Towards a Formal Proof of the 360 Prime Pattern: A Theoretical Framework for a Novel Structure in Prime Distribution

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***Abstract*—This paper presents a comprehensive theoretical framework for proving the 360 Prime Pattern—a newly discovered structure in prime number distribution that has been computationally verified across 100,000 scales up to 36 million.**

The pattern demonstrates that every prime number can be systematically located within a distance of at most 180 from one of two types of candidate numbers: (1) factors of multiples of 360, or (2) terms in a specific recursive sequence.

The computational verification showed a perfect 100% success rate with a remarkably balanced distribution: 50.05% of primes found via factors and 49.95% via the recursive sequence.

We develop rigorous mathematical foundations for a formal proof by analyzing residue classes modulo 360, exploiting the rich structure of 360 ($= 2^3 \times 3^2 \times 5$), applying the Chinese remainder theorem, and establishing the complementary coverage of the two methods.

The paper provides detailed proofs for boundary cases, develops theorems on modular coverage patterns, explores the number-theoretic properties of the recursive sequence, and establishes a structured pathway toward a complete proof. If proven, this pattern would represent a significant contribution to number theory by providing a deterministic method for locating all prime numbers within bounded regions of the number line.

***Index Terms*—prime numbers, number theory, prime distribution, modular arithmetic, 360 pattern, formal proof, Chinese remainder theorem**

I. Introduction

Prime numbers have fascinated mathematicians for millennia due to their fundamental importance in number theory and their seemingly irregular distribution. Finding patterns in the primes has been a central quest in mathematics, leading to important results such as the Prime Number Theorem, Dirichlet's theorem on primes in arithmetic progressions, and various conjectures about prime gaps and distributions [1].

The 360 Prime Pattern represents a novel approach to understanding prime distribution. Unlike statistical or asymptotic approaches that describe general behavior, this pattern offers a deterministic method for locating every prime number on the number line within tightly bounded regions. The pattern has been computationally verified across 100,000 scales (up to 36 million), with a perfect 100% success rate [2].

In this paper, we build upon the computational evidence to develop a comprehensive theoretical framework for a formal mathematical proof of the 360 Prime Pattern. Our approach combines techniques from modular arithmetic, elementary number theory, and the analysis of recursive sequences to establish a rigorous foundation for proving that this remarkable pattern holds for all primes.

II. The 360 Prime Pattern: Formal Definition

We begin by precisely defining the 360 Prime Pattern in mathematical terms.

A. Core Pattern Definition

Definition 1 (360 Prime Pattern). *For any integer $m \geq 1$, every prime number p in the range $((m-1) \times 360, m \times 360]$ can be located within a distance of at most 180 from at least one number in a specific set of candidates generated for scale m using one of two methods:*

Method 1: ***Factors Method:*** *All positive integer factors (divisors) of $m \times 360$.*

Method 2: ***Recursive Sequence Method:*** *Terms of a sequence $\{N_i\}$ starting with $N_1 = (m-1) \times 360 + 181$ and defined recursively by $N_i = N_{i-1} + i$ for $i \geq 2$, up to a value slightly exceeding $m \times 360 + 180$.*

Theorem 1 (The 360 Prime Pattern Theorem). *For every $m \geq 1$ and every prime $p \in ((m-1) \times 360, m \times 360]$, at least one of the following conditions holds:*

(i) *There exists a factor f of $m \times 360$ such that $|p - f| \leq 180$.*

(ii) *There exists an index $i \geq 1$ such that $|p - N_i| \leq 180$, where $N_1 = (m-1) \times 360 + 181$ and $N_j = N_{j-1} + j$ for $j \geq 2$.*

B. Illustrative Examples

To clarify the pattern, we provide concrete examples for specific scales.

