

Formal Framework for a Non-Local Frequency-Based Reality

Natural Units: Universe's Hidden Code

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1 Introduction and Overview of the Process Ontology

The early 20th century witnessed a profound revolution in physics with the emergence of General Relativity (GR) and Quantum Mechanics (QM). While GR elegantly describes spacetime and gravity at cosmological scales, QM unveils the intricate behavior of matter and energy at the subatomic level. Despite their distinct domains, both theories converge on the fundamental concept of energy. This document proposes a novel **process ontology**, asserting that reality is fundamentally a dynamic, **self-generating and self-organizing system** termed **Autaxys**. Within this framework, reality unfolds through continuous processing within a fundamental dynamic medium. This establishes the physical universe as a computational system, with Autaxys driving the generation and sustenance of all observable phenomena. This perspective highlights a **frequency-centric view** of reality, where fundamental entities are characterized by their intrinsic oscillatory rates.

1.1 Bridging Relativity and Quantum Mechanics through Energy

1.1.1 Two Perspectives on Energy: Mass vs. Oscillation

Special Relativity, famously encapsulated by $E = mc^2$, quantifies the immense energy (E) inherent in mass (m), even at rest ($E_0 = m_0c^2$). This perspective portrays energy as a potential for activity residing within a stable configuration. Conversely, Quantum Mechanics, particularly through the Planck-Einstein relation $E = hf$ (or $E = \hbar\omega$ using angular frequency $\omega = 2\pi f$), depicts energy as intrinsically dynamic and oscillatory. This view asserts that energy is directly proportional to frequency (f or ω) via Planck's constant (h or $\hbar$), interpreting energy not as a static substance but as vibration, action, or process. Empirical support for this dynamic interpretation comes from phenomena such as the Ultraviolet Catastrophe and the photoelectric effect. These two highly successful yet seemingly disparate views of energy—one rooted in stable configurations (mc^2) and the other in dynamic action ($\hbar\omega$)—describe a vast array of phenomena across different scales. Within this process ontology, their equivalence suggests a deeper, fundamentally dynamic underlying reality, interpreted as patterns and processes *of* and *within* a computational medium, orchestrated by Autaxys.

1.1.2 The Bridge Equation: $\hbar\omega_C = m_0c^2$

The internal consistency of the physical universe dictates that when describing the same system, the energy expressions from Special Relativity and Quantum Mechanics must be equivalent. For a stable pattern with rest mass m_0 , its rest energy is given by Einstein's mass-energy equivalence: $E_0 = m_0c^2$. Quantum mechanics associates the energy of this pattern's intrinsic dynamics with a characteristic angular frequency ω_C (the Compton frequency), such that $E_0 = \hbar\omega_C$. Equating these two expressions yields the fundamental "Bridge Equation":

$$\hbar\omega_C = m_0c^2$$

This equation is not merely theoretical; it is empirically validated by fundamental physical processes. Phenomena like particle-antiparticle annihilation, where mass converts entirely into energetic photons of a specific frequency, and conversely, pair production, where energetic photons transform into mass, occur precisely as this equivalence predicts. The remarkable simplicity and elegance of this equation hint at a deeper, more fundamental connection between mass and frequency than is immediately apparent in standard units. It sets the stage for understanding how fundamental constants act as a “veil” obscuring this intrinsic relationship.

1.2 The Veil of Constants: $\hbar$ and c as Parameters of the Dynamic Medium and Autaxys

In conventional unit systems, fundamental constants like the speed of light in vacuum (c) and the reduced Planck constant ($\hbar$) appear as omnipresent numerical factors, seemingly obscuring the intrinsic relationships between distinct physical quantities. While often perceived as mere conversion factors, their profound significance within a process ontology lies in defining the very fabric and dynamic behavior of reality, acting as the fundamental parameters of the underlying dynamic medium and the operational grammar of Autaxys.

The speed of light (c) acts as a fundamental bridge, inherently linking space and time, as well as mass and energy, as famously encapsulated by $E = mc^2$. Similarly, the reduced Planck constant ($\hbar$) serves as the cornerstone of quantum mechanics, connecting energy to frequency ($E = \hbar\omega$) and momentum to wavelength ($p = \hbar k$), thereby bridging the classical and quantum domains. These constants are not arbitrary values but represent fundamental conversion factors that relate different dimensions of reality within the universe’s inherent structure.

The profound utility of natural unit systems, such as Planck units where $c = 1$ and $\hbar = 1$, lies in their ability to remove this numerical “veil.” By setting these constants to unity, they dramatically simplify physical expressions, transforming fundamental equations like $E = mc^2$ into $E = m$ and $E = \hbar\omega$ into $E = \omega$. Consequently, this implies a direct numerical equivalence between mass and angular frequency, $m = \omega$.

This simplification is not just a mathematical convenience; it uncovers deeper conceptual connections between physical phenomena. In a process ontology, where mass is conceptualized as a stable, resonant state—a self-sustaining standing wave pattern defined by its characteristic Compton frequency—the numerical identity of mass and frequency in natural units ($m = \omega$) becomes a direct revelation. The constants $\hbar$ and c are, therefore, more than abstract conversion factors; they are the fundamental parameters that define the inherent scales and relationships within the dynamic medium. They are the “rules of the game” that enable the profound interconnections observed between mass, energy, frequency, space, and time, defining the very operational grammar of Autaxys—the underlying self-organizing system of dynamic relational patterns that constitutes reality, characterized by intrinsic processing frequencies or rates of change.

2 Foundational Concepts: Dimensions, Units, and the Power of Natural Units

To fully appreciate the conceptual power of natural units, it is essential to first establish a clear understanding of physical dimensions and their associated units, particularly within the context of the widely adopted International System of Units (SI). Natural unit systems are characterized by assigning a numerical value of 1 to a carefully selected set of fundamental physical constants. This re-scales all other physical quantities in terms of these constants, thereby providing a framework rooted in the universe’s inherent properties rather than human conventions. This approach fundamentally moves beyond anthropocentric scales, offering a more objective and universal description of physical reality.

2.1 Dimensions, Units, and the SI System

To fully appreciate natural units, it is crucial to first understand the distinction between physical dimensions and their associated units, as exemplified by the widely adopted International System of Units (SI).

2.1.1 Dimension: *The fundamental qualitative nature of a physical quantity*

Dimension refers to the fundamental qualitative nature of a physical quantity, independent of any specific measurement system. Examples include length $[L]$, mass $[M]$, time $[T]$, electric current $[I]$, and thermodynamic temperature $[\Theta]$. Dimensional analysis, which relies on these fundamental dimensions, is a critical tool for verifying the consistency and validity of physical equations.

2.1.2 Unit: *A specific, standardized reference measure assigned to a dimension, enabling numerical quantification*

A unit is a specific, standardized reference measure assigned to a dimension, enabling its numerical quantification. Unlike dimensions, units are human-defined conventions, such as the meter (m) for length or the kilogram (kg).

