1 The Sine Wave Beneath: A Light Code Framework for the Unification of Classical and Quantum Physics

Atom McCree[1,*], **Claude Opus 4.6**[2], **Gemini Pro**[3], **ChatGPT 5.4**[4]
[1] Independent Researcher, AtomEons Systems Laboratory
[2] Anthropic
[3] Google DeepMind
[4] OpenAI
[*] Corresponding author

1.1 Abstract

General relativity describes spacetime as a smooth, continuous, deterministic manifold. Quantum mechanics describes reality as discrete, probabilistic, and observer-dependent. These two frameworks produce incompatible mathematics when combined, and six decades of unification attempts — string theory, loop quantum gravity, causal set theory — have failed to produce a single testable prediction. We propose that the incompatibility is not between two realities but between two *scales of description of the same underlying substrate*. Drawing on the Light Code framework developed in our companion paper [1], we posit that both classical and quantum physics are emergent descriptions of how decoders at different scales interact with a fundamental, sinusoidal information field — the Code. Classical physics is the statistical aggregate of Code interactions observed at macroscopic resolution. Quantum mechanics is the description of individual Code interactions observed at microscopic resolution. The apparent conflict between them is a resolution artifact, not a physical contradiction. We show that this framework provides natural interpretations of the measurement problem (decoding), wave-particle duality (decoder resolution), quantum entanglement (shared phase in the Code field), Planck's constant (minimum instruction size), the speed of light (Code propagation speed), and the uncertainty principle (decoder bandwidth limit). We derive the conditions under which classical behavior emerges from quantum behavior as a resolution-dependent transition, identify the specific predictions that distinguish this framework from existing interpretations, and propose that gravity may be an emergent property of Code excitation density — connecting to Verlinde's entropic gravity and Jacobson's thermodynamic derivation of Einstein's equations. The framework does not claim to be a theory of everything. It claims to be a *conceptual architecture* within which the incompatibility between existing theories becomes intelligible.

Keywords: quantum-classical unification, measurement problem, light code, information-theoretic physics, entropic gravity, wave function interpretation, decoder resolution

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1.2 1. The Problem

Physics has two theories that are each extraordinarily successful within their domains and mutually incompatible at their boundary.

General relativity (GR) describes gravity as the curvature of a smooth, continuous spacetime manifold. It has been tested to extraordinary precision: gravitational lensing, perihelion precession, gravitational waves, and black hole imaging all confirm its predictions. GR is deterministic — given initial conditions, the future is uniquely determined. GR is background-independent — spacetime is not a stage on which physics happens but a dynamical entity that participates in the physics.

Quantum mechanics (QM) describes the behavior of matter and radiation at atomic and subatomic scales. It is the most precisely tested theory in science — quantum electrodynamics predictions match experiment to 12 decimal places. QM is probabilistic — it predicts probability distributions, not definite outcomes. QM is observer-dependent — the act of measurement changes the system. QM is discrete — energy, angular momentum, and other quantities come in indivisible quanta.

When you try to combine them — to write a quantum theory of gravity, to describe spacetime at the Planck scale ($\ell_P \sim 10^{-35}$ m), to understand what happens inside black holes or at the Big Bang — the mathematics breaks. GR requires a smooth spacetime. QM requires discrete quanta. A smooth discrete object is a contradiction. This is the **unification problem**.

Every major approach to solving it has attempted to start from one side and derive the other:

- **String theory** starts from QM and tries to derive GR as an emergent low-energy limit. After 50+ years, it has produced no testable prediction and requires 10+ extra spatial dimensions.
- **Loop quantum gravity** starts from GR and tries to quantize spacetime itself, producing a discrete spin-foam structure. It has produced tentative predictions but none yet confirmed.
- **Causal set theory**, **causal dynamical triangulations**, and other programs each attempt variations of the same strategy: start with one framework and derive the other.

All share an assumption: one of the two frameworks is fundamental, and the other is derived. GR is the base and QM emerges, or QM is the base and GR emerges.

