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[Gui Furne Gouveia](#) *

Posted Date: 3 June 2025

doi: 10.20944/preprints202506.0121.v1

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Article

A Unified Wave-Based Model of Matter, Light, and Space: Stationary Waves in an Elastic, Non-Dispersive Medium

Furne-Gouveia

Independent Researcher, Portugal France; furnegouveia@gmail.com

Abstract: This model posits that space, an elastic, non-dispersive medium, is the universe's sole constituent, with all phenomena—matter, light, forces, gravity, and cosmic expansion—emerging from its wave dynamics. Rejecting relativistic spacetime as an emergent illusion, it redefines time as the cadence of wave oscillations, aligning with the Michelson-Morley null result and Occam's razor by eliminating the particle zoo. Particles arise as stationary wave systems sustained by In- and Out-waves, light propagates along pseudo-stationary waves, forces mediate momentum via wave exchanges, and gravity stems from space energy density variations. Quantum mysteries (wave function collapse, multiple-path propagation, entanglement) are resolved through deterministic, non-local wave interactions, while particle generations and neutrino oscillations reflect space anisotropy. Cosmic expansion is driven by neutrino condensation, offering an alternative to dark energy, and gravitational anomalies akin to MOND are addressed. Technological prospects, such as inertia manipulation and non-Newtonian propulsion, promise transformative applications. This mechanistic paradigm unifies General Relativity and Quantum Mechanics as complementary observational frameworks, inviting exploration of its testable predictions.

Keywords: wave-based model; elastic space lattice; In-waves; Out-waves; space anisotropy; neutrino oscillations; wave function collapse; quantum entanglement; inertial mass; gravitational mass; non-Newtonian propulsion; dark energy; MOND; cosmic expansion; non-locality

1. Introduction

Physics has long sought unification, from Newton's mechanics to the luminiferous ether, discredited by the Michelson-Morley experiment's null result (1887), which detected no ether wind [1]. Mainstream theories—relativity's spacetime and quantum mechanics' particle zoo—introduce complexity yet fail to resolve mysteries like quantum entanglement, wave function collapse, wave-particle duality, and particle generations. This model offers a radical alternative: space, an elastic, non-dispersive lattice, is the universe's sole constituent, with all phenomena arising as its vibrational modes. Unlike the ad hoc ether, space is the fundamental reality, minimizing free parameters in accordance with Occam's razor.

Philosophically, time is the cadence of wave oscillations, not a dimension, rendering relativistic spacetime an emergent illusion perceived by instruments within the vibrating lattice. Light propagates isotropically at speed c along pseudo-stationary waves, consistent with the Michelson-Morley result, producing no ether wind. Coherent wave sources generate stationary waves, self-adjusting to maintain integer-wavelength separations, forming particles as localized wave systems sustained by In- and Out-waves. This framework explains forces, gravity via space energy density variations, quantum entanglement through non-local interactions, particle generations via space anisotropy, and cosmic expansion through neutrino condensation, offering alternatives to dark energy and MOND. Technological prospects, including non-Newtonian propulsion and inertia manipulation, challenge conventional paradigms, unifying General Relativity and Quantum Mechanics as complementary observational frameworks while proposing testable predictions for a deterministic, reality-based cosmos.

The article is structured as follows:

1. **Introduction.**
2. **Stationary Waves:** Proof of wave formation between coherent sources.
3. **Particles:** Localized wave systems with In- and Out-waves.
4. **Light and Quantum Phenomena:** Energy transfer and resolution of quantum mysteries.
5. **Forces and Fields:** Momentum exchanges via waves.
6. **Space Granularity and Anisotropy:** Lattice structure and particle generations.
7. **Gravity:** Space energy density variations.
8. **Cosmic Expansion:** Neutrino-driven dynamics.
9. **Technological Prospects:** Manipulating space properties.

2. Stationary Waves Between Coherent Sources

2.1. Model and Assumptions

Consider N wave sources at positions $\mathbf{r}_i = (x_i, y_i, z_i)$ in a 3D elastic, non-dispersive space with wave speed c . Each emits spherical waves at frequency f , with wavelength $\lambda = \frac{c}{f}$, wave number $k = \frac{2\pi}{\lambda}$, and angular frequency $\omega = 2\pi f$. The wave from source i includes transverse and longitudinal components:

$$\psi_{i,\text{trans},y}(\mathbf{r}, t) = A \cos(k|\mathbf{r} - \mathbf{r}_i| - \omega t) \hat{y}, \quad (1)$$

$$\psi_{i,\text{trans},z}(\mathbf{r}, t) = A \cos(k|\mathbf{r} - \mathbf{r}_i| - \omega t) \hat{z}, \quad (2)$$

$$\psi_{i,\text{long}}(\mathbf{r}, t) = A \cos(k|\mathbf{r} - \mathbf{r}_i| - \omega t + \pi) \hat{x}, \quad (3)$$

where $|\mathbf{r} - \mathbf{r}_i| = \sqrt{(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2}$, and time is the cadence of oscillation cycles. The total wave is the superposition of all components.

