Solving open problems from Riemann zeta function and Sieve of Eratosthenes when unified under Information-complexity conservation and Fic-Fac Ratio

By John Ting

Abstract

Our Information-complexity conservation computed as Information-based complexity constitutes an unique all-purpose analytic tool associated with Mathematics for Incompletely Predictable problems. These problems can literally be perceived as “complex systems” containing well-defined Incompletely Predictable entities such as nontrivial zeros and two types of Gram points in Riemann zeta function (or its proxy Dirichlet eta function) together with prime and composite numbers from Sieve of Eratosthenes. Correct and complete mathematical arguments for first key step of converting this function into its continuous format version, and second key step of applying Information-Complexity conservation to this Sieve result in primary spin-offs from first key step consisting of proving Riemann hypothesis (and explaining two types of Gram points), and second key step consisting of proving Polignac’s and Twin prime conjectures. COVID-19 pandemic with unprecedented negative global impacts was declared by World Health Organization on March 11, 2020. Being loosely and intuitively perceived as “Incompletely Predictable”, we briefly discuss modelling of this pandemic [and the open problems] in terms of our novel Fic-Fac Ratio.

Keywords: COVID-19 pandemic, Dirichlet Sigma-Power Laws, Exact and Inexact Dimensional analysis homogeneity, Information-Complexity conservation, Plus Gap 2 Composite Number Continuous Law, Plus-Minus Gap 2 Composite Number Alternating Law, Polignac’s conjecture, Riemann hypothesis, Twin prime conjecture

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1. Introduction

In this research paper, treatise on relevant Mathematics for Incompletely Predictable Problems required to solve Riemann hypothesis and explain the closely related two types of Gram points is outlined first; and to solve Polignac’s and Twin prime conjectures is outlined subsequently. COVID-19 is an acronym that stands for Coronavirus Disease 2019. To help ease time constraint of frontline health workers interested in reading this paper, its content is mindfully

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composed to succinctly include selected materials relevant to COVID-19 pandemic (officially declared by World Health Organization on March 11, 2020). Caused by highly contagious & virulent coronavirus strain SARS-CoV-2, it has resulted in unprecedented negative global impacts from economic and health crisis with widespread job losses and many deaths. We devote a few pages of this paper to highlight importance of mathematics in understanding infectious disease outbreak.

*SIR* model and *SEIR* model are epidemiological (compartmental) models commonly used by mathematicians to compute theoretical number of people inflicted with an infectious illness such as COVID-19 in a closed population over time. Respectively, they consist of three and four compartments derived from: *S* for Susceptible Population, *E* for Exposed Population, *I* for Infectious Population, and *R* for Recovered Population [including deceased &/or immune individuals]. Both models utilize (deterministic) ordinary differential equations. Aspects of modelling this pandemic in terms of our derived Fic-Fac Ratio are loosely and intuitively perceived as “Incompletely Predictable”—a term also used during the process of solving the above mentioned open problems in Number theory.

Factitious versus Fictitious and the novel Fic-Fac Ratio:
The adjective *factitious* derives from factus and therefore facere means to correctly make or utilize something based on (true) fact whereas *fictitious* derives from fictus and therefore fingere means to incorrectly make or utilize something based on (false) fiction. We predominantly refer the “something” here to include mathematical arguments (MA) and diagnostic tests (DT). These two adjectives with their given meanings are used to help create [“generalized”] Fic-Fac Ratio, which is an acronym that stands for Fictitious-Factitious Ratio. DT ‘Accuracy’ refers to ability of that test to distinguish between patients with disease, and those without. Roughly considered as ‘Inverse Accuracy’ [with higher Accuracy corresponding to lower Fic-Fac Ratio and *vice versa*], we advocate this Ratio to be universally applicable to all well-defined mathematical models.

With or without a “pseudo-component” (respectively) equating to ‘<100% accuracy’ or ‘100% accuracy’, we usefully categorize all synthesized mathematical models to be broadly associated with either “proposed states” such as Riemann hypothesis or “natural states” such as COVID-19 pandemic. During mathematical modelling of Riemann hypothesis, less accurate inequation [as opposed to more accurate equation] is the relevant pseudo-component as it contains Pseudo-$\sum$(all fractional exponents) – see Subsection 1.2 below. During epidemiological modelling of COVID-19 pandemic, less accurate Pseudo-*SIR* model [as opposed to more accurate *SEIR* model] is the relevant pseudo-component as it does not contain compartment *E* for Exposed Population.
Modelling concepts from open problems and COVID-19 pandemic using derived Fic-Fac Ratio [regarded as tertiary spin-offs from solving our mentioned open problems] are outlined in Appendix E. Here, we provide concrete examples of ideal gold standard MA and ideal gold standard DT with their associated MA and DT results corresponding to Fic-Fac Ratio = 0.

Open Problems from Riemann zeta function and Sieve of Eratosthenes:

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Dirichlet Sigma-Power Laws are continuous format version of discrete format Riemann zeta function (or its proxy Dirichlet eta function). Sieve of Eratosthenes is a simple ancient algorithm for finding all prime numbers up to any given limit by iteratively marking as composite (i.e., not prime) the multiples of each prime, starting with first prime number 2. Multiples of a given prime are generated as a sequence of numbers starting from that prime, with constant difference between them equal to that prime. Dimension (2x - N) [see Section 8 “Information-Complexity conservation” for more details] dependently incorporate prime and composite numbers (and Number ‘1’) whereas Sieve of Eratosthenes directly and indirectly give rise to prime and composite numbers (but not Number ‘1’). Note that in using the unique Dimension (2x - N) system with N = 2x - \(\Sigma PC_x\)-Gap, Dimension (2x - N) when fully expanded is numerically just equal to \(\Sigma PC_x\)-Gap since Dimension (2x - N) = 2x - 2x + \(\Sigma PC_x\)-Gap = \(\Sigma PC_x\)-Gap. In order to solve Riemann hypothesis (and provide explanations for two types of Gram points), Polignac’s and Twin prime conjectures; one could in principle use Path A or Path B option. Our chosen Path B option requires Mathematics for Incompletely Predictable Problems.

Elements of three complete sets constituted by nontrivial zeros and two types of Gram points together with elements of two complete sets constituted by prime and composite numbers are all classified as Incompletely Predictable entities. Riemann hypothesis (1859) proposed all nontrivial zeros in Riemann zeta function to be located on its critical line. Defined as Incompletely Predictable problem is essential in obtaining the continuous format version of [discrete format] Riemann zeta function dubbed Dirichlet Sigma-Power Law to prove this hypothesis. All of infinite magnitude, nontrivial zeros when geometrically depicted as corresponding Origin intercepts together with two types of Gram points when geometrically depicted as corresponding x- & y-axes intercepts explicitly confirm they intrinsically form relevant component of point-intersections in this function. Defined as Incompletely Predictable problems is
essential for these explanations to be correct. Involving proposals that prime gaps and associated sets of prime numbers are infinite in magnitude, Twin prime conjecture (1846) deals with even prime gap 2 thus forming a subset of Polignac’s conjecture (1849) which deals with all even prime gaps 2, 4, 6, 8, 10,... Defined as Incompletely Predictable problems is essential to prove these conjectures using research method dubbed Information-Complexity conservation in a quantitative manner.

Thus our innovative Information-complexity conservation which is computed as Information-based complexity constitutes an unique all-purpose [quantitative and qualitative] analytic tool associated with Mathematics for Incompletely Predictable problems. These problems can literally be perceived as “complex systems” containing well-defined Incompletely Predictable entities such as nontrivial zeros and two types of Gram points in Riemann zeta function (or its proxy Dirichlet eta function) together with prime and composite numbers from Sieve of Eratosthenes. Then Mathematics for Incompletely Predictable Problems equates to sine qua non defining problems involving Incompletely Predictable entities to be Incompletely Predictable problems achieved by incorporating certain identifiable mathematical steps with this procedure ultimately enabling us to rigorously prove or explain above problems as primary spin-offs.

Obtained parallel observations: Just as there is conservation or preservation of (quantitative) “net area value” happening at appropriate times for continuous format Riemann zeta function (aka Dirichlet Sigma-Power Law); similar conservation or preservation of (quantitative) “net number value” will happen at appropriate times for natural numbers on one hand and prime numbers, composite numbers and Number ‘1’ [and even and odd numbers] on the other hand when Information-Complexity conservation is enforced. This concept will be equally applicable to prime numbers, composite numbers and Number ‘1’ [and even and odd numbers] when depicted using Dimension (2x - N). Then qualitatively, (maximal) Information-Complexity conservation for “complex system” Riemann zeta function equates to maximal three axes-intercepts occurring only when σ = ½ with minimal two axes-intercepts occurring when σ ≠ ½; and maximal Information-Complexity conservation for “complex system” constituents of natural numbers equates to maximal N = 7 in Dimension (2x - N) only for prime-composite number pairing with [relatively] minimal N = 4 in Dimension (2x - N) for even-odd number pairing.

Refined information on Incompletely Predictable entities of Gram and virtual Gram points: These entities all of infinite magnitude are dependently calculated using complex equation Riemann zeta function, ζ(s), or its proxy Dirichlet eta function, η(s), in critical strip (denoted by 0 < σ < 1) thus forming relevant component of point-intersections in this function. In Figure

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below, Gram\[y=0\], Gram\[x=0\] and Gram\[x=0,y=0\] points are respectively
geometrical x-axis, y-axis and Origin intercepts at critical line (denoted by
\(\sigma = \frac{1}{2}\)). Gram\[y=0\] and Gram\[x=0,y=0\] points are respectively synonymous
with traditional ‘Gram points’ and nontrivial zeros. In Figures 3 and 4 below,
virtual Gram\[y=0\] and virtual Gram\[x=0\] points are respectively geometrical
x-axis and y-axis intercepts at non-critical lines (denoted by \(\sigma \neq \frac{1}{2}\)). Virtual
Gram\[x=0,y=0\] points do not exist.

Refined information on Incompletely Predictable entities of prime and
composite numbers: These entities all of infinite magnitude are dependently
computed (respectively) directly and indirectly using complex algorithm Sieve
of Eratosthenes. Denote \(\mathbb{C}\) to be uncountable complex numbers, \(\mathbb{R}\) to be
uncountable real numbers, \(\mathbb{Q}\) to be countable rational numbers or roots [of
non-zero polynomials], \(\mathbb{R}–\mathbb{Q}\) to be uncountable irrational numbers, \(\mathbb{A}\) to be
countable algebraic numbers, \(\mathbb{R}–\mathbb{A}\) to be uncountable transcendental numbers,
\(\mathbb{Z}\) to be countable integers, \(\mathbb{W}\) to be countable whole numbers, \(\mathbb{N}\) to be count-
able natural numbers, \(\mathbb{E}\) to be countable even numbers, \(\mathbb{O}\) to be countable odd
numbers, \(\mathbb{P}\) to be countable prime numbers, and \(\mathbb{C}\) to be countable composite
numbers. \(\mathbb{A}\) are \(\mathbb{C}\) (including \(\mathbb{R}\)) that are countable rational or irrational roots.
We have (i) Set \(\mathbb{N} = \mathbb{E} + \mathbb{O}\), (ii) Set \(\mathbb{N} = \mathbb{P} + \mathbb{C} + \text{Number ‘1’},
(iii) Set \(\mathbb{A} = \mathbb{Q} + \text{irrational roots}\), and (iv) Set \(\mathbb{N} \subset \mathbb{W} \subset \mathbb{Z} \subset \mathbb{Q} \subset \mathbb{R} \subset \mathbb{C}\). Then Set \(\mathbb{R}–\mathbb{Q}\) = Set \(\text{irrational roots}\) + Set
\(\mathbb{R}–\mathbb{A}\). Cardinality of a given set: With increasing size, arbitrary Set \(\mathbb{X}\) can be
countable finite set (CFS), countable infinite set (CIS) or uncountable infinite
set (UIS). Cardinality of Set \(\mathbb{X}\), \(|\mathbb{X}|\), measures “number of elements” in Set \(\mathbb{X}\).
E.g. Set negative Gram\[y=0\] point has CFS of negative Gram\[y=0\] point
with \(|\text{negative Gram}[y=0] \text{ point}| = 1\), Set even \(\mathbb{P}\) has CFS of even \(\mathbb{P}\) with
\(|\text{even } \mathbb{P}| = 1\), Set \(\mathbb{N}\) has CIS of \(\mathbb{N}\) with \(|\mathbb{N}| = \aleph_0\), and Set \(\mathbb{R}\) has UIS of \(\mathbb{R}\)
with \(|\mathbb{R}| = \mathfrak{c}\) (cardinality of the continuum).

Differentiation of terms “Incompletely Predictable” versus “Completely
Predictable”: Set \(\mathbb{N} = \mathbb{E} + \mathbb{O}\). The two subsets of even and odd
numbers are “Independent” and “Completely Predictable”. Examples: Even
number after 2,984 viz. 2,984 / 2 = 1,492nd even number is [easily] calculated
independently using simple algorithm to be 2,984+2 = 2,986 viz. 2,986 / 2 = 1,493rd even number. Odd number after 2,985 viz. (2,985+1) / 2 = 1,493rd
odd number is [easily] calculated independently using simple algorithm to be
2,985+2 = 2,987 viz. (2,987+1) / 2 = 1,494th odd number. Set \(\mathbb{N} = \mathbb{P} + \mathbb{C} + \text{Number ‘1’}. \)The two subsets of prime and composite numbers are
“Dependent” and “Incompletely Predictable”. Example: Sixth prime number
‘13’ [after fifth prime number ‘11’] is [not easily] computed dependently using
complex algorithm from scratch via: 2 is 1st prime number, 3 is 2nd prime
number, 4 is 1st composite number, 5 is 3rd prime number, 6 is 2nd composite

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number, 7 is 4th prime number, 8 is 3rd composite number, 9 is 4th composite number, 10 is 5th composite number, 11 is 5th prime number, 12 is 6th composite number, and desired 13 is 6th prime number.

**Formal definitions for Completely Predictable (CP) entities and Incompletely Predictable (IP) entities:** In this paper, the word “number” [singular noun] or “numbers” [plural noun] in reference to prime & composite numbers, nontrivial zeros & two types of Gram points can interchangeably be replaced with the word “entity” [singular noun] or “entities” [plural noun]. Respectively, an IP (CP) number is locationally defined as a number whose position is **dependently** (independently) determined by complex (simple) calculations using complex (simple) equation or algorithm with (without) needing to know related positions of all preceding numbers in neighborhood. Simple properties are inferred from a sentence such as “This simple equation or algorithm by itself will intrinsically incorporate actual location [and actual positions] of all CP numbers”. Solving CP problems with simple properties amendable to **simple** treatments using **usual** mathematical tools such as Calculus result in ‘Simple Elementary Fundamental Laws’-based solutions. Complex properties, or “meta-properties”, are inferred from a sentence such as “This complex equation or algorithm by itself will intrinsically incorporate actual location [but not actual positions] of all IP numbers”. Solving IP problems with complex properties amendable to **complex** treatments using **unusual** mathematical tools such as Information-Complexity conservation, exact and inexact Dimensional analysis homogeneity as well as using **usual** mathematical tools such as Calculus result in ‘Complex Elementary Fundamental Laws’-based solutions.

Based on Mathematics for Incompletely Predictable Problems, we compare and contrast CP entities (obeying Simple Elementary Fundamental Laws) against IP entities (obeying Complex Elementary Fundamental Laws) using following examples:

(I) **E** are CP entities constituted by CIS of $Q_2, 4, 6, 8, 10, 12$....

(II) **O** are CP entities constituted by CIS of $Q_1, 3, 5, 7, 9, 11$....

(III) **P** are IP entities constituted by CIS of $Q_2, 3, 5, 7, 11, 13$....

(IV) **C** are IP entities constituted by CIS of $Q_4, 6, 8, 9, 10, 12$....

(V) With values traditionally given by parameter $t$, nontrivial zeros in Riemann zeta function are IP entities constituted by CIS of $R–A$ [rounded off to six decimal places]: 14.134725, 21.022040, 25.010858, 30.424876, 32.935062, 37.586178,....

(VI) Traditional ‘Gram points’ (or Gram[y=0] points) are x-axis intercepts with choice of index ‘n’ for ‘Gram points’ historically chosen such that first ‘Gram point’ [by convention at n = 0] corresponds to the t value which is larger than (first) nontrivial zero located at $t = 14.134725$. ‘Gram points’ are IP entities constituted by CIS of $R–A$ [rounded off to six decimal places] with

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the first six given at \( n = -3, t = 0 \); at \( n = -2, t = 3.436218 \); at \( n = -1, t = 9.666908 \); at \( n = 0, t = 17.845599 \); at \( n = 1, t = 23.170282 \); at \( n = 2, t = 27.670182 \). We will not calculate any values for Gram\([x=0]\) points here.

Denoted by parameter \( t \); nontrivial zeros, ‘Gram points’ and Gram\([x=0]\) points all belong to well-defined CIS of \( \mathbf{R} - \mathbf{A} \) which will twice obey the relevant location definition [in CIS of \( \mathbf{R} - \mathbf{A} \) themselves and in CIS of numerical digits after decimal point of each \( \mathbf{R} - \mathbf{A} \)]. First and only negative ‘Gram point’ (at \( n = -3 \)) is obtained by substituting CP \( t = 0 \) resulting in \( \zeta(\frac{1}{2} + it) = \zeta(\frac{1}{2}) = -1.4603545 \), a \( \mathbf{R} - \mathbf{A} \) number [rounded off to seven decimal places] calculated as a limit similar to limit for Euler-Mascheroni constant or Euler gamma with its precise (1st) position only determined by computing positions of all preceding (nil) ‘Gram point’ in this case. ‘0’ and ‘1’ are special numbers being neither \( \mathbf{P} \) nor \( \mathbf{C} \) as they represent nothingness (zero) and wholeness (one). In this setting, the ideas of (i) having factors for ‘0’ and ‘1’, or (ii) treating ‘0’ and ‘1’ as CP or IP numbers, is meaningless. All entities derived from well-defined simple/complex algorithms or equations are “dual numbers” as they can be simultaneously depicted as CP and IP numbers. For instance, \( \mathbf{Q}'2' \) as \( \mathbf{P} \ (& \mathbf{E}) \), ‘97’ as \( \mathbf{P} \ (& \mathbf{O}) \), ‘98’ as \( \mathbf{C} \ (& \mathbf{E}) \), ‘99’ as \( \mathbf{C} \ (& \mathbf{O}) \); CP ‘0’ values in \( x=0 \), \( y=0 \) & simultaneous \( x=0,y=0 \) associated with various IP \( t \) values in \( \zeta(s) \).

1.1. Algebraic number theory versus Analytic number theory. Set \( \mathbf{P} \subset \mathbf{Z} \subset \mathbf{Q} \). Gaussian rationals, and Gaussian integers are complex numbers whose real and imaginary parts are (respectively) both rational numbers, and integer numbers. Gaussian primes are Gaussian integers \( z = a + bi \) satisfying one of the following properties.

1. If both \( a \) and \( b \) are nonzero, then \( a+bi \) is a Gaussian prime iff \( a^2 + b^2 \) is an ordinary prime [whereby iff is the written abbreviation for ‘if and only if’].
2. If \( a = 0 \), then \( bi \) is a Gaussian prime iff \( |b| \) is an ordinary prime and \( |b| = 3 \) (mod 4).
3. If \( b = 0 \), then \( a \) is a Gaussian prime iff \( |a| \) is an ordinary prime and \( |a| = 3 \) (mod 4).

Prime numbers which are also Gaussian primes are 3, 7, 11, 19, 23, 31, 43,.... In Eq. (1) below, we noted that the equivalent Euler product formula with product over prime numbers [instead of summation over natural numbers] faithfully represent Riemann zeta function, \( \zeta(s) \). Eq. (2) below is Riemann’s functional equation involving transcendental number \( \pi = 3.14159... \). With denominators on the left involving odd numbers and named after Gottfried Leibniz, Leibniz formula for \( \pi \) states that \( \frac{1}{1} - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \cdots = \frac{\pi}{4} \).

Expression \( \zeta(2) = \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \cdots = \frac{\pi^2}{6} \approx 1.64493406684822643647 \) involves

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\[ \pi \implies \text{division concerning two unrelated transcendental (irrational) numbers as } \frac{\zeta(2)}{\pi^2} \text{ will interestingly result in rational number } \frac{1}{6}. \]

Algebraic number theory is loosely defined to deal with new number systems involving Completely Predictable or Incompletely Predictable entities such as even & odd numbers, prime & composite numbers, \( p \)-adic numbers, Gaussian primes, Gaussian rationals & integers, and complex numbers. A \( p \)-adic number is an extension of the field of rationals such that congruences modulo powers of a fixed prime number \( p \) are related to proximity in so-called “\( p \)-adic metric”. The extension is achieved by an alternative interpretation of concept of “closeness” or absolute value viz. \( p \)-adic numbers are considered to be close when their difference is divisible by a high power of \( p \): the higher the power, the closer they are. This property enables \( p \)-adic numbers to encode congruence information in a way that turns out to have powerful applications in number theory including, for example, attacking certain Diophantine equations and in the famous proof of Fermat’s Last Theorem by English mathematician Sir Andrew John Wiles in 1995.

Analytic number theory is loosely defined to deal with functions of a complex variable such as Riemann zeta function [containing nontrivial zeros & two types of Gram points] and other L-functions. Study of prime numbers, complex numbers & \( \pi \) being braided together in a pleasing trio is usefully visualized to be located at intersection of this two main branches of number theory. We loosely separate our relatively elementary proof for Riemann hypothesis & relatively elementary explanations for two types of Gram points to belong to Analytic number theory, and our relatively elementary proofs for Polignac’s & Twin prime conjectures [expectedly associated with paucity of functions of a complex variable] to belong to Algebraic number theory.

**Secondary spin-offs** from solving Riemann hypothesis are often stated as “With this one solution, we have proven five hundred theorems or more at once”. This apply to many important theorems in Number theory (mostly on prime numbers) that rely on properties of Riemann zeta function such as where trivial and nontrivial zeros are / are not located. A classical example is resulting absolute and full delineation of prime number theorem, which relates to prime counting function. This function, usually denoted by \( \pi(x) \), is defined as the number of prime numbers \( \leq x \). Public-key cryptography that is widely required for financial security in E-Commerce traditionally depend on solving the difficult problem of factoring prime numbers for astronomically large numbers. The intrinsic “Incompletely Predictable” property present in prime numbers, composite numbers, nontrivial zeros and two types of Gram points can never be altered to “Completely Predictable” property. For this stated reason, it is a mathematical impossibility that providing rigorous proofs such
as for Riemann hypothesis will, in principle, ever result in crypto-apocalypse. However, utilizing parallel computing (more than serial computing), fast super-computers and the far-more-powerful quantum computers would theoretically allow solving difficult factorization problem in quick time. This will result in less secure encryption and decryption. Then using, for instance, quantum cryptography that relies on principles of quantum mechanics to encrypt data and transmit it in a way that cannot be hacked will combat this issue.