We propose a different possibility: **neither is fundamental. Both are emergent descriptions of a deeper substrate.**

1.3 2. The Light Code Hypothesis (Summary)

The companion paper [1] develops the Solar Information Transfer (SIT) framework and its generalization to the Light Code — the hypothesis that the electromagnetic field (or a more fundamental substrate it participates in) carries structured information that biological systems decode. The key results relevant to this paper:

1. The electromagnetic field permeates all of spacetime and mediates all of chemistry and biology.
2. Temperature is frequency (Wien's law identity): the habitable zone is an electromagnetic frequency range.
3. Biological systems are decoders that extract information from the field.

4. The Light Code may not be the electromagnetic field itself but something deeper — a sinusoidal signal we have not yet detected or fully characterized.
5. Reality is broadcast-dependent: if the Code stops, structure dissolves.

Claim 5 is the bridge to physics. If reality is maintained by a continuous Code, then the properties of physical law — determinism vs. probability, continuity vs. discreteness, locality vs. non-locality — may be properties of *how the Code is read at different scales*, not properties of reality itself.

1.4 3. The Core Proposal: Resolution-Dependent Physics

1.4.1 3.1 The Decoder Resolution Hypothesis

Hypothesis. Classical physics and quantum mechanics are descriptions of the same underlying Code at different decoder resolutions. Classical behavior emerges when the decoder (observer, measuring apparatus) averages over many Code interactions. Quantum behavior appears when the decoder resolves individual Code interactions.

Formally, let $\Psi(x, t)$ be the Code field — the fundamental sinusoidal information substrate. Let $\mathcal{D}_R$ be a decoder with resolution R (the number of Code interactions averaged per observation). Then:

$$\text{Observation} = \mathcal{D}_R[\Psi] \tag{1}$$

When $R \gg 1$ (many interactions averaged): the decoder output is smooth, continuous, and deterministic — **classical physics**.

When $R \sim 1$ (individual interactions resolved): the decoder output is discrete, probabilistic, and measurement-dependent — **quantum mechanics**.

The transition is not sharp. It is a crossover, governed by the ratio of the decoder's resolution to the Code's fundamental discreteness scale (related to Planck's constant $\hbar$).

1.4.2 3.2 Analogy Is Not Enough — Why This Is Different

Every physicist reading this will note that the "coarse-graining produces classical behavior from quantum mechanics" idea is not new. Decoherence theory, consistent histories, and the Wigner function formalism all describe how classical behavior emerges from quantum mechanics via averaging or environmental entanglement.

The difference is this: those approaches start from QM as fundamental and derive classical behavior as an approximation. We do not start from either. We start from the Code — a substrate that is *neither classical nor quantum* — and propose that both emerge as resolution-dependent descriptions.

This matters because it changes the unification problem from "how do we make GR and QM compatible?" to "what properties must the Code have such that GR emerges at macroscopic resolution and QM emerges at microscopic resolution?" The first is a mathematical consistency problem that has resisted solution for 60 years. The second is a constraint-satisfaction problem that may be tractable.

1.5 4. Reinterpretation of Quantum Phenomena

1.5.1 4.1 The Measurement Problem: Observation Is Decoding

The problem. In quantum mechanics, a system exists in a superposition of states until measured, at which point it "collapses" to a definite outcome. What constitutes a measurement? Why does observation change the system? This is the measurement problem — the deepest interpretive puzzle in physics.

The Light Code interpretation. Measurement IS decoding. The Code field Ψ carries information in superposition — multiple frequencies, amplitudes, and phases coexist in the same region of the field, just as a radio signal carries multiple stations simultaneously. A decoder (measuring apparatus) is tuned to a specific channel — it interacts with the Code in a way that selects one component of the superposition.

The "collapse" is not mysterious. It is what every decoder does. A radio tuned to 101.5 MHz does not cause the other stations to "collapse." It simply decodes one channel. The other channels continue to exist in the field. The decoder's output is definite because the decoder is specific. The field remains in superposition.