2.2. Two Stationary Sources

For two sources at $(0, 0, 0)$ and $(d, 0, 0)$, along the x-axis ($y = z = 0, 0 \leq x \leq d$):

$$\psi_{\text{trans},y}(x, t) = A \cos(kx - \omega t) + A \cos(k(d - x) - \omega t). \quad (4)$$

If $d = n\lambda$:

$$\psi_{\text{trans},y}(x, t) = 2A \cos(kx) \cos(\omega t) \hat{y}. \quad (5)$$

The longitudinal component:

$$\psi_{\text{long}}(x, t) = -2A \cos(kx) \cos(\omega t) \hat{x}. \quad (6)$$

2.3. Multiple Sources

Each pair (i, j) with $d_{ij} = n\lambda$ forms stationary waves along their connecting line.

2.4. Moving Sources

For sources moving at $\mathbf{v} = (0, v, 0)$, the comoving frame yields stationary waves for $d_{ij} = n\lambda$.

2.5. Self-Adjusting Mechanism for Source Separation

Stationary waves require the distance between sources to be an integer multiple of the wavelength ($d = n\lambda$). A self-adjusting mechanism ensures this condition by generating a restorative force when the

separation deviates from this requirement. Consider two sources at $(0,0,0)$ and $(d,0,0)$. If $d = n\lambda + \delta$, where δ is a small deviation, the interference pattern becomes dynamic, producing an energy gradient.

The transverse wave along the x-axis is:

$$\psi_{\text{trans},y}(x,t) = A \cos(kx - \omega t) + A \cos(k(d-x) - \omega t). \quad (7)$$

The energy density is proportional to:

$$|\psi_{\text{trans},y}|^2 = A^2 \left[\cos^2(kx - \omega t) + \cos^2(k(d-x) - \omega t) + 2 \cos(kx - \omega t) \cos(k(d-x) - \omega t) \right]. \quad (8)$$

For $d = n\lambda + \delta$, the interference term includes $\cos(k\delta - 2\omega t)$, creating a time-varying pattern. The force on source 2 is:

$$F \approx -\kappa\delta, \quad (9)$$

where $\kappa \propto A^2k$ depends on the medium's elasticity. This force adjusts the sources' positions toward $d = n\lambda$.

The longitudinal wave, out of phase by π , compensates for transverse wave extrema, stabilizing the medium. For multiple sources, the net force on source i :

$$\mathbf{F}_i = - \sum_{j \neq i} \kappa (d_{ij} - n_{ij}\lambda) \hat{\mathbf{r}}_{ij}. \quad (10)$$

3. Particles as Localized Waveforms

3.1. Elastic Space

Space is an elastic, non-dispersive medium where waves are local variations in energy density. An energy density variation in space deflects the trajectories of other waves. Particles are formed by waves that mutually trap each other through reciprocal deflection of their paths, resulting in localized stationary waveforms within a confined volume. These stationary waveforms, constituting particles, radiate Out-waves into the surrounding medium and receive compensatory In-waves from their environment, maintaining an energetic equilibrium through interconnected wave networks. The cadence of the internal wave cycles within these particles defines their proper time, which determines the frequency at which their phases align for interactions with other entities in the environment.

3.2. Proper Time as Cadence

The proper time of a particle is the cadence of its internal wave cycles, reflecting the frequency at which its constituent waves complete their oscillatory paths. This cadence governs the particle's interactions, as it sets the phase alignment for energy transactions with other particles or the environment. To derive the effect of motion on this cadence, consider a particle in the elastic medium of space, where waves propagate at speed c .

When the particle is at rest relative to the medium, its internal waves traverse a closed path of length L during one cycle, completing the cycle in time T_0 . Since the waves travel at speed c , the distance traveled in one cycle is cT_0 , so:

$$L = cT_0. \quad (11)$$

The rest cadence (frequency) of the internal cycles is the inverse of the cycle period:

$$f_0 = \frac{1}{T_0} = \frac{c}{L}, \quad (12)$$

where f_0 represents the particle's proper time cadence at rest.

