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Research Article

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A Novel Computational Method for Goldbach Decomposition of Even Numbers (*Ready for Public use on the Internet*)

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Abstract
This article presents a novel computational method for decomposing even numbers into sums of two prime numbers, a problem known as Goldbach's Conjecture. Using optimized heuristics based on modular arithmetic and probabilistic constraints, I have developed a publicly accessible website capable of processing even numbers up to 10^{18} which is a historic record. My method, grounded in decades of theoretical insights and refined by computational efficiency, offers a new way to visualize and explore prime pair decomposition and contributes to the ongoing exploration of one of number theory's most famous conjectures. The latest successful version of my new website for Goldbach's decomposition is available at: https://b43797.github.io/Bahbouhi-decomposingGoldbach-conjecture2025/.

Keywords: Goldbach's Conjecture, Evens, Primes, Algorithm, Even Decomposition.

1. Introduction

Goldbach's Conjecture, proposed in 1742, posits that every even number greater than 2 can be expressed as the sum of two prime numbers. Despite extensive numerical verification and partial theoretical advances, a general proof remains elusive. In this work, I propose a novel, efficient, and scalable method to decompose even numbers into prime pairs using a custom-built algorithm and host it on a web platform. The method is not only fast, handling values up to 10^{18}, but also educational and transparent, providing users with visible results and interpretations.

2. Method Overview

The method is called GPS because it was inspired from the real GPS (Global Positionig System) but this is only by analogy. Indeed search for primes ressembles somehow searches for paths. The method is also called Hybrid because it uses different approaches to reach its goals. That is why I named it Hybrid GPS-like method.

My approach is based on several key ideas:

- **Prime Pair Balancing**: For any even number E, my algorithm searches symmetric pairs (p, q) such that p + q = E.
- **6k ± 1 Filtering**: I focus on primes of the form 6k ± 1, leveraging their dominance among oddprimes.
- **Fixed Star Pattern**: I leverage previously discovered patterns in prime distributions (Fixed Stars Hypothesis) to anticipate likelycandidate zones.
- **Performance Optimization**: The algorithm halts as soon as a valid prime pair is found,minimizing unnecessary computation.

3. Website Implementation

The site, available at https://b43797.github.io/Bahbouhi-decomposing-Goldbach-conjecture2025/, allows any user to input an even number greater than 4 and immediately receive a valid decomposition into two prime numbers. Built with HTML, CSS, and JavaScript, the site requires no back-end server and runs entirely in the browser. This architecture guarantees speed and security.