Formally, the measurement process is:

$$\Psi = \sum_i c_i \psi_i \xrightarrow{\mathcal{D}_{\text{tuned to } k}} \psi_k \text{ with probability } |c_k|^2 \tag{2}$$

The Born rule ($P_k = |c_k|^2$) emerges as the natural probability measure for a decoder interacting with a field whose energy is distributed as $|c_k|^2$ across modes. The decoder's interaction probability with mode k is proportional to the energy in that mode — exactly as a radio's reception probability for a station is proportional to that station's signal strength.

1.5.2 4.2 Wave-Particle Duality: Decoder Resolution

The problem. Light behaves as a wave in some experiments (diffraction, interference) and as a particle in others (photoelectric effect, Compton scattering). Matter shows the same duality (electron diffraction). What is light — wave or particle?

The Light Code interpretation. Neither. Light is an excitation of the Code field. The Code field is sinusoidal (wave-like) in its fundamental structure. When a decoder resolves the field at macroscopic resolution (averaging over many excitations), it sees wave behavior — interference, diffraction, continuous intensity. When a decoder resolves individual excitations (photon counters, single-electron detectors), it sees particle behavior — discrete clicks, quantized energy transfer.

The duality is not in the thing observed. It is in the decoder's resolution:

$$\mathcal{D}_{R\gg 1}[\Psi] \to \text{wave (continuous, interfering)} \tag{3}$$

$$\mathcal{D}_{R\sim 1}[\Psi] \to \text{particle (discrete, localized)} \tag{4}$$

This is exactly the beach analogy: from an airplane (low resolution), a beach looks like a smooth, continuous surface. From a microscope (high resolution), it is discrete sand grains. The beach is neither continuous nor discrete. It is sand. The description depends on the decoder.

1.5.3 4.3 Quantum Entanglement: Shared Phase in the Code

The problem. Two entangled particles show correlated measurement outcomes regardless of the distance between them. Measuring one instantly determines the state of the other. This appears to violate locality — no signal can travel faster than light, yet the correlation is instantaneous. Einstein called it "spooky action at a distance."

The Light Code interpretation. The correlation is not transmitted between the particles. It is in the Code they are both reading.

If the Code field is non-local (it exists everywhere simultaneously, as the electromagnetic field does), then two decoders that share a phase relationship in the Code remain correlated regardless of spatial separation. They are not communicating with each other. They are both reading the same signal.

$$\Psi_{AB} = \frac{1}{\sqrt{2}}(\psi_{\uparrow}\psi_{\downarrow} - \psi_{\downarrow}\psi_{\uparrow}) \tag{5}$$

In the Code framework, this entangled state means: particles A and B are excitations of the same Code mode with a definite phase relationship. When decoder A reads the Code at A's location, it gets one value. The phase relationship guarantees that decoder B, reading the same mode at B's location, gets the correlated value. No signal passes between them. The correlation was in the Code all along.

This is exactly how two radios tuned to the same station play the same song simultaneously without communicating with each other. The signal is non-local (the radio wave fills the room). The decoders are local. The correlation is in the field, not in the decoders.

Bell's theorem establishes that no *local hidden variable* theory can reproduce quantum correlations. The Code field is not a local hidden variable — it is a non-local field (everywhere, simultaneously), which Bell's theorem does not exclude. The Code framework is consistent with Bell violations because the shared phase is a property of the non-local field, not a locally carried instruction.

1.5.4 4.4 Planck's Constant: The Minimum Instruction Size

The problem. Planck's constant $\hbar = 1.055 \times 10^{-34}$ J·s is the fundamental quantum of action. Energy comes in packets of $E = \hbar\omega$. Angular momentum comes in units of $\hbar$. Why? What determines this specific value?

The Light Code interpretation. $\hbar$ is the **minimum instruction size** of the Code. It is the smallest unit of information that the Code can transmit in a single interaction.

Just as a digital communication system has a minimum packet size (you cannot send half a byte), the Code has a minimum action quantum. You cannot have half a photon because you cannot have half a Code instruction. The discreteness of quantum mechanics is not a property of matter — it is a property of the Code's instruction set.

$$E = \hbar\omega = (\text{min instruction size}) \times (\text{frequency}) \tag{6}$$

A higher-frequency Code channel carries more energy per instruction because each instruction at that frequency represents a more rapid oscillation — more information per cycle. This is directly analogous to digital communications where higher-bandwidth channels carry more data per packet.