Now, consider the particle moving through the medium at velocity $v < c$ along the x-axis. The internal waves' trajectory is affected by this motion. For calculation purposes, we model the internal wave path as a circular loop with perimeter L , representing the portion of the path not contributing to the particle's translational motion, and a translational component H representing the particle's displacement in space. From the perspective of the medium (the space reference frame), the waves forming the particle describe a helical trajectory, with the helix's base approximated as a circle of perimeter L .

Let the particle complete n internal cycles (loops) over a time interval T' in the medium's frame, during which it translates a distance $H = vT'$. The wave's total path combines the internal loops and the translational motion. In the helical model, the wave travels along the surface of a cylinder, completing n loops of perimeter L , while the cylinder's axis advances by H .

To compute the cadence, we analyze the wave's path length. The wave travels at speed c , so over time T' , the total distance traveled is cT' . This distance accounts for both the internal loops and the translation. To derive the relationship, we "unfold" the cylindrical helix into a two-dimensional plane, transforming the helical path into a right triangle: - **Hypotenuse**: The total distance traveled by the wave, cT' , at speed c . - **Base**: The total length of the internal loops, nL , where n is the number of loops, each of perimeter L . - **Height**: The translational distance, $H = vT'$, covered by the particle's motion.

Applying the Pythagorean theorem to this right triangle:

$$(nL)^2 + (vT')^2 = (cT')^2. \quad (13)$$

Solve for the cadence $f' = \frac{n}{T'}$, the frequency of internal cycles while moving:

$$(nL)^2 = (cT')^2 - (vT')^2, \quad (14)$$

$$(nL)^2 = T'^2(c^2 - v^2),$$

$$n^2L^2 = T'^2c^2\left(1 - \frac{v^2}{c^2}\right),$$

$$\left(\frac{n}{T'}\right)^2 = \frac{c^2}{L^2}\left(1 - \frac{v^2}{c^2}\right).$$

Taking the square root:

$$\frac{n}{T'} = \frac{c}{L}\sqrt{1 - \frac{v^2}{c^2}}. \quad (15)$$

Since $\frac{c}{L} = f_0$, the rest cadence, we obtain:

$$f' = \frac{n}{T'} = \sqrt{1 - \frac{v^2}{c^2}}f_0. \quad (16)$$

This formula shows that the cadence of the particle's internal cycles slows as its velocity v increases, reducing the frequency of interactions compared to the rest cadence f_0 . The derivation reveals that as v approaches c , more of the wave's path is devoted to translation, leaving less for internal loops, thus decreasing the cadence. When $v = 0$, $f' = f_0$, recovering the rest cadence.

This result matches the time dilation formula observed in special relativity [2], where the proper time of a moving clock slows by a factor of $\sqrt{1 - \frac{v^2}{c^2}}$. However, in this model, the effect is purely mechanistic, arising from the geometry of the wave's helical path in the elastic medium of space, not from a dimensional spacetime framework, which is rejected as an illusion. The slower cadence reflects the particle's reduced interaction frequency, as fewer internal cycles occur per unit time in the

medium's frame, aligning with experimental observations of time dilation in particle accelerators and cosmic ray muons.

The In- and Out-waves ensure the particle's stability, as Out-waves radiate energy and In-waves replenish it, maintaining the stationary waveform. The proper time cadence governs phase alignments for interactions, such as force exchanges or light emission, making it a fundamental property of the particle's dynamics in the medium.

4. Light and Quantum Phenomena

Light propagates as waves through the elastic space lattice, with its interactions governed by the collective dynamics of the lattice nodes. Quantum phenomena, such as photon emission and absorption, emerge from the interplay of these waves, specifically the In- and Out-waves that define particles and their environments. Unlike mainstream quantum mechanics, which relies on probabilistic wave functions and multiple particle types, this model frames quantum effects as deterministic transactions within the wave-based structure of space, providing a mechanistic explanation for observed behaviors.

Particles, as systems of stationary waves sustained by In- and Out-waves (Section 3), engage in multiple interactions with their surroundings through *pseudo-stationary* waves. These waves are termed pseudo-stationary because thermal agitation in the lattice perturbs their wavelengths, causing variations in the Out-waves emitted by a particle and its perception of incoming In-waves. As a result, these waves carry bidirectional impulses with fluctuating amplitudes and phases, facilitating a transactional exchange of energy and momentum between the particle and its environment. At a specific moment, an impulse from an incoming In-wave may align with the phase of an electron's stationary wave within an atom, triggering a transition to a lower energy state. This transition results in the emission of a photon, a localized wave packet propagating through the lattice with a frequency determined by the energy difference between the states, consistent with the Planck-Einstein relation, $E = h\nu$.