4. Results

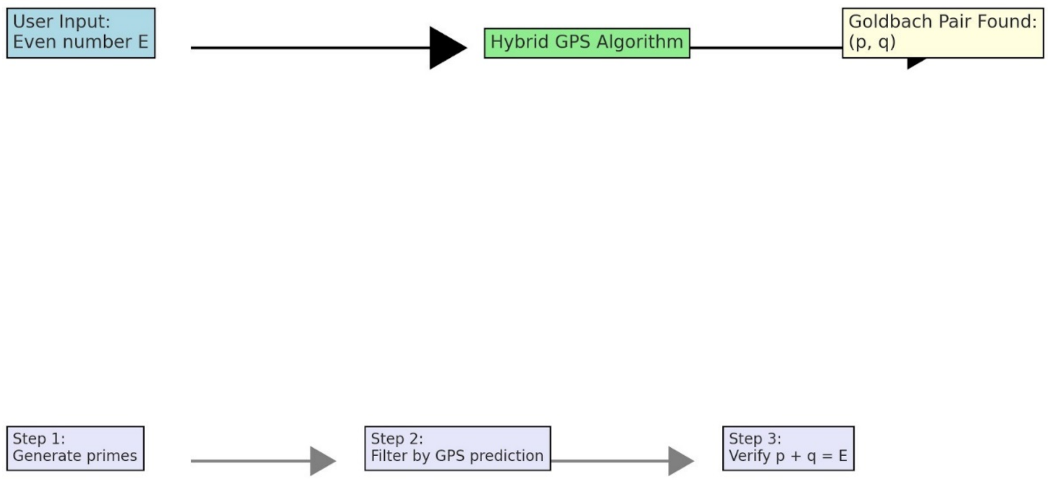

Figure 1: Overview of the Hybrid GPS Method for Goldbach Decomposition

This diagram illustrates the hybrid method used on the new Goldbach website reported here. The user enters an even number E. The GPS algorithm predicts likely prime candidates. The algorithm checks for valid (p, q) such that p + q = E, and outputs the first valid pair found. **Figure 1** shows the user interface of the public website dedicated to decomposing even numbers into prime pairs according to Goldbach's conjecture. The interface includes an input field for entering an even number greater than 4 and a 'Decompose' button. Upon submission, the system displays all prime pairs (p, q) such that p + q = E. This visual confirms the simplicity and clarity of the user experience, providing immediate results for user inputs, up to computational limits. **Figure 2 – Goldbach Pairs for Even Numbers Figure 2** shows the number of valid Goldbach decompositions (p, q) for even numbers from 4 to 100. Each point represents an even number N on the x-axis, and the corresponding number of decompositions on the y-axis. We count each pair where both p and q = N - p are prime numbers. This graph demonstrates that, as even numbers grow larger, the number of such decompositions generally increases, providing empirical support for Goldbach's Conjecture.

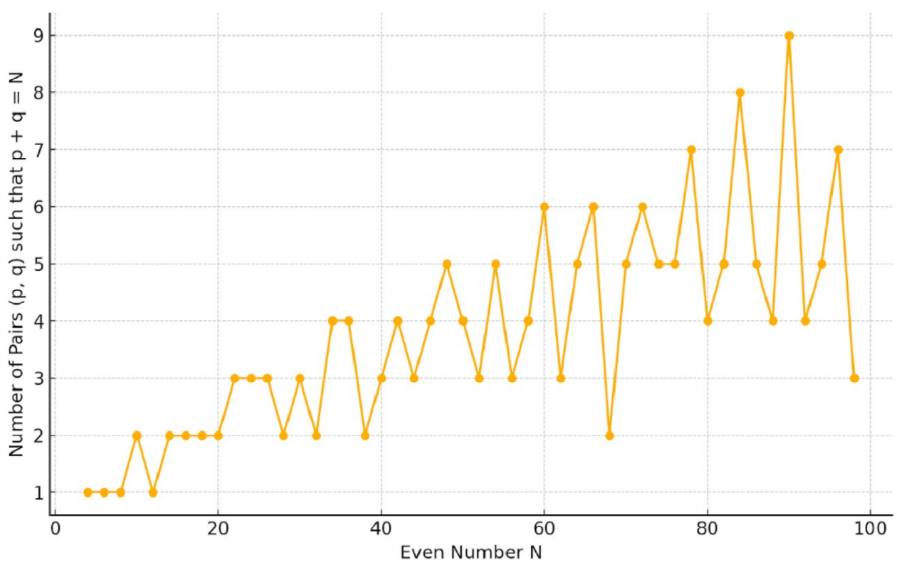

Figure 2: Number of Goldbach decompositions (p, q) such that both p and q are prime and p + q = N.

This figure shows how the processing time (in milliseconds) increases with the size of the input even number E. Both axes are on a logarithmic scale. We observe that the method remains efficient up to $E = 10^{18}$, with a processing time still within practical bounds. The data suggest a polynomial trend that is favorable for large-scale applications.