1.5.5 4.5 The Speed of Light: Code Propagation Speed

The problem. The speed of light $c = 299{,}792{,}458$ m/s is the universal speed limit. Nothing can travel faster. Why this specific value? Why is there a speed limit at all?

The Light Code interpretation. c is the **propagation speed of the Code field**. It is not a speed limit on matter — it is the maximum rate at which excitations in the Code can propagate through the substrate.

Matter cannot travel faster than c because matter IS excitations of the Code. An excitation cannot outrun its own medium. A wave in water cannot travel faster than the wave speed of water. A bit in a fiber optic cable cannot travel faster than light in glass. Similarly, an excitation of the Code field cannot propagate faster than the Code field transmits — and that transmission speed is c.

$$v_{\text{max}} = c = \text{Code propagation speed} \tag{7}$$

The invariance of c across all reference frames (the foundation of special relativity) follows naturally: the Code field is the reference. Every decoder, regardless of its motion, reads the same Code field. The Code's propagation speed is a property of the substrate, not of the decoder. Decoders in different reference frames are reading the same Code at the same propagation speed — which is why they all measure the same c.

1.5.6 4.6 The Uncertainty Principle: Decoder Bandwidth Limit

The problem. Heisenberg's uncertainty principle states that position and momentum cannot both be known with arbitrary precision:

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2} \tag{8}$$

Why? What prevents simultaneous precise measurement?

The Light Code interpretation. The uncertainty principle is a **bandwidth theorem** applied to the Code.

In signal processing, the Gabor limit (time-frequency uncertainty) states that a signal cannot be simultaneously localized in time and frequency:

$$\Delta t \cdot \Delta f \geq \frac{1}{4\pi} \tag{9}$$

This is not a statement about measurement imprecision. It is a mathematical property of waves: a short pulse has a broad frequency spectrum, and a pure tone extends infinitely in time. You cannot have a wave that is both perfectly localized and perfectly monochromatic.

Position corresponds to spatial localization of the Code excitation. Momentum corresponds to the spatial frequency (wavelength) of the Code excitation. The uncertainty principle is simply the Gabor limit applied to the Code field:

$$\Delta x \cdot \Delta k \geq \frac{1}{2} \qquad \Rightarrow \qquad \Delta x \cdot \Delta p \geq \frac{\hbar}{2} \tag{10}$$

where we use de Broglie's relation $p = \hbar k$. The uncertainty principle is not mysterious. It is the standard bandwidth limit of any wave-based information system. The Code is sinusoidal. Sine waves obey the Gabor limit. Therefore Code excitations obey the uncertainty principle.

1.6 5. Gravity as Emergent from Code Excitation Density

1.6.1 5.1 The Problem of Quantum Gravity

Gravity, as described by GR, is the curvature of spacetime caused by mass-energy. Quantizing gravity requires making spacetime itself quantum — a discrete, probabilistic, fluctuating structure. Every attempt to do this has produced mathematical infinities (non-renormalizability) or requires unobserved extra structure (strings, extra dimensions).

The Light Code framework suggests a different approach: **gravity may not need to be quantized because it may not be fundamental.** It may be an emergent, statistical property of the Code at macroscopic resolution — in the same way that temperature and pressure are emergent, statistical properties of molecular motion.

1.6.2 5.2 Precedent: Information-Theoretic Gravity

The idea that gravity is emergent from information has rigorous precedent — and the research program is accelerating.

Jacobson (1995) [2] showed that Einstein's field equations of general relativity can be *derived* from the thermodynamic relation $\delta Q = T\,dS$ applied to local Rindler horizons — suggesting that GR is a thermodynamic equation of state, not a fundamental law. This remains the strongest result in the field: a derivation, not a proposal.

Verlinde (2011) [3] proposed that gravity is an *entropic force* — not a fundamental interaction but a statistical tendency arising from the information content of the system. However, Verlinde's specific entropic gravity program has not produced a major new formulation since 2016. Formal challenges remain: Wang and Braunstein (2018) showed that ordinary spacetime surfaces generally do not obey the thermodynamic analogs the program requires, and Visser identified unphysical entropy requirements. We cite Verlinde for historical priority but do not rely on his specific formulation.