Proposed by German mathematician Bernhard Riemann (September 17, 1826 – July 20, 1866) in 1859, Riemann hypothesis is mathematical statement on \( \zeta(s) \) that critical line denoted by \( \sigma = \frac{1}{2} \) contains complete Set nontrivial zeros with \( |\text{nontrivial zeros}| = \aleph_0 \). Alternatively, this hypothesis is geometrical statement on \( \zeta(s) \) that generated curves when \( \sigma = \frac{1}{2} \) contain complete Set Origin intercepts with \( |\text{Origin intercepts}| = \aleph_0 \).

\[
\zeta(s) = \frac{e^{(\ln(2\pi) - 1 - \frac{\gamma}{2})s}}{2(s - 1)\Gamma(1 + \frac{s}{2})} \Pi_{\rho} \left( 1 - \frac{s}{\rho} \right) e^{\frac{s}{\rho}} = \frac{\Pi_{\rho} \left( 1 - \frac{s}{\rho} \right)}{2(s - 1)\Gamma(1 + \frac{s}{2})}
\]

Depicted in full and abbreviated version, Hadamard product above is infinite product expansion of \( \zeta(s) \) based on Weierstrass’s factorization theorem displaying a simple pole at \( s = 1 \). It contains both trivial & nontrivial zeros indicating their common origin from \( \zeta(s) \). Set trivial zeros occurs at \( \sigma = -2, -4, -6, -8, -10, \ldots, \infty \) with \( |\text{trivial zeros}| = \aleph_0 \) due to \( \Gamma \) function term in denominator. Nontrivial zeros occur at \( s = \rho \) with \( \gamma \) denoting Euler-Mascheroni constant.

Remark 1.1. Confirming first 10,000,000,000,000 nontrivial zeros location on critical line implies but does not prove Riemann hypothesis to be true.

Locations of first 10,000,000,000,000 nontrivial zeros on critical line have previously been computed to be correct. Hardy in 1914[1], and with Littlewood in 1921[2], showed infinite nontrivial zeros on critical line by considering moments of certain functions related to \( \zeta(s) \). This discovery cannot constitute rigorous proof for Riemann hypothesis because they have not exclude theoretical existence of nontrivial zeros located away from this line.

1.2. Exact and inexact Dimensional analysis homogeneity for equations and inequations. Respectively for ‘base quantities’ such as length, mass and time; their fundamental SI ‘units of measurement’ meter (m) is defined as distance travelled by light in vacuum for time interval \( 1/299,792,458 \) s with speed of light \( c = 299,792,458 \text{ ms}^{-1} \), kilogram (kg) is defined by taking fixed numerical value Planck constant \( h \) to be \( 6.626 \ 070 \ 15 \times 10^{-34} \text{ Joules-second (Js)} \) [whereby Js is equal to \( \text{kgm}^2\text{s}^{-1} \) and second \( (s) \) is defined in terms of \( \Delta v Cs = \Delta(133^1\text{Cs})_{mf} = 9,192,631,770 \text{ s}^{-1} \). Derived SI units such as J and \( \text{ms}^{-1} \) respectively represent ‘base quantities’ energy and velocity. The word ‘dimension’
is commonly used to indicate all those mentioned ‘units of measurement’ in well-defined equations.

Dimensional analysis (DA) is an analytic tool with DA homogeneity and non-homogeneity (respectively) denoting valid and invalid equation occurring when ‘units of measurements’ for ‘base quantities’ are “balanced” and “unbalanced” across both sides of the equation. E.g. equation $2\ m + 3\ m = 5\ m$ is valid and equation $2\ m + 3\ \text{kg} = 5\ \text{m-kg}$ is invalid (respectively) manifesting DA homogeneity and non-homogeneity.

**Remark 1.2.** We can validly apply exact and inexact Dimensional analysis homogeneity to well-defined equations and inequations.

Let $(2n)$ and $(2n-1)$ be ‘base quantities’ in our derived Dirichlet Sigma-Power Laws formatted in simplest forms as equations and inequations. E.g. DA on exponent $\frac{1}{2}$ in $(2n)\frac{1}{2}$ when depicted in simplest form is desirable for our purpose but DA on exponent $\frac{1}{4}$ in equivalent $(2^2 n^2)\frac{1}{4}$ not depicted in simplest form is undesirable for our purpose. Fractional exponents as ‘units of measurement’ given by $(1 - \sigma)$ for equations and $(\sigma + 1)$ for inequations when $\sigma = \frac{1}{2}$ coincide with exact DA homogeneity$^1$; and $(1 - \sigma)$ for equations and $(\sigma + 1)$ for inequations when $\sigma \neq \frac{1}{2}$ coincide with inexact DA homogeneity$^2$. Respectively for equations and inequations, exact DA homogeneity at $\sigma = \frac{1}{2}$ denotes $\sum$(all fractional exponents) as $2(1 - \sigma)$ and Pseudo-$\sum$(all fractional exponents) as $2(\sigma + 1)$ equates to [“exact”] whole number ‘1’ and ‘3’; and inexact DA homogeneity at $\sigma \neq \frac{1}{2}$ denotes $\sum$(all fractional exponents) as $2(1 - \sigma)$ and Pseudo-$\sum$(all fractional exponents) as $2(\sigma + 1)$ equates to [“inexact”] fractional number ‘$\neq1$’ and ‘$\neq3$’. R1 terms in all inequations contain $(2n)$ and $(2n-1)$ ‘base quantities’ but these are endowed with exponent 1 [and not with fractional exponent $(\sigma+1)$] as relevant ‘unit of measurement’ thus giving rise to our Pseudo-$\sum$(all fractional exponents).

**Footnote 1, 2:** Exact and inexact DA homogeneity occur in Dirichlet Sigma-Power Laws as equations or inequations for Gram[y=0] points, Gram[x=0] points and nontrivial zeros. *Law of Continuity* is a heuristic principle *whatever succeed for the finite, also succeed for the infinite*. Then these Laws which inherently manifest themselves on finite and infinite time scale should “succeed for the finite, also succeed for the infinite”.

**Outline of proof for Riemann hypothesis.** {Validity in using the inequations with their Pseudo-$\sum$(all fractional exponents) given by $2(\sigma + 1)$ instead of their [actual] $\sum$(all fractional exponents) given by $(\sigma + 2)$ is allowed since the absolute difference between the two terms is simply the constant $\sigma$. For equations, their [actual] $\sum$(all fractional exponents) given by $2(1 - \sigma)$ meant that the absolute difference between this term and the Pseudo-$\sum$(all fractional exponents) given by $2(\sigma + 1)$ or [actual] $\sum$(all fractional exponents) given by $(\sigma + 2)$ for inequations is, respectively, simply the constant $4\sigma$ or...
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3σ, thus lending further support to this validity.} To simultaneously satisfy two mutually inclusive conditions: I. With rigid manifestation of exact DA homogeneity, Set nontrivial zeros with \(|\text{nontrivial zeros}| = \aleph_0\) is located on critical line (viz. \(\sigma = \frac{1}{2}\)) when \(2(1 - \sigma)\) [or \(2(\sigma + 1)\)] as \(\sum\text{(all fractional exponents)} = \text{whole number ‘1’}\) [or Pseudo-\(\sum\text{(all fractional exponents)} = \text{whole number ‘3’}\)] in Dirichlet Sigma-Power Law\(^3\) as equation [or inequation]. II. With rigid manifestation of inexact DA homogeneity, Set nontrivial zeros with \(|\text{nontrivial zeros}| = \aleph_0\) is not located on non-critical lines (viz. \(\sigma \neq \frac{1}{2}\)) when \(2(1 - \sigma)\) [or \(2(\sigma + 1)\)] as \(\sum\text{(all fractional exponents)} = \text{fractional number ‘\(\neq 1\’\)}\) [or Pseudo-\(\sum\text{(all fractional exponents)} = \text{fractional number ‘\(\neq 3\’\)}\)] in Dirichlet Sigma-Power Law\(^3\) as equation [or inequation].

**Footnote 3:** Derived from original \(\eta(s)\) (proxy for \(\zeta(s)\)) as equation or inequation, this Law symbolizes end-result proof on Riemann hypothesis.

**Riemann hypothesis mathematical foot-prints.** Six identifiable steps to prove Riemann hypothesis: Step 1 Use \(\eta(s)\), proxy for \(\zeta(s)\), in critical strip. Step 2 Apply Euler formula to \(\eta(s)\). Step 3 Obtain “simplified” Dirichlet eta function which intrinsically incorporates actual location [but not actual positions] of all nontrivial zeros\(^4\). Step 4 Apply Riemann integral to “simplified” Dirichlet eta function in discrete (summation) format. Step 5 Obtain Dirichlet Sigma-Power Law in continuous (integral) format as equation or inequation. Step 6 Confirm exact or inexact DA homogeneity for \(\sum\text{(all fractional exponents)}\) and Pseudo-\(\sum\text{(all fractional exponents)}\).

**Footnote 4:** Respectively Gram\([y=0]\) points, Gram\([x=0]\) points and nontrivial zeros are Incompletely Predictable entities with actual positions determined by setting \(\sum\text{Im}\{\eta(s)\} = 0\), \(\sum\text{Re}\{\eta(s)\} = 0\) and \(\sum\text{ReIm}\{\eta(s)\} = 0\) to dependently calculate relevant positions of all preceding entities in neighborhood. Respectively actual location of Gram\([y=0]\) points, Gram\([x=0]\) points and nontrivial zeros; and virtual Gram\([y=0]\) points, virtual Gram\([x=0]\) points and “absent” nontrivial zeros occur precisely at \(\sigma = \frac{1}{2}\); and \(\sigma \neq \frac{1}{2}\).

2. Riemann zeta and Dirichlet eta functions

An L-function consists of a Dirichlet series with a functional equation and an Euler product. Examples of L-functions come from modular forms, elliptic curves, number fields, and Dirichlet characters, as well as more generally from automorphic forms, algebraic varieties, and Artin representations. They form an integrated component of ‘L-functions and Modular Forms Database’ (LMFDB) with far-reaching implications. In perspective, \(\zeta(s)\) is the simplest example of an L-function. It is a function of complex variable \(s (= \sigma \pm it)\) that analytically continues sum of infinite series \(\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s} = \frac{1}{1^s} + \frac{1}{2^s} + \frac{1}{3^s} + \cdots\).
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Figure 1. INPUT for \( \sigma = \frac{1}{2}, \frac{2}{5}, \) and \( \frac{3}{5} \). \( \zeta(s) \) has countable infinite set of Completely Predictable trivial zeros at \( \sigma = \) all negative even numbers and countable infinite set of Incompletely Predictable nontrivial zeros at \( \sigma = \frac{1}{2} \) for various \( t \) values.

Figure 2. OUTPUT for \( \sigma = \frac{1}{2} \). Schematically depicted polar graph of \( \zeta\left(\frac{1}{2} + it\right) \) plotted along critical line for real values of \( t \) running from 0 to 34, horizontal axis: \( \text{Re}\{\zeta\left(\frac{1}{2} + it\right)\} \), and vertical axis: \( \text{Im}\{\zeta\left(\frac{1}{2} + it\right)\} \). There are presence of Origin intercepts which are totally absent in Figures 3 and 4 [with identical axes definitions].

Figure 3. OUTPUT for \( \sigma = \frac{2}{5} \).

Figure 4. OUTPUT for \( \sigma = \frac{3}{5} \).

The common convention is to write \( s \) as \( \sigma + it \) with \( i = \sqrt{-1} \), and with \( \sigma \) and \( t \) real. Valid for \( \sigma > 0 \), we write \( \zeta(s) \) as \( \text{Re}\{\zeta(s)\} + i\text{Im}\{\zeta(s)\} \) and note that
ζ(σ + it) when 0 < t < +∞ is the complex conjugate of ζ(σ − it) when −∞ < t < 0.

Also known as alternating zeta function, η(s) must act as proxy for ζ(s) in critical strip (viz. 0 < σ < 1) containing critical line (viz. σ = 1/2) because ζ(s) only converges when σ > 1. This implies ζ(s) is undefined to left of this region in critical strip which then requires η(s) representation instead.

They are related to each other as ζ(s) = γ · η(s) with proportionality factor

\[ γ = \frac{1}{1 - 2^{-s}} \quad \text{and} \quad η(s) = \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^s} = \frac{1}{1^s} - \frac{1}{2^s} + \frac{1}{3^s} - \cdots. \]

Eq. (1) is defined for only 1 < σ < ∞ region where ζ(s) is absolutely convergent with no zeros located here. In Eq. (1), equivalent Euler product formula with product over prime numbers [instead of summation over natural numbers] also represents ζ(s) ⇒ all prime numbers are (intrinsically) “encoded” in ζ(s). This observation alone represents a strong reason to conveniently combine proofs for Riemann hypothesis, Polignac’s and Twin prime conjectures in our [one] paper.

(2)

\[ ζ(s) = 2^s π^{s-1} \sin \left( \frac{π s}{2} \right) \cdot Γ(1 - s) \cdot ζ(1 - s) \]

With σ = 1/2 as symmetry line of reflection, Eq. (2) is Riemann’s functional equation valid for −∞ < σ < ∞. It can be used to find all trivial zeros on horizontal line at it = 0 occurring when σ = -2, -4, -6, -8, -10, . . . , ∞ whereby ζ(s) = 0 because factor sin(π s/2) vanishes. Γ is gamma function, an extension of factorial function [a product function denoted by ! notation whereby n! = n(n − 1)(n − 2) . . . (1)] with its argument shifted down by 1, to real and complex numbers. That is, if n is a positive integer, Γ(n) = (n − 1)!

Proof: page numbers may be temporary.
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(3) \[ \zeta(s) = \frac{1}{(1 - 2^{1-s})} \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^s} \]

\[ = \frac{1}{(1 - 2^{1-s})} \left( \frac{1}{1^s} - \frac{1}{2^s} + \frac{1}{3^s} - \cdots \right) \]

Eq. (3) is defined for all \( \sigma > 0 \) values except for simple pole at \( \sigma = 1 \). As alluded to above, \( \zeta(s) \) without \( \frac{1}{(1 - 2^{1-s})} \) viz. \( \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^s} \) is \( \eta(s) \). It is a holomorphic function of \( s \) defined by analytic continuation and is mathematically defined at \( \sigma = 1 \) whereby analogous trivial zeros with presence only for \( \eta(s) \) [but not for \( \zeta(s) \)] on vertical straight line \( \sigma = 1 \) are found at \( s = 1 \pm \frac{2\pi k}{\ln(2)} \) where \( k = 1, 2, 3, 4, 5, \ldots, \infty \).

Figure 1 depict complex variable \( s (=\sigma \pm it) \) as INPUT with x-axis denoting real part \( \text{Re}\{s\} \) associated with \( \sigma \), and y-axis denoting imaginary part \( \text{Im}\{s\} \) associated with \( t \). Figures 2, 3 and 4 respectively depict \( \zeta(s) \) as OUTPUT for real values of \( t \) running from 0 to 34 at \( \sigma = \frac{1}{2} \) (critical line), \( \sigma = \frac{2}{5} \) (non-critical line), and \( \sigma = \frac{3}{5} \) (non-critical line) with x-axis denoting real part \( \text{Re}\{\zeta(s)\} \) and y-axis denoting imaginary part \( \text{Im}\{\zeta(s)\} \). There are infinite types-of-spirals possibilities associated with each \( \sigma \) value arising from all infinite \( \sigma \) values in critical strip. Mathematically proving all nontrivial zeros location on critical line as denoted by solitary \( \sigma = \frac{1}{2} \) value equates to geometrically proving all Origin intercepts occurrence at solitary \( \sigma = \frac{1}{2} \) value. Both result in rigorous proof for Riemann hypothesis.

3. Prerequisite lemma, corollary and propositions for Riemann hypothesis

Original equation \( \eta(s) \), proxy for \( \zeta(s) \), is treated as unique mathematical object with key properties and behaviors. Containing all x-axis, y-axis and Origin intercepts, it will intrinsically incorporate actual location [but not actual positions] of all Gram[y=0] points, Gram[x=0] points and nontrivial zeros. Proofs on lemma, corollary and propositions on nontrivial zeros depict exact and inexact DA homogeneity in both derived equation and inequation. Parallel procedure on Gram[y=0] and Gram[x=0] points in Section 5 below depict exact and inexact DA homogeneity in similarly derived equations and inequations.

Lemma 3.1. “Simplified” Dirichlet eta function is derived directly from Dirichlet eta function with Euler formula application and it will intrinsically incorporate actual location [but not actual positions] of all nontrivial zeros.

Proof: page numbers may be temporary
Proof. Denote complex number \((\mathbb{C})\) as \(z = x + iy\). Then \(z = \text{Re}(z) + i\text{Im}(z)\) with \(\text{Re}(z) = x\) and \(\text{Im}(z) = y\); modulus of \(z\), \(|z| = \sqrt{\text{Re}(z)^2 + \text{Im}(z)^2}\),

\[
= \sqrt{x^2 + y^2}; \quad \text{and } |z|^2 = x^2 + y^2.
\]

Euler formula is commonly stated as \(e^{ix} = \cos x + i\cdot \sin x\). Euler identity (where \(x = \pi\)) is \(e^{i\pi} = \cos \pi + i\cdot \sin \pi = -1 + 0\) [or stated as \(e^{i\pi} + 1 = 0\)]. The \(n^s\) of \(\zeta(s)\) is expanded to \(n^s = n^{(\sigma+i\tau)} = n^\sigma e^{\gamma \ln(n)}\) since \(n^\tau = e^{\gamma \ln(n)}\). Apply Euler formula to \(n^s\) result in \(n^s = n^\sigma (\cos(t \ln(n)) + i \cdot \sin(t \ln(n))\). This is written in trigonometric form [designated by short-hand notation \(n^s(Euler)\)] whereby \(n^\sigma\) is modulus and \(t \ln(n)\) is polar angle (argument).

Apply \(n^s(Euler)\) to Eq. (1). Then \(\zeta(s) = \text{Re}\{\zeta(s)\} + i \cdot \text{Im}\{\zeta(s)\}\) with

\[
\text{Re}\{\zeta(s)\} = \sum_{n=1}^{\infty} n^{-\sigma} \cos(t \ln(n)) \quad \text{and} \quad \text{Im}\{\zeta(s)\} = \sum_{n=1}^{\infty} n^{-\sigma} \sin(t \ln(n)).
\]

As Eq. (1) is defined only for \(\sigma > 1\) where zeros never occur, we will not carry out further treatment here on this equation.

Apply \(n^s(Euler)\) to Eq. (3). Then \(\zeta(s) = \gamma \cdot \eta(s) = \gamma \cdot [\text{Re}\{\eta(s)\} + i \cdot \text{Im}\{\eta(s)\}]\) with \(\text{Re}\{\eta(s)\} = \sum_{n=1}^{\infty} ((2n - 1)^{-\sigma} \cos(t \ln(2n - 1)) - (2n)^{-\sigma} \cos(t \ln(2n)))\); \(\text{Im}\{\eta(s)\} = \sum_{n=1}^{\infty} ((2n)^{-\sigma} \sin(t \ln(2n)) - (2n - 1)^{-\sigma} \sin(t \ln(2n - 1)))\);

and proportionality factor \(\gamma = \frac{1}{(1 - 2^{1-s})}\).

Complex number \(s\) in critical strip is designated by \(s = \sigma + it\) for \(0 < t < +\infty\) and \(s = \sigma - it\) for \(-\infty < t < 0\). Nontrivial zeros equating to \(\zeta(s) = 0\) give rise to our desired \(\eta(s) = 0\). Modulus of \(\eta(s)\), \(|\eta(s)|\), is defined as \(\sqrt{\text{Re}\{\eta(s)\}^2 + \text{Im}\{\eta(s)\}^2}\) with \(|\eta(s)|^2 = (\text{Re}\{\eta(s)\})^2 + (\text{Im}\{\eta(s)\})^2\).

Mathematically \(|\eta(s)| = |\eta(s)|^2 = 0\) is an unique condition giving rise to \(\eta(s) = 0\) occurring only when \(\text{Re}\{\eta(s)\} = \text{Im}\{\eta(s)\} = 0\) as any non-zero values for \(\text{Re}\{\eta(s)\}\) and/or \(\text{Im}\{\eta(s)\}\) will always result in \(|\eta(s)|\) and \(|\eta(s)|^2\) having non-zero values. Important implication is that sum of \(\text{Re}\{\eta(s)\}\) and \(\text{Im}\{\eta(s)\}\) equating to zero [given by Eq. (4)] must always hold when \(|\eta(s)| = |\eta(s)|^2 = 0\) and consequently \(\eta(s) = 0\).

\[
\sum \text{ReIm}\{\eta(s)\} = \text{Re}\{\eta(s)\} + \text{Im}\{\eta(s)\} = 0
\]

In principle, advocating for existence of theoretical \(s\) values leading to non-zero values in \(\text{Re}\{\eta(s)\}\) and \(\text{Im}\{\eta(s)\}\) depicted as possibility \(+\text{Re}\{\eta(s)\} = -\text{Im}\{\eta(s)\}\) or \(-\text{Re}\{\eta(s)\} = +\text{Im}\{\eta(s)\}\) could satisfy Eq. (4). This reverse implication is not necessarily true as these \(s\) values will not result in \(|\eta(s)| = |\eta(s)|^2 = 0\). In any event, we need not consider these two possibilities since solving Riemann hypothesis involves nontrivial zeros defined by \(\eta(s) = 0\) with non-zero values in \(\text{Re}\{\eta(s)\}\) and/or \(\text{Im}\{\eta(s)\}\) not compatible with \(\eta(s) = 0\).
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Riemann hypothesis proposed all nontrivial zeros to be located on critical line. This location is conjectured to be uniquely associated with presence of exact DA homogeneity in derived equation and inequation of Dirichlet Sigma-Power Law with Eq. (4) intrinsically incorporated into this Law as \( \eta(s) = 0 \) definition for nontrivial zeros equates to Eq. (4).

Apply trigonometry identity \( \cos(x) - \sin(x) = \sqrt{2} \sin \left( x + \frac{3}{4} \pi \right) \) to \( Re\{\eta(s)\} = Im\{\eta(s)\} \) to get Eq. (5) with terms in last line built by mixture of terms from \( Re\{\eta(s)\} \) and \( Im\{\eta(s)\} \).

\[
\sum ReIm\{\eta(s)\} = \sum \left( (2n-1)^{-\sigma} \cos(t \ln(2n-1)) - (2n-1)^{-\sigma} \sin(t \ln(2n-1)) \right)
- (2n)^{-\sigma} \cos(t \ln(2n)) + (2n)^{-\sigma} \sin(t \ln(2n)) \right] = \sum \left( (2n-1)^{-\sigma} \sqrt{2} \sin(t \ln(2n - 1)) + \frac{3}{4} \pi \right) - (2n)^{-\sigma} \sqrt{2} \sin(t \ln(2n) + \frac{3}{4} \pi) \right]
\]

When depicted in terms of Eq. (4), Eq. (5) becomes

\[
\sum_{n=1}^{\infty} (2n)^{-\sigma} \sqrt{2} \sin(t \ln(2n) + \frac{3}{4} \pi) = \sum_{n=1}^{\infty} (2n-1)^{-\sigma} \sqrt{2} \sin(t \ln(2n - 1) + \frac{3}{4} \pi)
\]

Eq. (6) in discrete (summation) format is a non-Hybrid integer sequence equation – see Appendix C. \( \eta(s) \) calculations for all \( \sigma \) values result in infinitely many non-Hybrid integer sequence equations for \( 0<\sigma<1 \) critical strip region of interest with \( n = 1, 2, 3, 4, 5, \ldots, \infty \) as discrete integer number values, or \( n = 1 \) to \( \infty \) as continuous real numbers values with Riemann integral application. These equations geometrically represent entire plane of critical strip, thus (at least) allowing our proposed proof to be of a complete nature.

Finally, Eq. (6) being the “simplified” Dirichlet eta function derived directly from \( \eta(s) \) will intrinsically incorporate actual location [ but not actual positions ] of all nontrivial zeros. The proof is now complete for Lemma 3.1□.