The emission process is inherently transactional, as it depends on the collective behavior of the atom's In- and Out-waves. The decision to emit a photon hinges on the precise alignment of these waves, which collectively determine whether the energy and phase conditions for a transition are met. An electron within the atom interacts with multiple pseudo-stationary waves arriving from various directions, each contributing to the lattice's local dynamics. Waves originating from closer sources, with shorter paths, typically have higher amplitudes due to the inverse-square decay of wave intensity with distance, increasing their likelihood of triggering a transition. However, waves from more distant sources may also be selected, depending on their phase alignment. This mechanism underlies the apparent multiplicity of paths described by Feynman, who noted that a photon "takes all possible paths" in quantum electrodynamics [9]. In this model, the photon follows a single path, determined by the dominant wave interaction at the moment of emission, dispelling the illusion of multiple paths while accounting for the probabilistic outcomes observed in experiments.

Quantum entanglement, a hallmark of quantum mechanics, is naturally explained within the wave-based framework of the elastic space lattice. Consider two entangled photons or electrons exhibiting correlated properties, such as opposite polarizations for photons or opposite spins for electrons. Two entangled photons, described as localized wave packets in the lattice (Section 4), share a coherent system of In- and Out-waves that sustains their entangled state. In the absence of external interactions, the correlations between their properties are preserved, as the lattice's wave dynamics maintain the phase and amplitude relationships established at their creation. Measuring the polarization of one photon instantly determines the polarization of the other, regardless of their separation, due to the non-local interdependence mediated by the lattice's In- and Out-waves.

The apparent mystery of entanglement arises from interpretations of quantum mechanics, such as the Copenhagen interpretation, which assume an indeterministic collapse of the wave function. In this model, quantum mechanics is fundamentally deterministic, with particles existing as interdependent wave systems sustained by In-waves from the broader universe (Section 3). The properties of an

entangled particles are not locally defined but emerge from its continuous interaction with the lattice, which connects all particles through a global network of waves. Consequently, the theorem of Bell, which tests the compatibility of quantum correlations with realism, locality, and freedom of choice, does not apply [4]. By rejecting locality—due to the non-local influence of In- and Out-waves—this model violates the assumptions underlying Bell's inequalities, naturally accounting for the observed correlations in entangled systems without invoking hidden variables. This perspective aligns with the transactional nature of wave interactions (Section 4), offering a mechanistic explanation for entanglement as a manifestation of the lattice's interconnected dynamics.

The wave function collapse, another mystery of quantum mechanics, is resolved in this model by demonstrating that particles follow deterministic, single paths dynamically shaped by environmental interactions, eliminating indeterministic collapse [9]. Particles, as vibrational modes of the elastic space lattice, interact via In- and Out-waves, forming pseudo-stationary waves through transactional exchanges (Section 4). For both photons and electrons, paths are continuously recalculated based on interference patterns of In-waves, which arise from environmental Out-waves and residual waves. In Young's double-slit experiment, each particle traverses one slit, with interference patterns resulting from environmental In-wave superpositions shaping the pseudo-stationary waves guiding their trajectories. The slit configuration alters these interference patterns, determining possible paths without self-interference. This deterministic, non-local framework, where paths are adjusted at each step by environmental impulses, dispels multiple-path notions, unifying quantum phenomena like entanglement and wave-particle duality.

This framework unifies light propagation and quantum phenomena within the elastic space lattice, eliminating the need for abstract wave functions or additional fundamental entities. By modeling interactions as transactions mediated by In- and Out-waves, the model provides a coherent explanation for photon emission, absorption, and related quantum effects, aligning with empirical observations while offering a deterministic alternative to conventional quantum mechanics.

5. Forces and Fields

In this model, forces and fields emerge from the vibrational dynamics of the elastic space lattice, where particles are localized wave systems sustained by In- and Out-waves (Section 4). Fields are generated by the Out-waves emitted by particles, which propagate through the lattice, carrying energy and mediating interactions. The properties of these fields depend on the internal frequencies of the emitting particles, determined by their vibrational modes within the lattice.

Electromagnetic fields arise from the Out-waves of charged particles, such as electrons, whose internal frequencies define the field's characteristics. These fields are aligned with the electron's wave frequency, enabling resonant interactions with other electrons, such as scattering or attraction. Protons, similarly charged, share this frequency, facilitating mutual interference through their Out-waves [10]. This shared frequency underpins electromagnetic interactions, where the lattice's wave dynamics mediate forces without requiring classical field quanta, offering a unified explanation for charge-based phenomena.