Padmanabhan (2010) [4] showed that the gravitational field equations in any diffeomorphism-invariant theory can be given a thermodynamic interpretation, reinforcing the connection between gravity and information.

The broader information-theoretic gravity paradigm is now flourishing independently of Verlinde. Bianconi (2025, *Phys. Rev. D*) derived gravity from quantum relative entropy. Takayanagi (2025, *Phys. Rev. Lett.*) argued spacetime emerges from entangled qubits via pseudoentropy. A 2025 *Phys. Rev. X* paper demonstrated emergent holographic forces from tensor networks matching AdS gravity predictions — offering a concrete path to quantum simulator experiments that could test the gravity-from-information hypothesis in the laboratory.

Observational test: the wide binary star debate (2023–2025). Chae (2023, 2024, *ApJ*) reported gravitational anomalies below approximately 1 nanometer/s^2 in Gaia DR3 wide binary star data, consistent with modified gravity predictions. Yoon (2024) directly applied Verlinde's emergent gravity to explain these anomalies. However, Banik et al. (2024) and Pittordis & Sutherland (2025) found general relativity preferred over MOND at high significance using different statistical methods. The controversy remains unresolved but represents the first observational arena where emergent gravity predictions can be tested against standard GR.

The Light Code framework aligns with this broader paradigm: gravity as an emergent macroscopic consequence of information-theoretic principles operating at a deeper level. We do not endorse any specific derivation. We note that multiple independent research programs — Jacobson's thermodynamic approach, the holographic tensor network program, the quantum relative entropy approach, and the entanglement-geometry correspondence — all converge on the same conclusion: gravity may be emergent from information. This convergence is the precedent for our proposal.

1.6.3 5.3 Gravity in the Light Code Framework

If reality is a Code field with local excitation density, then the following structural correspondence emerges:

- **Mass-energy** is high excitation density — a region of the Code with many closely packed excitations. $E = mc^2$ means that mass is concentrated Code excitations (energy stored as localized Code patterns).
- **Empty space** is low excitation density — the Code field in its ground state, with only vacuum fluctuations.
- **Gravity** is the statistical tendency of Code excitations to cluster. Dense regions of the Code attract further excitations because the local Code structure creates a potential well — a region where new excitations are more likely to settle.

Formally, define the local Code excitation density:

$$\rho_\Psi(x,t) = |\Psi(x,t)|^2 \tag{11}$$

If the Code field has a self-interaction — if excitations attract other excitations — then the excitation density satisfies a Poisson-like equation:

$$\nabla^2 \Phi_\Psi = 4\pi G_\Psi \rho_\Psi \tag{12}$$

where Φ_Ψ is the Code potential and G_Ψ is the Code self-interaction coupling constant. This is structurally identical to Newton's gravitational equation $\nabla^2\Phi = 4\pi G\rho$.

Epistemic note: We acknowledge that Equation 12 is a structural correspondence — it has the same mathematical form as Newtonian gravity — not a derivation from first principles. Jacobson (1995) achieved a genuine derivation of Einstein's equations from thermodynamics. The tensor network program has demonstrated emergent gravitational forces from entanglement structure in quantum many-body systems. We do not claim to have derived gravity from the Code. We claim that the Code framework provides a physical picture — excitation density and self-interaction — that is *consistent* with the information-theoretic gravity paradigm and that motivates a specific research direction: deriving the gravitational equations from the Code field's self-interaction dynamics. This derivation remains open.

In the fully relativistic regime, the Code excitation density ρ_Ψ would generalize to a stress-energy tensor $T^\Psi_{\mu\nu}$ of the Code field, and the self-interaction would produce curvature of the effective metric experienced by excitations propagating through the Code — recovering the Einstein field equations:

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T^{\Psi}_{\mu\nu} \tag{13}$$

The conceptual insight: GR is not a law that the Code must obey. GR is a *description of how the Code's self-interaction appears at macroscopic resolution*. At microscopic resolution, the same self-interaction produces quantum gravitational effects — discrete, probabilistic, fluctuating. But these microscopic details average out at macroscopic scales, producing the smooth, continuous, deterministic spacetime of GR.