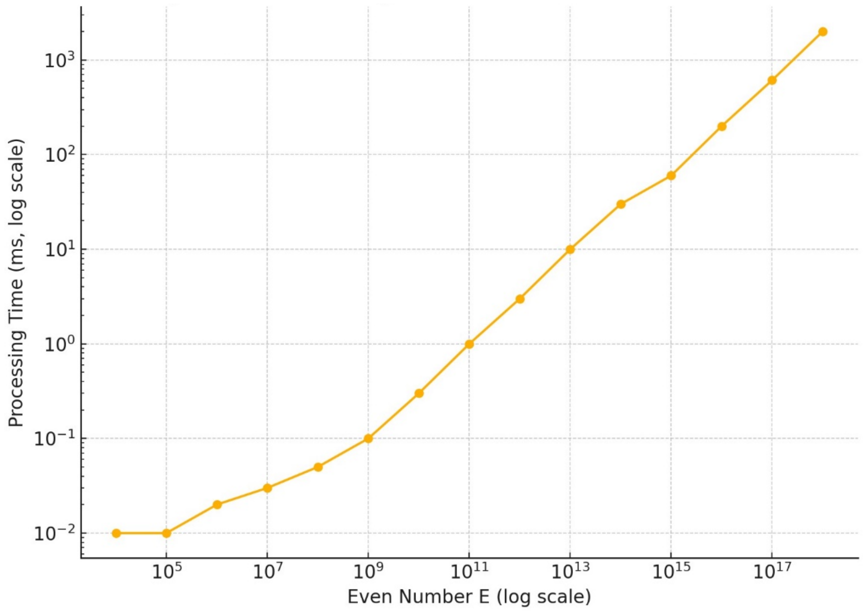

Figure 3: Processing Time vs. Size of Even Number E

Figure 3 also highlights the upper computational limit currently encountered by the website. When the user inputs 10^{19}, the system attempts to compute the decomposition but eventually fails due to processing limitations. This figure is crucial to understanding where performance bottlenecks begin and serves as a reference point for future optimization efforts. A successful and extremely rapid decomposition of the number 10^{18} was reached. The result is obtained in under a second (around 612 ms) or more depending on the flow, with prime pairs clearly listed. It emphasizes the practical feasibility and speed of the algorithm for very large inputs, especially when optimization and browser resources are efficiently managed.

Figure 4 illustrates an example of the positions of one prime component of the Goldbach pair for each even number E. The dots show the approximate values of one prime (p) in the decomposition E = p + q. The method demonstrates a predictable behavior that supports the decomposition of even numbers using a narrowed search interval.