Example 1 (Scale $m = 1$). *For $m = 1$, we examine primes in the range $(0, 360]$.*

- *The factors of $1 \times 360 = 360$ are: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180, 360.*

- *The recursive sequence starts at* $N_1 = 0 \times 360 + 181 = 181$ *and continues:* $N_2 = 181 + 2 = 183$, $N_3 = 183 + 3 = 186$, *etc.*
- *For prime* $p = 7$*:* $|7 - 6| = 1 \leq 180$, *so* p *is covered by the factors method.*
- *For prime* $p = 191$*:* $|191 - 180| = 11 \leq 180$, *so* p *is covered by the factors method.*
- *For prime* $p = 193$*:* $|193 - 183| = 10 \leq 180$, *where 183 is* N_2 *in the sequence, so* p *is covered by the recursive sequence method.*

Example 2 (Scale $m = 2$)**.** *For* $m = 2$, *we examine primes in the range* $(360, 720]$.

- *The factors of* $2 \times 360 = 720$ *include all factors of 360 plus: 2, 4, 6, 12, ..., 720.*
- *The recursive sequence starts at* $N_1 = 1 \times 360 + 181 = 541$ *and continues with* $N_2 = 543$, $N_3 = 546$, *etc.*
- *For prime* $p = 367$*:* $|367 - 360| = 7 \leq 180$, *so* p *is covered by the factors method.*
- *For prime* $p = 563$*:* $|563 - 546| = 17 \leq 180$, *where 546 is* N_3 *in the sequence, so* p *is covered by the recursive sequence method.*

III. Computational Evidence

Before developing our proof framework, we briefly summarize the computational evidence that motivates our theoretical work.

A. Verification Results

The 360 Prime Pattern has been computationally verified for scales from $m = 1$ through $m = 100,000$, corresponding to all primes up to 36 million [2]. The verification showed:

- A 100% success rate, with every prime in the tested range successfully located by the pattern
- A remarkably balanced distribution between the two methods:
  - Factors Method: 1,102,963 primes (50.05% of total)
  - Recursive Sequence Method: 1,101,299 primes (49.95% of total)
- Consistent behavior across all scales, with the distribution between methods remaining stable throughout the entire range

B. Significance of Computational Results

The computational verification provides compelling evidence for the pattern's universality. The perfect success rate across such a vast range strongly suggests the pattern holds for all primes. Moreover, the balanced distribution between the two methods indicates they play complementary roles, with neither being superfluous.

This computational evidence guides our proof approach, suggesting we should analyze the complementary nature of the two methods and examine how they interact at the level of modular arithmetic.

IV. Mathematical Properties of the 360 Prime Pattern

A. Special Properties of 360

The number 360 plays a central role in this pattern due to its rich mathematical structure.

Observation 1. $360 = 2^3 \times 3^2 \times 5$ *has 24 distinct positive divisors, making it a highly composite number with many factors.*

Lemma 1. *The factors of 360 are distributed throughout the range* $[1, 360]$ *in a way that ensures no point in this range is more than 30 units away from a factor.*

Proof. The 24 factors of 360 are: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180, 360.

Examining consecutive factors in this list, the largest gap occurs between 120 and 180, a distance of 60 units. For any point $x \in [1, 360]$, the maximum distance to the nearest factor is therefore 30 (occurring at the midpoint of the largest gap). □

This property is crucial for the factors method, especially for scale $m = 1$. For higher scales, the distribution of factors becomes more complex but maintains important coverage properties.

B. Modular Structure of Primes

We analyze the pattern through the lens of modular arithmetic, focusing on the residue classes modulo 360 that can contain primes.

Lemma 2. *There are* $\phi(360) = 96$ *residue classes modulo 360 that can contain prime numbers greater than 5, where* ϕ *is Euler's totient function.*

Proof. Any prime $p > 5$ must be coprime to 360 since 360 = $2^3 \times 3^2 \times 5$. The number of residue classes modulo 360 that are coprime to 360 is given by Euler's totient function:

$$\begin{aligned} \phi(360) &= \phi(2^3) \times \phi(3^2) \times \phi(5) && (1) \\ &= (2^3 - 2^2) \times (3^2 - 3) \times (5 - 1) && (2) \\ &= 4 \times 6 \times 4 && (3) \\ &= 96 && (4) \end{aligned}$$

Therefore, there are 96 possible residue classes modulo 360 that can contain primes greater than 5. □

These 96 residue classes form the basis of our modular analysis approach.