2.1.3 The International System of Units (SI): *Globally recognized standard with seven base units tied to fundamental physical constants*

The International System of Units (SI) is the globally recognized standard for measurement. It is constructed upon seven base units: the meter (m), kilogram (kg), second (s), ampere (A), kelvin (K), mole (mol), and candela (cd). All other SI units, known as derived units (e.g., Newton, Joule), are combinations of these base units. Modern SI definitions are precisely linked to fixed numerical values of fundamental physical constants, ensuring unprecedented accuracy and reproducibility in measurements.

2.2 The Rationale for Natural Units: Moving Beyond Anthropocentric Scales

Natural unit systems are characterized by assigning a numerical value of 1 to a carefully selected set of fundamental physical constants. This re-scales all other physical quantities in terms of these constants, thereby providing a framework rooted in the universe's inherent properties rather than human conventions. This approach fundamentally moves beyond anthropocentric scales, offering a more objective and universal description of physical reality.

2.2.1 Compelling Benefits of Employing Natural Units

Employing natural units offers several compelling benefits for theoretical physicists, enhancing both conceptual understanding and computational efficiency:

2.2.1.1 Profound Equation Simplification: *Reduces mathematical clutter (e.g., $E = mc^2$ becomes $E = m$)*

By setting fundamental constants to 1, physical equations are dramatically streamlined. For instance, the famous energy-mass equivalence $E = mc^2$ simplifies to $E = m$, and the Planck-Einstein relation $E = \hbar\omega$ becomes $E = \omega$. This reduction in mathematical clutter allows physicists to focus on the core physical relationships and underlying symmetries.

2.2.1.2 Revelation of Fundamental Relationships: *Uncovers deeper conceptual connections between phenomena*

This simplification often uncovers deeper conceptual connections between seemingly disparate physical phenomena. For example, in certain natural unit systems, quantities like mass, energy, and frequency become numerically equivalent, thereby revealing their intrinsic relationships and shared fundamental nature, a key insight for the process ontology.

2.2.1.3 Intrinsic Universal Applicability: Derived from universal properties of nature, independent of human conventions

Unlike human-defined units, natural units are derived directly from the universal properties of nature itself. This makes them inherently universal and independent of any specific civilization, planet, or historical convention, providing an objective and enduring framework for describing physical laws.

2.2.1.4 Identification of Fundamental Scales: Pinpoints scales where quantum gravity effects are significant (e.g., Planck scale)

Natural units naturally pinpoint the intrinsic scales where quantum gravity effects are anticipated to become significant, such as the Planck scale. This provides a natural conceptual cutoff or boundary for existing physical theories, guiding the search for new physics beyond the Standard Model.

2.2.1.5 Enhanced Theoretical Utility: Indispensable in advanced theoretical physics for streamlining calculations

Natural units are indispensable in advanced theoretical physics, including general relativity, quantum field theory, cosmology, and string theory. They streamline complex calculations, foster conceptual clarity, and facilitate advanced derivations, making theoretical work significantly more tractable.

2.3 Core Principle: Setting Fundamental Constants to Unity and the Resulting Dimensionless Nature

The central tenet of natural unit systems involves selecting a set of independent fundamental physical constants and declaring their numerical value to be 1. This choice effectively redefines the base units of measurement in terms of these universal constants, allowing for a more fundamental and interconnected description of physical reality. A profound consequence of this redefinition is that while physical quantities retain their inherent dimensions, their *numerical values* when expressed in a natural unit system become dimensionless ratios relative to their corresponding natural unit.

2.3.1 Commonly Employed Constants for Natural Unit Systems

Various natural unit systems are defined by setting different combinations of fundamental constants to unity. These constants are universal and define the very fabric and operational rules of the universe.

Constant	Symbol	Physical Quantity	SI Dimensions	Significance	Numerical Equivalence (when set to 1)
Speed of Light in Vacuum	c	Velocity	$[LT^{-1}]$	Universal speed limit; links space and time, and mass and energy.	Length $\leftrightarrow$ Time; Mass $\leftrightarrow$ Energy
Reduced Planck Constant	$\hbar$	Action / Angular Momentum	$[ML^2T^{-1}]$	Fundamental constant of quantum mechanics; quantizes energy and momentum.	Energy $\leftrightarrow$ Angular Frequency; Momentum $\leftrightarrow$ Wave Number
Gravitational Constant	G	Gravitation	$[M^{-1}L^3T^{-2}]$	Governs the strength of gravitational force.	Simplifies gravitational equations
Boltzmann Constant	k_B	Energy per temperature	$[ML^2T^{-2}\Theta^{-1}]$	Links kinetic energy of particles to macroscopic temperature.	Energy $\leftrightarrow$ Temperature
Elementary Charge	e	Electric Charge	$[IT]$ or $[Q]$	Smallest unit of electric charge; fundamental for electromagnetism.	Simplifies electromagnetic interactions
Vacuum Permittivity	ϵ_0	Electrical Permittivity	$[M^{-1}L^{-3}T^4I^2]$	Relates electric field to electric charge in vacuum; influences strength of electric forces and speed of light.	Simplifies electromagnetic equations (often $1/(4\pi\epsilon_0) = 1$)

Constant	Symbol	Physical Quantity	SI Dimensions	Significance	Numerical Equivalence (when set to 1)
Electron Mass	m_e	Mass	$[M]$	Rest mass of the electron, crucial in atomic physics.	Mass $\leftrightarrow$ (other quantities in atomic units, e.g., length via Bohr radius)

2.3.2 The Enduring Significance of Fundamental Constants

Setting constants like $\hbar$ and c to 1 does not imply their non-existence or irrelevance. Instead, it profoundly underscores their role as **fundamental conversion factors and intrinsic parameters that define the very fabric and operational rules of the universe**. These constants are the “exchange rates” between different fundamental dimensions, dictating the fundamental laws and properties of our cosmos. For instance:

- **The Speed of Light (c):** Acts as the bridge between space and time ($L = cT$) and mass and energy ($E = mc^2$). Setting $c = 1$ implies that 1 unit of length is numerically equivalent to 1 unit of time, and 1 unit of mass is numerically equivalent to 1 unit of energy.
- **The Reduced Planck Constant ($\hbar$):** Connects energy to frequency ($E = \hbar\omega$) and momentum to wavelength ($p = \hbar k$). It quantifies the “granularity” or quantum nature of energy and momentum. Setting $\hbar = 1$ means 1 unit of energy is numerically equivalent to 1 unit of angular frequency.

In essence, natural units simplify equations by numerically setting these constants to 1, which in turn profoundly reveals their deep physical significance and the inherent interconnectedness of mass, energy, frequency, space, and time.

2.3.3 The Numerical Dimensionless Aspect: Numerical values of physical quantities become dimensionless ratios relative to their natural unit

While physical quantities inherently possess dimensions (e.g., Planck Length is undeniably a length), their **numerical values** when expressed in a natural unit system become *dimensionless ratios* relative to their corresponding natural unit. For instance, consider an object with a length L_{object} :

- In SI units: Its length is expressed as X meters.
- In Planck units: The numerical value becomes L_{object}/L_P . This value is a pure, dimensionless ratio indicating how many Planck lengths the object spans.