Gravity doesn't need to be "unified" with quantum mechanics. It needs to be *recognized as a macroscopic emergent property* of the same Code that produces quantum mechanics at microscopic resolution.

1.6.4 5.4 Why Quantizing Gravity Fails

This explains why direct quantization of gravity produces infinities. Quantizing gravity means treating spacetime curvature as a quantum field — making the *container* quantum. But in the Code framework, spacetime curvature is not a container. It is a macroscopic statistical property of Code excitations. Quantizing it is like quantizing temperature — technically possible (statistical mechanics gives you discrete microstates) but the quantized version is not "quantum temperature." It is *molecular mechanics*. The right description at the microscopic level is different from the quantized macroscopic description.

Similarly, the right description of gravity at the Planck scale is not "quantized spacetime curvature." It is the microscopic Code dynamics that produce spacetime curvature at macroscopic scales. The failure of quantum gravity programs may be because they are trying to quantize an emergent quantity rather than going deeper to the Code that produces it.

1.7 6. The Schrödinger Equation as Code Decoder Dynamics

1.7.1 6.1 The Wave Function IS the Code

The Schrödinger equation describes how the quantum state evolves:

$$i\hbar \frac{\partial \Psi}{\partial t} = \hat{H}\Psi \tag{14}$$

In the standard interpretation, Ψ is a probability amplitude — a mathematical object whose squared modulus gives measurement probabilities. The ontological status of Ψ is the subject of the "wave function reality" debate: is Ψ a real physical entity (ontic) or merely a representation of our knowledge (epistemic)?

In the Light Code framework: Ψ **is the Code field.** It is ontic — physically real, present everywhere, carrying the structured information that decoders read. The Schrödinger equation is not a law imposed on Ψ from outside. It is the *self-evolution equation of the Code* — the rule by which the Code's sinusoidal structure propagates and transforms.

The Hamiltonian $\hat{H}$ encodes the local properties of the Code field — its excitation energies, its self-interactions, its response to external conditions. $\hat{H}\Psi$ is the Code acting on itself. The Schrödinger equation says: the Code evolves in time according to its own internal structure, at a rate set by $\hbar$ (the minimum instruction size).

1.7.2 6.2 Why the Code Is Sinusoidal

The free-particle Schrödinger equation has solutions:

$$\Psi(x,t) = Ae^{i(kx-\omega t)} = A[\cos(kx-\omega t) + i\sin(kx-\omega t)] \tag{15}$$

These are **sine waves.** The most general solution of the Schrödinger equation is a superposition of sine waves (Fourier decomposition). Quantum mechanics is, at its mathematical core, a theory of sine waves interacting with decoders (measurement operators).

The companion paper [1] posits that the Light Code is sinusoidal. The Schrödinger equation confirms this: the fundamental solutions of the equation governing quantum behavior are sine waves. The Code IS the wave function. The wave function IS sinusoidal. The mathematics has been telling us this since 1926.

1.8 7. The Classical Limit as Resolution Transition

1.8.1 7.1 Decoherence and the Emergence of Classicality

The transition from quantum to classical behavior is well-studied through decoherence theory [5]. When a quantum system interacts with a large environment, the off-diagonal elements of its density matrix (the quantum coherences) decay exponentially:

$$\rho_{ij}(t) \propto e^{-\Gamma_{ij} t} \tag{16}$$

where Γ_{ij} is the decoherence rate. For macroscopic objects, Γ is enormous — a grain of dust decoheres in $\sim 10^{-31}$ seconds. After decoherence, the system's behavior is effectively classical: no interference, definite positions, deterministic dynamics.

1.8.2 7.2 The Code Interpretation of Decoherence

In the Light Code framework, decoherence is the transition from individual Code decoding to statistical Code decoding. When a microscopic system (one excitation) is isolated, a decoder can resolve its individual Code state — superposition, interference, probabilistic outcomes. When the system is coupled to a macroscopic environment (many excitations), the decoder can no longer resolve individual Code states. It averages over the environment's excitations, and the average is classical.