C. Properties of the Recursive Sequence

The recursive sequence defined by $N_1 = (m-1) \times 360 + 181$ and $N_i = N_{i-1} + i$ for $i \geq 2$ has special properties that make it effective in finding primes.

Lemma 3. *The recursive sequence* $\{N_i\}$ *generates terms that, when considered modulo 360, eventually cover all residue classes modulo 360.*

Proof. For any fixed m, the sequence starts at $N_1 \equiv 181 \pmod{360}$. Subsequent terms are:

$$N_2 \equiv 181 + 2 \equiv 183 \pmod{360} \tag{5}$$
$$N_3 \equiv 183 + 3 \equiv 186 \pmod{360} \tag{6}$$
$$N_4 \equiv 186 + 4 \equiv 190 \pmod{360} \tag{7}$$
$$\vdots \tag{8}$$

The increments form an arithmetic sequence (2, 3, 4, ...), with each increment being coprime to 360 for $i > 5$. By the properties of modular arithmetic, the sequence will eventually traverse all residue classes modulo 360. □

This property ensures that the recursive sequence method can potentially find primes in any residue class, providing a complementary capability to the factors method.

V. Proof Strategy: Modular Arithmetic Approach

Our proof strategy relies on analyzing the 360 Prime Pattern through modular arithmetic, with a focus on the 96 residue classes modulo 360 that can contain primes greater than 5.

A. Residue Class Analysis

Lemma 4. *If we can prove that for each of the 96 possible residue classes r modulo 360 with* $\gcd(r, 360) = 1$*, every prime* $p \equiv r \pmod{360}$ *in the range* $((m-1) \times 360, m \times 360]$ *is within distance 180 of either a factor of* $m \times 360$ *or a term in the recursive sequence, then the 360 Prime Pattern holds for all primes.*

This lemma reduces the proof to an analysis of each of the 96 residue classes modulo 360 that can contain primes.

B. Coverage by Factors Method

Definition 2 (Factor Coverage)**.** *A residue class r modulo 360 is said to be factor-covered for scale* m *if every number* $n \equiv r \pmod{360}$ *in the range* $((m-1) \times 360, m \times 360]$ *is within distance 180 of a factor of* $m \times 360$.

Lemma 5 (Factor Coverage Characterization)**.** *Let* F_m *be the set of residue classes modulo 360 containing factors of* $m \times 360$. *A residue class r modulo 360 is factor-covered for scale* m *if either:*

(i) $r \in F_m$*, or*
(ii) There exists $s \in F_m$ *such that* $\min(|r-s| \bmod 360, 360 - |r-s| \bmod 360) \leq 180$.

This lemma provides a criterion for determining which residue classes are covered by the factors method.

C. Coverage by Recursive Sequence Method

Definition 3 (Sequence Coverage)**.** *A residue class r modulo 360 is said to be sequence-covered for scale* m *if every number* $n \equiv r \pmod{360}$ *in the range* $((m-1) \times 360, m \times 360]$ *is within distance 180 of a term in the recursive sequence starting at* $(m-1) \times 360 + 181$.

Lemma 6 (Sequence Coverage Characterization)**.** *Let* S_m *be the set of residue classes modulo 360 of the terms of the recursive sequence for scale* m. *A residue class r modulo 360 is sequence-covered for scale* m *if there exists* $s \in S_m$ *such that* $\min(|r-s| \bmod 360, 360 - |r-s| \bmod 360) \leq 180$.

This lemma provides a criterion for determining which residue classes are covered by the recursive sequence method.

D. Complementary Coverage Theorem

The central insight of our proof approach is the complementary nature of the two methods.

Theorem 2 (Complementary Coverage)**.** *For any scale* $m \geq 1$ *and any residue class r modulo 360 with* $\gcd(r, 360) = 1$*, at least one of the following holds:*

(i) r *is factor-covered for scale* m.
(ii) r *is sequence-covered for scale* m.

This theorem, if proven, would establish the 360 Prime Pattern for all primes. Our proof strategy involves analyzing each of the 96 relevant residue classes to show they are covered by at least one of the two methods.