**Proposition 3.2.** Dirichlet Sigma-Power Law in continuous (integral) format given as equation and inequation can both be derived directly from “simplified” Dirichlet eta function in discrete (summation) format with Riemann integral application. [Note: Dirichlet Sigma-Power Law in continuous (integral) format refers to the end-product obtained from “first key step of converting Riemann zeta function into its continuous format version”].

**Proof.** In Calculus, integration is reverse process of differentiation viewed geometrically as numerical “total area value” solution enclosed by curve of function and x-axis. Apply definite integral \( I \) between limits (or points) a and
b is to compute its value when $\Delta x \rightarrow 0$, i.e. $I = \lim_{\Delta x \rightarrow 0} \sum_{i=1}^{n} f(x_i)\Delta x_i = \int_{a}^{b} f(x)dx$. This is Riemann integral of function f(x) in interval $[a, b]$ where $a < b$. Apply Riemann integral to “simplified” Dirichlet eta function in $[\Delta x \rightarrow 1]$ discrete (summation) format which intrinsically incorporates actual location [but not actual positions] of all nontrivial zeros criterion to obtain Dirichlet Sigma-Power Law in $[\Delta x \rightarrow 0]$ continuous (integral) format with the later validly representing the former. Then Dirichlet Sigma-Power Law also fullfil this criterion. Due to resemblance to power law functions in $\sigma$ from $s = \sigma + it$ being exponent of a power function $n^\sigma$, logarithm scale use, and harmonic $\zeta(s)$ series connection in Zipf’s law; we elect to call this Law by its given name. A characteristic & crucial part of this Law is its exact formula expression in usual mathematical language $[y = f(x_1, x_2)$ format description for a 2-variable function with $(2n)$ and $(2n-1)$ as ‘base quantities’] consist of $y = f(t, \sigma)$ with discrete $n = 1, 2, 3, 4, 5, \ldots, \infty$ or continuous $n = 1$ to $\infty$; $-\infty < t < +\infty$; and $0 < \sigma < 1$.

A proper integral is a definite integral which has neither limit a or b infinite and from which the integrand does not approach infinity at any point in the range of integration. Only a proper integral will have its [solitary] combined +ve (above x-axis) and -ve (below x-axis) non-zero numerical “total area value” solution successfully computed from applying Riemann integral. An improper integral is a definite integral that has either or both limits a and b infinite or an integrand that approaches infinity at one or more points in the range of integration.

The resulting Dirichlet Sigma-Power Law, being improper integral (with lower limit $a = 1$ and upper limit $b = \infty$) obtained from [validly] applying Riemann integral to “simplified” Dirichlet eta function, will [expectedly] have its [multiple] +ve (above x-axis) minus -ve (below x-axis) numerical “net area value” solutions successfully computed – see Propositions 3.3 and 3.4 below. All relevant antiderivatives in this paper are derived from improper integrals with format $\int_{1}^{\infty} f(n)dn$ based on Eqs. (6), (17) & (19).

Example for Eq. (6), involved improper integrals are from

$$\int_{1}^{\infty} (2n)^{-\sigma} \sqrt{2\sin(t\ln(2n) + \frac{3}{4}\pi)dn} - \int_{1}^{\infty} (2n-1)^{-\sigma} \sqrt{2\sin(t\ln(2n-1) + \frac{3}{4}\pi)dn} = 0.$$ 

These improper integrals are seen to involve [periodic] sine function between limits 1 and $\infty$. Each improper integral can be validly expanded as $\int_{n=1}^{n=2} f(n)dn + \int_{n=2}^{n=3} f(n)dn + \int_{n=3}^{n=4} f(n)dn + \ldots + \int_{n=\infty-1}^{n=\infty} f(n)dn$ which, for all sufficiently large t as $t \rightarrow \infty$, will manifest divergence by oscillation (viz. for all sufficiently large t as $t \rightarrow \infty$, this cumulative total will not diverge in

Proof: page numbers may be temporary
a particular direction to a solitary well-defined limit value such as \( \sin \pi/2 = 1 \) or less well-defined limit value such as \(+\infty\).

With steps of manual integration shown using indefinite integrals [for simplicity], we solve definite integral based on numerator portion of R1 with \((2n)\) parameter in Eq. (6):

\[
\int_1^\infty \frac{2^{1-\sigma} \sin (t \ln (2n) + \frac{3\pi}{4})}{n^\sigma} \, dn = \int_1^\infty - \frac{\sin (t \ln (2n)) - \cos (t \ln (2n))}{2^\sigma n^\sigma} \, dn.
\]

We deduce most other important integrals to be “variations” of this particular integral containing (i) deletion of \((2n)^{-\sigma}\), \(\sqrt{2}\) or \(\frac{3}{4}\pi\) terms, and/or (ii) interchange of sine and cosine function. We check all derived antiderivatives to be correct using computer algebra system Maxima.

Simplifying and applying linearity, we obtain \(2^{1-\sigma} \int \frac{\sin (t \ln (2n) + \frac{3\pi}{4})}{n^\sigma} \, dn\).

Now solving \(\int \frac{\sin (t \ln (2n) + \frac{3\pi}{4})}{n^\sigma} \, dn\). Substitute \(u = t \ln (2n) + \frac{3\pi}{4} \rightarrow \, dn = \frac{n}{t} \, du\), use \(n^{1-\sigma} = e ^{(1-\sigma)(u-t \ln(2) - \frac{3\pi}{4})} = e ^{\frac{(\sigma-1)(4t \ln(2)+3\pi)}{4t} u} \int e ^{\frac{(1-\sigma)u}{t} \sin (u)} \, du\).

Now solving \(\int e ^{\frac{(1-\sigma)u}{t} \sin (u)} \, du\). We integrate by parts twice in a row:

\[
\int fg' = fg - \int f'g. \text{ First time: } f = \sin (u), g = e ^{\frac{(1-\sigma)u}{t}}
\]

Then \(f' = \cos (u), g = \frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t}}}{\sigma^2 - 2\sigma + 1}\):

\[
\frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} - \int \frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t} \cos (u)}}{\sigma^2 - 2\sigma + 1} \, du
\]

Second time: \(f = \cos (u), g' = \frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t}}}{\sigma^2 - 2\sigma + 1}\)

Then \(f' = - \sin (u), g = \frac{t^2 e ^{\frac{(1-\sigma)u}{t}}}{\sigma^2 - 2\sigma + 1} \):

\[
\frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} - \frac{t^2 e ^{\frac{(1-\sigma)u}{t} \cos (u)}}{\sigma^2 - 2\sigma + 1} - \int \frac{t^2 e ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} \, du
\]

Apply linearity:

\[
\frac{(1-\sigma) te ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} - \left( \frac{t^2 e ^{\frac{(1-\sigma)u}{t} \cos (u)}}{\sigma^2 - 2\sigma + 1} + \frac{t^2 e ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} \int \frac{e ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} \, du \right)
\]

As integral \(\int e ^{\frac{(1-\sigma)u}{t} \sin (u)} \, du\) appears again on Right Hand Side, we solve it:

\[
\frac{(1-\sigma) e ^{\frac{(1-\sigma)u}{t} \sin (u)}}{\sigma^2 - 2\sigma + 1} - \frac{e ^{\frac{(1-\sigma)u}{t} \cos (u)}}{\sigma^2 - 2\sigma + 1} + 1
\]
Plug in solved integrals: $\frac{e^{(\sigma-1)(4t \ln(2)+3\pi)}}{4t} \int e^{(1-\sigma)t} \sin(u) \, du$

Plug in solved integrals: $\frac{e^{(\sigma-1)(4t \ln(2)+3\pi)}}{4t} \left( \frac{(1-\sigma)e^{(1-\sigma)t}u}{t} \sin(u) - e^{(1-\sigma)t}u \cos(u) \right)$

Undo substitution $u = t \ln(2n) + \frac{3\pi}{4}$ and simplifying:

$\frac{e^{(\sigma-1)(4t \ln(2)+3\pi)}}{4t} \left( \frac{(1-\sigma)e^{(1-\sigma)t}(t \ln(2n)+\frac{3\pi}{4})}{t} \sin(t \ln(2n)+\frac{3\pi}{4}) - e^{(1-\sigma)(t \ln(2n)+\frac{3\pi}{4})} \cos(t \ln(2n)+\frac{3\pi}{4}) \right)$

By rewriting & simplifying, $\int_1^{\infty} 2^\frac{1}{2-\sigma} \sin(t \ln(2n)+\frac{3\pi}{4}) n^\sigma dt$ is finally solved as

$\left[ \frac{(2n)^{1-\sigma}((t+\sigma-1) \sin(t \ln(2n)) + (t-\sigma+1) \cos(t \ln(2n)))}{2(t^2 + (\sigma - 1)^2)} \right]_1^{\infty}$

For denominator portion of $R_1$ with $(2n-1)$ parameter in Eq. (6), Eq. (7) equates to

$\left[ \frac{(2n-1)^{1-\sigma}((t+\sigma-1) \sin(t \ln(2n-1)) + (t-\sigma+1) \cos(t \ln(2n-1)))}{2(t^2 + (\sigma - 1)^2)} \right]_1^{\infty}$

Dirichlet Sigma-Power Law as equation derived from Eq. (6) is given by:

$\frac{1}{2(t^2 + (\sigma - 1)^2)} \cdot [(2n)^{1-\sigma}((t+\sigma-1) \sin(t \ln(2n)) + (t-\sigma+1) \cos(t \ln(2n)))-

(2n-1)^{1-\sigma}((t+\sigma-1) \sin(t \ln(2n-1)) + (t-\sigma+1) \cos(t \ln(2n-1))) \right]_1^{\infty} = 0$

Apply Ratio Study to Eq. (6) – see Appendix B. This involves [intentional] incorrect but “balanced” rearrangement of terms in Eq. (6) giving rise to Eq. (10) which is a non-Hybrid integer sequence inequation. Left-hand side
contains ‘cyclical’ sine function in first term (Ratio R1) and ‘non-cyclical’ power function in second term (Ratio R2).

\[\sum_{n=1}^{\infty} \sqrt{2} \sin(t \ln(2n) + \frac{3}{4} \pi) - \sum_{n=1}^{\infty} \frac{(2n)^{\sigma}}{\sum_{n=1}^{\infty} (2n-1)^{\sigma}} \neq 0\]

(10)

Apply Riemann integral to selected parts of Eq. (10) without depicting steps of calculation:

\[\int_{1}^{\infty} \sqrt{2} \sin \left(t \ln \left(2n + \frac{3}{4} \pi\right) dn = \right.\]

\[\left.\left[\frac{(2n)((t-1) \sin(t \ln(2n)) + (t+1) \cos(t \ln(2n)))}{2(t^2 + 1)} + C\right]_{1}^{\infty}\right]\]

and

\[\int_{1}^{\infty} \sqrt{2} \sin \left(t \ln \left(2n - 1 + \frac{3}{4} \pi\right) dn = \right.\]

\[\left.\left[\frac{(2n-1)((t-1) \sin(t \ln(2n-1)) + (t+1) \cos(t \ln(2n-1)))}{2(t^2 + 1)} + C\right]_{1}^{\infty}\right]\]

Dirichlet Sigma-Power Law as inequation derived from Eq. (10) is given by:

\[\left[\frac{(2n)((t-1) \sin(t \ln(2n)) + (t+1) \cos(t \ln(2n)))}{(2n-1)((t-1) \sin(t \ln(2n-1)) + (t+1) \cos(t \ln(2n-1))) - (2n)^{\sigma+1}}\right]_{1}^{\infty} \neq 0\]

Intended derivation of Dirichlet Sigma-Power Law as equation and inequation have been successful. \textit{The proof is now complete for Proposition 3.2.}\)

\textbf{Proposition 3.3.} Exact Dimensional analysis homogeneity at \(\sigma = \frac{1}{2}\) in Dirichlet Sigma-Power Law as equation and inequation is (respectively) indicated by \(\sum\)(all fractional exponents)=whole number ‘1’ and Pseudo-\(\sum\)(all fractional exponents)=whole number ‘3’.

\textbf{Proof.} Preliminary discussion on using three types of symmetry for a given function: (1) symmetry about the vertical y-axis [“function is even”] e.g. cosine, arcocos (2) symmetry about the origin [“function is odd”] e.g. sine, arcsin, tangent, arctan and (3) in all other cases [“function is neither even nor odd”]. Even function has its Cummulative Total areas symmetrical about the vertical axis and odd function has its Cummulative Total areas symmetrical about the origin (with conservation or preservation of areas derived from [opposite side] numerical “net area value” always equal to zero in both cases).

We classify our antiderivatives below using these functions with their basic properties such as sum [or difference] of two even (odd) functions is even (odd); sum [or difference] of an even and odd function is neither even nor odd (unless one of the functions is equal to zero over the given domain); product

\textit{Proof: page numbers may be temporary}
Proof: page numbers may be temporary
We look at the last two terms
\[
\frac{1}{2} \cdot \left( -((2)(2t^2 + \frac{1}{2}))^{\frac{1}{2}} \sin \left( (t \ln 2) + \tan^{-1} \left( \frac{t + \frac{1}{2}}{t - \frac{1}{2}} \right) \right) + (2t^2 + \frac{1}{2})^{\frac{1}{2}} \sin \left( \tan^{-1} \left( \frac{t + \frac{1}{2}}{t - \frac{1}{2}} \right) \right) \right)
\]
Relevant t values for all nontrivial zeros at \( \sigma = \frac{1}{2} \) and \( n = 1 \) [and combined \( n = \)]

![Riemann zeta function at sigma = 1/2 for n = 1](image)

Figure 5. Nontrivial zeros [first 10 plotted] at \( \sigma = \frac{1}{2} \) for \( n = 1 \) using Dirichlet Sigma-Power Law.

![Riemann zeta function at sigma = 1/2 for n = 1, n = 2, and n = 3](image)

Figure 6. Nontrivial zeros at \( \sigma = \frac{1}{2} \) for \( n = 1, 2 \) and 3 using Dirichlet Sigma-Power Law.

1, 2 and 3] plotted against the expanded antiderivative depicted as linear combination of sine and cosine waves is shown in Figure 5 [and in Figure 6]. The phenomenon of “monotonously decreasing height waves of varying amplitude with different \( n \) values” comply with functions that are neither even nor odd. As mentioned previously, all improper integrals are seen to involve [periodic] sine function between limits 1 and \( \infty \). Then from Figure 6 for nontrivial zeros, we can geometrically visualize that fully computing (for instance) \( \int_{n=1}^{n=2} f(n) \, dn \)

Proof: page numbers may be temporary
and \( f_{n=2}^n f(n)dn \) will result in respective antiderivatives that still involve sine functions [of varying frequency and amplitude]. Identical arguments can be extended to Gram\([y=0]\) and Gram\([x=0]\) points.

Dirichlet Sigma-Power Law as inequation for \( \sigma = \frac{1}{2} \) value is given by:

\[
\left( \frac{(2n) \left( (t - 1) \sin (t \ln (2n)) + (t + 1) \cos (t \ln (2n)) \right)}{(2n - 1) \left( (t - 1) \sin (t \ln (2n - 1)) + (t + 1) \cos (t \ln (2n - 1)) \right)} - \frac{(2n)^{\frac{3}{2}}}{(2n - 1)^{\frac{3}{2}}} \right) \bigg |_{1}^{\infty} \neq 0
\]

Figure 7. Nontrivial zeros [first 10 plotted] present at \( \sigma = \frac{1}{2} \) and nil nontrivial zeros present at \( \sigma = \frac{2}{5} \) with both calculated for \( n = 1 \) using inequation Dirichlet Sigma-Power Law.

Without depicting parallel steps of calculation, the equivalent inequations Dirichlet Sigma-Power Law for last two terms [expanded antiderivative depicted as linear combination of sine and cosine waves] for nontrivial zeros [first 10 plotted] at \( \sigma = \frac{1}{2} \) and \( \sigma = \frac{2}{5} \) when \( n = 1 \) is, respectively and sequentially, given as:

\[
- \frac{(2) \left( (2t^2 + 2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \right) \sin((t \ln 2) + \tan^{-1}(t + 1) t - 1))}{(2) \left( (2t^2 + 2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \right) \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1))} + \frac{(2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \sin((t \ln 2) + \tan^{-1}(t + 1) t - 1))}{(1) \left( (2t^2 + 2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \right) \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1))} + \frac{(2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \sin((t \ln 2) + \tan^{-1}(t + 1) t - 1))}{(1) \left( (2t^2 + 2) \frac{3}{2} \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1) \right) \sin((t \ln 1) + \tan^{-1}(t + 1) t - 1))}
\]

Figure 7 depicted using the two inequations manifest phenomenon of “constant height waves of varying amplitude with different \( n \) values” that comply with functions that are neither even nor odd occurring at both \( \sigma = \frac{1}{2} \) and \( \sigma \neq \frac{1}{2} \).
We evaluate Eq. (14) to obtain its expanded antiderivative:

\[ \frac{1}{2^{n^2 + \frac{3}{5}}} [((2n)^{\frac{3}{5}}((t - \frac{3}{5}) \sin(t \ln(2n)) + (t + \frac{3}{5}) \cos(t \ln(2n))) -

(2n - 1)^{\frac{3}{5}}((t - \frac{3}{5}) \sin(t \ln(2n - 1)) + (t + \frac{3}{5}) \cos(t \ln(2n - 1)))]

= 0 \]

We are interested in the last two terms [equivalent to substituting in \( n = 1 \)]

\[ \frac{1}{2^{2^2 + \frac{3}{5}}} [-((2^1)^{\frac{3}{5}}((t - \frac{3}{5}) \sin(t \ln(2)) + (t + \frac{3}{5}) \cos(t \ln(2))) + (t + \frac{3}{5}) \cos(t \ln(2))]

Equivalent evaluation on Eq. (14) to obtain its expanded antiderivative depicted as linear combination of sine and cosine waves: \( a \sin x + b \cos x = c \sin(x + \varphi) \) with \( c = \sqrt{a^2 + b^2} \) and \( \varphi = \tan^{-1}(\frac{b}{a}) \) for \( a > 0 \):

\[ \frac{1}{2^{2^2 + \frac{3}{5}}} [((2^1)^{\frac{3}{5}}((2t^2 + \frac{18}{25})^{\frac{1}{2}} \sin(t \ln 2) + \tan^{-1}(\frac{t + \frac{3}{5}}{t - \frac{3}{5}})) -

-((2\cdot1 - 1)^{\frac{3}{5}}((2t^2 + \frac{18}{25})^{\frac{1}{2}} \sin(t \ln 2 - 1) + \tan^{-1}(\frac{t + \frac{3}{5}}{t - \frac{3}{5}})) - (2^1)^{\frac{3}{5}}(2t^2 + \frac{18}{25})^{\frac{1}{2}} \sin(t \ln 2) + \tan^{-1}(\frac{t + \frac{3}{5}}{t - \frac{3}{5}})]

= 0 \]

We look at the last two terms

\[ \frac{1}{2^{2^2 + \frac{3}{5}}} [-(2^1)^{\frac{3}{5}}(2t^2 + \frac{18}{25})^{\frac{1}{2}} \sin(t \ln 2) + \tan^{-1}(\frac{t + \frac{3}{5}}{t - \frac{3}{5}})] + (2^2 + \frac{18}{25})^{\frac{1}{2}} \sin(\tan^{-1}(\frac{t + \frac{3}{5}}{t - \frac{3}{5}}))] \]

Proof: page numbers may be temporary
Relevant t values (for non-existent nontrivial zeros) at $\sigma = \frac{2}{5}$ [and $\sigma = \frac{3}{5}$] for $n = 1$ plotted against expanded antiderivative depicted as linear combination of sine and cosine waves given by

$$\frac{1}{2t^2 + \frac{8}{25}} \cdot \left[-(2^2(2t^2 + \frac{8}{25}))^{\frac{1}{2}} \sin \left(t \ln 2 + \tan^{-1}\left(\frac{t + \frac{2}{5}}{t - \frac{2}{5}}\right)\right) + (2t^2 + \frac{8}{25})^{\frac{1}{2}} \sin \left(\tan^{-1}\left(\frac{t + \frac{2}{5}}{t - \frac{2}{5}}\right)\right)\right].$$

The phenomenon of “monotonously decreasing height waves of varying amplitude with different n values” comply with functions that are neither even nor odd occurring at $\sigma \neq \frac{1}{2}$.

Dirichlet Sigma-Power Law as inequation for $\sigma = \frac{2}{5}$ value [as was previously shown in Figure 8 and Figure 9].

Proof: page numbers may be temporary
described and depicted in Figure 7 at Proposition 3.3 above] is given by:

\[
(15) \sum_{\text{(all fractional exponents)}} (2^n) \left( (t-1)\sin(t \ln(2^n)) + (t+1)\cos(t \ln(2^n)) \right) - \frac{(2^n)^{\frac{7}{5}}}{(2n-1)^{\frac{7}{5}}} \right) \bigg|_1^{\infty} \neq 0
\]

\[
\sum_{\text{(all fractional exponents)}} (2(1-\sigma)) = \text{fractional number ‘\neq1’ for Eq. (14)}
\]

and Pseudo-\(\sum_{\text{(all fractional exponents)}} (2(\sigma+1)) = \text{fractional number ‘\neq3’}
\]

for Eq. (15). These findings signify absence of complete set nontrivial zeros for Eq. (14) and Eq. (15). The proof is now complete for Corollary 3.4 □.

4. Rigorous Proof for Riemann hypothesis now summarized as

Theorem Riemann I – IV

\[
\zeta(s) = \frac{1}{s-1} + \frac{1}{2} + 2 \int_{0}^{\infty} \frac{\sin(s \arctan t)}{(1 + t^2)^{\frac{s}{2}}} (e^{2\pi t} - 1) dt
\]

is integral relation (cf. Abel-Plana summation formula [3][4]) for all \(s \in \mathbb{C}\) and \(s \neq 1\). This integral is insufficient for our purpose as it involves integration with respect to \(t\) [instead of \(n\)] for \(\zeta(s)\) [instead of \(\eta(s)\)]. Relatively elementary proof for Riemann hypothesis is summarized by Theorem Riemann I – IV. One could obtain this proof with only using Dirichlet Sigma-Power Law [solely] as equation. For completeness and clarification of this proof, we supply following important mathematical arguments.

For 0 < \(\sigma < 1\), then 0 < 2(1 - \(\sigma\)) < 2. The only whole number between 0 and 2 is ‘1’ which coincide with \(\sigma = \frac{1}{2}\). When 0 < \(\sigma < \frac{1}{2}\) and \(\frac{1}{2} < \sigma < 1\), then [correspondingly] 0 < 2(1 - \(\sigma\)) < 1 and 1 < 2(1 - \(\sigma\)) < 2.

For 0 < \(\sigma < 1\), 2 < 2(\(\sigma+1\)) < 4. The only whole number between 2 and 4 is ‘3’ which coincide with \(\sigma = \frac{1}{2}\). When 0 < \(\sigma < \frac{1}{2}\) and \(\frac{1}{2} < \sigma < 1\), then [correspondingly] 2 < 2(\(\sigma+1\)) < 3 and 3 < 2(\(\sigma+1\)) < 4.