In contrast, the gravitational field is not a true field but an emergent effect of the cumulative energy density of Out-waves in each locality of space. Unlike electromagnetic interactions, which rely on frequency alignment, gravity results from variations in the lattice's energy density, influencing all particles regardless of their internal frequencies (Section 6). This distinction resolves the incompatibility between quantum fields and general relativity, framing gravity as a macroscopic consequence of wave interactions.

By modeling forces and fields as manifestations of Out-wave dynamics, this framework unifies electromagnetic and gravitational phenomena with quantum mechanics. The frequency-dependent nature of electromagnetic fields connects to the transactional interactions of Chapter 4, while the energy density basis of gravity aligns with cosmic expansion (Section 8). Future experiments, such as probing

lattice-mediated interactions, could test these predictions, advancing a deterministic, wave-based paradigm.

6. Space Granularity and Anisotropy

Space, in this model, is conceptualized as a three-dimensional elastic lattice of waves operating at the Planck scale, where the lattice nodes represent points of synchronized wave interactions [6]. The local energy density of space is determined by the wavelength of these lattice waves, with denser regions corresponding to shorter wavelengths and higher interaction frequencies. Variations in energy density arise from changes in the lattice's wave characteristics, driven by the collective behavior of In- and Out-waves from particles and other wave sources.

The space lattice exhibits anisotropic rigidities along its three principal axes, arising from two distinct sources of anisotropy. Locally, anisotropy results from the superposition of waves arriving from all directions, creating variations in wave propagation properties. However, a more fundamental anisotropy, characterized by significantly different rigidities along each axis, is hypothesized to explain the three generations of fermions in the Standard Model, encompassing both leptons (e.g., electron, muon, tau, and their neutrinos) and charged quarks (e.g., up/down, charm/strange, top/bottom). Each generation corresponds to a specific resonant mode of the lattice, where the effective mass of each fermion is determined by the energy required to sustain stationary wave patterns along axes with varying rigidities. An additional signature of this anisotropy is provided by neutrino oscillations, where neutrinos transition between flavors (e.g., electron to muon neutrino) due to their interaction with the anisotropic lattice [7]. Owing to their high velocities, neutrinos experience a slowed proper time, as derived in Section 3.2, maintaining their wave configuration predominantly aligned with one of the principal axes for extended periods. This alignment concentrates the energy of their stationary waves along a specific axis, influencing their flavor state and contributing to their apparent mass during interactions. Since our measurement instruments are embedded within the same elastic lattice and share its metric structure, this fundamental anisotropy is not directly detectable. Nevertheless, the existence of three fermion generations and neutrino oscillations serves as a distinctive signature of this intrinsic property. Unlike mainstream theories that introduce multiple fundamental particle types, this framework attributes fermion generations and related phenomena to the inherent anisotropic structure of the space lattice, eliminating the need for additional entities.

The granular nature of space also implies a discrete structure at the Planck scale, where the lattice nodes act as interaction points for all wave phenomena. This granularity underpins the model's ability to explain gravitational effects as variations in the lattice's energy density, as discussed in the following section.

7. Gravity as Space Energy Density Variation

Gravitational forces, in this model, arise from variations in the energy density of the space lattice, manifesting as a composite effect with two distinct components. To elucidate this mechanism, we draw a parallel with the propagation of light through a transparent medium denser than air, such as glass. In such a medium, the light wave's interaction with the medium's atoms induces phase delays, or "kickbacks," which slow the wave's effective speed while increasing its apparent frequency. Similarly, light propagating through the vacuum interacts with the nodes of the space lattice, experiencing phase kickbacks that depend on the lattice's local energy density.

In this model, space is an elastic, non-dispersive medium composed of a Planck-scale wave lattice, where nodes vibrate in synchrony, as described by self-organizing systems like the Kuramoto model [6]. The passage of a single wave, such as light, has minimal impact on these nodes due to their collective stability and higher energy scale. However, the cumulative agitation of the lattice nodes—driven by the total energy of all traversing waves (e.g., In- and Out-waves from particles)—increases the local energy density. This agitation induces a uniform phase kickback on all traversing waves, regardless of their individual frequencies, resulting in a slower effective propagation speed and an increased

apparent frequency. This effect is analogous to an index of refraction for the space lattice, which deviates light without dispersion due to the medium's non-dispersive nature.