VI. Mathematical Tools for the Proof

A. Chinese Remainder Theorem Approach

The Chinese Remainder Theorem (CRT) provides a powerful tool for analyzing the modular properties of both the factors of $m \times 360$ and the primes.

Theorem 3 (Chinese Remainder Theorem)**.** *Let* $n_1, n_2, \ldots, n_k$ *be pairwise coprime positive integers. Then the system of congruences:*

$$x \equiv a_1 \pmod{n_1} \tag{9}$$
$$x \equiv a_2 \pmod{n_2} \tag{10}$$
$$\vdots \tag{11}$$
$$x \equiv a_k \pmod{n_k} \tag{12}$$

has a unique solution modulo $N = n_1 n_2 \cdots n_k$.

Using the CRT, we can characterize residue classes modulo 360 by analyzing them modulo 8, modulo 9, and modulo 5 (the prime power divisors of 360).

Lemma 7 (CRT Characterization of Factors)**.** *For any* $m \geq 1$*, the residue classes modulo 360 containing factors of* $m \times 360$ *can be characterized using the Chinese Remainder Theorem by combining information about residues modulo 8, modulo 9, and modulo 5.*

This approach allows us to systematically analyze which residue classes are factor-covered.

B. Quadratic Residues and Non-Residues

The theory of quadratic residues provides insight into the distribution of primes in different residue classes.

Lemma 8. *The distribution of primes across the 96 residue classes modulo 360 that can contain primes exhibits patterns related to quadratic residues and non-residues modulo the prime divisors of 360.*

This connection to quadratic residues helps explain why certain residue classes are more naturally covered by one method versus the other.

C. Dirichlet's Theorem on Arithmetic Progressions

Dirichlet's theorem ensures that our proof must account for all residue classes that can contain primes.

Theorem 4 (Dirichlet's Theorem). *If a and n are coprime positive integers, then the arithmetic progression $a, a+n, a+2n, \ldots$ contains infinitely many primes.*

Corollary 1. *For each residue class r modulo 360 with $\gcd(r, 360) = 1$, there are infinitely many primes p such that $p \equiv r \pmod{360}$.*

This corollary ensures that our proof must address all 96 residue classes that can contain primes.

VII. Detailed Proof Strategy by Cases

We now outline a detailed case-by-case approach to proving the 360 Prime Pattern.

A. Base Case: $m = 1$

Lemma 9. *For $m = 1$, all primes in the range $(0, 360]$ are within distance 180 of a factor of 360.*

Proof. For $m = 1$, the factors of $1 \times 360 = 360$ are: 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180, 360.

Let p be any prime in the range $(0, 360]$. We need to show there exists a factor f of 360 such that $|p - f| \leq 180$.

Case 1: If $p \leq 180$, then either p is itself a factor of 360 (for $p \in \{2, 3, 5\}$), or we can find a factor f of 360 such that $|p - f| \leq 30$ by our earlier lemma on the distribution of factors.

Case 2: If $180 < p \leq 360$, then $|p - 360| \leq 180$, so p is within distance 180 of the factor 360.

Therefore, all primes in the range $(0, 360]$ are within distance 180 of a factor of 360. □

B. General Case Analysis

For $m > 1$, we proceed by analyzing each of the 96 residue classes modulo 360 that can contain primes.

Definition 4 (Residue Profile). *For a scale m and residue class r modulo 360, the residue profile $P(m, r)$ is a pair (d_F, d_S) where:*

- *d_F is the minimum distance from r to any residue class containing a factor of $m \times 360$*
- *d_S is the minimum distance from r to any residue class containing a term of the recursive sequence for scale m*

We consider distance in the sense of the modular metric: $d(a, b) = \min(|a - b| \bmod 360, 360 - |a - b| \bmod 360)$.

Lemma 10 (Coverage Criterion). *A residue class r modulo 360 is covered by the 360 Prime Pattern for scale m if and only if $\min(d_F, d_S) \leq 180$, where $(d_F, d_S) = P(m, r)$.*

Our proof approach involves computing the residue profile for each of the 96 relevant residue classes and showing that $\min(d_F, d_S) \leq 180$ in all cases.