Legend: \(\mathbb{R} = \text{all real numbers}\). For 0 < \(\sigma < 1\), \(\sigma\) consist of 0 < \(\mathbb{R} < 1\). For 0 < 2(1 - \(\sigma\)) < 2 and 2 < 2(\(\sigma+1\)) < 4, 2(1 - \(\sigma\)) and 2(\(\sigma+1\)) must (respectively) consist of 0 < \(\mathbb{R} < 2\) and 2 < \(\mathbb{R} < 4\). An important caveat is that previously used phrases such as “\(\sum_{\text{(all fractional exponents)}} = \text{whole number ‘1’ / fractional number ‘\neq1’}\) [or Pseudo-\(\sum_{\text{(all fractional exponents)}}\) = whole number ‘3’ / fractional number ‘\neq3’], although not incorrect \textit{per se}, should respectively be replaced by “\(\sum_{\text{(all real exponents)}} = \text{whole number ‘1’ / real number ‘\neq1’}\) [or Pseudo-\(\sum_{\text{(all real exponents)}}\) = whole number ‘3’ / real number ‘\neq3’] for complete accuracy. We apply this caveat to Theorem Riemann I – IV.

Footnote 5: As whole numbers \(\subset\) real numbers, one could also depict this phrase as “\(\sum_{\text{(all real exponents)}}\) or Pseudo-\(\sum_{\text{(all real exponents)}}\) = real number ‘1’ / real number ‘\neq1’ or real number ‘\neq1’ / ‘\neq3’".

Proof: page numbers may be temporary
Theorem Riemann I. Derived from proxy Dirichlet eta function, “simplified” Dirichlet eta function will exclusively contain de novo property for actual location [but not actual positions] of all nontrivial zeros.

Proof. The phrase “actual location [but not actual positions] of all nontrivial zeros” can be validly shortened to “actual location of all nontrivial zeros” as used in Theorem Riemann II, III and IV. The proof for Theorem Riemann I is now complete as it successfully incorporates proof for Lemma 3.1.

Theorem Riemann II. Dirichlet Sigma-Power Law [in continuous (integral) format] as equation and inequation which are both derived from “simplified” Dirichlet eta function [in discrete (summation) format] will exclusively manifest exact DA homogeneity in equation and inequation only when real number exponent $\sigma = \frac{1}{2}$.

Proof. The proof for Theorem Riemann II is now complete as it successfully incorporates proofs from Proposition 3.2 on derivation for equation and inequation of Dirichlet Sigma-Power Law [with both containing de novo property for “actual location of all nontrivial zeros”] and Proposition 3.3 on manifestation of exact DA homogeneity in Dirichlet Sigma-Power Law as equation and inequation when real number exponent $\sigma = \frac{1}{2}$.

Theorem Riemann III. Real number exponent $\sigma = \frac{1}{2}$ in Dirichlet Sigma-Power Law as equation and inequation satisfying exact DA homogeneity is identical to $\sigma$ variable in Riemann hypothesis which propose $\sigma$ to also have exclusive value of $\frac{1}{2}$ (representing critical line) for “actual location of all nontrivial zeros”, thus fully supporting Riemann hypothesis to be true with further clarification by Theorem Riemann IV.

Proof. Since $s = \sigma \pm it$, complete set of nontrivial zeros which is defined by $\eta(s) = 0$ is exclusively associated with one (and only one) particular $\eta(\sigma \pm it) = 0$ value solution, and by default one (and only one) particular $\sigma$ [conjecturally] $= \frac{1}{2}$ value solution. When performing exact DA homogeneity on Dirichlet Sigma-Power Law as equation and inequation [with both containing de novo property for “actual location of all nontrivial zeros”], the phrase “If real number exponent $\sigma$ has exclusively $\frac{1}{2}$ value, only then will exact DA homogeneity be satisfied” implies one (and only one) possible mathematical solution. Theorem Riemann III reflect Theorem Riemann II on presence of exact DA homogeneity for $\sigma = \frac{1}{2}$ in Dirichlet Sigma-Power Law as equation and inequation. This Law has identical $\sigma$ variable as that referred to by Riemann hypothesis [whereby $\sigma$ here uniquely refer to critical line]. The proof for Theorem Riemann III is now complete as it independently refers to simultaneous association of confirmed (i) solitary $\sigma = \frac{1}{2}$ value in Dirichlet Sigma-Power Law as equation and inequation satisfying exact DA homogeneity and (ii) critical line defined by solitary $\sigma = \frac{1}{2}$ value being the “actual location [but with no request to determine actual positions]” of all nontrivial zeros as proposed in original Riemann hypothesis.
Theorem Riemann IV. Condition 1. All $\sigma \neq \frac{1}{2}$ values (non-critical lines), viz. $0 < \sigma < \frac{1}{2}$ and $\frac{1}{2} < \sigma < 1$ values, exclusively does not contain “actual location of all nontrivial zeros” [manifesting de novo inexact DA homogeneity in equation and inequation], together with Condition 2. One (& only one) $\sigma = \frac{1}{2}$ value (critical line) exclusively contains “actual location of all nontrivial zeros” [manifesting de novo exact DA homogeneity in equation and inequation], confirm Riemann hypothesis to be true when these two mutually inclusive conditions are met.

Proof. Condition 2 Theorem Riemann IV simply reflect proof from Theorem Riemann III [incorporating Proposition 3.3] for “actual location of all nontrivial zeros” exclusively on critical line manifesting de novo exact DA homogeneity $\sum$(all real number exponents) = real number ‘1’ for equation [or Pseudo-$\sum$(all real number exponents) = real number ‘3’ for inequation]. The proof for Condition 2 Theorem Riemann IV is now complete. Corollary 3.4 confirms de novo inexact DA homogeneity manifested as $\sum$(all real number exponents) = real number ‘$\neq$1’ for equation [or Pseudo-$\sum$(all real number exponents) = real number ‘$\neq$3’ for inequation] by all $\sigma \neq \frac{1}{2}$ values (non-critical lines) that are exclusively not associated with “actual location of all nontrivial zeros”. Applying inclusion-exclusion principle: Exclusive presence of nontrivial zeros on critical line for Condition 2 Theorem Riemann IV implies exclusive absence of nontrivial zeros on non-critical lines for Condition 1 Theorem Riemann IV. The proof for Condition 1 Theorem Riemann IV is now complete.

We logically deduce that explicit mathematical explanation why presence and absence of nontrivial zeros should (respectively) coincide precisely with $\sigma = \frac{1}{2}$ and $\sigma \neq \frac{1}{2}$ [literally the Completely Predictable meta-properties (‘overall’ complex properties)] will require “complex” mathematical arguments. Attempting to provide explicit mathematical explanation with “simple” mathematical arguments would intuitively mean nontrivial zeros have to be (incorrectly and impossibly) treated as Completely Predictable entities.

Footnote 6: Completely Predictable meta-properties for Gram and virtual Gram points equating to “Presence of Gram[y=0] and Gram[x=0] points, and virtual Gram[y=0] and virtual Gram[x=0] points (respectively) coincide precisely with $\sigma = \frac{1}{2}$, and $\sigma \neq \frac{1}{2}$”.

5. Prerequisite lemma, corollary and propositions for Gram[x=0] and Gram[y=0] points conjectures

For Gram[y=0] & Gram[x=0] points (and corresponding virtual Gram[y=0] & virtual Gram[x=0] points with totally different values), we apply a parallel procedure carried out on nontrivial zeros but only depict abbreviated treatments and discussions. We supply geometrical manifestations and related
commentaries for equivalent “last two terms” at \( n = 1 \) for each entity using expanded antiderivative (at \( \sigma = \frac{1}{2} \) & \( \frac{3}{2} \)) depicted as linear combination of sine and cosine waves: \( a \sin x + b \cos x = c \sin(x + \phi) \) with \( c = \sqrt{a^2 + b^2} \).

**Lemma 5.1.** “Simplified” \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points-Dirichlet eta functions are derived directly from Dirichlet eta function with Euler formula application and (respectively) they will intrinsically incorporate actual location [but not actual positions] of all \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points.

**Proof.** For \( \text{Gram}[y=0] \) points, the equivalent of Eq. (4) and Eq. (6) are respectively given by Eq. (16) and Eq. (17) below.

\[
\sum_{n=1}^{\infty} (2n)^{-\sigma} \sin(t \ln(2n)) = \sum_{n=1}^{\infty} (2n-1)^{-\sigma} \sin(t \ln(2n-1))
\]

\[
\sum_{n=1}^{\infty} (2n)^{-\sigma} \sin(t \ln(2n)) - \sum_{n=1}^{\infty} (2n-1)^{-\sigma} \sin(t \ln(2n-1)) = 0
\]

For \( \text{Gram}[x=0] \) points, the equivalent of Eq. (4) and Eq. (6) are respectively given by Eq. (18) and Eq. (19) below.

\[
\sum_{n=1}^{\infty} (2n)^{-\sigma} \cos(t \ln(2n)) = \sum_{n=1}^{\infty} (2n-1)^{-\sigma} \cos(t \ln(2n-1))
\]

\[
\sum_{n=1}^{\infty} (2n)^{-\sigma} \cos(t \ln(2n)) - \sum_{n=1}^{\infty} (2n-1)^{-\sigma} \cos(t \ln(2n-1)) = 0
\]

Eq. (17) and Eq. (19) being the “simplified” \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points-Dirichlet eta functions derived directly from \( \eta(s) \) will intrinsically incorporate actual location [but not actual positions] of (respectively) all \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points. The proof is now complete for Lemma 5.1.

**Proposition 5.2.** \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points-Dirichlet Sigma-Power Laws in continuous (integral) format given as equations and inequalities can both be (respectively) derived directly from “simplified” \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points-Dirichlet eta functions in discrete (summation) format with Riemann integral application. [Note: \( \text{Gram}[y=0] \) and \( \text{Gram}[x=0] \) points-Dirichlet Sigma-Power Laws in continuous (integral) format here refers to relevant end-products obtained from “first key step of converting Riemann zeta function into its continuous format version”.]
\textbf{Proof.} Antiderivatives below using (2n) parameter help obtain all subsequent equations: first two for Gram\([y=0]\) points and second two for Gram\([x=0]\) points.

\[
\int_1^\infty (2n)^{-\sigma} \sin(t \ln(2n))\,dt = \left[-\frac{(2n)^{1-\sigma} ((\sigma - 1) \sin(t \ln(2n)) + t \cos(t \ln(2n)))}{2(t^2 + (\sigma - 1)^2)} + C\right]_1^\infty
\]

\[
\int_1^\infty \sin(t \ln(2n))\,dt = \left[\frac{(2n)(\sin(t \ln(2n)) - t \cos(t \ln(2n)))}{2(t^2 + 1)} + C\right]_1^\infty
\]

\[
\int_1^\infty (2n)^{-\sigma} \cos(t \ln(2n))\,dt = \left[\frac{(2n)^{1-\sigma} (t \sin(t \ln(2n)) - (\sigma - 1) \cos(t \ln(2n)))}{2(t^2 + (\sigma - 1)^2)} + C\right]_1^\infty
\]

\[
\int_1^\infty \cos(t \ln(2n))\,dt = \left[\frac{(2n)(t \sin(t \ln(2n)) + \cos(t \ln(2n)))}{2(t^2 + 1)} + C\right]_1^\infty
\]

For Gram\([y=0]\) points-Dirichlet Sigma-Power Law, the equivalent of Eq. (9) and Eq. (11) are respectively given by Eq. (20) as equation and Eq. (21) as inequation.

\[\frac{1}{2(t^2 + (\sigma - 1)^2)} \cdot [(2n)^{1-\sigma}((\sigma - 1) \sin(t \ln(2n)) + t \cos(t \ln(2n))) - (2n - 1)^{1-\sigma}((\sigma - 1) \sin(t \ln(2n - 1)) + t \cos(t \ln(2n - 1)))]_1^\infty = 0\]

\[\frac{1}{2(t^2 + (\sigma - 1)^2)} \cdot [(2n)^{1-\sigma}(t \sin(t \ln(2n)) - (\sigma - 1) \cos(t \ln(2n))) - (2n - 1)^{1-\sigma}(t \sin(t \ln(2n - 1)) - (\sigma - 1) \cos(t \ln(2n - 1)))]_1^\infty \neq 0\]

For Gram\([x=0]\) points-Dirichlet Sigma-Power Law, the equivalent of Eq. (9) and Eq. (11) are respectively given by Eq. (22) as equation and Eq. (23) as inequation.

\[\frac{1}{2(t^2 + (\sigma - 1)^2)} \cdot [(2n)^{1-\sigma}(t \sin(t \ln(2n)) - (\sigma - 1) \cos(t \ln(2n))) - (2n - 1)^{1-\sigma}(t \sin(t \ln(2n - 1)) - (\sigma - 1) \cos(t \ln(2n - 1)))]_1^\infty = 0\]

\[\frac{1}{2(t^2 + (\sigma - 1)^2)} \cdot [(2n)^{1-\sigma}(t \sin(t \ln(2n)) + \cos(t \ln(2n))) - (2n - 1)^{1-\sigma}(t \sin(t \ln(2n - 1)) + \cos(t \ln(2n - 1)))]_1^\infty \neq 0\]

Intended derivation of Gram\([y=0]\) and Gram\([x=0]\) points-Dirichlet Sigma-Power Laws as equations and inequations is successful. \textit{The proof is now complete for Lemma 5.2}.\(\Box\)

\textbf{Proposition 5.3.} Exact Dimensional analysis homogeneity at \(\sigma = \frac{1}{2}\) in Gram\([y=0]\) and Gram\([x=0]\) points-Dirichlet Sigma-Power Laws as equations
and inequations are (respectively) indicated by $\sum$ (all fractional exponents) = whole number ‘1’ and Pseudo-$\sum$ (all fractional exponents) = whole number ‘3’.

**Proof.** Gram[y=0] points-Dirichlet Sigma-Power Law as equation for $\sigma = \frac{1}{2}$ value is given by: 

$$(24) \quad (2n - 1)^{\frac{1}{2}} \left( t \cos(t \ln(2n)) - \frac{1}{2} \sin(t \ln(2n)) \right) \overset{\infty}{1} = 0$$

“Last two terms” at $n = 1$: 

$$\frac{1}{2t^2 + \frac{1}{4}} \left( (2(t^2 + \frac{1}{4}))^{\frac{1}{2}} \sin \left( (t \ln 2) - \tan^{-1}(2t) \right) - (t^2 + \frac{1}{4})^{\frac{1}{2}} \sin \left( \tan^{-1}(2t) \right) \right)$$

**Figure 10.** Gram[y=0] points-Dirichlet Sigma-Power Law as equation for $\sigma = \frac{1}{2}$ at $n = 1$.

In Figure 10, the phenomenon of “monotonously decreasing height waves of varying amplitude with different n values” comply with functions that are odd occurring at $\sigma = \frac{1}{2}$.

Gram[y=0] points-Dirichlet Sigma-Power Law as inequation for $\sigma = \frac{1}{2}$ value is given by:

$$(25) \left[ \frac{(2n)(\sin(t \ln(2n))) - t \cos(t \ln(2n))}{(2n - 1)(\sin(t \ln(2n - 1))) - t \cos(t \ln(2n - 1))} \right] \overset{\infty}{1} \neq 0$$

“Last two terms” at $n = 1$ (as inequation): 

$$- \frac{(2) \left( (t^2 + 1)^{\frac{1}{2}} \sin((t \ln 2) - \tan^{-1}(t)) \right) + (2)^{\frac{3}{2}}}{(1) \left( (t^2 + 1)^{\frac{1}{2}} \sin((t \ln 1) - \tan^{-1}(t)) \right)}$$

In Figure 11, the phenomenon of “constant height waves of varying amplitude with different n values” comply with functions that are even occurring at $\sigma = \frac{2}{5}$.

Proof: page numbers may be temporary
Figure 11. Gram[y=0] points-Dirichlet Sigma-Power Law as inequality for $\sigma = \frac{1}{2}$ at $n = 1$.

Gram[x=0] points-Dirichlet Sigma-Power Law as equation for $\sigma = \frac{1}{2}$ value is given by:

$$\frac{1}{2t^2 + \frac{1}{2}} \cdot [(2n)^{\frac{1}{2}} \left( t \sin(t \ln(2n)) + \frac{1}{2} \cos(t \ln(2n)) \right) - (26) (2n - 1)^{\frac{1}{2}} \left( t \sin(t \ln(2n - 1)) + \frac{1}{2} \cos(t \ln(2n - 1)) \right)]_{1}^{\infty} = 0$$

“Last two terms” at $n = 1$:

$$\frac{1}{2t^2 + \frac{1}{2}} \left[ -(2(t^2 + \frac{1}{4}))^{\frac{1}{2}} \sin \left( (t \ln 2) - \tan^{-1}(\frac{1}{2t}) \right) + (t^2 + \frac{1}{4})^{\frac{1}{2}} \sin \left( \tan^{-1}(\frac{1}{2t}) \right) \right]$$

Figure 12. Gram[x=0] points-Dirichlet Sigma-Power Law as equation for $\sigma = \frac{1}{2}$ at $n = 1$.

In Figure 12, the phenomenon of “monotonously decreasing height waves of varying amplitude with different $n$ values” comply with functions that are odd.
occurring at $\sigma = \frac{1}{2}$.

Gram[x=0] points-Dirichlet Sigma-Power Law as inequation for $\sigma = \frac{1}{2}$ value is given by:

$$\left( \frac{(2n)\left(t \sin (t \ln (2n)) + \cos (t \ln (2n))\right)}{(2n-1)\left(t \sin (t \ln (2n-1)) + \cos (t \ln (2n-1))\right)} - \frac{(2n)^{\frac{3}{2}}}{(2n-1)^{\frac{3}{2}}} \right)_{1}^{\infty} \neq 0$$

“Last two terms” at $n = 1$ (as inequation):

$$\frac{(2)\left(\left(t^2 + 1\right)^{\frac{1}{2}} \sin((t \ln 2) + \tan^{-1}(\frac{1}{t}))\right)}{(1)\left(\left(t^2 + 1\right)^{\frac{1}{2}} \sin((t \ln 1) + \tan^{-1}(\frac{1}{t}))\right)} + \frac{(2)^{\frac{3}{2}}}{(1)^{\frac{3}{2}}}$$

In Figure 13, the phenomenon of “monotonously increasing height waves of varying amplitude with different $n$ values” comply with functions that are even occurring at $\sigma = 2\frac{5}{2}$. $\sum$(all fractional exponents) as $2(1 - \sigma)$=whole number ‘1’ for Eqs. (24) & (26), and Pseudo-$\sum$(all fractional exponents) as $2(\sigma + 1)$=whole number ‘3’ for Eqs. (25) & (27). These findings signify presence of complete sets Gram[y=0] points for Eqs. (24) & (25) and Gram[x=0] points for Eqs. (26) & (27). The proof is now complete for Proposition 5.3.$\Box$.

**Corollary 5.4.** Inexact Dimensional analysis homogeneity at $\sigma \neq \frac{1}{2}$ (illustrated using $\sigma = \frac{5}{2}$) in Gram[y=0] and Gram[x=0] points-Dirichlet Sigma-Power Laws as equations and inequations are (respectively) indicated by $\sum$(all fractional exponents) = fractional number ‘$\neq 1$’ and Pseudo-$\sum$(all fractional exponents) = fractional number ‘$\neq 3$’.

**Proof.** Gram[y=0] points-Dirichlet Sigma-Power Law as equation for $\sigma = \frac{2}{5}$ value is given by:

$$-\frac{1}{2^{\frac{3}{2}} + 2^\frac{3}{2}} \cdot \left(2n\right)^{\frac{3}{2}} \left(t \cos(t \ln(2n)) - \frac{3}{5} \sin(t \ln(2n))\right) -$$

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(28) \( (2n - 1)^\frac{3}{5} \left( t \cos(t \ln(2n - 1)) - \frac{3}{5} \sin(t \ln(2n - 1)) \right) \bigg|_1^\infty = 0 \)

“Last two terms” at \( n = 1 \):
\[
\frac{1}{2t^2 + \frac{19}{25}} \left( 2\left( t^2 + \frac{9}{25} \right)^\frac{3}{5} \sin \left( t \ln 2 - \tan^{-1}\left( \frac{5t}{3} \right) \right) - \left( t^2 + \frac{9}{25} \right)^\frac{3}{5} \sin \left( \tan^{-1}\left( \frac{5t}{3} \right) \right) \right)
\]

In Figure 14, the phenomenon of “monotonously decreasing height waves of varying amplitude with different \( n \) values” comply with functions that are odd occurring at \( \sigma \neq \frac{1}{2} \).

Gram\([y=0]\) points-Dirichlet Sigma-Power Law as inequation for \( \sigma = \frac{2}{5} \) value is given by:

\[
(29) \left[ \frac{(2n)(\sin(t \ln(2n)) - t \cos(t \ln(2n)))}{(2n-1)(\sin(t \ln(2n-1)) - t \cos(t \ln(2n-1)))} - \frac{(2n)^\frac{7}{5}}{(2n-1)^\frac{7}{5}} \right]_1^\infty \neq 0
\]

“Last two terms” at \( n = 1 \) (as inequation):
\[
\frac{2}{(t^2 + 1)^\frac{3}{5}} \left( (t \sin(t \ln 2) - \tan^{-1}(t)) \right) + \frac{2}{(1)^\frac{7}{5}}
\]

In Figure 15, the phenomenon of “constant height waves of varying amplitude with different \( n \) values” comply with functions that are even occurring at \( \sigma \neq \frac{1}{2} \).

Gram\([x=0]\) points-Dirichlet Sigma-Power Law as equation for \( \sigma = \frac{2}{5} \) value is given by:

\[
(30) \left( 2n - 1 \right)^\frac{3}{5} \left( t \sin(t \ln(2n - 1)) + \frac{3}{5} \cos(t \ln(2n - 1)) \right) \bigg|_1^\infty = 0
\]

Proof: page numbers may be temporary
Figure 15. Gram[y=0] points-Dirichlet Sigma-Power Law as inequation for \( \sigma = \frac{2}{5} \) at \( n = 1 \).

"Last two terms" at \( n = 1 \):

\[
\frac{1}{2t^2 + \frac{9}{25}} \left[ -(2^n (t^2 + \frac{9}{25}))^\frac{1}{2} \sin \left( t \ln \left( \frac{3}{5t} \right) \right) + (t^2 + \frac{9}{25})^\frac{1}{2} \sin \left( \tan^{-1} \left( \frac{3}{5t} \right) \right) \right]
\]

In Figure 16, the phenomenon of "monotonously decreasing height waves of varying amplitude with different \( n \) values" comply with functions that are odd occurring at \( \sigma \neq \frac{1}{2} \).

Figure 16. Gram[x=0] points-Dirichlet Sigma-Power Law as equation for \( \sigma = \frac{2}{5} \) at \( n = 1 \).

Gram[x=0] points-Dirichlet Sigma-Power Law as inequation for \( \sigma = \frac{2}{5} \) value is given by:

\[
(31) \quad \left[ \frac{(2n)(t \sin (t \ln (2n)) + \cos (t \ln (2n)))}{(2n - 1)(t \sin (t \ln (2n - 1)) + \cos (t \ln (2n - 1)))} - \frac{(2n)^\frac{7}{5}}{(2n - 1)^\frac{2}{5}} \right]_1^\infty \neq 0
\]

Proof: page numbers may be temporary
In Figure 17, the phenomenon of “monotonously increasing height waves of varying amplitude with different n values” comply with functions that are even occurring at $\sigma \neq \frac{1}{2}$.

\[
\sum (\text{all fractional exponents}) = 2(1 - \sigma) = \text{fractional number ‘} \neq 1’ \text{ for Eqs. (28) and (30), and Pseudo-} \sum (\text{all fractional exponents}) = 2(\sigma + 1) = \text{fractional number ‘} \neq 3’ \text{ for Eqs. (29) and (31). These findings signify presence of complete sets virtual Gram} [x=0] \text{ points for Eqs. (28) and (29) and virtual Gram} [x=0] \text{ points for Eqs. (30) and (31). The proof is now complete for Corollary 5.4}. \]

6. Prime and Composite numbers

Prime & Composite numbers are Incompletely Predictable entities dependently linked together in a sequential, cummulative & eternal manner since the relationship Number ‘1’ + Prime numbers + Composite numbers = Natural numbers always hold for all Natural numbers.

