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# A Langland Bridge Between Analysis and Number Theory

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## Abstract
Langland promised more opportunities for insights and solutions from the connections of different areas of mathematics. In the following, a relation between analysis and number theory is used to describe the distribution of prime numbers. An important point here is the possibility of using mathematical operators that allow a general representation of the mechanisms. Therefore, some additions to the terminology are made, which can be regarded as suggestions. With the help of algebra, the possibility of confirming Goldbach's conjecture has already been demonstrated, although the factorisation of each number occurring in the prime series has so far only been examined in detail for the numbers 5 and 7. For Goldbach's conjecture, the differences between any natural numbers and the next smallest prime number are considered. These differences should be less than 27 so that each number can be decomposed into a maximum of three summands of prime numbers.

**Keywords:** Langland Bridges, Number Theory, Prime Numbers, Analysis, Number Series

## Introduction
The possibility of separating all-natural numbers into three groups leads to a sequence of numbers that contains only prime numbers and multiples of the elements of this series, which is referred to below as the prime number series [1]. In the following, it will be shown that these multiples can also be identified and represented using series. A disadvantage of earlier descriptions of prime numbers and their relationships is the missing mathematical equations, for which options are presented.

## Recognizing and Using Number Series – for Prime Number Identification
### The Prim series
The prime number series is formed by separating all numbers that are divisible by 2 and 3. All natural numbers are thus assigned to three groups. Group 3 contains all-natural numbers that are divisible by 3. Group 2 contains all-natural numbers that are divisible by 2 but not by 3, and group 1 contains the remaining natural numbers. This group is the prime series $\mathbf{P}_f$, which includes all prime numbers and multiples of the elements of this series. The numbers 2 and 3 are also prime numbers, but as a result of the separation of the numbers, they are not included in the prime series. To form the prime series, starting with 1, the numbers 4 and 2 are added alternately to find the next number in the series, see Figure 1.

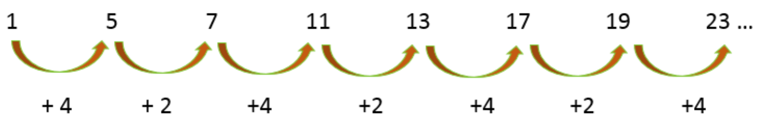


**Figure 1: Formation of the Prime Series by Alternating Summation of 4 and 2**

As a mathematical description for forming the prime series a symbol from matrix calculus can be used to show that 4 and 2 are alternately added to the number 1, see Equation 1, to obtain all subsequent elements of this series.

Equation 1:
Formation rule of the prime series: Prime series Pf with all prime numbers P and multiples of the elements of this series ($\in P_f = 5 \ldots \infty$).

$$\mathbb{P}_f = 1 + 4 \quad 2 = 1; 5; 7; 11; 13; 17; 19\ldots = \mathbb{P} + \prod_{\in \mathbb{P}_f = 5}^{\infty} \in \mathbb{P}_f$$

The prime series contains all prime numbers **P** as well as their multiples of the elements of this series (products Π), with the exception of the numbers 2 and 3.

## Necessary Elimination Steps in the Prime Series

Since this series also contains the multiples of each number appearing in it, these multiples must be eliminated. The elimination of multiples from the prime series follows patterns that are applied to the positions in this series. After applying the necessary elimination steps, the prime numbers remain. Below is a general elimination rule for the steps that must be applied alternately starting from the respective square number of each element of the prime series. Starting (→) with the square of an element of the prime series ($\in P_f^{\,2}$), first the number at position 'A' is eliminated, and then the number at position 'B' is eliminated, continuing indefinitely from there. Alternating elimination allows the removal of all multiples of the squared number used as the starting position in the prime sequence.

Equation 2:
General, alternating elimination steps starting from the square number of each element in the prime series

$$\longrightarrow \in \mathbb{P}_f^{\,2} \ \emptyset \ \text{POS“A“} \qquad \text{POS“B“}$$

The steps for elimination follow a pattern that is equidistant and alternating from each square number in the series. The first numbers in the prime series are 1, 5, 7, 11, 13, 17, 19, 23. The first square number is 25, which is the square of 5. Next, the product of 5x7 must be eliminated, i.e. 35 and further products of 5.

Figure 2: Example of elimination of multiples from the prime sequence:

…, 25, 29, 31, 35, 37, 41, 43, 47, 49, 53, 55, 59, 61, 65, 67, 71, 73, 77, 79, 83, 85, 89, 91, 95, 97, 101…

-> Multiples of 5 in red
-> Multiples of 7 in green

For this, starting with the square number 5, i.e. 25, every 3rd and 7th position in the prime number series must be eliminated alternately, as they are multiples of 5, see Fig. 2. The next elimination pattern must be taken into consideration, from 49 as a square of 7. To do this, the 9th and 5th positions are eliminated alternately. Table 1 shows the elimination steps for some consecutive prime numbers. The elimination pattern to be applied is indicated by positions and distances.

| Element of the prime series (∈ ?f ) | 5 | 7 | 11 | 13 | 17 | 19 |
|---|---|---|---|---|---|---|
| Step 1 – next elimination position | 3 | 9 | 7 | 17 | 11 | 25 |
| Step 2 – next elimination position | 7 | 5 | 15 | 9 | 23 | 13 |

**Table 1: Elimination Steps for Positions in the Prime Series, Alternating. Starting from the Square Numbers (detail)**

Each number in the prime series, i.e. each of its elements ($\in \mathbf{P}_f$), has an alternating and endlessly repeating elimination pattern. Elimination steps 1 and 2 must be applied starting from the respective square number of the prime sequence elements. As an example, the elimination pattern for multiples of 5 can be expressed by Equation 3 and for multiples of 7 by Equation 4.