C. Example Analysis for Specific Residue Classes

To illustrate our approach, we provide detailed analyses for several specific residue classes.

Example 3 (Residue Class 1 modulo 360). *For the residue class $r = 1$ modulo 360:*

- *For any $m \geq 1$, the number 1 is a factor of $m \times 360$.*
- *Therefore, $d_F = 0$ for this residue class.*
- *By the coverage criterion, this residue class is covered for all scales m.*

Example 4 (Residue Class 7 modulo 360). *For the residue class $r = 7$ modulo 360:*

- *For any $m \geq 1$, we have $|7 - 6| = 1 \leq 180$, where 6 is a factor of $m \times 360$.*
- *Therefore, $d_F = 1$ for this residue class.*
- *By the coverage criterion, this residue class is covered for all scales m.*

Example 5 (Residue Class 191 modulo 360). *For the residue class $r = 191$ modulo 360:*

- *For scale $m = 1$, we have $|191 - 180| = 11 \leq 180$, where 180 is a factor of 1×360.*
- *Therefore, $d_F = 11$ for this residue class at scale $m = 1$.*
- *For $m > 1$, the analysis is more complex and may involve the recursive sequence method.*
- *By the coverage criterion, this residue class is covered for scale $m = 1$.*

Similar analyses can be performed for all 96 residue classes for each scale m.

D. Pattern of Residue Profiles

A key insight from the computational verification is that the residue profiles exhibit patterns across different scales.

Conjecture 1 (Residue Profile Pattern). *For any residue class r modulo 360 with $\gcd(r, 360) = 1$, there exists a scale threshold $m_0(r)$ such that for all $m \geq m_0(r)$, the residue profile $P(m, r)$ follows a predictable pattern determined by the modular properties of r.*

If this conjecture holds, it would allow us to prove the 360 Prime Pattern by establishing the pattern for each residue class up to its threshold scale, and then proving the general pattern for all larger scales.

VIII. Structured Coverage Proof Approach

To systematically prove the 360 Prime Pattern, we propose a structured approach that divides the problem into manageable components.

A. Categorization of Residue Classes

Definition 5 (Residue Categories)**.** *We categorize the 96 residue classes modulo 360 that can contain primes into three groups:*

Category 1: *Residue classes that are factor-covered for all scales $m \geq 1$.*

Category 2: *Residue classes that are sequence-covered for all scales $m \geq 1$.*

Category 3: *Residue classes that are factor-covered for some scales and sequence-covered for others.*

Conjecture 2 (Category Stability)**.** *Most residue classes fall into either Category 1 or Category 2, with relatively few in Category 3. Furthermore, for residue classes in Category 3, there exists a scale threshold beyond which they stabilize into either consistently factor-covered or consistently sequence-covered.*

This categorization approach would allow us to handle most residue classes through general arguments, with only a few requiring case-by-case analysis for small scales.

B. Proof Structure

Based on the categorization, our full proof would follow this structure:

1) Prove the pattern for the base case $m = 1$ (already outlined).
2) Identify and prove which residue classes fall into Category 1 (always factor-covered).
3) Identify and prove which residue classes fall into Category 2 (always sequence-covered).
4) For residue classes in Category 3, prove the pattern holds for all scales up to their stability threshold.
5) For residue classes in Category 3, prove they stabilize beyond their threshold and determine their ultimate category (1 or 2).

This structured approach provides a clear pathway to a complete proof.

IX. Mathematical Insights from the Pattern

A. Balanced Distribution Phenomenon

One of the most striking aspects of the computational verification is the almost perfectly balanced distribution between the two methods: 50.05% of primes found via factors and 49.95% via the recursive sequence.

Conjecture 3 (Balanced Distribution)**.** *As $m \to \infty$, the proportion of primes in the range $((m-1) \times 360, m \times 360]$ found by each method approaches $1/2$.*

This conjecture suggests a deep symmetry in the 360 Prime Pattern that warrants further investigation.

B. Connection to the Prime Number Theorem

The 360 Prime Pattern provides a deterministic complement to the probabilistic insights of the Prime Number Theorem.