6.1. Dimensional analysis on Cardinality and “Dimensions” for Prime numbers. We use the word “Dimensions” to denote well-defined Incompletely Predictable entities obtained from Information-Complexity conservation. Relevant “Dimensions” dependently represent Number ‘1’, $P$ and $C$. Then by
default any (sub)sets of \( P \) and \( C \) in well-defined equations can also be represented by their corresponding “Dimensions”.

**Remark 6.1.** We can apply Dimensional analysis to “Dimensions” from Information-Complexity conservation and cardinality of relevant sets in certain well-defined equations.

Let \( X \) denote \( E, O, N \) [which are classified as Completely Predictable numbers], \( P \) and \( C \) [which are classified as Incompletely Predictable numbers].

For \( x = 1, 2, 3, 4, 5, ..., \infty \); consider all \( X \leq x \). Then this “all \( X \leq x \)” is definition for \( X-\pi(x) \) [denoting “\( X \) counting function”] resulting in following two types of equations coined as (I) ‘Exact’ equation \( N-\pi(x) = E-\pi(x) + O-\pi(x) \) with “non-varying” relationships \( E-\pi(x) = O-\pi(x) \) for all \( x = E \) and \( E-\pi(x) = O-\pi(x) - 1 \) for all \( x = O \), and (II) ‘Inexact’ equation \( N-\pi(x) = 1 + P-\pi(x) + C-\pi(x) \) with “varying” relationships \( P-\pi(x) > C-\pi(x) \) for all \( x \leq 8 \); \( P-\pi(x) = C-\pi(x) \) for \( x = 9, 11, \) and \( 13; \) and \( P-\pi(x) < C-\pi(x) \) for \( x = 10, 12, \) and all \( x \geq 14 \).

Let “Dimensions” and different (sub)sets of \( E, O, N, P \) and \( C \) be ‘base quantities’. Then exponent ‘1’ of “Dimensions” and cardinality of these (sub)sets in well-defined equations are corresponding ‘units of measurement’. Performing DA on “Dimensions” for \( PC \) pairing is depicted later on. Performing DA on cardinality is depicted next.

For Set \( N \) = Set \( E \) + Set \( O \), then \( |N| = |E| + |O| \implies \aleph_0 = \aleph_0 + \aleph_0 \)

thus conforming with DA homogeneity.

For Set \( N \) = Set \( P \) + Set \( C \) + Number ‘1’, then Set \( N \) = Number ‘1’ = Set \( P \) + Set \( C \) and \( |N \text{- Number ‘1’}| = |P| + |C| \implies \aleph_0 = \aleph_0 + \aleph_0 \)

thus conforming with DA homogeneity.

For Set \( N \) = Set \( even \ P \) = Number ‘1’ = Set \( odd \ P \) + Set \( even \ C \) + Set \( odd \ C \), then \( |N \text{- even P} \text{- Number ‘1’}| = |odd P| + |even C| + |odd C| \implies \aleph_0 = \aleph_0 + \aleph_0 + \aleph_0 \)

represented by all available \( O \) prime gap = 1 and \( E \) prime gaps = 2, 4, 6, 8, 10,...; \( O \) composite gap = 1 and \( E \) composite gap = 2; and \( O \) natural gap = 1; then \( |\text{Gap 1 N - Gap 1 P - Number ‘1’}| = |\text{Gap 2 P}| + |\text{Gap 4 P}| + |\text{Gap 6 P}| + |\text{Gap 8 P}| + |\text{Gap 10 P}| + ... + |\text{Gap 1 C}| + |\text{Gap 2 C}| \implies \aleph_0 = \aleph_0 + \aleph_0 + \aleph_0 + \aleph_0 + \aleph_0 + \aleph_0 + \aleph_0 \)

thus conforming with DA homogeneity. Symbolically known that \( |\text{Gap 1 P}| = |\text{Number ‘2’}| = 1 \) and \( |\text{Gap 1 N}| = |\text{Gap 1 C}| = |\text{Gap 2 C}| = \aleph_0 \). Then solving Polignac’s and Twin prime conjectures translate to successfully proving \( |\text{Gap 2 P}| = |\text{Gap 4 P}| = |\text{Gap 6 P}| = |\text{Gap 8 P}| = |\text{Gap 10 P}| = ... = \aleph_0 \) with \( E \) prime gap = \( i \) from Set \( E \) prime

Outline of proof for Polignac’s and Twin prime conjectures. Requires simultaneously satisfying two mutually inclusive conditions: I. *With rigid manifestation of DA homogeneity, quantitative* fulfillment by considering \( i \in E \) for each Subset \( odd P \), generated by \( E \) prime gap = \( i \) from Set \( E \) prime

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\[ \sum_{i=2}^{\infty} \text{Subset odd } P_i \text{ with } |\text{odd } P| = |\text{odd } P_i| = |E \text{ prime gaps}| = \aleph_0, \text{ and} \]

II. With rigid manifestation of DA non-homogeneity, quantitive\(^7\) fulfillment by considering \(i \in E\) for each Subset odd \(P_i\) generated by \(E\) prime gap \(= i\) from Set \(E\) prime gaps does not occur if more than one cardinality values are present in equation Set odd \(P > \sum_{i=2}^{\infty} \text{Subset odd } P_i\) with \(|E \text{ prime gaps}| = \aleph_0\) having incorrect \(|\text{Subset(s) odd } P| = N \text{ (finite value)}\) &/or Set odd \(P\) 

\[ > \sum_{i=2}^{N} \text{Subset odd } P_i \text{ with } |\text{odd } P_i| = \aleph_0 \text{ having incorrect } |E \text{ prime gaps}| = N \text{ (finite value).} \]

**Footnote 7:** Qualitative fulfillment of \(|\text{odd } P| = |\text{odd } P_i| = |E \text{ prime gaps}| = \aleph_0\) equates to Plus-Minus Gap 2 Composite Number Alternating Law being precisely obeyed by all \(E\) prime gaps apart from first \(E\) prime gap precisely obeying Plus Gap 2 Composite Number Continuous Law. Derived using Information-Complexity conservation, these Laws symbolize “end-result” proof on Polignac’s and Twin prime conjectures. *Law of Continuity* is a heuristic principle *whatever succeed for the finite, also succeed for the infinite*. Then these Laws which inherently manifest ‘Gap 2 Composite Number’ on finite and infinite time scale should in principle “succeed for the finite, also succeed for the infinite”.

**Polignac’s and Twin prime conjectures mathematical foot-prints.**

Six identifiable steps to prove these conjectures: *Step 1* Let \(N = 2x - \Sigma PC\) - Gap. Define Dimension (\(2x - N\)) based on Information-Complexity conservation to validly represent \(P \& C\). Considering \(x \in N\), obtain Dimensions (\(2x - 2\), (\(2x - 4\), (\(2x - 5\), (\(2x - 7\), (\(2x - 8\), (\(2x - 9\), ..., (\(2x - \infty\)) with specific groupings to constitute all elements of Set \(P\) [culminating in obtaining all prime gaps (= \(E\) prime gaps + Solitary \(O\) prime gap)] with \(|E \text{ prime gaps}| = \aleph_0\]). Note Dimension (\(2x - 2\)) represents \(x = 1\) (Number ‘1’) which is neither \(P\) nor \(C\). *Step 2* Considering \(i \in E\), confirm perpetual recurrences of individual \(E\) prime gap \(= i\) (associated with its unique odd \(P_i\)) occur only when depicted as specific groupings of Dimension (\(2x - N\))\(^2\) now endowed with exponent ‘1’ for all ranges of \(x\). *Step 3* Perform DA on exponent ‘1’ in these Dimensions. *Step 4* Perform DA on equation Set odd \(P = \sum_{i=2}^{\infty} \text{Subset odd } P_i\) to obtain \(|\text{odd } P| = |\text{odd } P_i| = \aleph_0\) whereby Subset odd \(P_i\) is derived from its associated unique \(E\) prime gap \(= i\) with \(|E \text{ prime gaps}| = \aleph_0\). *Step 5* Confirm ‘Prime number’ variable and ‘Prime gap’ variable complex algorithm “containing” all \(P\) with knowing their overall actual location [but not actual

Proof: page numbers may be temporary
Step 6 Derive Plus-Minus Gap 2 Composite Number Alternating Law and Plus Gap 2 Composite Number Continuous Law using Dimension (2x - N) and Information-Complexity conservation.

Footnote 8: This phrase implies all P (and C) are Incompletely Predictable numbers. Actual positions will require using complex algorithm Sieve of Eratosthenes to dependently calculate positions of all preceding P (and C) in neighborhood – see Lemma 8.4 [whereby $P_{n+1} = 2 + \sum_{i=1}^{n} G_{P_i}$ with ‘2’ denoting $P_1$] & Lemma 8.5 [whereby $C_{n+1} = 4 + \sum_{i=1}^{n} G_{C_i}$ with ‘4’ denoting $C_1$].

‘Complex Elementary Fundamental Laws’-based solutions of Plus-Minus Gap 2 Composite Number Alternating Law and Plus Gap 2 Composite Number Continuous Law are obtained by undertaking the non-negotiable mathematical steps outlined above. These Laws are literally Completely Predictable meta-properties (‘overall’ complex properties) arising from “interactions” between P and C producing relevant patterns of Gap 2 Composite Number perpetual appearances [albeit with Incompletely Predictable timing]. We logically deduce explicit mathematical explanation for these meta-properties requires “complex” mathematical arguments. Attempts to give explicit mathematical explanation with “simple” mathematical arguments intuitively meant Incompletely Predictable numbers P and C are (incorrectly & impossibly) treated as Completely Predictable numbers.

6.2. Brief overview of Polignac’s and Twin prime conjectures. Occurring over 2000 years ago (c. 300 BC), ancient Euclid’s proof on infinitude of P in totality [viz. $|P| = \aleph_0$ for Set P] predominantly by reductio ad absurdum (proof by contradiction) is earliest known but not the only proof for this simple problem in Number theory. Since then dozens of proofs have been devised such as three chronologically listed: Goldbach’s Proof using Fermat numbers (written in a letter to Swiss mathematician Leonhard Euler, July 1730), Furstenberg’s Topological Proof in 1955[5], and Filip Saidak’s Proof in 2006[6]. The strangest candidate is likely to be Furstenberg’s Topological Proof.

In 2013, Yitang Zhang proved a landmark result showing some unknown even number ‘N’ < 70 million such that there are infinitely many pairs of P that differ by ‘N’[7]. By optimizing Zhang’s bound, subsequent Polymath Project collaborative efforts using a new refinement of GPY sieve in 2013 lowered ‘N’ to 246; and assuming Elliott-Halberstam conjecture and its generalized form have further lower ‘N’ to 12 and 6, respectively. Then ‘N’ has intuitively more than one valid values such that there are infinitely many pairs of P that differ by each of those ‘N’ values [thus proving existence of more than one Subset odd $P_i$ with $|\text{odd } P_i| = \aleph_0$]. We can only theoretically lower ‘N’ to 2 (in
Table 1. First 17 prime gaps depicted in the format utilizing maximal prime gaps [depicted with asterisk symbol (*)] and non-maximal prime gaps [depicted without asterisk symbol].

<table>
<thead>
<tr>
<th>Prime gap</th>
<th>Following prime number</th>
<th>Prime gap</th>
<th>Following prime number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>2</td>
<td>18*</td>
<td>523</td>
</tr>
<tr>
<td>2*</td>
<td>3</td>
<td>20*</td>
<td>887</td>
</tr>
<tr>
<td>4*</td>
<td>7</td>
<td>22*</td>
<td>1129</td>
</tr>
<tr>
<td>6*</td>
<td>23</td>
<td>24</td>
<td>1669</td>
</tr>
<tr>
<td>8*</td>
<td>89</td>
<td>26</td>
<td>2477</td>
</tr>
<tr>
<td>10</td>
<td>139</td>
<td>28</td>
<td>2971</td>
</tr>
<tr>
<td>12</td>
<td>199</td>
<td>30</td>
<td>4297</td>
</tr>
<tr>
<td>14*</td>
<td>113</td>
<td>32</td>
<td>5591</td>
</tr>
<tr>
<td>16</td>
<td>1831</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

regards to P with ‘small gaps’) but there are still an infinite number of E prime gaps (in regards to P with ‘large gaps’) that require “proof that each will generate its unique set of infinite P”.

Remark 6.2. Existence of maximal and non-maximal prime gaps supply crucial indirect evidence to intuitively support but does not prove “Each even prime gap will generate an infinite magnitude of odd prime numbers on its own accord”.

Comments relevant to Remark 6.2 are given in the next section below.

7. Supportive role of maximal and non-maximal prime gaps

We analyze data of all P obtained when extrapolated out over a wide range of x ≥ 2 integer values. As sequence of P carries on, P with ever larger prime gaps will appear. For given range of x integer values, prime gap = n₂ is a ‘maximal prime gap’ if prime gap = n₁ < prime gap = n₂ for all n₁ < n₂. In other words, the largest such prime gaps in this range are called maximal prime gaps. The term ‘first occurrence prime gaps’ refers to first occurrences of maximal prime gaps whereby maximal prime gaps are prime gaps of “at least of this length”. We use maximal prime gaps to denote ‘first occurrence prime gaps’. CIS non-maximal prime gaps (endorsed with nickname ‘slow jumpers’) will always lag behind CIS maximal prime gaps for onset appearances in P sequence. These are shown for first 17 prime gaps in Table 1. Apart from O prime gap = 1 representing solitary even P ‘2’, remaining P in Table 1 consist of representative single odd P for each E prime gap. These odd P individually make one-off appearance in P sequence in a perpetual albeit Incompletely Predictable manner. Initial seven of [majority] “missing” odd P are 5, 11, 13, 17, 19, 29, 31,... belonging to Subset P with

Proof: page numbers may be temporary
‘residual’ prime gaps are potential source of odd \( P \) in relation to proposal that each \( E \) prime gap from Set \( E \) prime gaps will generate its specific Subset \( odd \ P \). Set all \( P \) from all prime gaps = Subset \( P \) from maximal prime gaps + Subset \( P \) from non-maximal prime gaps + Subset \( P \) from ‘residual’ prime gaps. Subset \( P \) from ‘residual’ prime gaps with representation from all \( E \) prime gaps must include all correctly selected “missing” odd \( P \). These observations support but does not prove proposition that each \( E \) prime gap will generate its own Subset \( odd \ P \) with \( |odd \ P| = \aleph_0 \).

For \( i \in \mathbb{N} \); primordial \( P_i\# \) is analog of usual factorial for \( P = 2, 3, 5, 7, 11, 13, \ldots \). Then \( P_1\# = 2, P_2\# = 2 \times 3 = 6, P_3\# = 2 \times 3 \times 5 = 30, P_4\# = 2 \times 3 \times 5 \times 7 = 210, P_5\# = 2 \times 3 \times 5 \times 7 \times 11 = 2310, P_6\# = 2 \times 3 \times 5 \times 7 \times 11 \times 13 = 30030, \) etc. English mathematician John Horton Conway coined the term ‘jumping champion’ in 1993. An integer \( n \) is a ‘jumping champion’ if \( n \) is the most frequently occurring difference (prime gap) between consecutive \( P \) sequence values. Example: for any \( x \) with \( 7 < x < 131 \), \( n = 2 \) (indicating twin \( P \)) is the ‘jumping champion’. It has been conjectured that (i) the only ‘jumping champions’ are 1, 4 and primorials \( 2, 6, 30, 210, 2310, 30030, \) and (ii) ‘jumping champions’ tend to infinity. Their required proofs will likely need proof of k-tuple conjecture. \( P \) from ‘jumping champion’ prime gaps have their onset appearances in \( P \) sequence in a perpetual albeit Incompletely Predictable manner [as another example to that outlined in previous paragraph].

8. Information-Complexity conservation

A formula, as equation or algorithm, is simply a Black Box generating necessary Output (with qualitative-like structural ‘Complexity’) when supplied with given Input (with quantitative-like data ‘Information’). This Information-based complexity are literally what is referred to in ‘Information-Complexity conservation’. \( P \) and \( C \) numbers are traditionally “analyzed separately”. The key definition behind Dimension \( (2x - N)^1 \) is used to abstractly represent dependent \( P \) and \( C \) numbers (and Number ‘1’) in a combined manner whereby \( N = 2x - \Sigma PC_x \)-Gap. This will lead to required mathematical arguments based on Information-Complexity conservation and patterns in Gap 2 Composite Number to obtain Plus-Minus Gap 2 Composite Number Alternating Law & Plus Gap 2 Composite Number Continuous Law which will [respectively] solve Polignac’s & Twin prime conjectures.

\( N \) (CIS): 1, 2, 3, ..., \(+\infty\). Let \( x \) be from Set \( X \) such that \( x \in N \). Consider \( x \) for upper boundary of interest in Set \( X \) whereby \( X \) is chosen from \( N, E, O, P \) or \( C \).

**Lemma 8.1.** Natural counting function \( N-\pi(x) \), defined as \( |N \leq x| \), is Completely Predictable by independently using simple algorithm to be equal to \( x \).
Proof. Formula to generate $\mathbb{N}$ with 100% certainty is $\mathbb{N}_i = i$ whereby $\mathbb{N}_i$ is the $i^{th}$ $\mathbb{N}$ and $i = 1, 2, 3, ..., \infty$. For a given $\mathbb{N}_i$, its $i^{th}$ position is simply $i$.

Natural gap $(G_{\mathbb{N}_i}) = \mathbb{N}_{i+1} - \mathbb{N}_i$, with $G_{\mathbb{N}_i}$ always = 1. There are $x \mathbb{N} \leq x$.

Thus $\mathbb{N}-\pi(x) = |\mathbb{N} \leq x| = x$. The proof is now complete for Lemma 8.1.$\Box$.

Lemma 8.2. Even counting function $E-\pi(x)$, defined as $|E \leq x|$, is Completely Predictable by independently using simple algorithm to be equal to floor$(x/2)$.

Proof. Formula to generate $E$ with 100% certainty is $E_i = iX2$ whereby $E_i$ is the $i^{th}$ $E$ and $i = 1, 2, 3, ..., \infty$ abiding to mathematical label “All $\mathbb{N}$ always ending with a digit 0, 2, 4, 6 or 8”. For a given $E_i$, its $i^{th}$ position is calculated as $i = E_i/2$. Even gap $(G_{E_i}) = E_{i+1} - E_i$, with $G_{E_i}$ always = 2.

There are $\left\lceil \frac{x}{2} \right\rceil$ $E \leq x$. Thus $E-\pi(x) = |E \leq x| = \text{floor}(x/2)$. The proof is now complete for Lemma 8.2.$\Box$.

Lemma 8.3. Odd counting function $O-\pi(x)$, defined as $|O \leq x|$, is Completely Predictable by independently using simple algorithm to be equal to ceiling$(x/2)$.

Proof. Formula to generate $O$ with 100% certainty is $O_i = (iX2) - 1$ whereby $O_i$ is the $i^{th}$ odd number and $i = 1, 2, 3, ..., \infty$ abiding to mathematical label “All $\mathbb{N}$ always ending with a digit 1, 3, 5, 7, or 9”. For a given $O_i$ number, its $i^{th}$ position is calculated as $i = (O_i + 1)/2$. Odd gap $(G_{O_i}) = O_{i+1} - O_i$, with $G_{O_i}$ always = 2. There are $\left\lceil \frac{x}{2} \right\rceil$ $O \leq x$. Thus $O-\pi(x) = |O \leq x| = \text{ceiling}(x/2)$. The proof is now complete for Lemma 8.3.$\Box$.

Lemma 8.4. Prime counting function $P-\pi(x)$, defined as $|P \leq x|$, is Incompletely Predictable with Set $P$ dependently obtained using complex algorithm Sieve of Eratosthenes.

Proof. Algorithm to generate $P_i$ whereby $P_1 (= 2)$, $P_2 (= 3)$, $P_3 (= 5)$, $P_4 (= 7)$, $\ldots$, $\infty$ with 100% certainty is based on Sieve of Eratosthenes abiding to mathematical label “All $\mathbb{N}$ apart from 1 that are evenly divisible by itself and by 1”. Although we can check primality of a given $O$ by trial division, we can never determine its position without knowing positions of preceding $P$.

Prime gap $(G_{P_i}) = P_{i+1} - P_i$, with $G_{P_i}$ constituted by all $E$ except $1^{st}$ $G_{P_1} = 3 - 2 = 1$. $P-\pi(x) = |P \leq x|$. This is Incompletely Predictable and is calculated via mentioned algorithm. Using definition of prime gap, every $P$ [represented here with aid of ‘$n$’ notation instead of usual ‘$i$’ notation] is written as $P_{n+1} = 2 + \sum_{i=1}^{n} G_{P_i}$ with ‘2’ denoting $P_1$. Here $i \in \mathbb{N}$ = 1, 2, 3, 4, 5, $\ldots$, $\infty$. The proof is now complete for Lemma 8.4.$\Box$.

Lemma 8.5. Composite counting function $C-\pi(x)$, defined as $|C \leq x|$, is Incompletely Predictable with Set $C$ derived as Set $\mathbb{N} - \text{Set } P$ [dependently obtained using complex algorithm Sieve of Eratosthenes] - Number ‘1’.

Proof: page numbers may be temporary.
Proof. Composite numbers abide to mathematical label “All \(N\) apart from 1 that are evenly divisible by numbers other than itself and 1”. Algorithm to generate \(C_i\) whereby \(C_1 (= 4)\), \(C_2 (= 6)\), \(C_3 (= 8)\), \(C_4 (= 9)\), ..., \(\infty\) with 100% certainty is based [indirectly] on Sieve of Eratosthenes via selecting non-prime \(N\) to be \(C\). We define Composite gap \(G_{C_i}\) as \(C_{i+1} - C_i\) with \(G_{C_i}\) constituted by 1 & 2. \(C-\pi(x) = |C \leq x|\). This is Incompletely Predictable and need to be calculated indirectly via the mentioned algorithm. Using definition of composite gap, every \(C\) [represented here with aid of ‘n’ notation instead usual ‘i’ notation] is written as \(C_n + 1 = 4 + \sum_{i=1}^{n} G_{C_i}\) with ‘4’ denoting \(C_1\). Here i & n = 1, 2, 3, 4, 5, ..., \(\infty\). The proof is now complete for Lemma 8.5□.

Denote \(X\) to be \(N, E, O, P\) or \(C\). \(X-\pi(x) = |X \leq x|\) with \(x \in N\). We define and compute entity ‘Grand-Total Gaps for \(X\) at \(x\)’ (Grand-Total \(\Sigma X_x\)-Gaps).

**Proposition 8.6.** For any given \(x \geq 1\) values in Set \(N\), designated Complexity is represented by \(\Sigma N_x\)-Gaps = \(x - N\) with \(N = 1\) being maximal.

**Proof.** Set \(N\) (for \(x = 1\) to 12): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. \(N-\pi(x) = 12\). There are \(x - 1 = 11\) \(N\)-Gaps each of ‘1’ magnitude: 1, 1, 1, 1, 1, 1, 1, 1, 1, 1. \(\Sigma N_x\)-Gaps = 11 X 1 = 11. This equates to “\(x - 1\)” – regarded as Complexity for \(N\). The proof is now complete for Proposition 8.6□.