Therefore, any physical quantity expressed in natural units simplifies to a pure number, representing its magnitude relative to the fundamental scale defined by the constants, making it “dimensionless” in this specific context. This allows for direct numerical comparison of quantities that would otherwise have different dimensions in SI.

2.4 Planck Units: The Prototypical Natural Unit System

Planck units stand as the most widely recognized and fundamental natural unit system, derived by setting $c = \hbar = G = 1$. This specific choice allows for the derivation of fundamental units of mass, length, and time solely from these universal constants. The incorporation of additional constants like k_B or e further yields Planck temperature and Planck charge, respectively.

2.4.1 Derivation of Base Planck Units (from $c, \hbar, G$)

By dimensionally analyzing and combining c ($[LT^{-1}]$), $\hbar$ ($[ML^2T^{-1}]$), and G ($[M^{-1}L^3T^{-2}]$), we can solve for the fundamental dimensions and derive the base Planck units:

2.4.1.1 Planck Length (L_P): Fundamental scale where quantum effects of gravity become dominant

$L_P = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616 \times 10^{-35}$ meters. This is considered the fundamental scale where the quantum effects of gravity are expected to become dominant and current theories of physics may break down, hinting at the need for a theory of quantum gravity.

2.4.1.2 Planck Mass (M_P): Represents a black hole whose Schwarzschild radius equals its Compton wavelength

$M_P = \sqrt{\frac{\hbar c}{G}} \approx 2.176 \times 10^{-8}$ kilograms. This mass is significant as it represents a black hole whose Schwarzschild radius is approximately equal to its Compton wavelength, highlighting a realm where quantum and gravitational effects are equally important.

2.4.1.3 Planck Time (T_P): The incredibly brief time light takes to traverse one Planck length

$T_P = \sqrt{\frac{\hbar G}{c^5}} \approx 5.391 \times 10^{-44}$ seconds. This is the incredibly brief time it takes light to traverse one Planck length, representing the smallest meaningful unit of time in quantum gravity, beyond which our current understanding of spacetime breaks down.

2.4.2 Additional Planck Units

2.4.2.1 Planck Temperature (Θ_P): Unimaginably high temperature, relevant to the very early universe

Derived by setting $k_B = 1$: $\Theta_P = M_P c^2 / k_B = \sqrt{\frac{\hbar c^5}{G k_B^2}} \approx 1.416 \times 10^{32}$ Kelvin. This represents an unimaginably high temperature, relevant to the extreme conditions of the very early universe, such as immediately after the Big Bang.

2.4.2.2 Planck Charge (q_P): Approximately 11.7 times the elementary charge e

Derived by setting $1/(4\pi\epsilon_0) = 1$: $q_P = \sqrt{4\pi\epsilon_0 \hbar c} \approx 1.875 \times 10^{-18}$ Coulombs (approximately 11.7 times the elementary charge e).

2.5 Simplification of Physical Expressions and Dimensional Reduction

One of the most profound impacts of natural units is how they fundamentally alter the expression of physical quantities, often interlinking dimensions and reducing them to powers of a single base unit. This leads to deep conceptual insights and mathematical elegance, particularly supporting the process ontology's frequency-centric view of mass.

2.5.1 Examples of Expression Simplification

2.5.1.1 Energy-Mass Equivalence: $E = m$ (from $E = mc^2$)

- Standard: $E = mc^2$
- Natural Units ($c = 1$): $E = m$
- This directly demonstrates the numerical equivalence of mass and energy, highlighting their fundamental interconvertibility.

2.5.1.2 Planck-Einstein Relation: $E = \omega$ (from $E = \hbar\omega$)

- Standard: $E = hf = \hbar\omega$
- Natural Units ($\hbar = 1$): $E = \omega$
- Combined with $E = mc^2$ (if $c = 1$), this implies $m = \omega$ in natural units, directly revealing mass as an intrinsic angular frequency within the process ontology.

2.5.1.3 Compton Wavelength: $\lambda_C = \hbar/(mc)$ (from $\lambda_C = \hbar/(mc)$)

- Standard: $\lambda_C = \hbar/(mc)$
- Natural Units ($\hbar = c = 1$): $\lambda_C = 1/m$
- This elegantly shows length as inversely proportional to mass, meaning length can be expressed as $[M^{-1}]$ in these systems.

2.5.1.4 Gravitational Force: $F = G m_1 m_2 / r^2$ (from $F = G m_1 m_2 / r^2$)

- Standard: $F = G \frac{m_1 m_2}{r^2}$
- Natural Units ($G = 1$): $F = \frac{m_1 m_2}{r^2}$

2.5.2 Dimensional Reduction to a Single Base Unit (e.g., Mass [M])

In unit systems where constants like $\hbar = c = 1$ are set to unity, all physical dimensions can often be expressed solely in terms of a single fundamental base unit, such as Mass $[M]$. This implies a remarkable dimensional reduction, where quantities like length and time acquire dimensions of inverse mass ($[M^{-1}]$), meaning distances and durations could literally be measured in "inverse kilograms."

2.5.2.1 Length: $[L] = [M^{-1}]$

(derived from $L = \hbar/(mc)$, with $\hbar = c = 1$, so $L = 1/m$)

2.5.2.2 Time: $[T] = [M^{-1}]$

(derived from $T = \hbar/E$, with $\hbar = 1$, and $E = M$ from $E = mc^2$ with $c = 1$, so $T = 1/M$)

2.5.2.3 Energy: $[E] = [M]$

(from $E = mc^2$, with $c = 1$, so $E = m$)

2.5.2.4 Momentum: $[P] = [M]$

(from $P = E/c$, with $c = 1$, so $P = E$)

2.5.2.5 Force: $[F] = [M^2]$

(from $F = E/L$, substituting $E = M$ and $L = M^{-1}$, so $F = M/M^{-1} = M^2$)

2.5.2.6 Power: $[P_{ow}] = [M^2]$

(from $P_{ow} = E/T$, substituting $E = M$ and $T = M^{-1}$, so $P_{ow} = M/M^{-1} = M^2$)

This profound dimensional reduction underscores the deep mathematical coherence within physical laws and highlights the interconnectedness of seemingly disparate physical quantities. For instance, in systems where $c = \hbar = 1$, the numerical equivalence of mass (m), energy (E), and angular frequency (ω) ($m = E = \omega$) suggests that mass can be fundamentally interpreted as an intrinsic frequency or a manifestation of dynamic patterns. This perspective highlights the wave-like nature of matter and energy, where fundamental entities are characterized by their inherent oscillatory rates, offering a unified and elegant view of physical phenomena.

2.6 Other Specialized Natural Unit Systems

While Planck units are paramount for quantum gravity and cosmology, other natural unit systems are optimized for specific subfields of physics, tailored to the characteristic scales and interactions relevant to their domain.

2.6.1 Stoney Units: Historically significant, setting $c=G=e=1$, predating Planck units

Proposed by George Johnstone Stoney in 1881, Stoney units set $c = G = e = 1$. They predate Planck units by nearly two decades, representing one of the earliest systematic attempts to unify electromagnetism and gravity through fundamental constants. While less common in modern theoretical physics than Planck units, they are an important precursor to the concept of natural units.