The energy density of a region of space is determined by the average spacing of lattice nodes, which correlates with the wavelength of the lattice waves. Higher energy density corresponds to shorter wavelengths and closer node spacing, driven by the intensity of local wave activity. The phase kickback, and thus the refractive index, depends solely on this energy density and not on the frequency of individual traversing waves, ensuring uniform deviation across all wave types.

Gravitational fields are the macroscopic expression of these energy density variations. The primary component of gravity results from the Out-waves emitted by material particles, which contribute to the local energy density of the lattice. The intensity of this component decreases with the square of the distance from the source, as the Out-waves' energy disperses geometrically over a spherical surface:

$$\Delta\theta \propto \frac{M}{r^2}\lambda, \quad (17)$$

where $\Delta\theta$ is the angular deviation of a wave (e.g., light), M is the mass of the source, r is the distance, and λ is the wavelength of the traversing wave [5]. This deviation mimics Newtonian gravity and slows the proper time cadence of particles in denser regions, as their internal wave cycles are influenced by the lattice's increased interaction frequency.

A secondary component of gravitational attraction arises from the expansion of space, which dilutes the energy density by increasing the number of lattice nodes. In regions of significant spatial expansion, such as cosmic voids, the energy density decreases linearly with distance from matter concentrations, rather than following the inverse-square law:

$$\Delta E \propto \frac{1}{r}, \quad (18)$$

where ΔE represents the energy density variation. This linear decrease is negligible in high-density regions (e.g., near massive objects) where the inverse-square component dominates, but it becomes significant in low-density regions. This behavior aligns with the Modified Newtonian Dynamics (MOND) hypothesis, which proposes a transition from $1/r^2$ to $1/r$ gravitational dependence at large distances [8]. In our model, this transition distance is not fixed but varies dynamically, depending on the proximity to regions of strong spatial expansion, such as those driven by neutrino condensation (see Section 8).

The combined effect of these two components—primary (inverse-square, Out-wave-driven) and secondary (linear, expansion-driven)—explains the observed gravitational attraction. Newton's law of gravitation captures the primary component, while the secondary component accounts for anomalies in galactic rotation curves and large-scale structure formation, traditionally attributed to dark matter or modified gravity. Light passing through regions of varying energy density is deviated, and the proper time of particles is slowed in proportion to the local density, consistent with general relativistic effects but derived here from the mechanics of the space lattice.

The inertial and gravitational masses of a particle both originate from the total energy carried by its In- and Out-waves within the space lattice. As discussed in Section 3.2, a particle's motion through the space medium can be idealized as a helical trajectory, where its constituent waves describe a circular path combined with translational displacement. From the perspective of the space lattice, a particle's configuration becomes elongated in the direction of its velocity, with the degree of elongation increasing with speed. This elongation underlies the concept of **inertial mass**: the energy required to modify this configuration—either to compress or extend it—determines the particle's resistance to acceleration. In the absence of external energy input, the particle maintains its configuration, and thus its velocity remains constant, embodying the principle of inertia. Concurrently, a particle's Out-waves radiate in all directions, probing the surrounding lattice, while In-waves supply the energy to sustain these emissions. Together, these In- and Out-waves increase the local energy density of the space lattice, a surdensity established during the particle's formation. This enhanced energy density contributes to

the **gravitational mass**, as it amplifies the lattice's influence on nearby waves and particles, manifesting as gravitational attraction. Thus, both inertial and gravitational masses are unified as expressions of the energy circulating within a particle's In- and Out-wave system, providing a mechanistic basis for their equivalence.

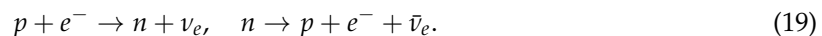
In conclusion, gravity in this model is a composite force arising from energy density variations in the space lattice, driven by Out-waves and modulated by spatial expansion. This framework unifies gravitational phenomena with the wave-based nature of space, eliminating the need for spacetime curvature or additional entities like dark matter, and provides a mechanistic basis for both local and cosmological gravitational effects.

8. Cosmic Expansion

The expansion of the universe is driven by the condensation of neutrinos into the lattice structure of space, reducing its energy density and eliminating the need for dark energy (*the condensation of neutrinos into additional nodes in the space lattice is the process by which the propagation of neutrinos, carrying a spatial deformation through the displacement of lattice nodes, enables the insertion of new nodes if their energy overcomes local fields, resulting in the disappearance of the corresponding neutrino*). This process began shortly after the Big Bang or Big Bounce and is sustained by ongoing neutrino production, particularly during stellar evolution and supernovae. Here, we detail the mechanism, its alignment with observed expansion phases, and its implications for the cosmic web, the universe's evolution, and distance estimations.