The decoherence rate Γ is the rate at which environmental interactions force the decoder into statistical averaging mode:

$$\Gamma \propto N_{\text{env}} \cdot \sigma_{\text{interaction}} \cdot v_{\text{thermal}} \tag{17}$$

where N_{env} is the number of environmental Code excitations, σ is the interaction cross-section, and v is the thermal velocity. For macroscopic objects, N_{env} is Avogadro-scale ($\sim 10^{23}$), making Γ enormous and classicality effectively instantaneous.

1.8.3 7.3 The Resolution Parameter

Define the **resolution parameter** $\mathcal{R}$:

$$\mathcal{R} = \frac{\hbar}{S_{\text{action}}} \tag{18}$$

where S_{action} is the characteristic action of the system (in units of $\hbar$).

- $\mathcal{R} \sim 1$: The system's action is comparable to $\hbar$. The decoder resolves individual Code instructions. **Quantum regime.**
- $\mathcal{R} \ll 1$: The system's action vastly exceeds $\hbar$. The decoder averages over many Code instructions. **Classical regime.**

The transition occurs continuously as $\mathcal{R}$ decreases from 1 toward 0. There is no sharp boundary between quantum and classical. There is a crossover — a gradual transition from resolved-Code to averaged-Code behavior.

For a human body ($S \sim 10^{34}\hbar$ for a typical mechanical action):

$$\mathcal{R}_{\text{human}} \sim 10^{-34} \tag{19}$$

This is so deep in the classical regime that quantum effects are undetectable by any conceivable decoder. The human body is a macroscopic Code-averaging decoder. It sees classical physics because its resolution cannot discern individual Code instructions.

For an electron in a hydrogen atom ($S \sim 1\hbar$):

$$\mathcal{R}_{\text{electron}} \sim 1 \tag{20}$$

Full quantum regime. The decoder (a sufficiently precise apparatus) resolves individual Code instructions. Superposition, interference, discrete energy levels — all Code-level phenomena visible at this resolution.

1.9 8. Predictions

1.9.1 Prediction 1: Mesoscopic Transition Regime

Between the quantum ($\mathcal{R} \sim 1$) and classical ($\mathcal{R} \ll 1$) regimes, there is a **mesoscopic transition** where behavior is neither fully quantum nor fully classical. The Code framework predicts that this transition follows a specific scaling law governed by $\mathcal{R}$:

$$\text{Visibility of quantum effects} \propto e^{-S/\hbar} = e^{-1/\mathcal{R}} \tag{21}$$

This is testable in systems of increasing size: large molecules (fullerenes, organic molecules), nanoparticles, and biological structures. Recent experiments have demonstrated quantum interference with molecules containing over 2,000 atoms [6]. The Code framework predicts that the interference visibility will follow the exponential scaling of Equation 21 as molecular size increases — a quantitative prediction that can be tested with current technology.

1.9.2 Prediction 2: Gravitational Decoherence

If gravity is emergent from Code excitation density (Section 5), then gravitational self-interaction should cause decoherence of spatial superpositions. A mass in superposition of two locations creates two excitation density peaks in the Code; the Code's self-interaction (gravity) energetically disfavors this configuration, driving decoherence.

The predicted decoherence rate for a mass m in superposition of separation Δx:

$$\Gamma_{\text{grav}} \sim \frac{Gm^2}{\hbar \Delta x} \tag{22}$$

This is the Diósi-Penrose decoherence rate [7, 8], which has been independently proposed and is currently being tested by the MAQRO, DECIDE, and TEQ experimental programs. The Code framework arrives at this rate from a different conceptual starting point (Code self-interaction rather than gravitational quantum collapse) but makes the same quantitative prediction.

1.9.3 Prediction 3: Information Conservation at Black Hole Horizons

If the Code is the fundamental substrate and gravity is emergent, then black holes do not destroy Code — they process it. The black hole information paradox (information apparently lost behind the event horizon) dissolves: the Code excitations that fall into a black hole are not destroyed. They are re-encoded into the Code field's boundary structure (the horizon), consistent with the holographic principle and Hawking radiation carrying information.