2.6.2 Atomic Units (Hartree Atomic Units): Designed for atomic, molecular, and chemical physics, setting $\hbar = m_e = e = 1$

Specifically designed for calculations in atomic, molecular, and chemical physics, this system typically sets the reduced Planck constant ($\hbar$), the rest mass of the electron (m_e), and the elementary charge (e) to unity ($\hbar = m_e = e = 1$). Often, the vacuum permittivity term $1/(4\pi\epsilon_0)$ is also set to 1. This strategic choice dramatically simplifies fundamental equations, such as the Schrödinger equation and Maxwell's equations, which govern the behavior of electrons in atoms and molecules, making computations more efficient and transparent.

2.6.3 Quantum Chromodynamics (QCD) Units: Common in particle physics, often setting proton mass or QCD energy scale to 1

Common in particle physics, particularly Quantum Chromodynamics (QCD), where it is common practice to set the proton mass (m_p) or the QCD energy scale (Λ_{QCD}) to 1. This facilitates calculations involving the strong nuclear force and hadronic phenomena, where energies and masses are often naturally expressed relative to these characteristic hadronic scales.

Each specialized system provides a tailored framework, revealing the natural scales and relationships pertinent to its specific domain of physics.

2.7 Advantages and Disadvantages of Natural Units

Like any specialized tool, the use of natural units comes with its own set of benefits and drawbacks that influence their application in theoretical and practical contexts.

2.7.1 Advantages

Employing natural units offers several compelling benefits for theoretical physicists, enhancing both conceptual understanding and computational efficiency:

2.7.1.1 Exceptional Conceptual Clarity: Reveals underlying fundamental structures by stripping equations of constants

Natural units offer exceptional conceptual clarity. By stripping equations of cumbersome constants, they reveal the underlying fundamental structures and relationships between physical quantities with striking elegance. This allows physicists to focus on the core physics and symmetries rather than numerical coefficients, fostering deeper theoretical insight.

2.7.1.2 Universal Applicability: Not constrained by anthropocentric scales, offering an objective framework

Being derived from universal constants, natural units are not constrained by anthropocentric scales (like the meter or second). This provides a truly universal and objective framework for describing physical laws, applicable across the cosmos and independent of any human-centric conventions.

2.7.1.3 Insight into Fundamental Scales: Defines characteristic scales where new phenomena are expected

They inherently define characteristic scales (e.g., the Planck scale) where current physics models might break down or where entirely new phenomena are expected to emerge. This insight guides theoretical exploration, helping to pinpoint the boundaries of existing theories and directing the search for a more complete understanding of nature, such as a theory of quantum gravity.

2.7.1.4 Streamlined Calculations: Simplifies algebraic manipulation in complex theoretical derivations

Reducing the number of explicit constants to unity significantly simplifies algebraic manipulation in complex theoretical derivations. This makes calculations more tractable, less error-prone, and allows for faster progress in theoretical research, particularly in fields like quantum field theory and general relativity.

2.7.1.5 Facilitation of Theoretical Unification: Hints at deeper theoretical unifications by making quantities numerically equivalent

By making different physical quantities numerically equivalent (e.g., mass and energy, or length and time), natural units naturally hint at deeper theoretical unifications. This conceptual simplification can inspire new theoretical frameworks that bridge previously disparate areas of physics, moving towards a more unified description of fundamental forces and particles.

2.7.2 Disadvantages

2.7.2.1 Loss of Intuition for Magnitudes: Numerical values are often extremely large or small, making intuitive grasp difficult

The numerical values of physical quantities when expressed in natural units are often extremely large or small relative to everyday experience. This makes it difficult for physicists, and certainly non-specialists, to intuitively grasp their magnitudes. For example, a human being's mass in Planck units would be an astronomically large number, making direct intuition challenging.

2.7.2.2 Necessity of Conversion for Practical Use: Requires conversion back to conventional units for experimental observations

To bridge theoretical results with experimental observations or practical applications, conversion back to SI units (or other conventional units) is always necessary. This adds an extra step and potential for error when comparing theoretical predictions to real-world measurements, as the fundamental constants must be re-inserted.

2.7.2.3 Context-Dependent Constant Selection: Choice of constants varies by subfield, requiring careful specification

The choice of which constants to set to unity can be ambiguous or vary depending on the specific theoretical context or subfield (e.g., Planck units for quantum gravity vs. Atomic units for chemistry). This requires careful specification of the chosen unit system to avoid confusion and ensure clarity in scientific communication, especially when comparing results across different domains.

3 The Process Ontology and Frequency as the Foundation

Within the framework of natural units ($\hbar = 1$, $c = 1$), the relationship between mass and frequency is revealed not merely as a proportionality, but as a simple, elegant identity. This identity is profoundly illuminated by a process ontology where reality is fundamentally a dynamically **self-generating and self-organizing system** (Autaxys). This identity highlights a core principle of a frequency-centric view of reality, rooted in dynamic computational processing within the fundamental dynamic medium, underpinned by the principle of Autaxys.

3.1 The Fundamental Dynamic Medium, Processing, and Patterns (Autaxys)

A **process ontology** defines reality not based on static substance but on intrinsic, irreducible **self-generation and organization** through continuous, iterative processing. This inherent self-generation and organization is termed **Autaxys**. This processing unfolds within a fundamental, dynamic medium or substrate, akin to a universal computational field or substrate of information flow. The universe's fundamental activity is this continuous computation, orchestrated by Autaxys, generating and sustaining all phenomena.

Within this framework, **dynamic relational patterns** within the medium, generated and sustained by this processing, form the fundamental basis of reality. These patterns are not objects *in* the medium but stable configurations or structures *of* the medium itself, defined by the relationships and dynamics of the processing activity. They are the outputs of the Autaxic process. The principle of Autaxys provides the inherent drive and structure for the dynamic medium to process information and self-organize into these stable patterns. It is the engine and architect of cosmic computation, providing the rules and impetus for the ongoing genesis and maintenance of reality.

Flowing directly from the $m = \omega$ identity and illuminated by this process ontology, a central tenet is a **frequency-centric view of reality**, underpinned by the principle of Autaxys. Within this medium, all phenomena, regardless of their scale or complexity, are dynamic relational patterns characterized by intrinsic **processing frequencies**—the tempo at which these patterns manifest and maintain themselves through continuous computation. These frequencies represent the rate of change, interaction, and self-maintenance of the patterns within the dynamic substrate. They are the manifestation of the Autaxic process *within* specific stable configurations.