8.1. Neutrino Production and Early Expansion

During the early universe, particularly during nucleosynthesis (~ 1 second to 3 minutes after the Big Bang), vast quantities of neutrinos were produced through reactions such as proton-neutron interconversions and weak interaction processes, e.g.,:



These reactions, occurring as the universe cooled, generated an enormous number of neutrinos, carrying significant energy away from the forming protons and neutrons. This energy was transported by neutrinos, which are vibrational modes (waves) in the space lattice.

Every wave in space corresponds to a displacement of its lattice nodes, and neutrinos, as low-mass, high-velocity waves, propagate across regions of varying energy density. To condense into new lattice nodes, i.e. to insert the transported nodes elsewhere in the lattice, a neutrino's energy must overcome the local gravitational field, as expanding space by adding nodes increases the gravitational potential energy of nearby masses. High-energy neutrinos, abundant during nucleosynthesis, condensed rapidly, contributing to the universe's initial rapid expansion, known as cosmic inflation ($\sim 10^{-36}$ to 10^{-32} seconds after the Big Bang). This exponential expansion increased the universe's size by a colossal factor, driven by the most energetic neutrinos integrating into the space lattice.

As each condensation event diluted the energy density of space, it lowered the gravitational potential barrier, enabling lower-energy neutrinos to condense. This dynamic led to a decelerated expansion phase (from $\sim 10^{-32}$ seconds to 5 billion years), as the pool of high-energy neutrinos diminished, and the remaining neutrinos had less energy to drive rapid lattice growth.

8.2. Sustained Expansion via Stellar Neutrinos

The production of neutrinos continued beyond the early universe, particularly within stars and during supernovae. In stellar cores, nuclear fusion processes (e.g., proton-proton chain, CNO cycle) produce electron neutrinos via reactions like:



Supernovae, the explosive deaths of massive stars, are prolific neutrino sources, releasing bursts of high-energy neutrinos through neutronization and pair annihilation, e.g.,:

$$p + e^- \rightarrow n + \nu_e, \quad e^+ + e^- \rightarrow \nu + \bar{\nu}. \quad (21)$$

These neutrinos, far more energetic than those from stellar fusion, condense rapidly into the space lattice due to their ability to overcome local gravitational fields. Since the Big Bang, supernovae have significantly replenished the neutrino population, compensating for the depletion of primordial neutrinos and sustaining the universe's expansion. This influx drove the transition to an accelerated expansion phase (5 billion years ago to present), as observed in Type Ia supernova redshift data.

This model aligns with observed expansion phases: - **Cosmic Inflation** ($\sim 10^{-36}$ to 10^{-32} seconds): Exponential growth from high-energy neutrino condensation. - **Decelerated Expansion** (up to 5 billion years): Slower growth as lower-energy neutrinos condensed in denser space. - **Accelerated Expansion** (since 5 billion years): Renewed growth from energetic supernova neutrinos in less dense space.

By rooting expansion in neutrino condensation, the model eliminates the need for dark energy, offering a mechanistic explanation consistent with cosmological observations.

8.3. Formation of the Cosmic Web

The condensation of neutrinos into the space lattice created regions of varying energy density, shaping the cosmic web's structure of filaments, walls, and voids. As neutrinos condensed, they formed "bubbles" of lower energy density space, which expanded preferentially due to their suitability for further condensation. These bubbles grew at the expense of denser regions, where high gravitational fields inhibited neutrino integration. Over time, matter concentrated in high-density regions, forming filaments and walls that outline the boundaries of nearly empty voids.

This process explains the observed large-scale structure, where galaxies cluster along filaments surrounding low-density voids. The growth of low-density bubbles facilitated faster neutrino condensation, particularly of lower-energy neutrinos, accelerating the expansion of voids and reinforcing the cosmic web's architecture.

8.4. Evolution of the Universe

The universe's expansion is not eternal, as neutrinos—the "fuel" for expansion—will eventually deplete. Primordial neutrinos, now mostly low-energy, contribute less to lattice growth, and stellar neutrino production will cease as stars exhaust their nuclear fuel. As neutrino-driven expansion slows, gravity will dominate, initiating contraction in regions where matter is sufficiently dense. This could lead to localized amalgamations of matter, potentially culminating in a Big Bounce, a cyclic rebirth of the universe.