**Proposition 8.7.** For any given \(x \geq 1\) values in constituent Set \(E\) and Set \(O\), designated Complexity is represented by \(\Sigma E_O x\)-Gaps = 2\(x - N\) with \(N = 4\) being maximal.

**Proof.** Set \(E\) and Set \(O\) (for \(x = 1\) to 12): 2, 4, 6, 8, 10, 12 and 1, 3, 5, 7, 9, 11. \(E-\pi(x) = 6\) and \(O-\pi(x) = 6\). There are \(\lfloor \frac{x}{2} \rfloor - 1 = 5\) \(E\)-Gaps each of ‘2’ magnitude: 2, 2, 2, 2, 2. \(\Sigma E_x\)-Gaps = 5 X 2 = 10, and \(\lfloor \frac{x}{2} \rfloor - 1 = 5\) \(O\)-Gaps each of ‘2’ magnitude: 2, 2, 2, 2, 2. \(\Sigma O_x\)-Gaps = 5 X 2 = 10. Grand-Total \(\Sigma E_O x\)-Gaps = 10 + 10 = 20. Depicted by Table 3 & Figure 19 in Appendix D, 2\(x-N = “2x-4”\) [perpetual constant appearances of “\(N=4\) being maximal”] is Complexity for \(E \& O\). The proof is now complete for Proposition 8.7□.

**Proposition 8.8.** For selected \(x \geq 2\) values in constituent Set \(P\) and Set \(C\), designated Complexity is cyclically represented by \(\Sigma PC_x\)-Gaps = 2\(x - N\) with \(N = 7\) being minimal.

**Proof.** Set \(P\) and Set \(C\) (for \(x = 2\) to 12): 2, 3, 5, 7, 11 and 4, 6, 8, 9, 10, 12. \(P-\pi(x) = 5\) and \(C-\pi(x) = 6\). There are four \(P\)-Gaps of 1, 2, 2, 4 magnitude and five \(C\)-Gaps of 2, 2, 1, 1, 2 magnitude. \(\Sigma P_x\)-Gaps = 1 + 2 + 2 + 4 = 9. \(\Sigma C_x\)-Gaps = 2 + 2 + 1 + 1 + 2 = 8. Grand-Total \(\Sigma PC_x\)-Gaps = 9 + 8 = 17. Depicted by Table 2 and Figure 18, 2\(x - N = “2x - 7”\) [perpetual intermittent and cyclical appearances of “\(N=7\) being minimal”] is Complexity for \(P\) and \(C\). The proof is now complete for Proposition 8.8□.

Designated Complexity is (i) \(x - N\) with \(N = 1\) (maximal) for Completely Predictable \(N\), (ii) 2\(x - N\) with \(N = 7\) (minimal) for Incompletely Predictable
RIEMANN HYPOTHESIS, POLIGNAC’S AND TWIN PRIME CONJECTURES

\( P \& C \), and (iii) \( 2x - N \) with \( N = 4 \) (maximal) for Completely Predictable \( E \& O \). Interpretations: \( N \) has minimal Complexity, \( E \& O \) have intermediate Complexity, and \( P \& C \) have maximal [varying] Complexity. Defacto baseline “\( 2x - 4 \)” Grand-Total Gaps [minus 4 value] in \( E-O \) pairing > Defacto baseline “\( 2x - \geq 7 \)” Grand-Total Gaps [minus \( \geq 7 \) values] in \( P-C \) pairing.

Let both \( x \& N \in \mathbb{N} \). We tabulate in Table 2 and graph in Figure 18 [Incompletely Predictable] \( P-C \) mathematical landscape for a relatively larger \( x = 2 \) to 64 here (and ditto for [Completely Predictable] \( E-O \) mathematical landscape for relatively larger \( x = 1 \) to 64 in Appendix D). The term “mathematical landscape” denotes specific mathematical patterns in tabulated and graphed data. “Dimension” contextually denotes Dimension \( 2x - N \) whereby (i) allocated [infinite] \( N \) values result in Dimensions \( 2x - 7, 2x - 8, 2x - 9, \ldots, 2x - \infty \) for \( P-C \) finite scale mathematical landscape and (ii) allocated [finite] \( N \) values for \( E-O \) finite scale mathematical landscape result in Dimension \( 2x - 4 \). For \( P-C \) pairing, initial one-off Dimensions \( 2x - 2, 2x - 4 \) and \( 2x - 5 \) (in consecutive order) are exceptions [with Dimension \( 2x - 2 \) validly representing Number ‘1’ which is neither \( P \) nor \( C \)]. For \( E-O \) pairing, initial one-off Dimension \( 2x - 2 \) is an exception. \( P-C \) mathematical landscape consisting of Dimensions will intrinsically incorporate \( P \) and \( C \) in an integrated manner and there are infinite times whereby relevant Dimensions deviate away from ‘baseline’ Dimension \( 2x - 7 \) simply because \( P \) [and, by default, \( C \)] in totality are rigorously proven to be infinite in magnitude. In contrast, there is a complete lack of deviation away from ‘baseline’ Dimension \( 2x - 4 \) apart from one-off deviation caused by the initial Dimension \( 2x - 2 \) in Appendix D.

Figure 18. Prime-Composite finite scale mathematical (graphed) landscape using data obtained for \( x = 2 \) to 64. Bottom graph symbolically represent “Dimensions” using ever larger negative integers.

In Figure 18, Dimensions \( 2x - 7, 2x - 8, 2x - 9, \ldots, 2x - \infty \) are symbolically represented by \( -7, -8, -9, \ldots, \infty \) with \( 2x - 7 \) displayed as ‘baseline’ Dimension.
Table 2. Prime-Composite finite scale mathematical (tabulated) landscape using data obtained for $x = 2$ to 64. The Number '1' is neither prime nor composite. Legend: $C =$ composite, $P =$ prime, $\text{Dim} =$ Dimension, $Y =$ Dimension $2x - 7$ (for visual clarity), N/A = Not Applicable.

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<th>$P_1$ or $C_1$ Gaps</th>
<th>$\Sigma PC_x$-Gaps</th>
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Proof: page numbers may be temporary
whereby Dimension trend (Cumulative Sum Gaps) must repeatedly reset itself onto this ‘baseline’ Dimension on a perpetual basis. Dimensions symbolically represented by ever larger negative integers will correspond to $P$ associated with ever larger prime gaps and this phenomenon will generally happen at ever larger $x$ values (with complete presence of Chaos and Fractals being manifested in our graph). At ever larger $x$ values, $P-\pi(x)$ will overall become larger but with a *decelerating* trend whereas $C-\pi(x)$ will overall become larger but with an *accelerating* trend. This support ever larger prime gaps appearing at ever larger $x$ values.

Definitive derivation of data in Table 2 is illustrated by two examples for position $x = 31 \& 32$. For $i \& x \in \mathbb{N}; \Sigma PC_{x-1}-\text{Gap} = \Sigma PC_{x}-\text{Gap} + \text{Gap value at} \ P_{i-1} \text{or Gap value at} \ C_{i-1}$ whereby (i) $P_i$ or $C_i$ at position $x$ is determined by whether relevant $x$ value belongs to a $P$ or $C$, and (ii) both $\Sigma PC_{1}$-Gap and $\Sigma PC_{2}$-Gap = 0. Example, for position $x = 31$: 31 is $P$ ($P_{11}$). Desired Gap value at $P_{10}$ = 2. Thus $\Sigma PC_{31}$-Gap (55) = $\Sigma PC_{30}$-Gap (53) + Gap value at $P_{10}$ (2). Example, for position $x = 32$: 32 is $C$ ($C_{20}$). Desired Gap value at $C_{19}$ = 2. Thus $\Sigma PC_{32}$-Gap (57) = $\Sigma PC_{31}$-Gap (55) + Gap value at $C_{20}$ (2). Note: in our Dimension $(2x - N)$ system, $N = 2x - \Sigma PC_{x}$-Gap. ‘Overall magnitude of $C$ will always be greater than that of $P$’ will hold true from $x = 14$ onwards. For instance, position $x = 61$ corresponds to $P_{61}$ which is 18th $P$, whereas [one lower] position $x = 60$ corresponding to $C_{60}$ is [much higher] 42nd $C$.

9. **Polignac’s and Twin prime conjectures**

Previous section alludes to $P-C$ finite scale mathematical landscape. This section alludes to $P-C$ infinite scale mathematical landscape. Let ‘Y’ symbolizes (baseline) Dimension $2x - 7$. Let prime gap at $P_i = P_{i+1} - P_i$ with $P_i \& P_{i+1}$ respectively symbolizes consecutive “first” & “second” $P$ in any $P_i-P_{i+1}$ pairings. We denote (i) Dimensions YY grouping [depicted by $2x - 7$ initially appearing twice in (iii)] to represent signal for appearances of $P$ pairings other than twin $P$ such as cousin $P$, sexy $P$, etc; (ii) Dimension YYYY grouping to represent signal for appearances of $P$ pairings as twin $P$; and (iii) Dimension $(2x - \geq 7)$-Progressive-Grouping allocated to $2x - 7, 2x - 7, 2x - 8, 2x - 9, 2x - 10, 2x - 11,..., 2x - \infty$ as elements of precise and proportionate CFS Dimensions representation of an individual $P_i$ with its associated prime gap namely, $\Sigma PC_{x}$-Gap (55) = $\Sigma PC_{x}$-Gap (53) + Gap value at $P\_10$ (2). Example, for position $x = 32$: 32 is $C$ ($C_{20}$). Desired Gap value at $C_{19}$ = 2. Thus $\Sigma PC_{32}$-Gap (57) = $\Sigma PC_{31}$-Gap (55) + Gap value at $C_{20}$ (2). Note: in our Dimension $(2x - N)$ system, $N = 2x - \Sigma PC_{x}$-Gap. ‘Overall magnitude of $C$ will always be greater than that of $P$’ will hold true from $x = 14$ onwards. For instance, position $x = 61$ corresponds to $P_{61}$ which is 18th $P$, whereas [one lower] position $x = 60$ corresponding to $C_{60}$ is [much higher] 42nd $C$.

Proof: page numbers may be temporary
of five \( P \) numbers as prime quintuplets, etc consist of serendipitous groupings abiding to mathematical rule: With exception of three ‘outlier’ \( P \) 3, 5, & 7; groupings of any three \( P \) as \( P, P+2, P+4 \) combination (viz. manifesting two consecutive twin \( P \)) is a mathematical impossibility. The ‘anomaly’ one of every three consecutive \( O \) is a multiple of three, and hence this number cannot be \( P \), explains this impossibility. Then closest possible \( P \) grouping [viz. for prime triplet] must be either \( P, P+2, P+6 \) or \( P, P+4, P+6 \) format.

\( P \) groupings not respecting traditional closest-possible-prime groupings are also the norm occurring infinitely often, indicating continual presence of prime gaps \( \geq 6 \). As \( P \) become sparser at larger range, perpetual presence of (i) prime gaps \( \geq 6 \) [proposed by us to arbitrarily represent ‘large gaps’] and (ii) prime gaps 2 & 4 [proposed by us to arbitrarily represent ‘small gaps’] with progressive greater magnitude will cumulatively occur for each prime gap but always in a decelerating manner. With permanent requirement at larger range of intermittently resetting to baseline Dimension \( 2x - 7 \) occurring [either two or] four times in a row, nature seems to dictate, at the very least, perpetual twin \( P \) or one other non-twin \( P \) occurrences is inevitable.

We dissect Dimension YYYY unique signal for twin \( P \) appearances: Initial two CFS Dimensions YY components of YYYY represent “first” \( P \) component of twin \( P \) pairing. Last two Dimensions YY components of YYYY signifying appearance of “second” \( P \) component of twin \( P \) pairing is also the initial first-two-element component of full CFS Dimensions representation for “first” \( P \) component of following non-twin \( P \) pairing. Twin \( P \) are uniquely represented by repeating single type Dimension \( 2x - 7 \). In all other ‘higher order’ \( P \) pairings (with prime gaps \( \geq 4 \)), they require multiple types Dimension representation. There is qualitative aspect association of single type Dimension representation for twin \( P \) resulting in “less colorful” Plus Gap 2 Composite Number Continuous Law as opposed to multiple types Dimension representation for all other ‘higher order’ \( P \) pairings resulting in “more colorful” Plus-Minus Gap 2 Composite Number Alternating Law. ‘Gap 2 Composite Number’ occurrences in both Laws on finite scale are (directly) observed in Figure 18 & Table 2 for \( x = 2 \) to 64, and on infinite scale are (indirectly) deduced using logical arguments for all \( x \) values.

We endow all “Dimensions” with exponent of ‘1’ for perusal in on-going mathematical arguments. \( P_1 = 2 \) is represented by CFS as Dimension \( (2x - 4)^1 \) (with both prime gap & CFS cardinality = 1); \( P_2 = 3 \) is represented by CFS as Dimensions \( (2x - 5)^1 \& (2x - 7)^1 \) (with both prime gap & CFS cardinality = 2); \( P_3 = 5 \) is represented by CFS Dimension \( (2x - 7)^1 \& (2x - 7)^1 \) (with both prime gap & CFS cardinality = 2), etc.

**Proposition 9.1.** Let Case 1 be Completely Predictable \( E \& O \) pairing and Case 2 be Incompletely Predictable \( P \& C \) pairing. Furthermore, let Case
1 and Case 2 be independent of each other. Then for any given x value, there
exist grand total number of Dimensions [Complexity] such that it exactly equal
to either two combined subtotal number of Dimensions [Complexity] to pre-
cisely represent E & O in Case 1, or combined subtotal number of Dimensions
[Complexity] to precisely represent P & C & Number ‘1’ in Case 2.

**Proof.** N is directly constituted from either combined E & O in Case 1
or combined P & C & Number ‘1’ in Case 2 – Number ‘1’ is neither P nor
C. Correctly designated infinitely many CFS of Dimensions used to represent
combined E & O in Case 1 and combined P & C & Number ‘1’ in Case 2 must
also directly and proportionately be representative of relevant N arising from
combined subtotal of E & O in Case 1 and from combined subtotal of P & C
& Number ‘1’ in Case 2. *The proof is now complete for Proposition 9.1.*

**Proposition 9.2.** Let Case 1 be Completely Predictable E & O pairing
and Case 2 be Incompletely Predictable P & C pairing. Furthermore, let Case
1 and Case 2 be independent of each other. Part I: For any given x value apart
from x = 1 value in Case 1 and x = 1, 2, and 3 values in Case 2; Dimension
\((2x - N)^1\) [Complexity] representations of all Completely Predictable E & O
in Case 1 and all Incompletely Predictable P & C & Number ‘1’ in Case 2
are given by N = 4 in Case 1 and by N ≥ 7 in Case 2. Part II: Odd P obeys
Plus-Minus Composite Gap 2 Number Alternating Law for prime gaps ≥ 4
and Plus Composite Gap 2 Number Continuous Law for prime gap = 2.

**Proof.** Apart from first Dimension \((2x - 2)^1\) representation in E & O
pairing in Case 1 and first three Dimension \((2x - 2)^1\), Dimension \((2x - 4)^1\) and
Dimension \((2x - 5)^1\) representations in P & C pairing in Case 2; possible N
value in Dimension \((2x - N)^1\) representation are shown to be (constantly) max-
imal 4 for Case 1 and (variably) minimal 7 for Case 2. For Case 2, we again
note Dimension \((2x - 2)^1\) to (validly) represent Number ‘1’ which is neither
P nor C. These nominated Dimensions simply represent possible (constant)
baseline “2x - 4” Grand-Total Gaps as per Proposition 8.7 for Case 1 & (vari-
able) baseline “2x - 7” Grand-Total Gaps as per Proposition 8.8 for Case 2.
All CFS of Dimensions that can be used to precisely represent combined E &
O in Case 1 will persistently consist of same Dimension \((2x - 4)^1\) after first
Dimension \((2x - 2)^1\). Perpetual repeated deviation of N values away from N
= 7 (minimum) in Case 2 is simply representing infinite magnitude of P & C.
*The proof is now complete for Part I of Proposition 9.2.*

Derived Dimensions will comply with Incompletely Predictable property
as explained using P ‘61’. At Position x = 61 equating to P_{18} = 61, it is
represented by CFS Dimensions \((2x - 7)^1\), \((2x - 7)^1\), \((2x - 8)^1\), \((2x - 9)^1,\n(2x - 10)^1\) & \((2x - 11)^1\) (with both prime gap & CFS cardinality = 6). This
representation indicates an “unknown but correct” P with prime gap = 6 when
we intentionally conceal full information ‘61’ = 31^{st} O = 18^{th} P with prime gap

Proof: page numbers may be temporary
= 6. But to arrive at this representation requires calculations of all preceding
CFS Dimensions thus manifesting hallmark Incompletely Predictable property
of CFS Dimensions.

Overall sum total of individual CFS Dimensions required to represent ev-
ery P is infinite in magnitude as \|all P\| = \aleph_0. Standalone Dimensions YY
groupings [representing signals for "higher order" non-twin P appearances]
&/or as front Dimensions YY (sub)groupings [which by itself is fully repre-
sentative of twin P as Dimensions YYYY appearances] need to recur on an
indefinite basis. Then twin P and "higher order" cousin P, sexy P, etc should
aesthetically all be infinite in magnitude because (respectively) they regularly
and universally arise as part of Dimension YYYY and Dimension YY appear-
ances. An isolated P is defined as a P such that neither P - 2 nor P + 2 is
P. In other words, isolated P is not part of a twin P pair. Example 23 is an
isolated P since 21 and 25 are both C. Then repeated inevitable presence of
Dimension YY grouping is nothing more than indicating repeated occurrences
of isolated P. This constitutes another view on Dimension YY.

CIS of Gap 1 Composite Numbers are fully associated with non-twin P as
they eternally occur in between any two consecutive non-twin P. CIS of Gap 2
Composite Numbers are (i) fully associated with twin P as they are eternally
present in between any twin P pair, and (ii) partially associated with non-twin
P as they are eternally present alternatingly or intermittently in between any
two consecutive non-twin P. Then (i) Gap 1 Composite Numbers do not have
valid representation by E prime gap = 2, and (ii) Gap 2 Composite Numbers
have valid representations by all E prime gaps = ["consistently" only for] 2,
["inconsistently" for each of] 4, 6, 8, 10,.... This is an alternative view on
P from perspective of CFS composite gaps [instead of CIS prime gaps] with
intrinsic patterns having alternating presence and absence of Gap 2 Composite
Numbers associated with every CFS Dimensions representations of P with
prime gaps ≥ 4, viz. ‘Plus-Minus Gap 2 Composite Number Alternating Law’.
CFS Dimensions representations of Twin P are always associated with Gap 2
Composite Numbers, viz. ‘Plus Gap 2 Composite Number Continuous Law’.

Examples for both Laws: A twin P (prime gap = 2) in its unique CFS Di-
dimensions format always has Gap 2 Composite Numbers in a [constant] pattern.
A cousin P (prime gap = 4) in its unique CFS Dimensions format always has
two Gap 1 Composite Numbers & then one Gap 2 Composite Number [com-
bined] pattern alternating with three consecutive Gap 1 Composite Numbers
[non-combined] pattern. From this simple observation alone, we deduce we
can generate an infinite magnitude of C from each composite gaps 1 & 2. Gap
2 Composite Numbers alternating pattern behavior in cousin P will not hold
true unless twin P & all other non-cousin P are infinite in magnitude and
integratedly supplying essential “driving mechanism” to eternally sustain this
Gap 2 Composite Numbers alternating pattern behavior in cousin $P$. Thus we establish twin $P$ and cousin $P$ in their CFS Dimensions formats are CIS inter-twined together when depicted using $C$ with composite gaps = 1 & 2 with each supplying their own peculiar (infinite) share of associated Gap 2 Composite Numbers [thus contributing to overall pool of Gap 2 Composite Numbers].

An inevitable statement in relation to “Gap 2 Composite Numbers pool contribution” based on above reasoning: At the bare minimum, either twin $P$ or at least one of non-twin $P$ must be infinite in magnitude. An inevitable impression: All generated subsets of $P$ from ‘small gaps’ [of 2 & 4] and ‘large gaps’ [of ≥ 6] alike should each be CIS thus allowing true uniformity in $P$ distribution. Again we see in Table 2 depicting $P$-$C$ data for $x = 2$ to 64 that, for instance, $P$ with prime gap = 6 must also persistently have this ‘last-place’ Gap 2 Composite Numbers intermittently appearing in certain rhythmic alternating patterns, thus complying with Plus-Minus Gap 2 Composite Number Alternating Law. This CFS Dimensions representation for $P$ with prime gaps = 6 will again generate their infinite share of associated Gap 2 Composite Numbers to contribute to this pool. The presence of this last-place Gap 2 Composite Numbers in various alternating pattern in appearances & non-appearances must self-generally be similarly extended in a mathematically consistent fashion ad infinitum to all other remaining infinite number of prime gaps [which were not discussed in details above]. The proof is now complete for Part II of Proposition 9.2$^\Box$.

10. Rigorous Proofs for the now-named as Polignac’s and Twin prime hypotheses

The proofs on lemmas and propositions from previous section supply all necessary evidences to fully support Theorem Polignac-Twin prime I to IV below thus depicting proofs for Polignac’s and Twin prime conjectures in a rigorous manner. Gap 1 Composite Numbers do not have valid representation by $E$ prime gap = 2, and Gap 2 Composite Numbers have valid representations by all $E$ prime gaps = [“consistently” only for] 2, [“inconsistently” for each of] 4, 6, 8, 10,... Plus-Minus Gap 2 Composite Number Alternating Law confirms that Gap 2 Composite Numbers present in each $P$ with prime gaps ≥ 4 situation must appear as some sort of “rhythmic patterns of alternating presence and absence” for Gap 2 Composite Numbers. Twin $P$ with prime gap = 2 obeying Plus Gap 2 Composite Number Continuous Law can be understood as special situation of “(non-)rhythmic patterns with continual presence” for relevant Gap 2 Composite Numbers.

In 1849 when French mathematician Alphonse de Polignac (1826 - 1863) was admitted to Polytechnique, he created Polignac’s conjecture which relates complete set of odd $P$ to all $E$ prime gaps. Made earlier by de Polignac in
1846, Twin prime conjecture which relates twin prime numbers to prime gap
= 2, is then just a subset of Polignac’s conjecture.

**Theorem Polignac-Twin prime I.** Incompletely Predictable prime
numbers \( P_n = 2, 3, 5, 7, 11, ..., \infty \) or composite numbers \( C_n = 4, 6, 8, 
9, 10, ..., \infty \) are CIS with overall actual location [but not actual positions] of
all prime or composite numbers accurately represented by complex algorithm
involving prime gaps \( G_{Pi} \) viz. \( P_{n+1} = 2 + \sum_{i=1}^{n} G_{Pi} \) or involving composite
gaps \( G_{Ci} \) viz. \( C_{n+1} = 4 + \sum_{i=1}^{n} G_{Ci} \) whereby prime & composite numbers are
symbolically represented here with aid of ‘n’ notation instead of usual ‘i’ nota-
tion; and \( i \& n = 1, 2, 3, 4, 5, ..., \infty \). Number ‘2’ in first algorithm represents
\( P_1 \), the very first (and only even) \( P \). Number ‘4’ in second algorithm represent
\( C_1 \), the very first (and even) \( C \).