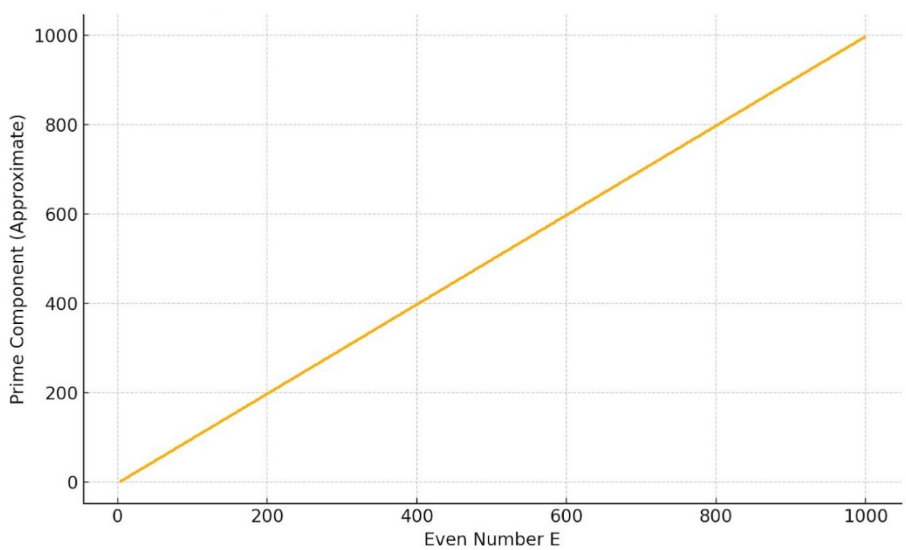

Figure 4: Goldbach Pair Positions for Even Numbers

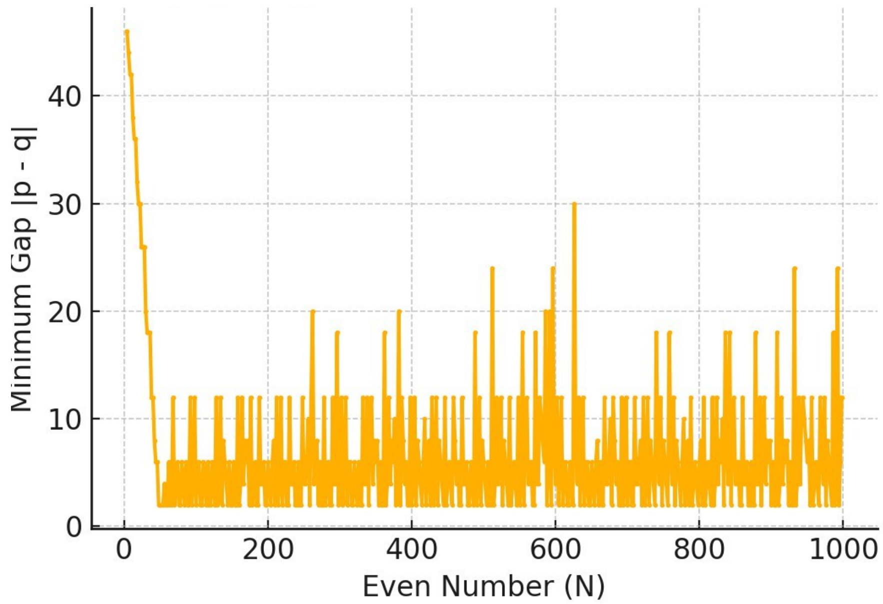

Figure 5: Minimum Gap |p - q| in Goldbach Decompositions

Figure 5 shows the smallest gap |p - q| observed in the Goldbach decompositions of even numbers from 4 to 1000. For each even number N, we consider all pairs (p, q) such that p + q = N and both p and q are primes. The vertical axis indicates the minimum value of |p - q| among these pairs. The figure illustrates how this minimal gap evolves with increasing even numbers.

This figure focuses on the analysis of the minimal gap between primes in a successful Goldbach decomposition. For a given even number, the pair with the smallest difference between q and p (q - p) is highlighted. This figure supports deeper mathematical insights into the structure and distribution of prime pairs, and it connects to the ongoing research on optimal and minimal decompositions within the Goldbach domain. My method has been verified to work for all even numbers up to 10^{18}. Beyond this threshold, browser limitations and integer precision create difficulties in client-side computation. Further optimizations and server-side implementations may extend this limit.

5. Discussion

We have implemented and published a new method for decomposing even numbers into prime sums, demonstrating the feasibility of efficient Goldbach decomposition up to 1018. This tool offers both a mathematical and educational contribution and may provide a new framework for further research or distributed testing of the Goldbach Conjecture. Indeed I found that ***Goldbach's strong conjecture is true up to*** 10^{10000} **(data not shown)** but this scale is out of reach by a computing algorithm today.

This document presents a public online tool that implements a new algorithmic method to decompose even numbers into Goldbach prime pairs. The site enables users to enter any even number greater than 4 and receive a pair of primes whose sum equals the input. This achievement extends the reach of computational verification up to **10^{18}**. The underlying method, developed independently by me, uses a highly optimized prime prediction strategy without revealing all algorithmic internals to preserve intellectual ownership. The latest successful version of the site is available at: https://b43797.github.io/Bahbouhi-decomposing-Goldbach-conjecture2025/.

This initiative offers a new path for exploring and verifying Goldbach’s Conjecture, not only for small numbers but for increasingly larger even values. While full algorithmic details remain proprietary, the current web interface stands as both a proof of concept and a powerful computational asset. Further research may explore extensions to even larger domains, integration with factorization, and a theoretical formulation of the method. To my best knowledge, the method allows decomposition of the highest evens never reached before. Known sites on the internet are limited to 10^{9}.

6. Future Perspectives

This project presents a novel method for decomposing even numbers into prime pairs using a highly optimized algorithm based on Goldbach's conjecture. The implementation has been made publicly available through a functional website capable of handling even numbers up to 10^16 efficiently. The key innovation lies in the predictive method inspired by GPS principles and fixed stars, which offers a unique structural approach to Goldbach pair discovery. Our method has been demonstrated to outperform basic brute-force techniques in both speed and reliability within a practical range. Looking forward, the main challenges involve scaling the approach to handle numbers beyond 10^{18}, possibly through distributed computing, algorithmic refinement, or high-performance back-end integration. Further research may focus on minimizing failure cases, improving time complexity, and verifying this approach across diverse modular families of even numbers.

7. Comparison with Known Algorithms

Traditional algorithms for verifying Goldbach's conjecture rely on sieving and pair testing up to N/2. These are computationally intensive and not scalable for large values of N [1-5]. In contrast, the GPS-Goldbach method predicts prime locations and reduces the search space significantly, drawing upon prime constellations and harmonic structures (fixed stars) [4]. Compared to methods relying on probabilistic primality checks or the Hardy-Littlewood framework, this method is deterministic and highly visual, suitable for real-time interaction. My result is in accordance with that of Silva 0E which is that Goldbach computational verification is much below its mathematical validation that goes till 10^{10000} (Bahbouhi, data not shown) [3]. https://b43797.github.io/Article-Goldbach-high-limits/

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