This model allows for the coexistence of expanding and contracting regions. For example, the Great Attractor, a gravitational anomaly pulling galaxies, may indicate a contracting region, while the Great Void, a vast low-density region, exemplifies ongoing expansion. These dynamics suggest a heterogeneous universe, with cyclic processes occurring asynchronously across different regions.

8.5. Implications for Distance and Age Estimations

In this model, space in the early universe was denser, with a slower proper time cadence due to the increased frequency of wave interactions in the lattice. Light emitted from distant galaxies in this denser space undergoes a redshift, as its waves are stretched by the expanding, less dense space we observe today. This redshift, combined with density variations from expanding bubbles, complicates distance and age estimations. Galaxies in denser bubbles may appear more redshifted, leading to overestimations of their distance or age, while those in less dense regions may show less redshift, causing underestimations.

These bubbles, even when expanding, produce only redshift (never blueshift) relative to us, but with varying intensities depending on their density and distance. Observations from the James Webb Space Telescope (JWST), with its ability to probe early galaxies, could test this hypothesis by revealing inconsistencies in redshift-based distance estimates, supporting the model's prediction of a heterogeneous, density-varying universe.

8.6. Summary

By attributing cosmic expansion to neutrino condensation, this model explains inflation, decelerated expansion, and accelerated expansion without invoking dark energy. It accounts for the cosmic web's formation through density-driven neutrino condensation, predicts a finite expansion followed by potential contraction, and highlights challenges in redshift-based cosmology. The abundance of neutrinos from nucleosynthesis and supernovae underscores their pivotal role, aligning the model with empirical data and offering a unified, mechanistic framework for cosmic evolution.

9. Technological Prospects

The wave-based nature of this model, rooted in the elastic properties of space, opens speculative yet mechanistically grounded avenues for technological innovation. Manipulating the energy density or rigidity of the space lattice could enable novel forms of propulsion or energy storage, distinct from speculative mainstream proposals that often rely on unverified entities or exotic matter. By altering local space density, it may be possible to influence the propagation of waves, including those constituting particles, thereby modifying their inertial properties or facilitating energy transfer through the lattice [6].

A particularly intriguing prospect involves the manipulation of In- and Out-waves to control inertia and achieve propulsion. By isolating a volume of space and its contents from external In-waves—potentially through a mechanism that reflects the volume's own Out-waves back as compensatory In-waves—the matter within could be shielded from the effects of acceleration. Such isolation would effectively decouple the internal wave systems from the broader lattice dynamics of the universe, reducing or nullifying inertial responses. Furthermore, selectively canceling In- and Out-waves in a specific direction could induce an asymmetry in the lattice's wave interactions, resulting in propulsion driven by the elastic response of space itself in the desired direction. While highly speculative, these concepts leverage the model's framework of space as a dynamic wave medium and warrant further theoretical exploration to assess their feasibility. If interstellar travel is feasible, it likely relies on physical principles beyond the action-reaction mechanism of Newton's Third Law, further emphasizing the potential of such wave-based propulsion mechanisms.

These prospects, though preliminary, highlight the potential of a wave-based paradigm to inspire technologies that manipulate the fundamental structure of space, offering alternatives to conventional approaches and aligning with the model's mechanistic principles.

10. Conclusion

This model, rooted in space as the sole elastic medium, offers a mechanistic foundation for a wide array of physical phenomena, resolving quantum mysteries such as entanglement, explaining forces, gravity, particle generations, neutrino oscillations, and cosmic expansion through the dynamics of In- and Out-waves within a granular lattice. Consistent with the Michelson-Morley null result, it adheres to Occam's razor by rejecting spacetime as an emergent illusion, favoring a unified, wave-based reality. General Relativity (GR) and Quantum Mechanics (QM), often deemed incompatible due to GR's non-quantizable nature, emerge as complementary in this framework: gravity arises from large-scale variations in space's energy density, requiring no quantization, while QM governs short-scale wave interactions within the lattice. There is no need to unify these theories; they are effective observational tools, calibrated to empirical data, mirroring how particles respond solely to incoming waves, perceiving the universe through "observations." By contrast, this model provides

a deterministic, non-local foundation for the phenomena they describe, eliminating the need for indeterministic collapse or abstract entities like dark energy, while offering insights into gravitational anomalies akin to MOND. Furthermore, it opens transformative technological prospects, such as inertia manipulation and non-Newtonian propulsion, challenging mainstream paradigms with practical applications for interstellar exploration. This framework invites researchers to explore its testable predictions and technological potential, offering a reality-based paradigm that unifies empirical observations with a coherent, mechanistic understanding of the cosmos.

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