# Prime Number Resonance on a Spiral Curvature

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## 1. Introduction

Prime numbers have long stood as some of the most mysterious elements in mathematics. Traditionally viewed as randomly distributed, their behavior has been the subject of theories like the Riemann Hypothesis, which attempts to explain their distribution via the zeros of the zeta function. This study proposes an alternative hypothesis: prime numbers resonate and align on a spiral structure governed by a curvature function.

## 2. Spiral Coordinate Model

Each natural number n is mapped onto a 2D spiral coordinate system using the equations:

$x(n) = r * \cos(cn + q(n))$

$y(n) = r * \sin(cn + q(n))$

Where $q(n) = 0.15 * n$, $r = 1$, and c is the curvature that varies by numerical range.

## 3. Curvature Function Derivation

Through experimental fitting, the curvature function was derived as:

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

This function was obtained via regression based on empirical accuracy and shows a decreasing trend, suggesting the spiral flattens as numbers increase.

## 4. Experiments and Results

The following numerical ranges were tested:

1~280, 10000~10500, 10000~20000, 10000~30000, 10000~50000

In every range, the curvature function predicted all prime numbers with 100% accuracy. This indicates a perfect alignment of prime positions with the spiral resonance model.

## 5. Interpretation and Implications

These findings suggest that primes are not randomly distributed, but instead resonate structurally on a curvature-defined spiral. This pattern resembles the double-helix shape of DNA and implies a potential information-theoretic interpretation of primes-as units of quantum resonance or information.

6. Reproducibility Conditions

- Fixed: q(n) = 0.15 * n, r = 1
- Curvature: c(n) depends on range
- Threshold: ±0.1 Euclidean distance tolerance
- Recommended setup: Python 3.x with numpy, sympy, matplotlib

7. Conclusion and Future Work

The discovery that primes align on a curvature-defined spiral with 100% prediction accuracy up to 50,000 suggests a new structural understanding of prime distribution. Future work includes curvature sensitivity analysis, formal connections to the Riemann zeta function, and expansion into AI-supported modeling and dynamic visualizations.

Appendix

- Summary of curvature values and tested ranges
- Full source code and parameter list
- Step-by-step reproducible experiment instructions

Appendix A: Experimental Curvature Table

| Range | Curvature | #Primes | Hits | Accuracy (%) |
|-----------|-----------|---------|------|----------------|
| 1~280 | 0.29 | 59 | 59 | 100.0 |
| 281~299 | 0.26 | 3 | 3 | 100.0 |
| 300~500 | 0.24 | 33 | 33 | 100.0 |
| 520~800 | 0.20 | 42 | 42 | 100.0 |
| 820~1200 | 0.16 | 55 | 55 | 100.0 |

Appendix B: Prime Spiral Visualizations

- See attached figures:
    - prime_spiral_visualization_1to5000.png
    - prime_spiral_visualization_10000to50000.png

Appendix C: Reproducibility Notes

This study is fully reproducible using the included code and instructions in the ZIP package.

The following files are essential for reimplementation:

- experiment/spiral_model.py - Main spiral coordinate model
- experiment/run_experiment.py - Curvature experiment runner
- appendix/reproducibility_steps.md - Step-by-step instructions

To reproduce the results:

1. Use Python 3.x with numpy, matplotlib, and sympy.
2. Follow the instructions in 'reproducibility_steps.md'.
3. Execute 'run_experiment.py' to visualize prime alignment by curvature.
4. Visual confirmations are saved as .png images under 'docs/'.

All necessary data and source code are packaged in the project ZIP.

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Attribution Note

This model and its experimental results were first proposed and published by hye hyeong cho on July 11, 2025, via the OSF platform.
All files and source code are timestamped and publicly accessible for verification.
This documentation ensures full reproducibility and transparent authorship.