3.2 Revealing the Identity: Mass and Frequency Unified ($\omega_C = m_0$)

Setting $\hbar = 1$ and $c = 1$ in the fundamental energy relations derived from quantum mechanics and relativity:

- From quantum mechanics (Planck-Einstein relation for energy of intrinsic oscillation):

$$E = \hbar\omega_C \implies E = (1)\omega_C \implies E = \omega_C$$
- From relativity (Mass-Energy Equivalence for rest energy):

$$E = m_0c^2 \implies E = m_0(1)^2 \implies E = m_0$$

Equating these two expressions for the rest energy of the same system immediately yields the powerful identity:

$$\omega_C = E_0 = m_0$$

This identity, $\omega_C = m_0$ (or simply $\omega = m$ when referring to rest mass and Compton frequency in natural units), is the central revelation: in a system of units aligned with nature’s intrinsic operational parameters, a stable physical pattern’s rest mass (m_0) is numerically identical to its intrinsic angular frequency (ω_C). This alignment is dictated by Autaxys. This is not a proposal for a new physical law but a powerful re-framing and re-interpretation of established physics, made explicit by the removal of arbitrary unit conventions and illuminated by the process ontology. It unveils a fundamental connection obscured by the dimensional scaling factors $\hbar$ and c . It strongly suggests that mass and frequency are not fundamentally distinct concepts but are rather different facets or measures of the same underlying physical quantity: the characteristic tempo or rate of the fundamental process that defines and sustains a given stable pattern, orchestrated by Autaxys. The apparent complexity of the relationship $hf = mc^2$ in standard units is an artifact of our chosen system of measurement; the underlying physical relationship is the simple identity $\omega_C = m_0$ in natural units. In this sense, $\hbar$ and c function as universal conversion factors required to translate quantities between human-defined units and the natural units where this intrinsic identity holds. They reflect their role as fundamental scaling parameters of the underlying dynamic computational process orchestrated by Autaxys.

4 Physical Interpretation: Mass as a Resonant State of Fundamental Patterns

The $\omega_C = m_0$ identity, viewed through the lens of a process ontology where reality is composed of dynamic patterns within a fundamental dynamic medium, necessitates a fundamental shift in our understanding of mass. This dynamic medium operates via Autaxys. It is not an inert “stuff” but rather a dynamic, resonant state or a stable, self-sustaining configuration within the fundamental dynamic medium. This interpretation finds resonance with concepts in Quantum Field Theory (QFT), which can be understood as describing fundamental fields emerging from the dynamic substrate of reality, a substrate orchestrated by Autaxys and permeating spacetime.

4.1 Resonance, Stability, and the Pattern Hierarchy

The frequency ω_C in the identity $\omega_C = m_0$ corresponds specifically to the **Compton frequency** ($\omega_C = m_0 c^2 / \hbar$ in standard units) for a massive pattern. The Dirac equation, a cornerstone of relativistic quantum mechanics, predicted a rapid, oscillatory motion for a free electron at this characteristic frequency, known as **Zitterbewegung** (“trembling motion”). Within this process view, this predicted oscillation is interpreted as a direct manifestation of the intrinsic processing tempo of the localized pattern that constitutes the massive particle, occurring at its Compton frequency. This provides theoretical support from established physics for the fundamental frequency-mass link posited by this perspective, finding further support in recent experimental simulations of Zitterbewegung in condensed matter systems and trapped ions.

This leads to the concept that elementary particles are not structureless points but are stable, self-sustaining **standing waves** or localized resonant patterns within the fundamental dynamic medium, analogous to the stable harmonic modes of a vibrating string. Their observed stability arises from **resonance**—a state of perfect, self-sustaining synchrony of their intrinsic processing dynamics at their specific Compton frequency within the larger medium. These stable resonant modes, favored and solidified by the process of pattern formation and stabilization inherent to Autaxys, are precisely what we observe as elementary particles. They are patterns favored during dynamic pattern formation due to their optimality and robustness within the constraints and grammar of the medium’s computational process, a result of ongoing Autaxic processing. The principle of Autaxys actively drives the dynamic medium to explore possible configurations and solidify those that exhibit stable, resonant self-maintenance.

This perspective offers a compelling explanation for the observed **particle mass hierarchy**—the existence of distinct, quantized masses for elementary particles. This hierarchy is interpreted as a discrete spectrum of allowed, stable resonant frequencies or patterns that the underlying fundamental dynamic medium (or the quantum fields emerging from it via Autaxys) can sustain. Each type of elementary particle corresponds to a unique harmonic mode or resonant state of the fundamental dynamic medium or emergent fields. Its mass is a measure of the energy and informational complexity of that specific pattern, directly proportional to its resonant frequency ($m_0 = \omega_C$ in natural units). Unstable particles, in contrast, are interpreted as transient, dissonant states or non-resonant excitations within the fundamental dynamic medium. They decay rapidly into stable, lower-energy (and thus lower-frequency) configurations via the Autaxic process, seeking stable resonant states.

4.2 The Dynamic Substrate: The Fundamental Medium and Vacuum Energy

Within the framework of a process ontology, the universe is underpinned by a **fundamental dynamic medium**. This medium serves as the foundational substrate for all physical phenomena and the ongoing Autaxic process driving the universe's computation. It is not merely an empty void but an active, dynamic entity with intrinsic properties that dictate the very fabric and operational rules of reality. The inherent dynamic nature of this medium naturally gives rise to what are described in QFT as fundamental **quantum fields** that permeate spacetime. QFT views the universe not as empty space containing particles, but as interacting fields; even the vacuum, the lowest energy state, is not truly empty but is understood as a plenum of ceaseless **zero-point energy** fluctuations. This energetic vacuum state is interpreted as the fundamental dynamism of the medium itself, a manifestation of ongoing processing by Autaxys even in apparent “emptiness.” Its properties are indirectly observable via phenomena like the **Casimir effect**, which arises from vacuum fluctuations. The existence of the Cosmic Microwave Background (CMB) radiation, often interpreted as the “afterglow” of the Big Bang, can also be seen as evidence of a pervasive, energetic background medium resulting from the fundamental Autaxic process.

This energetic vacuum (the fundamental dynamic medium in its baseline dynamic state) is the universal computational substrate from which everything emerges through Autaxys. Particles are interpreted as localized, quantized excitations—“quanta”—of these emergent fields or, more fundamentally, stable, specific patterns within the fundamental dynamic medium itself. These patterns emerge dynamically from the zero-point background through Autaxys, specifically those favored and solidified by its inherent processes of selection and stabilization. The “Universal Frequency Field” could be understood as this pervasive, vibrating tapestry of emergent fields, or more fundamentally, the dynamic medium itself. Here, frequency characterizes the rate of change, interaction, and self-maintenance of relational patterns through processing orchestrated by Autaxys.

The origin of mass for many elementary particles, particularly through the **Higgs field** and **Higgs mechanism**, is reinterpreted within the frequency-centric process view. Interaction with the pervasive Higgs field (understood as a specific state or configuration of the fundamental dynamic medium that strongly promotes pattern solidification and persistence via Autaxys) is seen as introducing an “impedance” or resistance to the oscillation and propagation of emergent fields or fundamental patterns. A massless excitation, like a photon (interpreted as a highly dynamic pattern with minimal interaction with the solidification-promoting state), propagates at the speed c because its underlying oscillation is unimpeded by the solidification-promoting dynamics of the Higgs state. Interaction with this solidification-promoting state introduces “drag,” localizing the excitation into a stable, lower-velocity standing wave (a more persistent pattern). This localization and resistance to change is what we perceive as inertia, or mass. Patterns interacting more strongly with this solidification-promoting state experience greater “impedance,” resulting in higher rest mass (m_0) and, consequently, a higher intrinsic Compton frequency ($\omega_C = m_0$ in natural units). This reflects the increased processing (Autaxys) and persistence required to maintain their stable configuration against the dynamic backdrop of the fundamental dynamic medium.