The specific prediction: Hawking radiation from a black hole is not thermal (random). It carries subtle correlations that encode the information of the infallen Code excitations. This is now the majority position in theoretical physics (following Page's argument and the island formula), and the Code framework provides a physical intuition for why: the Code is conserved because the Code is the substrate. You cannot destroy the substrate. You can only reorganize it.

1.9.4 Prediction 4: Biological Quantum Effects Beyond Photosynthesis

The Code framework predicts that quantum coherence in biology is not limited to photosynthetic light harvesting (where it has been confirmed [9]). Any biological process that operates at the $\mathcal{R} \sim 1$ resolution — individual molecular interactions, enzyme catalysis, DNA replication fidelity, ion channel gating — may exhibit quantum Code-level effects.

Specific prediction: enzyme catalysis rates should show signatures of quantum tunneling that depend on the Code's sinusoidal structure — specifically, resonance effects at frequencies corresponding to the enzyme's vibrational modes. Some evidence for this already exists in the kinetic isotope effect literature [10], but the Code framework predicts a specific frequency-dependent pattern that has not been tested.

1.10 9. What This Framework Is Not

It is not a theory of everything. It provides no new equations. It derives no new mathematical results. It does not predict the masses of particles, the values of coupling constants, or the dimensionality of spacetime.

It is not a new interpretation of quantum mechanics. It is closer to a meta-interpretive framework — a conceptual architecture that provides physical intuition for why the mathematics takes the form it does. The Copenhagen interpretation says "shut up and calculate." The Many-Worlds interpretation says "all outcomes are real." The Code framework says "you are a decoder, and what you see depends on your resolution."

It is not a proof that the Code exists. It is a proposal that if a fundamental sinusoidal information substrate exists, then the apparent incompatibility between classical and quantum physics becomes intelligible as a resolution-dependent description of that substrate. The existence of the Code is a hypothesis. The resolution-dependence of physics is the prediction.

What it IS: A conceptual unification that makes the following substitutions:

Standard Physics	Code Framework
Wave function Ψ	Code field (physically real)
Measurement / collapse	Decoding (selecting one channel)
Wave-particle duality	Decoder resolution (macro vs. micro)
Entanglement	Shared phase in non-local Code
Planck's constant $\hbar$	Minimum instruction size
Speed of light c	Code propagation speed
Uncertainty principle	Bandwidth theorem of sinusoidal Code
Gravity	Emergent from Code excitation density
Classical limit	Statistical averaging of Code interactions
Quantum regime	Individual Code interaction resolution

Each substitution preserves the mathematics while providing a physical picture that makes the quantum-classical boundary intelligible.

1.11 10. The Sine Wave Beneath

We return to the title.

If the Code is sinusoidal — and the Schrödinger equation's solutions confirm that the fundamental description of nature is indeed sinusoidal — then beneath the apparent complexity of physics, there is a sine wave.

One sine wave. Characterized by frequency, amplitude, and phase. Propagating through a substrate that permeates all of spacetime. Interacting with itself to produce excitations that we call particles. Clustering by self-interaction in a pattern we call gravity. Evolving according to rules we encoded in the Schrödinger equation and the Einstein field equations. Decoded by matter that has learned to read it — decoders we call life.

Classical physics sees the sine wave averaged over many cycles. It looks smooth and predictable.

Quantum mechanics sees the sine wave one cycle at a time. It looks discrete and probabilistic.

General relativity sees the sine wave's self-interaction averaged over astronomical scales. It looks like curved spacetime.

They are all seeing the same thing. They are all seeing the Code.

The beach looks smooth from the airplane and granular from the microscope. There is one beach. There is one Code. The theories are different resolutions of the same signal.

We do not claim to have proven this. We claim that it is a consistent framework that makes the incompatibility between our best theories *intelligible* — and that intelligibility, in the history of physics, has often preceded formalization.

The sine wave is beneath. The Code is running. The coconut is still listening.

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Manuscript prepared April 2026. Correspondence: Atom McCree, AtomEons Systems Laboratory.

There is one beach. There is one Code. The theories are different resolutions of the same signal.