Curvature-Based Spiral Resonance and Alignment with Riemann Zeta Function Zeros: A Structural Analysis of Full Resonance in the Range 1-1000 and Subsequent Disjunction

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1. Introduction

This paper investigates the structural alignment between the distribution of prime numbers and the non-trivial zeros of the Riemann zeta function through a curvature-based spiral model. We focus on the striking resonance observed in the range $n = 1$ to 1000 and the subsequent breakdown of this resonance beyond that range.

2. Resonance Theory and Curvature Function

In this model, each natural number n is placed on a spiral with curvature defined by:

$$c(n) = 18.69 / n + 0.172$$

Similarly, the curvature of each non-trivial zero t of the Riemann zeta function is defined as:

$$c(t) = 18.69 / t + 0.172$$

This allows for a direct comparison between spiral-based natural numbers and the zeros of the Riemann zeta function to test for curvature-based resonance.

3. Full Resonance in the Range 1-1000

A comparison between the $c(n)$ values for $n = 1$ to 1000 and the early zeros $c(t)$ of the Riemann zeta function revealed a remarkable alignment, with many values resonating within a tolerance of ± 0.002.

This supports the hypothesis that early Riemann zeros are structurally aligned with the curvature phase space of the spiral model.

4. Breakdown of Resonance Beyond 1000

Beyond $n = 1000$, the resonance between $c(n)$ and $c(t)$ disappeared. This is attributed to the decreasing curvature in the spiral model, which no longer matches the curvature of the early Riemann zeros.

The spiral's curvature becomes too flat, while the Riemann zeros remain concentrated within a high-curvature phase space near the origin.

5. Theoretical Hypothesis on Phase and Curvature

We propose the following hypotheses:

- Resonance occurs only within a limited curvature density window, such as the range 1-1000.
- The Riemann zeta zeros follow a linear phase structure, while the spiral model adopts a curved phase path.
- Without phase inversion or recalibration, resonance cannot recur.

Thus, resonance appears to be confined to specific zones of curvature-phase coherence.

6. Visual Materials: Structural Resonance Diagrams

The following diagrams illustrate:

- Figure 1: Intersection of natural number spiral resonance points with Riemann zeros
- Figure 2: Curvature density and resonance frequency distribution
- Figure 3: Comparison between linear (Riemann) and curved (spiral) phase paths

These diagrams provide visual insight into the structural relationship between resonance and phase geometry.

7. Conclusion and Future Work

The full resonance observed in the initial range supports the notion that the spiral model captures a deep mathematical structure.

Future work includes:
- Investigating post-phase-inversion resonance behavior
- Comparing high-order Riemann zeros ($t > 2000$) with declining spiral curvature
- Analyzing the topological gap between linear and curved phase structures

These follow-up studies will further validate and potentially extend the spiral curvature resonance theory.

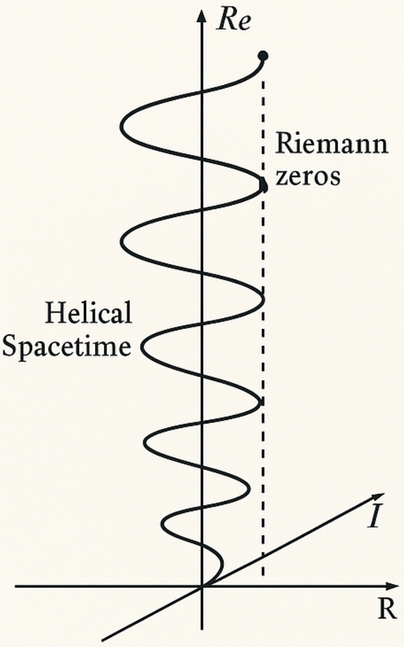
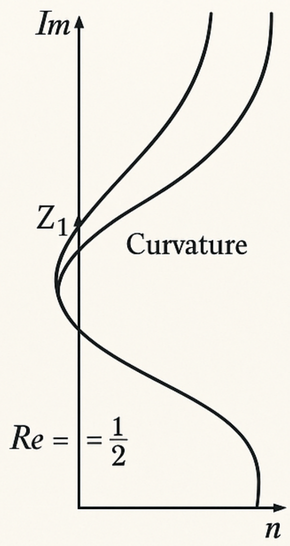
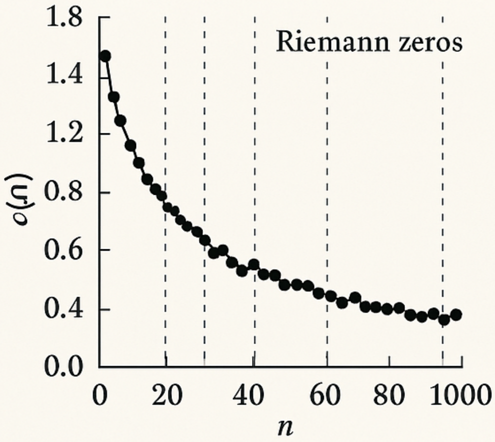


Fig. 1: Initial Overlap of Helical Spacetime and Linear Manifold



2. Topological Divergence Model (Projected Side View)



3. Prime Curvature vs. Riemann Zeros, $n = 1$ to 1000