 3D information, each bolstering endless recursive information.

The parallels with physics are striking: spherical harmonics, standing waves, scalar fields, and harmonic resonances all emerge naturally. Yet, primes provide these structures intrinsically, without requiring an external field.

4.1 Multi-resolution layering

An important feature of the prime field is that its structure is not limited to a single repeating scale. Instead, it supports multiple layers of resolution simultaneously. This is analogous to harmonic overtones in acoustics, or to wavelet decompositions in signal processing, where both low- and high-frequency information coexist in a single field. In the prime wave field, large nodal domains provide global coherence, while fine-scale oscillations encode local detail. This layered encoding highlights the capacity of the prime set to function as a multi-resolution information substrate.

5 Conclusion

Prime numbers encode a wave field, manifested through oscillations derived from prime gaps and revealed through interference. FFT analysis shows harmonic peaks, periodic analyses reveal quantized angular cycles, and field plots demonstrate nodal recurrence. Spherical and polar embeddings align with spherical harmonics, suggesting primes naturally encode closed-field structures. This evidence indicates that primes are not random scatterings, but structured encoders of a harmonic, scalar wave field.

A Equations and Methods

A.1 Fourier Transform of Primes

$$\hat{\chi}(k) = \sum_{n=1}^{N} \chi(n)\, e^{-2\pi i k n/N}.$$

A.2 Gap → Frequency Mapping

$$f_n = \frac{1}{g_n}, \qquad g_n = p_{n+1} - p_n.$$

A.3 Spherical Harmonic Basis

Solutions to the Laplacian on the sphere:

$$\nabla^2 Y_\ell^m(\theta, \phi) + \ell(\ell+1) Y_\ell^m(\theta, \phi) = 0.$$

Explicitly,

$$Y_\ell^m(\theta, \phi) = N\, P_\ell^m(\cos\theta)\, e^{im\phi},$$

where P_ℓ^m are the associated Legendre functions and N is a normalization constant.

A.4 Legendre Connection

The nodal lines in spherical prime fields correspond to zeros of $P_\ell(\cos\theta)$:

$$P_\ell(\cos\theta) = 0,$$

providing a natural mathematical description of the observed shell patterns.