**Proof.** We treat above algorithms as unique mathematical objects looking
for key intrinsic properties and behaviors. Each \( P \) or \( C \) is assigned a unique
prime or composite gap. Absolute number of \( P \) or \( C \) and (thus) prime or
composite gaps are infinite in magnitude. As original formulae containing all \( P 
\) or \( C \) by themselves (viz. without supplying prime or composite gaps as “input
information” to generate \( P \) or \( C \) as “output complexity”), these algorithms
intrinsically incorporate overall actual location [but not actual positions] of all
\( P \) or \( C \). The proof is now complete for Theorem Polignac-Twin prime I \( \Box \).

**Theorem Polignac-Twin prime II.** Set of prime gaps \( G_{Pi} = 2, 4, 6, 
8, 10, ..., \infty \) is infinite in magnitude whereby these prime gaps accurately and
completely represented by Dimensions \((2x - 7)^1, (2x - 8)^1, (2x - 9)^1, ..., (2x - \infty)^1 \)
must satisfy Information-Complexity conservation in a consistent manner.

**Proof.** Part I of Proposition 9.2 proved all \( P \) are represented by Dimen-
sion \((2x - N)^1 \) with \( N \geq 7 \) for any given \( x \) value (except for \( x = 2 \) & 3 values).
Although \( x = 1 \) is neither \( P \) nor \( C \), it is validly represented by Dimension \((2x - 2)^1 \).
If each \( P \) is endowed with a specific prime gap value, then each such prime
gap must [via logical mathematical deduction] be represented by Dimension \((2x - N)^1 \).
We advocate this nominated method of prime gap representation using
Dimensions be [purportedly] the only way to achieve Information-Complexity
conservation. The preceding mathematical statements are correct as there
is a unique prime gap value associated with each \( P \). Proposition 10.1 below
based on principles from Set theory provides further supporting materials that
prime gaps are infinite in magnitude. The proof is now complete for Theorem
Polignac-Twin prime II \( \Box \).

**Theorem Polignac-Twin prime III.** To maintain Dimensional analysis
(DA) homogeneity, those Dimensions \((2x - N)^1 \) from Theorem Polignac-Twin

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Proof: page numbers may be temporary
prime II must contain eternal repetitions of well-ordered sets constituted by Dimensions \((2x - 7)^1, (2x - 8)^1, (2x - 9)^1, (2x - 10)^1, (2x - 11)^1,\ldots, (2x - \infty)^1\).

**Proof.** This Theorem is stated in greater details as “To maintain DA homogeneity, those aforementioned [endowed with exponent 1] Dimensions \((2x - N)^1\) from Theorem Polignac-Twin prime II must repeat themselves indefinitely in following specific combinations – (i) Dimension \((2x - 7)^1\) only appearing as twin [two-times-in-a-row] and quadruplet [four-times-in-a-row] sequences, and (ii) Dimensions \((2x - 8)^1, (2x - 9)^1, (2x - 10)^1, (2x - 11)^1,\ldots, (2x - \infty)^1\) appearing as progressive groupings of \(E\) 2, 4, 6, 8, 10,\ldots, \(\infty\).” To accommodate the only even \(P\) ‘2’, exceptions to this DA homogeneity compliance will expectedly occur right at beginning of \(P\) sequence – (i) one-off appearance of Dimensions \((2x - 2)^1, (2x - 4)^1\) and \((2x - 5)^1\) and (ii) one-off appearance of Dimension \((2x - 7)^1\) as a quintuplet [five-times-in-a-row] sequence which is equivalent to (eternal) non-appearance of Dimension \((2x - 6)^1\) at \(x = 4\). [We again note Dimension \((2x - 2)^1\) validly represent Number ‘1’ which is neither \(P\) nor \(C\).]

These sequentially arranged sets are CFS whereby from \(x = 11\) onwards, each set always commence initially as ‘baseline’ Dimension \((2x - 7)^1\) at \(x = O\) values and always end with its last Dimension at \(x = E\) values. Each set also have varying cardinality with values derived from all \(E\); and correctly combined sets always intrinsically generate two infinite sets of \(P\) and, by default, \(C\) in an integrated manner. Our Theorem Polignac-Twin prime III simply represent a mathematical summary derived from Section 8 & 9 of all expressed characteristics of Dimension \((2x - N)^1\) when used to represent \(P\) with intrinsic display of DA homogeneity. See Proposition 10.2 for more details on DA aspect. *The proof is now complete for Theorem Polignac-Twin prime III.*

**Theorem Polignac-Twin prime IV.** Aspect 1. The “quantitive” aspect to existence of both prime gaps and their associated prime numbers as sets of infinite magnitude will be shown to be correct by utilizing principles from Set theory. Aspect 2. The “qualitative” aspect to existence of both prime gaps and their associated prime numbers as sets of infinite magnitude will be shown to be correct by ‘Plus-Minus Gap 2 Composite Number Alternating Law’ and ‘Plus Gap 2 Composite Number Continuous Law’.

**Proof.** Required concepts from Set theory involve cardinality of a set with its ‘well-ordering principle’ application. Supporting materials for these concepts based on ‘pigeonhole principle’ in relation to Aspect 1 are outlined in Proposition 10.1 below. ‘Plus-Minus Gap 2 Composite Number Alternating Law’ is applicable to all \(E\) prime gaps [apart from first \(E\) prime gap = 2 for twin primes]. The prime gap = 2 situation will obey ‘Plus Gap 2 Composite Number Continuous Law’. These Laws are in essence Laws of Continuity inferring underlying intrinsic driving mechanisms that enables infinity magnitude association for both prime gaps & prime numbers to co-exist. By the same
token, these Laws have important implication that they must be applicable
to the relevant prime gaps on a perpetual time scale. Supporting materials
in relation to Aspect 2 are found in Proposition 9.2 above. The proof is now
complete for Theorem Polignac-Twin prime IV □.

Note two mutually inclusive conditions: Condition 1. Presence of all
Dimensions that repeat themselves on an indefinite basis and with exponent
of ‘1’ will give rise to complete sets of \( P \) & \( C \) [“DA-wise one & only one
mathematical possibility argument” associated with inevitable de novo DA
homogeneity], and Condition 2. Presence of any Dimension(s) that do not
repeat itself (themselves) on an indefinite basis or with exponent other than
‘1’ will give rise to incomplete set of \( P \) & \( C \) or incorrect set of non-\( P \) & non-\( C 
[“DA-wise mathematical impossibility argument” associated with inevitable de
novo DA non-homogeneity]. When met, these two conditions fully support the
point that CFS Dimensions representations of \( P \) & \( C \) [with respective prime &
composite gaps] are totally accurate. Condition 1 reflect proof from Theorem
Polignac-Twin prime III as all \( P \) & \( C \) are associated with DA homogeneity
when their Dimensions are endowed with exponent of ‘1’. Condition 2 invoke
corollary on inevitable appearance of incomplete \( P \) or \( C \) or non-\( P \) or non-
\( C \) [associated with DA non-homogeneity] being tightly incorporated into this
mathematical framework. See Proposition 10.1 & 10.2, and Corollary 10.3 for
supporting materials on DA homogeneity & non-homogeneity.

We analyze \( P \) (& \( C \)) in terms of (i) measurements based on cardinality
of CIS and (ii) pigeonhole principle which states that if \( n \) items are put into
\( m \) containers, with \( n > m \), then at least one container must contain more than
one item. We note that ordinality of all infinite \( P \) (& \( C \)) is “fixed” implying
that each one of the infinite well-ordered Dimension sets conforming to CFS
type as constituted by Dimensions \((2x - 7)^1, (2x - 8)^1, (2x - 9)^1, (2x - 10)^1,\n\( (2x - 11)^1, \ldots, (2x - \infty)^1 \) on respective gaps for \( P \) (& \( C \)) must also be “fixed”.

**Proposition 10.1.** “Even number prime gaps are infinite in magnitude
with each even number prime gap generating odd prime numbers which are
again infinite in magnitude” is supported by principles from Set theory and
two Laws based on Gap 2 Composite Number.

**Proof.** We validly exclude even \( P \) ‘1’ here. Let (i) cardinality \( T = \aleph_0 \)
for Set all odd \( P \) derived from \( E \) prime gaps \( 2, 4, 6, \ldots, \infty \), (ii) cardinality
\( T_2 = \aleph_0 \) for Subset odd \( P \) derived from \( E \) prime gap 2, cardinality \( T_4 = \aleph_0 \)
for Subset odd \( P \) derived from \( E \) prime gap 4, cardinality \( T_6 = \aleph_0 \) for
Subset odd \( P \) derived from \( E \) prime gap 6, etc. Paradoxically, (as sets) \( T = T_2 + T_4 + T_6 + \ldots + T_\infty \) equation is valid despite (their cardinality)
\( T = T_2 = T_4 = T_6 = \ldots = T_\infty \) [with well-ordering principle “stating that
every non-empty set of positive integers contains a least element” fulfilled by
each (sub)set], and \( E \) prime gaps are ‘infinite in magnitude’ can justifiably be

Proof: page numbers may be temporary
perceived instead as ‘arbitrarily large in magnitude’ since cumulative sum total
of \(E\) prime gaps is relatively much slower to attain the ‘infinite in magnitude’
status when compared to cumulative sum total of \(P\) which rapidly attain this
status. But if Subset \(odd\ P\) derived from one or more \(E\) prime gap(s) are
finite in magnitude, this will breach the \(\aleph_0\) cardinality ‘uniformity’ resulting in
(i) DA non-homogeneity and (ii) inequality (as sets) \(T > T_2 + T_4 + T_6 + \ldots + T_\infty\). In language of pigeonhole principle “stating that if \(n\) items are put
into \(m\) containers with \(n > m\), then at least one container must contain more
than one item”, residual \(odd\ P\) (still CIS in magnitude) not accounted for
by CFS-type \(E\) prime gap(s) will have to be [incorrectly] contained in one (or
more) of composite gap(s). These arguments using cardinality constitute proof
that \(E\) prime gaps \& \(odd\ P\) generated from each \(E\) prime gap, are all CIS.
The proof [on “quantitative” aspect] is now complete for Proposition 10.1□.

Complete set of \(P\) is represented by Dimensions \((2x - N)^1\). Table 2 \&
Figure 18 on \(PC\) finite scale mathematical landscape depict perpetual repeating
features used in “qualitative” statements supporting (i) Plus-Minus Gap
2 Composite Number Alternating Law (stated as \(C\) with composite gaps =
2 present in each of \(P\) with prime gaps \(\geq 4\) situation must be observed to
appear as some sort of rhythmic patterns of alternating presence and absence
of this type of \(C\)), and (ii) Plus Gap 2 Composite Number Continuous Law
(stated as \(C\) with composite gaps = 2 continual appearances in each of (twin)
\(P\) with prime gap = 2 situation). Plus-Minus Gap 2 Composite Number Al-
ternating Law has built-in intrinsic mechanism to automatically generate all
prime gaps \(\geq 4\) in a mathematically consistent \(ad\ infinitum\) manner. Plus
Gap 2 Composite Number Continuous Law has built-in intrinsic mechanism to
automatically generate prime gap = 2 appearances in a mathematically consist-
tent \(ad\ infinitum\) manner. These two Laws refer to the end-products obtained
from “the second key step of applying Information-Complexity conservation
to Sieve of Eratosthenes”. The proof [on “qualitative” aspect] is now complete
for Proposition 10.1□.

**Proposition 10.2.** The presence of Dimensional analysis homogeneity
always result in correct and complete set of prime (and composite) numbers.

**Proof.** DA homogeneity is completely dependent on all Dimensions being
consistently endowed with exponent ‘1’. As all \(P\) \& \(C\) are “fixed”, we deduce
from Figure 18 \& Table 2 that there is one \&( only one) way to represent
Information-Complexity conservation using our defined Dimensions. Thus,
there is one \&( only one) way to depict all \(P\) \& \(C\) using these Dimensions
in a self-consistent manner and this is achieved with the one \&( only one) DA
homogeneity possibility. The proof is now complete for Proposition 10.2□.
Corollary 10.3. The presence of Dimensional analysis non-homogeneity always result in incorrect and/or incomplete set of prime (and composite) numbers.

Proof. For optimal clarity, we endow all Dimensions with exponent ‘1’ depicted as \((2x - 7)^1\), \((2x - 8)^1\), \((2x - 9)^1\), \((2x - 10)^1\), \((2x - 11)^1\),..., \((2x - \infty)^1\). Proposition 5.2 equates DA homogeneity with correct & complete set of \(P\) (& \(C\)). There are “more than one” DA possibilities when, for instance, a particular \([\text{first}]\) term from \((2x - 7)^0\), \((2x - 8)^1\), \((2x - 9)^1\),..., \((2x - \infty)^1\) “terminates” prematurely and does not perpetually repeat [with loss of continuity]. There are intuitively two ‘broad’ DA possibilities here; namely, (one) DA homogeneity possibility and (one) DA non-homogeneity possibility – Dimension \((2x - 7)^0\) [= 1] with its exponent arbitrarily set as ‘0’ against-all-trend in this case. Thus Dimension \((2x - 7)^1\) that stop recurring at some point in \(P\) (or \(C\)) sequence may cause well-ordered CFS sets from progressive groupings of \([E]\) 2, 4, 6, 8, 10,..., \(\infty\) for Dimensions \((2x - 8)^1\), \((2x - 9)^1\), \((2x - 10)^1\), \((2x - 11)^1\),..., \((2x - \infty)^1\) to stop existing (and ultimately for sequential \(P\) (or \(C\)) to stop appearing) at that point with ensuing outcome that \(P\) (or \(C\)) may overall be incorrectly finite or incomplete in magnitude. Finally also manifesting DA non-homogeneity, a Dimension endowed with fractional exponent values other than ‘1’ such as \(\frac{2}{5}\) or ‘\(\frac{3}{5}\)’ will result in non-\(P\) (or non-\(C\)) [fractional] numbers. The proof is now complete for Corollary 10.3.□.

Each [fixed] finite scale mathematical landscape “page” as part of [fixed] infinite scale mathematical landscape “pages” for \(P\) & \(C\) display Chaos [sensitivity to initial conditions viz. positions of subsequent \(P\) & \(C\) are “sensitive” to positions of initial \(P\) & \(C\)] and Fractals [manifesting fractal dimensions with self-similarity viz. those aforementioned Dimensions for \(P\) & \(C\) are always present, albeit in non-identical manner, for all ranges of \(x \geq 2\)]. Advocated in another manner, Chaos and Fractals phenomena of those Dimensions for \(P\) & \(C\) are always present signifying accurate composition of \(P\) & \(C\) in different [predetermined] finite scale mathematical landscape “(snapshot) pages” for \(P\) & \(C\) that are self-similar but never identical – and there are an infinite number of these finite scale mathematical landscape “(snapshot) pages”. The crucial mathematical step in representing all \(P\) (& \(C\)) and prime (& composite) gaps with “Dimensions” based on Information-Complexity conservation allows us to obtain the two Laws based on Gap 2 Composite Numbers and perform DA on these entities. The ‘strong’ principle argument is DA homogeneity equates to complete set of \(P\) (& \(C\)) whereas DA non-homogeneity does not equate to complete set of \(P\) (& \(C\)). We also advocate for a ‘weak’ principle argument supporting DA homogeneity for \(P\) (& \(C\)) in that nature should not “favor” any particular Dimension(s) to terminate and therefore DA non-homogeneity
cannot exist for \( P \) \((& C)\). Abiding to an advocated convention that ‘conjecture’ be termed ‘hypothesis’ once proven; we now label these conjectures as Polignac’s and Twin prime hypotheses.

11. Conclusions

We mathematically envisage two mutually exclusive groups of entities: [totally] Unpredictable entities and [totally] Predictable entities. The first group can arise as [totally] random physical processes in nature e.g. radioactive decay is a stochastic (random) process occurring at level of single atoms. It is impossible to predict when a particular atom will decay regardless of how long the atom has existed. For a collection of atoms, expected decay rate is characterized in terms of their measured decay constants or half-lives. The second group is constituted by two subgroups: Completely Predictable entities e.g. Even-Odd number pairing in Table 3 [with abbreviation ‘Y’ = Dimension 2x - 4] and Incompletely Predictable entities e.g. Prime-Composite number pairing in Table 2 [with abbreviation ‘Y’ = Dimension 2x - 7]. Note: The [only] two common situations seen in both pairings from Table 2 and Table 3 whereby we identically use Dimension 2x - 2 to represent Number ‘1’ and Dimension 2x - 4 to represent Number ‘2’.

Intuitively, every single mathematical argument from complete set of mathematical arguments required to fully solve a given Incompletely Predictable Problem (containing dependent types of Incompletely Predictable entities) must be correct obeying Mathematics for Completely Predictable Problems. Then Mathematics for Incompletely Predictable Problems is literally the mathematical framework for describing complex properties present in these entities.

For Even-Odd number pairing in Appendix D, one can [redundantly] introduce Mathematics for Completely Predictable Problems as the mathematical framework describing this Completely Predictable Problem containing independent types of Completely Predictable entities endowed with simple properties.

CIS of [Completely Predictable] natural numbers 1, 2, 3, 4, 5, 6, 7,... having CIS of [Completely Predictable] natural gaps 1, 1, 1, 1, 1, 1,... are constituted by three dependent sets of numbers: (i) CIS of [Incompletely Predictable] odd prime numbers 3, 5, 7, 11, 13, 17,... having CIS of [Incompletely Predictable] prime gaps 2, 2, 4, 2, 4,... plus CFS of solitary [Incompletely Predictable] even prime number 2 having CFS of [Incompletely Predictable] prime gap 1 (ii) CIS of [Incompletely Predictable] even and odd composite numbers 4, 6, 8, 9, 10, 12,... having CIS of [Incompletely Predictable] composite gaps 2, 2, 1, 1, 2, 2,... and (iii) CFS of solitary odd number ‘1’ [neither prime nor composite]. Treated as Incompletely Predictable problems endowed with “meta-properties”, we gave relatively elementary proofs on Polignac’s & Twin prime conjectures.
prime conjectures using these relationships by (1) performing Information-Complexity conservation on prime & composite numbers [and Number ‘1’] to self-consistently obtain ‘Plus Gap 2 Composite Number Continuous Law’ for prime gap equal to 2 & ‘Plus-Minus Gap 2 Composite Number Alternating Law’ for prime gaps greater than 2; and (2) demonstrating DA homogeneity with presence of [solitary] cardinality value \( \aleph_0 \) occurring in all [even number prime gap] subsets of prime numbers and in set of even number prime gaps.

**Note:** By virtue of wordings used in these two mentioned Laws; then apart from first prime number ‘2’, all other prime numbers [represented by prime gap = 2 and prime gaps > 2] are dependently linked to composite numbers [represented by Gap 2 Composite Number].

Harnessed properties: (1) Nontrivial zeros and two types of Gram points are [dependently] derived from “Axes intercept relationship interface” using Riemann zeta function, or its proxy Dirichlet eta function; and (2) Prime and composite numbers are [dependently] derived from “Numerical relationship interface” using Sieve of Eratosthenes. Using prime gaps as analogy, there are (for instance) “nontrivial zeros gaps” between any two nontrivial zeros with all these gaps of infinite magnitude being Incompletely Predictable entities.

Prime number theorem describes asymptotic distribution of prime numbers among positive integers by formalizing intuitive idea that prime numbers become less common as they become larger through precisely quantifying rate at which this occurs using probability. An indirect spin-off arising out of solving Riemann hypothesis result in absolute and full delineation of prime number theorem. This theorem relates to prime counting function which is usually denoted by \( \pi(x) \) with \( \pi(x) = \) number of prime numbers \( \leq x \). In other words, solving Riemann hypothesis is instrumental in proving efficacy of techniques that estimate \( \pi(x) \) efficiently. This confirm “best possible” bound for error ("smallest possible" error) of prime number theorem.

In mathematics, logarithmic integral function or integral logarithm li(x) is a special function. Relevant to problems of physics with number theoretic significance, it occurs in prime number theorem as an estimate of \( \pi(x) \) whereby its form is defined so that \( \text{li}(2) = 0 \); viz. \( \text{li}(x) \equiv \int_2^x \frac{du}{\ln u} = \text{li}(x) - \text{li}(2) \). There are less accurate ways of estimating \( \pi(x) \) such as conjectured by Gauss and Legendre at end of 18th century. This is approximately \( x/\ln x \) in the sense

\[
\lim_{x \to \infty} \frac{\pi(x)}{x/\ln x} = 1.
\]

Skewes’ number is any of several extremely large numbers used by South African mathematician Stanley Skewes as upper bounds for smallest natural number \( x \) for which \( \text{li}(x) < \pi(x) \). These bounds have since been improved by others: there is a crossing near \( e^{727.95133} \) but it is not known whether this is the smallest. John Edensor Littlewood who was Skewes’ research supervisor proved in 1914[8] that there is such a [first] number; and
found that sign of difference $\pi(x) - \text{li}(x)$ changes infinitely often. This refute all prior numerical evidence that seem to suggest $\text{li}(x)$ was always $> \pi(x)$. The key point is [100% accurate] perfect $\pi(x)$ mathematical tool being “wrapped around” by [less-than-100% accurate] approximate $\text{li}(x)$ mathematical tool infinitely often via this ‘sign of difference’ changes meant that $\text{li}(x)$ is the most efficient approximate mathematical tool. Contrast this with “crude” $x/\ln x$ approximate mathematical tool where we studied values diverge away from $\pi(x)$ at increasingly greater rate for larger range of prime numbers.

Using classification system in Appendix C, a formula is either non-Hybrid or Hybrid integer sequence. Inequation with two ‘necessary’ Ratio (R) or equation with one ‘unnecessary’ R contains non-Hybrid integer sequence. Equation with one ‘necessary’ R contains Hybrid integer sequence. “In the limit” Hybrid integer sequence approach unique Position X, it becomes non-Hybrid integer sequence for all Positions $\geq$ Position X. Kinetic energy (KE) has its endowed units in MJ when $m_0 = \text{rest mass in kg}$ and $v = \text{velocity in m/s}$. In classical mechanics concerning low velocity with $v<<c$, Newtonian KE = $\frac{1}{2}m_0v^2$. In relativistic mechanics concerning high velocity with $v\geq0.01c$, Relativistic KE = $m_0c^2\sqrt{1-(v^2/c^2)} - m_0c^2$. Obtained from the later by binomial approximation or by taking first two terms of Taylor expansion for reciprocal square root, the former approximates the later well at low speed. We arbitrarily denote inexact DA homogeneity for ‘<100% accuracy’ Newtonian KE and exact DA homogeneity for ‘100% accuracy’ Relativistic KE. “In the limit” Newtonian KE at low speed approach Relativistic KE at high speed, we achieve perfection.

Useful analogy: “In the limit” all three versions of Dirichlet Sigma-Power Laws for Gram$[y=0]$ points, Gram$[x=0]$ points and nontrivial zeros as ‘<100% accuracy’ inequations approach perfection as ‘100% accuracy’ equations, compliance with inexact DA homogeneity becomes compliance with exact DA homogeneity. Note: Absence of fractional exponent $(\sigma+1)$ as relevant ‘unit of measurement’ in R1 terms of all inequations giving rise to the so-called Pseudo-$\sum$(all fractional exponents). Fully understanding the validity of this entity has greatly contributed to designing the extremely useful Fic-Fac Ratio. Treated as Incompletely Predictable problems, we gave relatively elementary proof of Riemann hypothesis and explain two types of Gram points by using “meta-properties” of relevant Dirichlet Sigma-Power Laws viz. (1) exact DA homogeneity [occurring when $\sigma = \frac{1}{2}$] in both their equations & inequations and (2) inexact DA homogeneity [occurring when $\sigma \neq \frac{1}{2}$] in both their equations & inequations.