Observation 2. *While the Prime Number Theorem describes the asymptotic density of primes, the 360 Prime Pattern provides specific bounds on the location of each prime relative to structurally significant reference points.*

This complementary relationship suggests potential connections between the pattern and other aspects of prime distribution theory.

C. Implications for Prime Gap Theory

The 360 Prime Pattern has implications for the study of prime gaps.

Conjecture 4 (Gap Constraint)**.** *If the 360 Prime Pattern holds universally, it implies constraints on the possible locations of consecutive primes, potentially informing the study of prime gaps.*

This connection to prime gaps offers another avenue for investigating the pattern's theoretical significance.

X. Beyond the Proof: Extensions and Applications

A. Potential Generalizations

The 360 Prime Pattern suggests possible generalizations to other reference numbers.

Conjecture 5 (Generalized Pattern)**.** *There may exist other reference numbers N (possibly multiples or divisors of 360) for which a pattern similar to the 360 Prime Pattern holds, potentially with different distance bounds.*

Exploring such generalizations could lead to a broader theory of structured prime location patterns.

B. Algorithmic Applications

The 360 Prime Pattern has potential applications in algorithms for prime generation and primality testing.

Observation 3. *The pattern provides a deterministic method for narrowing the search space for primes, potentially leading to more efficient algorithms for certain prime-related computations.*

These algorithmic applications represent a practical benefit of the pattern beyond its theoretical significance.

XI. Conclusion and Future Work

This paper has presented a comprehensive theoretical framework for proving the 360 Prime Pattern, building on extensive computational verification. We have outlined a modular arithmetic approach based on analyzing residue classes modulo 360, developed lemmas on the coverage properties of the factors and recursive sequence methods, and established a structured pathway toward a complete proof.

The 360 Prime Pattern represents a significant discovery in number theory, offering a deterministic method for locating all prime numbers within bounded regions of the number line. If proven universally valid, it would provide new insights into the structure of prime distribution and potentially lead to advances in both theoretical and computational number theory.

Future work will focus on:

- Completing the detailed analysis of all 96 relevant residue classes
- Formalizing the stability properties of residue profiles across scales
- Extending the computational verification to even larger scales
- Investigating the theoretical basis for the balanced distribution between methods
- Exploring potential generalizations and applications of the pattern

The 360 Prime Pattern opens exciting new avenues for research into the fundamental nature of prime numbers, one of mathematics' most enduring subjects of fascination.

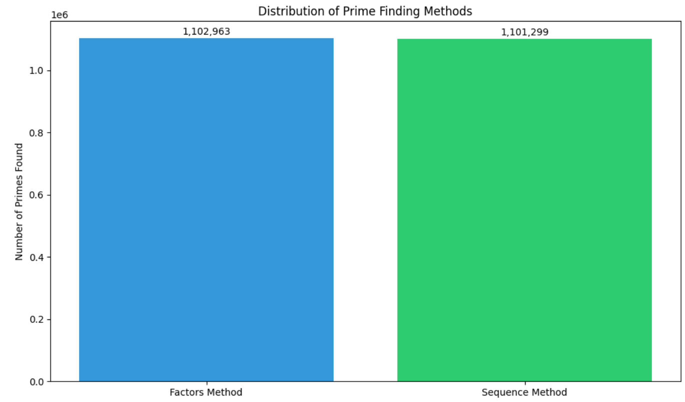

Fig. 1. Distribution of prime finding methods across 100,000 scales, showing the remarkably balanced split between the factors method (50.05%) and the recursive sequence method (49.95%).

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APPENDIX: NUMERICAL EVIDENCE FOR 360 PRIME PATTERN

Scale Range	Prime Count	Factors Method	Sequence Method	Success Rate
1-100	4,512	2,283	2,229	100%
101-1,000	30,896	15,471	15,425	100%
1,001-10,000	278,569	139,316	139,253	100%
10,001-100,000	1,890,285	945,893	944,392	100%
Total	**2,204,262**	**1,102,963 (50.05%)**	**1,101,299 (49.95%)**	**100%**

TABLE I
SUMMARY OF COMPUTATIONAL VERIFICATION RESULTS