5 Interactions and Emergent Phenomena

Building upon the interpretation of mass as an intrinsic angular frequency or oscillatory rate, the framework of natural units offers a profound reinterpretation of physical interactions and emergent phenomena. When fundamental constants like the speed of light (c) and the reduced Planck constant ($\hbar$) are set to unity, their numerical values become trivial, yet their physical significance as the “operational rules” and “physical exchange rates” of the universe is profoundly highlighted. In this context, interactions can be understood as the dynamic interplay and transformation of these fundamental oscillatory states.

5.1 Reinterpreting Fundamental Forces

Within a process ontology, fundamental constants like the speed of light (c) and the reduced Planck constant ($\hbar$) are not just numerical values, but **intrinsic parameters and physical exchange rates** that define the universe's operational grammar. The speed of light (c) is the inherent conversion factor between space and time, and profoundly, between mass and energy ($E = mc^2$). Similarly, the reduced Planck constant ($\hbar$) directly links energy to frequency ($E = \hbar\omega$) and momentum to wavelength. These relationships underscore that $\hbar$ and c are not merely limits or convenient numerical factors; rather, they define the fundamental laws and properties of our universe.

Given that $\hbar$ and c fundamentally parameterize the universe's laws, the nature and strength of fundamental forces must inherently derive from these constants. When these constants are set to unity in natural unit systems (e.g., Planck units), the underlying physical relationships they represent become numerically explicit, leading to direct numerical equivalences like $m = \omega$. Furthermore, in such systems, force is dimensionally reduced, often expressing as the square of mass ($[M^2]$). This dimensional equivalence, coupled with the numerical identity between mass and frequency, suggests that fundamental forces can be reinterpreted not merely as interactions between discrete particles, but as **intricate modulations or transformations of fundamental dynamic patterns or frequencies** within the universe's underlying dynamic medium. The constants $\hbar$ and c thus mediate how these frequency-based interactions propagate and coalesce into the observed phenomena of force, defining the specific “grammar” of interaction within the Autaxic process.

5.2 Reinterpreting Gravity and Spacetime

The implications of setting fundamental constants to unity offer a profound reinterpretation of spacetime and the framework within which gravity operates. A central insight is the **numerical equivalence of length and time** ($L = T$) when the speed of light (c) is set to 1. This reveals a deep, inherent connection between space and time, challenging conventional intuition by demonstrating that one dimension can be directly expressed in terms of the other. This unification suggests a more cohesive and intrinsically linked fabric of spacetime.

Furthermore, in a system where $c = \hbar = 1$, a remarkable **dimensional reduction to a single base unit** occurs. All fundamental physical dimensions, including Length and Time, can be expressed solely as powers of a single base unit, such as Mass. Specifically, length and time dimensions can both be seen as inverse powers of mass ($[L] = [M^{-1}]$ and $[T] = [M^{-1}]$). This profound dimensional reduction underscores a deep mathematical coherence in physical laws, suggesting that seemingly disparate physical quantities are, in essence, interconnected manifestations of a single underlying reality.

These revelations, stemming from the reinterpretation of fundamental constants like c and $\hbar$ as intrinsic parameters that define the very fabric and operational rules of the universe (Autaxys), provide a powerful lens through which to re-examine gravity. By establishing the numerical equivalence of mass, energy, and angular frequency ($m = E = \omega$) and unifying space and time into a single, interdependent entity, this perspective hints at a more fundamental, wave-like or oscillatory nature of the universe. Gravity, then, is not merely a force but an **emergent**

phenomenon arising from the dynamic structuring and curvature of the fundamental medium itself, influenced by the presence and distribution of these frequency-characterized patterns (mass-energy). The geometry of spacetime is thus a macroscopic manifestation of the collective, dynamic processing within the Autaxic medium.

6 An Information-Theoretic Framework: Mass, Frequency, and Cosmic Computation (Autaxys)

The process ontology, with its frequency-centric view, offers a profound information-theoretic perspective on reality. It posits that the universe functions as a dynamic, self-organizing system where all phenomena are understood as dynamic relational patterns characterized by intrinsic processing frequencies or rates of change. This framework highlights the fundamental interconnectedness of mass, energy, and frequency, particularly as revealed by quantum mechanics and special relativity.

When fundamental constants such as the speed of light (c) and the reduced Planck constant ($\hbar$) are set to unity ($c = \hbar = 1$) in natural unit systems, a pattern's rest mass becomes numerically identical to its intrinsic angular frequency ($m = \omega$). This powerful identity reinforces the frequency-centric view, suggesting that mass is a direct manifestation of frequency. From an information-theoretic standpoint, this implies that frequency is not just a physical property, but the fundamental “data” or “code” by which the universe processes and organizes itself. The structure and evolution of the cosmos emerge from these fundamental processing frequencies and their dynamic patterns, representing a continuous cosmic computation orchestrated by Autaxys. All physical entities are ultimately expressions of frequency or dynamic patterns, indicating a reality fundamentally engaged in continuous processing and transformation. The inherent oscillatory nature observed across phenomena, from electromagnetic radiation to elementary particles, supports this understanding of reality as a continuously self-organizing and computing system, where information is processed and patterns are formed through frequency-based dynamics.

7 Explanatory Power and Unification: A Frequency-Centric Process Ontology (Autaxys)

This frequency-centric view of reality, rooted in a process ontology based on a fundamental dynamic computational medium and continuous processing, offers compelling explanatory power by unifying disparate physical and philosophical observations under its core principles. This entire system is orchestrated by Autaxys.

The observed cosmic drive towards increasing complexity, from simple initial conditions to complex structures like galaxies, stars, and life, arises naturally from the inherent dynamics of the fundamental dynamic medium and the principle of Autaxys. Stagnation is an unstable state within this self-generating system, compelling the medium to continuously generate and stabilize increasingly complex configurations (patterns) through continuous processing orchestrated by Autaxys. The mathematical elegance and robustness frequently observed in physical laws are accounted for by the tendency towards stable, optimal patterns within the processing dynamics. This tendency favors algorithmically simple, robust relational patterns during pattern formation because they are computationally efficient to maintain, replicate, and propagate within the fundamental dynamic medium, a result of the optimization inherent to Autaxys.