Equation 3:
Elimination steps starting from the square number $5^2$ onwards, the multiples of 5 that occur are eliminated by eliminating positions 3 and 7 alternately, ad infinity.

$$\longrightarrow 5^2 \ \text{Ø POS“3“} \qquad \text{POS“7“}$$

Equation 4:
Elimination steps starting from the square number of 7 – from $7^2$ onwards, the multiples of 7 that occur are eliminated by alternating elimination of positions 9 and 5.

$$\longrightarrow 7^2 \ \text{Ø POS“9“} \qquad \text{POS“5“}$$

### The Elimination Steps Also Have Elimination Patterns

The principle of elimination is therefore applied to each square number so that ultimately the prime numbers remaining are obtained. Looking at the numbers marked in color (red and blue) in Table 2, these also appear to follow consistent patterns that grow steadily.

| Element of the prime series ($\in {}^{2}f$) | 5 | 7 | 11 | 13 | 17 | 19 |
|---|---|---|---|---|---|---|
| Step 1 – next elimination position | 3 | 9 | 7 | 17 | 11 | 25 |
| Step 2 – next elimination position | 7 | 5 | 15 | 9 | 23 | 13 |

**Table 2: Elimination Steps and Recognisable Sequences (detail)**

In general terms, an elimination pattern starts from the square number of each element in the prime series, which can also be represented by two alternating series. The blue number series ($E_{f1}$) starts at the square number of 5 with the first ${}^1E_{f1} = 3$.

From the square number of 7, ${}^2E_{f1}=5$ (addition of 2) starts. The red series ($E_{f2}$) starts for step 2 with ${}^1E_{f2}= 7$ and shows the second elimination step (step 2) for the multiples of 5. To develop this elimination series Ef2, the numbers 2 and 6 must be added alternately, starting with the number 7, see Table 2.

Equation 5:
Starting from the square number of an element in the prime series ($\in \mathbf{P}_f{}^2$), elimination series ($E_{f1}$ and $E_{f2}$) are applicable, which alternate in relation to their position to each other and are thus assigned alternately to the steps (Step 1 or Step 2).

$$\longrightarrow E_{f1/2}(\in \mathbb{P}_f^2) = \text{POS“}E_{f1/2}\text{“} \qquad \text{POS“}E_{f2/1}\text{“}$$

Equation 6: For elimination series 1 ($E_{f1}$), whose position starts at Step 1 and alternates with Step 2, the series can be developed starting with the number 3 by adding 2: blue series: $E_{f1}$ = 3, 5, 7, 9, 11, 13,… = Difference is 2

$$\longrightarrow {}^1E_{f1} = \text{POS“}S_1\text{“} \qquad \text{POS“}S_2\text{“} = 3 + 2$$

This results in the series shown in Table 2 (blue), which can be continued for all other elements of the prime series.

Equation 7:
For elimination series 2 ($E_{f2}$), which starts at Step 2 and alternates with Step 1, the series can be developed by alternately adding 2 and 6, starting with the number 7: red series: $E_{f2}$=7, 9, 15, 17, 23, 25, …= Differences vary by 2 and 6

$$\longrightarrow {}^1E_{f2} = \text{POS“}S_2\text{“} \qquad \text{POS“}S_1\text{“} = 7 + 2 \quad 6$$

These series enable the prediction of further elimination patterns for all multiples in the prime series, starting from their corresponding square number.

This means that not only can the prime series be easily mapped, but the elimination steps can also be developed from series. There are even simple relationships between the elements of the prime series and the elimination steps to be applied. For example, the difference between the respective prime number and the first difference grows steadily and continuously.

| | | | |
|---|---|---|---|
| $\in P_f - E_{f1}$ , if $E_{f1} < \in P_f$ : | $5 - 3 = 2$ | $11 - 7 = 4$ | $17 - 11 = 6$ |
| $\in P_f - E_{f2}$ , if $E_{f2} > \in P_f$ : | $7 - 9 = -2$ | $13 - 17 = -4$ | $19 - 25 = -6$ |

**Table 3: Interconnection Between Elements of Prime Series and Elimination Steps**

## Conclusion

The formation of the prime number series and the steps to eliminate multiples of the elements from this series follow simple patterns. Thus, analysis provides the solution to the question from number theory regarding the possibility of identifying prime numbers. Langlands' idea for the connection between number theory and analysis demonstrates its possibilities here. This connection, with algebra, is also suitable for confirming Goldbach's conjecture. In previous considerations [2], only the elimination of multiples of 5 and 7 was discussed. This resulted in a maximum difference of 8 between any number and the next smallest prime number. If we also take into account the increasing elimination patterns in the larger number range, we obtain larger differences.

For example, at 115, 119, 121, 125, several multiples follow each other in the prime series. If we now search for the Goldbach numbers (maximum 3 summands, which are only prime numbers) for the number 126, the next smallest prime number 113 is the first summand and the difference 13 is the second summand. In this case, two summands are sufficient to form the number 126. All differences smaller than 27 can be represented as sums of two prime numbers, (23,3), … (19,3),… (17,1),… (13,3),… (11,1),… (7,3)… , or even a prime number. This makes it possible to decompose any natural number into Goldbach numbers up to a difference of 26 to the next smallest prime number. For solving a mathematical problem, the most important factors are the perspective taken on the topic and the language available for use – that is, the mathematical expressions and operators that can be employed. In this case, we describe the pattern of formation of a set of numbers (prime series) in which, for each number, a pattern of elimination takes effect starting from its square, thereby giving us all the consecutive prime numbers. As the language of mathematics develops, it should become possible to express the solutions algebraically as well.

## References


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