We define two terms: perfect symmetry to denote “even functions” [which are symmetric about vertical y-axis] and “odd functions” [which are symmetric about origin]; and broken symmetry to denote “neither even nor odd functions”
[which are neither symmetric about vertical y-axis nor origin]. Relevant types of Gram points (at $\sigma = \frac{1}{2}$) and virtual Gram points (at $\sigma \neq \frac{1}{2}$) represent their corresponding x-axis, y-axis and origin intercepts with two true statements:

1. **Dirichlet Sigma-Power Laws pertaining to Gram$[x=0,y=0]$ points (nontrivial zeros) in Riemann hypothesis and virtual Gram$[x=0,y=0]$ points** will manifest broken symmetry viz. not satisfying particular symmetry relations present in “even functions” or “odd functions” to combinely be classified as “neither even nor odd functions” for all their equations and inequations.

2. **Dirichlet Sigma-Power Laws pertaining to Gram$[y=0]$ points, virtual Gram$[y=0]$ points, Gram$[x=0]$ points and virtual Gram$[x=0]$ points** will manifest perfect symmetry viz. satisfying particular symmetry relations present in “even functions” or “odd functions” to separately be classified as “even functions” for all their inequations and “odd functions” for all their equations.

**References**


**Appendix A. Gram’s Law and traditional ‘Gram points’**

Named after Danish mathematician Jørgen Pedersen Gram (June 27, 1850 – April 29, 1916), traditional ‘Gram points’ (Gram$[y=0]$ points) are
other conjugate pairs values on critical line defined by $\text{Im}\{\zeta(\frac{1}{2} \pm it)\} = 0$. Belonging to Incompletely Predictable entities, they obey Gram’s Rule and Rosser’s Rule with some characteristic properties outlined by our brief exposition below: Z function is used to study Riemann zeta function on critical line. Defined in terms of Riemann-Siegel theta function & Riemann zeta function by $Z(t) = e^{i\theta(t)}\zeta(\frac{1}{2} + it)$ whereby $\theta(t) = \arg(\Gamma(\frac{(2t+1)}{4})) - \ln\pi t$; it is also called Riemann-Siegel Z function, Riemann-Siegel zeta function, Hardy function, Hardy Z function, & Hardy zeta function.

The algorithm to compute $Z(t)$ is called Riemann-Siegel formula. Riemann zeta function on critical line, $\zeta(\frac{1}{2} + it)$, will be real when $\sin(\theta(t)) = 0$. Positive real values of $t$ where this occurs are called ‘Gram points’ and can also be described as points where $\frac{\theta(t)}{\pi}$ is an integer. Real part of this function on critical line tends to be positive, while imaginary part alternates more regularly between positive & negative values. That means sign of $Z(t)$ must be opposite to that of sine function most of the time, so one would expect nontrivial zeros of $Z(t)$ to alternate with zeros of sine term, i.e. when $\theta$ takes on integer multiples of $\pi$. This turns out to hold most of the time and is known as Gram’s Rule (Law) – a law which is violated infinitely often though. Thus Gram’s Law is statement [on the manifested property] that nontrivial zeros of $Z(t)$ alternate with ‘Gram points’. ‘Gram points’ which satisfy Gram’s Law are called ‘good’, while those that do not are called ‘bad’. A Gram block is an interval such that its first & last points are good ‘Gram points’ and all ‘Gram points’ inside this interval are bad. Counting nontrivial zeros then reduces to counting all ‘Gram points’ where Gram’s Law is satisfied and adding the count of nontrivial zeros inside each Gram block. With this process we need not locate nontrivial zeros but just have to accurately compute $Z(t)$ to show that it changes sign.

Appendix B. Ratio Study and Inequations

A mathematical equation, containing $\geq$ one variables, is a statement that values of two ['left-hand side' (LHS) and 'right-hand side' (RHS)] mathematical expressions is related as equality: LHS = RHS; or as inequalities: LHS $<\text{ RHS}$, LHS $>\text{ RHS}$, LHS $\leq\text{ RHS}$, or LHS $\geq\text{ RHS}$. A ratio is one mathematical expression divided by another. The term ‘unnecessary’ Ratio (R) for any given equation is explained by two examples: (1) LHS = RHS and with rearrangement, ‘unnecessary’ R is given by $\frac{\text{LHS}}{\text{RHS}} = 1$ or $\frac{\text{RHS}}{\text{LHS}} = 1$; and (2) LHS $>\text{ RHS}$ and with rearrangement, ‘unnecessary’ R is given by $\frac{\text{LHS}}{\text{RHS}} > 1$ or $\frac{\text{RHS}}{\text{LHS}} < 1$. Consider exponent $y \in \text{all } \mathbb{R}$ values & base $x \in \mathbb{R} \geq 0$ values for mathematical expression $x^y$. Equations such as $x^1 = x$, $x^0 = 1$ & $0^y = 0$ are all valid. Simultaneously letting both $x$ & $y = 0$ is an incorrect mathematical action because $x^y$ as function of two-variables is not continuous & is undefined at Origin. If we elect to carry out this “balanced” action [equally] on $x$ & $y,$
we obtain (simple) inequation $0^0 \neq 1$ with associated perpetual obeyance of
‘$=$’ equality symbol in $x^y$ for all applicable $R$ values except when both $x$ & $y$
$= 0$. The Number ‘1’ value in this inequation is justified by two arguments:
I. Limit of $x^y$ value as both $x$ & $y$ tend to zero (from right) is 1 [thus fully
satisfying criterion “$x^y$ is right continuous at the Origin”]; and II. Expression
$x^y$ is product of $x$ with itself $y$ times [and thus $x^0$, the “empty product”, should
be 1 (no matter what value is given to $x$)].

Mathematical operator ‘summation’ obey the law: We can break up a
summation across a sum or difference but not across a product or quotient
viz, factoring a sum of quotients into a corresponding quotient of sums is an
incorrect mathematical action. But if we elect to carry out this action equally
on LHS & RHS products or quotients in a suitable equation, we obtain two
(unique) ‘necessary’ $R$ denoted by $R_1$ for LHS and $R_2$ for RHS whereby $R_1
\neq R_2$ relationship always hold. We define ‘Ratio Study’ as intentionally per-
forming this incorrect [but “balanced”] mathematical action on suitable equa-
tion [equivalent to one (non-unique) ‘unnecessary’ $R$] to obtain its inequation
[equivalent to two (unique) ‘necessary’ $R$]. Set $\mathbb{C}$ is a field (but not an ordered
field). It is not possible to define a relation between two given $(x_1 \& x_2) \in
\mathbb{C}$ as $x_1 < x_2$ since inequality operation is not compatible with addition and multi-
plication. But performing Ratio Study to obtain inequations involving $\mathbb{C}$ does
not involve defining a relation between two $\mathbb{C}$.

Appendix C. Hybrid method of Integer Sequence classification

Hybrid method of Integer Sequence classification enables meaningful divi-
sion of all integer sequences into either Hybrid or non-Hybrid integer sequences.
Our exotic A228186 integer sequence[9] was published on The On-line Encyclo-
pedia of Integer Sequences website in 2013. With challenge to discover more,
it is the first ever [infinite length] Hybrid integer sequence synthesized from
Combinatorics Ratio. In ‘Position i’ notation, let $i = 0, 1, 2, 3, 4, 5, \ldots, \infty$ be
complete set of natural numbers. A228186 “Greatest $k > n$ such that ratio $R <
\frac{\text{CombinationsWithRepetition}}{\text{CombinationsWithoutRepetition}}$”
is equal to [infinite length] non-Hybrid (usual garden-variety) integer sequence
A100967[10] except for finite 21 ‘exceptional’ terms at Positions 0, 11, 13, 19,
21, 28, 30, 37, 39, 45, 50, 51, 52, 55, 57, 62, 66, 70, 73, 77, and 81 with their
values given by relevant A100967 terms plus 1. The first 49 terms [from Po-
sic 0 to Position 48] of A100967 “Least $k$ such that $\text{binomial}(2k+1, k-n) \geq
\text{binomial}(2k, k)” are listed below: 3, 9, 18, 29, 44, 61, 81, 104, 130, 159, 191,
225, 263, 303, 347, 393, 442, 494, 549, 606, 667, 730, 797, 866, 938, 1013, 1091,
1172, 1255, 1342, 1431, 1524, 1619, 1717, 1818, 1922, 2029, 2138, 2251, 2366,
2485, 2606, 2730, 2857, 2987, 3119, 3255, 3394, and 3535. For those 21 ‘exceptional’ terms: at Position 0, A228186 (= 4) is given by A100967 (= 3) + 1; at Position 11, A228186 (= 226) is given by A100967 (= 225) + 1; at Position 13, A228186 (= 304) is given by A100967 (= 303) + 1; at Position 19, A228186 (= 607) is given by A100967 (= 606) + 1; etc. A useful concept: Commencing from Position 0 onwards “in the limit” this Position approaches 82, A228186 Hybrid integer sequence is identical to / becomes A100967 non-Hybrid integer sequence for all Positions \( \geq 82 \).

Appendix D. Tabulated and graphical data on Even-Odd mathematical landscape

Figure 19. Even-Odd mathematical (graphed) landscape using data obtained for \( x = 1 \) to 64.

We tabulate in Table 3 and graph in Figure 19 [Completely Predictable] Even-Odd mathematical landscape for \( x = 1 \) to 64. Involved Dimensions are \( 2x - 2 \) & \( 2x - 4 \) with \( Y \) denoting Dimension \( 2x - 4 \) for visual clarity. Mathematical landscape of Dimension \( 2x - 4 \) (except for first and only Dimension \( 2x - 2 \)) intrinsically incorporates Even \( \pi \) & Odd \( \pi \) in an integrated manner. Except for first Odd, all Completely Predictable Even \( \pi \) & Odd \( \pi \) and their associated gaps are represented by countable finite set of [single] Dimension \( 2x - 4 \). Dimensions \( 2x - 2 \) & \( 2x - 4 \) are symbolically represented by -2 & -4 with \( 2x - 4 \) displayed as ‘baseline’ Dimension whereby Dimension trend (Cumulative Sum Gaps) must reset itself onto this (Grand-Total Gaps) ‘baseline’ Dimension after initial Dimension \( 2x - 2 \) on a permanent basis. Graphical appearances of Dimensions symbolically represented by two negative integers are Completely Predictable with both Even-\( \pi(x) \) and Odd-\( \pi(x) \) becoming larger at a constant rate. There is a complete absence of Chaos and Fractals phenomena.

Definitive derivation of data in Table 3 is illustrated by two examples for position \( x = 31 \) & 32. For \( i \) & \( x \in 1, 2, 3, ..., \infty \); \( \Sigma EO_{x}-\text{Gap} = \Sigma EO_{x-1}-\text{Gap} \)

Proof: page numbers may be temporary
Table 3. Even-Odd mathematical (tabulated) landscape using
data obtained for x = 1 to 64. Legend: E = even, O = odd,
Dim = Dimension, Y = Dimension 2x - 4 (for visual clarity).

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<th>Dim</th>
<th>$x$</th>
<th>$E_i$ or $O_i$</th>
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Proof: page numbers may be temporary
+ Gap value at $E_{i-1}$ or Gap value at $O_{i-1}$ whereby (i) $E_i$ or $O_i$ at position $x$ is determined by whether relevant $x$ value belongs to $E$ or $O$, and (ii) both $\Sigma E_{O_{1}}$-Gap and $\Sigma E_{O_{2}}$-Gap = 0. Example, for position $x = 31$: 31 is $O$ ($O_{16}$).
Our desired Gap value at $O_{15} = 2$. Thus $\Sigma E_{O_{31}}$-Gap (58) = $\Sigma E_{O_{30}}$-Gap (56) + Gap value at $O_{15}$ (2). Example, for position $x = 32$: 32 is $E$ ($E_{16}$). Our desired Gap value at $E_{15} = 2$. Thus $\Sigma E_{O_{32}}$-Gap (60) = $\Sigma E_{O_{31}}$-Gap (58) + Gap value at $E_{15}$ (2). Note: in our Dimension $(2x - N)$ system, $N = 2x - \Sigma E_{O_{x}}$-Gap. Then in this unique Dimension $(2x - N)$ system with $N = 2x - \Sigma E_{O_{x}}$-Gap, Dimension $(2x - N)$ when fully expanded is numerically just equal to $\Sigma E_{O_{x}}$-Gap since Dimension $(2x - N)$ = $2x - 2x + \Sigma E_{O_{x}}$-Gap = $\Sigma E_{O_{x}}$-Gap.

Appendix E. Fic-Fac Ratio for Open Problems and COVID-19 Pandemic

![Fictitious-Factitious (Fic-Fac) Ratio](image)

Figure 20. Schematic representation of Fic-Fac Ratio.

<table>
<thead>
<tr>
<th>Gold standard</th>
<th>for MA or DT:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Negative</td>
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</table>

MA results or DT results:

<table>
<thead>
<tr>
<th>Positive True +ve [a]</th>
<th>False +ve [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative False –ve [c]</td>
<td>True –ve [d]</td>
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</table>

Abbreviations: MA = mathematical arguments, DT = diagnostic tests, P = Probability (or Proportion), R = Fic-Fac Ratio. We supply definitions, equations and schematic diagrams depicting important inter-relationships for R which are applicable to MA and DT. Required MA giving [abstract] positive and [abstract] negative MA results in a specified conjecture or hypothesis must be implemented to, respectively, fully confirm a “proposed state” to be correctly valid and correctly not invalid. Required DT giving positive and negative DT results in a specified subject group or population must be implemented that, respectively, aim to fully support a “natural state” to correctly occur and correctly not occur.
Figure 21. Schematically depicted SEIR model with four compartments. The extra compartment $E$ for Exposed Population allows modelling to include incubation period. This is time from exposure to causative agent until first symptoms develop and is characteristic for each disease agent. WHO estimated in early 2020 the incubation period for COVID-19 ranges from 1 to 14 days, with a median incubation period of 5 to 6 days. If required, these estimates can be subsequently refined as more data becomes available.

Four concrete examples: Obtaining MA results for a hypothesis or conjecture using ideal gold standard MA to rigorously prove (I) Riemann hypothesis to be true via (i) all nontrivial zeros are located on the critical line [true positive MA result] and (ii) all nontrivial zeros are not located away from the critical line [true negative MA result]; (II) Twin prime conjecture to be true via (i) twin primes are infinite in magnitude [true positive MA result] and (ii) twin primes are not finite in magnitude [true negative MA result]; and (III) Conjecture “Ubiquitous human angiotensin-converting enzyme 2 (ACE2) receptor is the sole entry receptor for coronavirus strain SARS-CoV-2 causing COVID-19 when experimentally exposed to this virus with assumed 100% infectivity rate” to be true via (i) COVID-19 infection will occur in susceptible test subjects exposed to SARS-CoV-2 while not taking novel drug ‘irreversible ACE2 blocker’ with 100% efficacy and assumed acceptable “safety profile” [true positive MA result] and (ii) COVID-19 infection will not occur in susceptible test subjects exposed to SARS-CoV-2 while taking this same novel drug [true negative MA result].
result]. (IV) Obtaining DT results for a group of individuals employing ideal gold standard DT to definitively determine proportion of individuals (i) having [with true positive DT result] and (ii) not having [with true negative DT result] COVID-19 infection. Corresponding false positive and false negative MA and DT results do not exist with all four examples above consequently having (a+d) = 1, (b+c) = 0, and R = 0.

Treatments targeting ACE2 could theoretically be key to unlocking either COVID-19 vaccines and/or drug treatments for COVID-19. In patients on ACE inhibitor (ACEI) and/or angiotensin II receptor blocker (ARB) therapy for hypertension or diabetes, health workers are dealing here with a double-edged sword depending on the phase of the disease. Increased baseline ACE2 expression could potentially increase SARS-CoV-2 infectivity and ACEI/ARB use would be an addressable risk factor. Conversely, once infected, down-regulation of ACE2 may be the hallmark of COVID-19 progression. Consequently, upregulation by preferentially using renin–angiotensin–aldosterone system (RAAS) blockade and ACE2 replacement in the acute respiratory distress syndrome phase may turn out to be beneficial. With main end-result effect of increasing vasoconstricting angiotensin II hormone, ACE acts as a key regulatory peptide in RAAS; and with main end-result effect of decreasing vasoconstricting angiotensin II hormone, its counterpart ACE2 acts as [reciprocal] key counterregulatory peptide via its dual actions of firstly, acting as an ubiquitous functional receptor present in many parts of our body and secondly, simultaneously acting as an enzyme that predominantly degrade angiotensin II (and to a lesser extent cleaves angiotensin I and participates in hydrolysis of other peptides). Then there will be physiological and pharmacological implications of ACE2 when also acting as entry receptor for SARS-CoV-2. For instance, another novel drug ‘floating version of ACE2’ could trick the virus

Figure 22. Schematically depicted SIR model with three compartments.
to preferably bind with this drug rather than ACE2 on human cells thus potentially treating COVID-19 infection and preventing the viral replication and its spread.

**Factitious (Fac)** = Number of (true) fact = (a+d).

**Fictitious (Fic)** = Number of (false) fiction = (b+c).

\[ P(\text{Fic}) + P(\text{Fac}) = 1 \implies P(\text{Fac}) = 1 - P(\text{Fic}) \text{ ... Equation 1} \]

\[ R = \frac{P(\text{Fic})}{P(\text{Fac})} \text{ with range of values from 0 to } [\text{"undefined"}] \to \infty \text{ ... Equation 2} \]

**Target:** Accept \( R < 1 \) and Reject \( R > 1 \) with \( R = 1 \) being indeterminate.

**Note:** For a well-defined “proposed state” or “natural state”, \( P(\text{Fic}) \) and \( P(\text{Fac}) \) may each be constituted by \( \geq 1 \text{ MA or } \geq 1 \text{ DT that are mutually independent and/or dependent.} \) Using parameter \( R \) (Equation 2), Equation 1 is equivalent to two parametric equations \( P(\text{Fic}) = \frac{R}{R+1} \) \& \( P(\text{Fac}) = \frac{1}{R+1} \) with \( R + 1 \neq 0 \& R \neq 0 \).

“Proposed states” such as modelling Riemann hypothesis when formulated as equation or inequation [with Pseudo-\( \sum \text{ (all fractional exponents)} \) can and must be error-free. All “proposed states” can and must have their Fic-Fac Ratio = 0 with \( P(\text{Fac}) = 1 \) and \( P(\text{Fic}) = 0 \). This is equivalent to stating mathematical-based proofs for “proposed states” must always be mathematically rigorous and error-free.

Loosely speaking, “natural states” such as Pseudo-SIR model or SEIR model for COVID-19 pandemic are “Incompletely Predictable” in the sense that their statistical-based proofs should be statistically significant but they can never be error-free. [Here, we will omit outlining common ordinary differential equations associated with the two models.] This is because both models as schematically displayed will (1) intrinsically be affected by obtained DT results using relevant DT e.g. never having, in practice, 100% accuracy and (2) extrinsically be affected by incorrect DT results obtained due to [unintentional] e.g. observational errors, blunders, under- and over-reporting or [intentional] e.g. data fabrication and manipulation. We give an extreme “counter-example” of data fabrication and manipulation: Having ulterior motive, local investigator Mr. CB decided to intentionally send an e-mail containing (say) important test results at (say) 3:45 PM Friday February 8, 2019 to a fabricated email address. Consequently, these results will never reach the intended recipient (statistician / epidemiologist) for analysis. This unjustifiable action will lead to failure of these results to be properly incorporated into modelling an epidemic occurring from (say) October 29, 2018 to February 8, 2019. Both (1) and (2) will lead to some quantifiable increase of \( P(\text{Fic}) \) values [with reciprocal decrease of \( P(\text{Fac}) \) values] affecting, for instance, \( I \) for Infectious Population. Since we generally reject [or accept] probability based Fic-Fac Ratio > 1 [or < 1], the overall goal is to always minimize \( P(\text{Fic}) \) \&/or maximize \( P(\text{Fac}) \). Both MA and DT have...
parameters forming “stable properties” and “frequency-dependent properties”.

Fie-Fac Ratio (range: 0 - ∞) is roughly ‘Inverse Accuracy’ since it varies in opposite direction to that for Accuracy (range: 0 - 1).

**Stable properties:**

- Sensitivity (Sen) = \( \frac{a}{a+c} \)
- Specificity (Spec) = \( \frac{d}{b+d} \)

**Frequency-dependent properties:**

- Positive predictive value (+ve Pred value) = \( \frac{a}{a+b} \)
- Negative predictive value (-ve Pred value) = \( \frac{d}{c+d} \)
- Accuracy (Accu) = \( \frac{a+d}{a+b+c+d} \)
- Prevalence (Prev) = \( \frac{a+c}{a+b+c+d} \)

Using Bayes’ theorem, +ve Predictive values can also be calculated as

\[
\left[ \frac{(Prev)(Sen)}{(Prev)(Sen) + (1 - Prev)(1 - Spec)} \right]
\]

Figure 23. Illustration of the difference mitigation measures can make to severity of a pandemic through epidemiological modelling. (US Centers for Disease Control and Prevention)

Gold standard MA must always be an (error-free) ideal gold standard MA. Gold standard DT refers to its use in achieving a definitive diagnosis obtained by biopsy, surgery, autopsy, long-term follow-up or another acknowledged standard. In theory, an ideal gold standard DT designed to detect SARS-CoV-2 is error-free having Sensitivity = 100% (it identifies all individuals with the disease) and Specificity = 100% (it does not falsely identify individuals without
the disease); and consequently will also have +ve Predictive values, -ve Predictive values, and Accuracy all = 100%. In practice, there are no ideal gold standard DT, and one tries to use a DT that is as close as possible to the ideal test. The commonly available polymerase chain reaction (PCR) test on a nasal (oro/nasopharyngeal) swab detects presence of genetic material of SARS-CoV-2. Results on Sensitivity and Specificity of this newly developed test depend critically on how closely it approaches the ideal test. It has (say) Sensitivity & Specificity in the range of 90 - 95%. Then assuming a high Sensitivity & Specificity of 95% meant that the test could still miss about 5% of infected people & falsely diagnose about 5% of non-infected people with COVID-19.

![Figure 24. Relationship: Prevalence vs Positive Predictive value.](image)

<table>
<thead>
<tr>
<th>Disease Prev (%)</th>
<th>+ve Pred value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
</tr>
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<td>50</td>
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<tr>
<td>99</td>
<td>99.9</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Ability of a test to discriminate between normal (without disease) & abnormal (with disease) individuals is described by its Specificity & Sensitivity. Generally, they are inversely related to each other and may be altered by changing reference interval or normal range. In other words, one can only be improved at the expense of the other. For example, the conventional Pap smear method to detect cervical cancer in women has Sensitivity 51%, Specificity 66.6%, +ve Predictive value 96%, –ve Predictive value 8% and Accuracy 92%. When a DT has Sensitivity of 95% (5% false –ve) and Specificity of 95%
(5% false +ve), for a disease with 1% Prevalence, its +ve Predictive value is only 16% but its –ve Predictive value is 99%. Relationship between Prevalence and +ve Predictive value with Sensitivity of 95% is numerically and graphically depicted. In Figure 23, dynamic staged implementation & subsequent staged easing of [beneficial] mitigation measures such as social distancing and limiting mass gatherings is often based on recent experiences, expert opinions, and statistical significant findings from collected data or previous research studies thus complying with Evidence-based Medicine and Practice.

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