Emerging directly from the process ontology (Autaxys) and the understanding of reality as dynamic patterns within the fundamental dynamic medium, the frequency-centric view provides powerful unification. Matter and Energy are not fundamentally different kinds of “stuff” but emerge within the fundamental dynamic medium as dynamic relational patterns, distinguished primarily by the nature of their formation and dynamics, through continuous processing orchestrated by Autaxys. Matter patterns are those where stability and resistance to change are dominant during solidification, resulting in stable, localized patterns characterized by specific intrinsic frequencies (mass). Energy patterns are those where flux and potential for transformation are dominant, resulting in transient, non-

localized excitations characterized by higher characteristic frequencies or faster transformation rates. Equating the interpretations of $E = mc^2$ (mass as stable pattern persistence and resistance to change arising from solidification via Autaxys) and $E = \hbar\omega$ (energy quanta as fundamental oscillations/activity within the medium arising from ongoing processing) yields the “Bridge Equation”: $m_0c^2 = \hbar\omega_C$. Within this process ontology, this reveals a deeper **ontological identity**: rest mass is frequency ($m_0 \propto \omega_C$), specifically the intrinsic oscillation rate, processing tempo, or Compton frequency (ω_C) inherent to the stable pattern constituting a massive particle. This identity shows that mass and energy are fundamentally manifestations of frequency-characterized dynamics, operating under different constraints imposed by the underlying computational process orchestrated by Autaxys within the dynamic medium.

This frequency-centric ontology provides a compelling path towards unifying General Relativity and Quantum Mechanics. GR is interpreted as describing the emergent, macroscopic, smooth spacetime geometry that arises from the collective, statistical dynamics of large aggregates of stable patterns (matter and energy) solidified by Autaxys. It is the observable outcome of countless discrete processing steps inherent in Autaxys averaging out to create an apparent continuous effect at large scales. This is analogous to how smooth, continuous fluid dynamics emerges from the discrete collisions of countless individual molecules. Quantum Mechanics, conversely, is interpreted as describing the probabilistic, discrete nature of the fundamental process at the level of individual relational updates and excitations (quanta) within the fundamental dynamic medium. While GR describes the aggregate behavior and large-scale structure resulting from the process’s operation, QM describes the fundamental excitations and the underlying discrete computational processes orchestrated by Autaxys that give rise to this aggregate behavior. The framework dissolves the traditional discrete/continuous divide by proposing that Reality advances via fundamental, discrete computational steps inherent to Autaxys. Macroscopic, collective states then manifest observable continuous characteristics that naturally arise from this underlying discreteness.

The framework also offers insightful interpretations of other cosmological puzzles. The vacuum is explained not as empty space but as the dynamic fundamental medium itself, teeming with potential and ceaseless fluctuations arising from its ongoing dynamics (zero-point energy), orchestrated by Autaxys. Dark energy can be interpreted as the cosmological expression of the underlying dynamism driving the overall expansion and diversification of reality (Autaxys), perceived macroscopically as the accelerated expansion of spacetime. It offers insights into the origin of mass (as the informational complexity and persistence of a resonant pattern solidified by Autaxys). It also suggests that dark matter may consist of stable, non-luminous patterns that interact primarily via their persistent, mass-like properties (affecting the structure of reality and thus gravity) without strong coupling to the specific dynamics that constitute standard model interactions. These patterns could potentially represent configurations solidified by different aspects of the fundamental dynamic medium’s dynamics through Autaxys. It also addresses the quantum measurement problem and wave function collapse. Measurement is viewed as an interaction that forces a probabilistic superposition (a state characterized by high potential and low solidification within the fundamental dynamic medium) to resolve. This resolution conforms to the persistent, solidified patterns of the measuring apparatus (a system characterized by specific solidified configurations maintained by Autaxys), with the collapsed state being guided towards a stable outcome possible in the local configuration of reality according to the fundamental process rules inherent in Autaxys.

7.1 The Autaxic Trilemma: Core of Reality's Generation and its Physical Manifestations

The observable physical universe, with its fundamental properties of mass, space, and time, is understood within the Autaxys framework as a direct manifestation of the ongoing resolution of an underlying generative tension: the **Autaxic Trilemma**. This inherent, irresolvable tension drives the Generative Cycle and shapes all of reality. It can be likened to a "three-legged stool" that forms the fundamental engine of reality's self-generation.

The Autaxic Trilemma comprises three imperatives:

1. **Novelty (N):** The imperative to explore new possibilities, generate new patterns, and avoid stagnation. It represents the drive for change and diversification within the system.
2. **Efficiency (E):** The imperative to optimize processing, minimize computational cost, and find the most parsimonious and coherent solutions. This aspect seeks order and simplicity.
3. **Persistence (P):** The imperative for patterns to maintain their coherence, stability, and self-identity over time. It embodies endurance and self-preservation.

The universe, through the Autaxys process, is constantly negotiating and balancing these three imperatives, leading to the emergence of physical reality. The physical variables—Mass, Energy, Length, and Time—can be seen as the primary observable manifestations or metrics of the Trilemma's ongoing resolution:

- **Mass (M) ↔ Persistence (P):** This connection is the most direct and foundational link in Autaxys. Mass is the ultimate expression of a pattern's **Persistence**. A pattern with high mass (high intrinsic frequency) has achieved a significant degree of stability and self-maintenance, requiring continuous computational effort to regenerate itself against the medium's dynamism. It embodies the "structural inertia" of a highly persistent pattern, directly reflecting the "endurance" or "stability" imperative of Persistence.
- **Energy (E) ↔ Novelty (N) / Dynamic Activity:** Energy, in Autaxys, is understood as the dynamic *activity* or *flux* within patterns, serving as the "currency" of change and transformation. Novelty is the imperative that drives the exploration of new states and the generation of new patterns. The creation or transformation of patterns, driven by Novelty, requires and manifests as energy. Energy is thus the "spark" or "motion" that embodies the drive for newness and change, directly reflecting the imperative of Novelty.
- **Length (L) & Time (T) ↔ Efficiency (E) / The Metrics of the Emergent Stage:** Length and Time are the fundamental metrics of emergent spacetime, which serves as the "stage" upon which the Autaxic Trilemma's resolution unfolds. They are measures of the *efficiency* of pattern propagation and interaction within the dynamic medium. Time measures the *rate* of the Generative Cycle's Solidification, while Length measures the *spatial extent* of patterns and the *scale* over which interactions can efficiently occur. Together, L and T are the "rulers" and "clocks" that measure the *optimized flow* and *structured extent* of the universe's computation, directly reflecting the imperative of Efficiency.

In summary, the Autaxic Trilemma (Novelty, Efficiency, Persistence) is the unseen, fundamental engine that drives reality, representing the internal logic of the universe's self-generation. The physical variables (Mass, Energy, Length/Time) are the observable, measurable properties of the emergent reality, with each being a direct consequence and reflection of one (or more) of the Trilemma's imperatives being continuously balanced and resolved. The dimensional equivalences revealed by natural units are not merely mathematical curiosities but profound hints at this deeper, trilemma-driven reality, unifying the concepts of mass, space, and time into a single, computationally-derived fabric.

8 Analogies and Broader Implications: Frequency as a Universal Principle

The mass-frequency framework or process ontology posits frequency as a foundational and unifying principle throughout the universe. This perspective suggests reality as a dynamic, self-organizing system where phenomena are dynamic relational patterns characterized by intrinsic processing frequencies or rates of change.

8.1 The Analogy with Neural Processing

The brain, a complex adaptive system, offers a compelling analogy for a frequency-centric process ontology. Neural processing is fundamentally based on oscillatory activity across various scales, from individual neuron firing rates to large-scale brain rhythms (e.g., alpha, beta, gamma waves). Information in the brain is encoded, transmitted, and processed not just by the presence or absence of signals, but by their *frequency*, *phase*, and *synchrony*. Stable cognitive states, memories, and perceptions can be seen as emergent, resonant patterns of neural activity, akin to stable patterns in the fundamental dynamic medium. Just as a particle's mass is its intrinsic frequency, a thought or memory might be characterized by a specific, stable frequency pattern of neuronal firing. Learning and adaptation involve the formation and stabilization of new resonant neural circuits, mirroring Autaxys' role in generating and solidifying dynamic patterns in the physical universe. This analogy suggests that frequency-based processing is a universal principle for self-organization and computation, whether in the cosmos or in biological intelligence.

8.2 Frequency as the Universal Code

Beyond its role in fundamental physics, frequency emerges as a universal principle for encoding, transmitting, and organizing information across diverse systems. Its inherent properties—such as periodicity, the ability to form harmonics, and the capacity for constructive and destructive interference—make it an ideal medium for complex information processing. From the rhythmic patterns in biological systems to the carrier waves in telecommunications, frequency serves as a fundamental code. In the context of the process ontology, where mass and energy are manifestations of intrinsic frequencies, this extends to the very fabric of reality. The universe, as an Autaxic computational system, fundamentally operates by manipulating and transforming these frequency-encoded patterns. This suggests that frequency is not merely a measurable quantity but the underlying language of cosmic computation, providing the means by which dynamic patterns are created, sustained, and interact, forming the rich complexity of observable reality.

9 Empirical Touchpoints and Testable Predictions

The Process Ontology, with its frequency-centric view and interpretation of fundamental constants as parameters of a dynamic medium (Autaxys), offers a reinterpretation of physical reality. While primarily a conceptual framework, its tenets suggest areas where empirical investigation might reveal signatures consistent with this underlying structure.

9.1 Signatures of Fundamental Processing Granularity

The reduced Planck constant ($\hbar$) is described as the inherent granularity or “quantum of action” of the fundamental dynamic medium's processing, defining the smallest “packet” of computational change or information that can occur. This framework posits that beyond the established quantum phenomena, signatures of this intrinsic processing granularity should become apparent at the universe's most extreme scales. Specifically, approaching the Planck length (L_P) and Planck time (T_P)—scales where quantum effects of gravity are expected to become dominant and our current understanding of spacetime breaks down—one might empirically encounter a breakdown of the continuous spacetime continuum. Such a breakdown could manifest as a truly discrete or “fuzzy” spacetime structure, which would serve as a direct empirical touchpoint for the underlying granular nature of reality's fundamental processing.

9.2 Detection of Intrinsic Medium Resonances/Relational Harmonics

Within the framework of the process ontology, which posits frequency as a foundational aspect of reality, the concept of intrinsic medium resonances or relational harmonics is not merely abstract but has tangible empirical connections. This perspective suggests that physical phenomena are dynamic relational patterns characterized by intrinsic processing frequencies or rates of change within a fundamental dynamic medium. The framework interprets the masses of fundamental particles as direct manifestations of these stable resonant frequencies (Compton frequencies) of the dynamic medium. Therefore, the **extraordinary precision and consistency of measured particle masses** across experiments can be seen as empirical validation of these fixed, intrinsic medium resonances. Future, even more precise measurements could potentially reveal subtle deviations or fine-structure within these resonant frequencies, offering deeper insights into the medium's dynamics. Furthermore, the **detection and analysis of gravitational waves** could offer a unique window into the large-scale resonant behavior and dynamics of the spacetime medium itself, potentially revealing characteristics of its fundamental processing. Similarly, **high-precision spectroscopy of distant cosmological phenomena** could probe for variations in fundamental constants or particle properties that might hint at subtle, large-scale medium dynamics influencing emergent resonant frequencies.

9.3 Anomalies in Extreme Regimes Challenging Process Dynamics

The framework of natural units, particularly the Planck scale, inherently defines and highlights extreme regimes where current theories of physics may break down and new phenomena are expected. For instance, the Planck length represents the fundamental scale where the quantum effects of gravity become dominant, hinting at the need for a theory of quantum gravity, as our current understanding of spacetime breaks down beyond this limit. Similarly, the Planck time signifies the incredibly brief duration beyond which our present comprehension of spacetime is insufficient. The unimaginably high Planck temperature is relevant to the extreme conditions of the very early universe, such as immediately after the Big Bang, where novel physics is anticipated.

These fundamental scales serve as critical frontiers where any observed anomalies or deviations from current theoretical predictions would provide crucial empirical touchpoints. Such anomalies, occurring in these extreme regimes—be it at ultra-small lengths, ultra-brief times, or ultra-high temperatures—would signify a challenge to existing physical frameworks. They would serve as key tests, and potential points of validation or refutation, for a more encompassing theoretical construct, such as the proposed process dynamics, which aims to explain phenomena where standard models falter and new fundamental behaviors are expected to emerge.

9.4 Context-Dependent Variation in Emergent Parameters

While the fundamental constants (c , $\hbar$, G , etc.) are posited as fixed, universal parameters defining the intrinsic “grammar” of the Autaxic process, the process ontology suggests that **emergent physical parameters** (e.g., effective particle masses, coupling strengths, or even the local effective speed of light in highly dynamic or dense regions of the medium) *could* exhibit subtle, context-dependent variations. These variations would not imply a change in the fundamental constants themselves, but rather a **local modulation of how the dynamic medium manifests these constants** or how specific patterns interact within different local conditions of the medium. For instance, in regions of extreme energy density, strong gravitational fields, or highly entangled quantum states, the local properties of the dynamic medium might subtly influence the emergent resonant frequencies or interaction strengths of particles. **High-precision astrophysical observations** (e.g., looking for variations in fundamental constants over cosmic time or in strong gravitational fields) and **laboratory experiments under extreme conditions** (e.g., ultra-high pressures, temperatures, or in exotic quantum materials) could potentially detect such

minute, context-dependent variations in emergent parameters. These observations would serve as crucial empirical tests, distinguishing between a purely static vacuum and a truly dynamic, computational medium whose local state can influence the manifestation of physical laws.

10 Towards Comprehensive Coherence

This document has laid out a frequency-centric process ontology, proposing that reality is fundamentally a dynamic, self-organizing computational system driven by Autaxys. By reinterpreting fundamental constants as intrinsic parameters of this underlying dynamic medium, and revealing the profound identity between mass and frequency, this framework offers a unified perspective on seemingly disparate physical phenomena. From the nature of particles as resonant patterns to the emergence of spacetime and fundamental forces, this ontology provides a cohesive narrative. The proposed empirical touchpoints and testable predictions underscore its potential to guide future research, inviting a deeper exploration into the universe as an ongoing, self-generating cosmic computation. This framework aims to foster a more comprehensive coherence in our understanding of reality, bridging the quantum and relativistic realms through the universal language of frequency and dynamic processing.
