Abstract

We propose a new theoretical framework, Information-Triggered Collapse (ITC), which suggests that quantum wavefunction collapse occurs when the information content or complexity of a quantum system and its environment reaches a critical threshold. This idea is motivated by the growing recognition of information as a fundamental physical quantity, as seen in concepts like Wheeler's "it from bit" [1], Bekenstein's bound [2], and Quantum Darwinism [3]. We review the intellectual backdrop that supports an information-based approach to the measurement problem, including key contributions from Landauer, Zurek, and Grinbaum. We then outline the formal postulates of ITC, defining an intrinsic informational threshold for quantum state reduction and offering a heuristic motivation for the Born rule from algorithmic information theory. While ITC is inspired by established physics, its core hypothesis—that collapse is triggered by a finite information threshold—remains untested and requires empirical verification. We discuss potential experimental tests, such as investigations into macroscopic superpositions and controlled information flow in quantum systems, which could either support or falsify the theory. If confirmed, ITC could provide new insights into the quantum-to-classical transition and have implications for quantum computing and the foundations of physics.

Information-Triggered Collapse (ITC): An Information-Theoretic Approach to Wavefunction Reduction

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1 Introduction

The measurement problem of quantum mechanics—how definite outcomes emerge from the continuum of quantum possibilities—remains one of the most persistent foundational challenges. Standard quantum theory postulates that a measurement causes the wavefunction to collapse probabilistically into an eigenstate, but offers no deeper dynamical explanation for this process. A growing theme in modern quantum foundations is the idea that information may be the key to bridging this gap between quantum potentiality and classical reality. John A. Wheeler's famous aphorism "it from bit" encapsulates the notion that every physical "it" (entity) fundamentally arises from binary information bits—yes/no questions asked of nature [1]. In Wheeler's participatory universe picture, reality is not wholly objective but is co-defined by the information content of observations: "*all things physical are information-theoretic in origin.*" This provocative viewpoint suggests that quantum state collapse might itself be an information-driven phenomenon.

Subsequent developments in physics have underscored profound links between information and physical law. In black hole thermodynamics, Bekenstein's bound limits the maximum entropy (information) that can be contained within a finite region of space with finite energy [2]. Landauer's principle establishes that the erasure of a single bit of information dissipates a minimum energy of $E_{\min} = k_B T \ln 2$ as heat [4]. Such results reinforce the sense that information is a physical quantity with real energetic and structural consequences. At the quantum–classical interface, Zurek's theory of Quantum Darwinism [3] has further sharpened the role of information: the emergence of classical reality is explained as a selection of stable "pointer states" via the proliferation of redundant information about the system throughout its environment. In essence, environment-induced decoherence coupled with the spread of information leads to an objective classical outcome that can be observed by many without further disturbance.

These developments motivate the central hypothesis of this paper: that **information itself could be the trigger for quantum collapse**. We propose that there exists an intrinsic threshold of information (or complexity) such that when a quantum system's state (including its entanglement with an environment) exceeds this threshold, the superposition can no longer sustain itself and collapses to a definite outcome. The collapse is thus an information-triggered phase transition in the quantum dynamics, rather than an ad hoc external projection. Crucially, this hypothesis could reconcile why everyday macroscopic systems (which rapidly generate large amounts of information via myriad interactions) appear to obey classical physics, while isolated microscopic systems can maintain quantum coherence.

The paper is organized as follows. In Sec. 2 we review prior work: Wheeler's "it from bit," physical information limits by Bekenstein and Landauer, the Quantum Darwinism paradigm, Grinbaum's algorithmic complexity criterion, the Diósi–Penrose gravitational collapse model, and the informational viewpoints of QBism and Relational Quantum Mechanics. Section 3 introduces the formal postulates of ITC, including a heuristic motivation of the Born probability rule from algorithmic information. In Sec. 4 we delineate experimental predictions and suggest how ITC might be falsified or constrained. Section 5 discusses implications for quantum foundations, quantum computing, and philosophy. Section 6 summarizes conclusions and open questions.

2 Prior Work and Theoretical Background

2.1 Wheeler's "It from Bit"

The seed of viewing quantum mechanics through an informational lens can be traced to John Archibald Wheeler's "it from bit" doctrine [1]. Wheeler suggested that physical reality at its core is comprised of information, writing that "*every it—every particle, every field of force, even the spacetime continuum itself—derives its function, its meaning, its very existence entirely—even if in some contexts indirectly—from the apparatus-elicited answers to yes-or-no questions, binary choices, bits.*" In this participatory view, an observer's posed yes/no query to nature (a bit) is what brings about an observable reality ("it"). Reality thus arises from a network of binary observations, and information is elevated to a fundamental ontological status. Wheeler's idea, though philosophical, set the stage for later theories tying quantum mechanics to information theory. It implies that wavefunction collapse could be related to the acquisition of definite information from a quantum system. In the context of ITC, Wheeler's insight encourages us to ask: could the act of acquiring a *certain amount* of information cause the quantum state to "firm up" into a single reality?

2.2 Bekenstein's Bound on Information Content

If information is fundamental, one must consider how much information a given physical system can contain. The **Bekenstein bound** provides just such a limit: the maximum entropy S (informational content, in bits via $H = S/(k_B \ln 2)$) of a system with energy E confined to a sphere of radius R is finite [2]:

$$S \leq \frac{2\pi\, k_B\, R\, E}{\hbar\, c}. \tag{1}$$

In quantum field theory, naive "entropy in a region" definitions are UV-divergent; careful formulations use vacuum-subtracted entropies and relate the bound to positivity of relative entropy (and associated modular Hamiltonians) [5]. More recent analyses show that the validity and operational meaning of Bekenstein-type bounds depend sensitively on how one defines the system, its entropy, and the reference vacuum. In this work the bound is therefore used only as a heuristic indication that some notion of information capacity is finite, not as a rigorously derived dynamical law.

It does not, by itself, imply that coherent superpositions "cannot exist"; rather, it motivates the idea that any collapse criterion framed in terms of information must specify which operational information is being counted and under what physical assumptions the bound applies. In an ITC perspective, one might suspect that if a superposed state tried to carry more information than allowed by Bekenstein's bound, it would collapse or decohere, effectively "pruning" the overgrown state to respect the limit. Bekenstein's bound thus provides inspiration for an informational collapse criterion: the wavefunction may self-reduce when its Shannon entropy (or algorithmic information) reaches a maximal value determined by physical parameters of the system.

2.3 Landauer's Principle and Information Cost

Closely related to the Bekenstein bound in spirit is **Landauer's principle**, which connects information theory with thermodynamics [4]. In its most famous form, erasing one bit of information costs a minimum energy $E_{\min} = k_B T \ln 2$ dissipated as heat at temperature T. Equivalently, resetting a memory register increases the entropy of the environment by at least $\Delta S = k_B \ln 2$. This principle has been experimentally verified to high precision: Bérut et al. performed the first direct test using a colloidal particle in an optical trap [6]; Jun, Gavrilov and Bechhoefer achieved higher precision using a feedback trap [7]; Hong et al. tested it in nanomagnets [8]; and Yan et al. confirmed it in a quantum system (trapped ion) [9].

Landauer's principle bounds the minimal work cost of logically irreversible operations—most notably the erasure/reset of a memory register—rather than implying that every act of measurement or correlation-formation must dissipate $k_B T \ln 2$ as heat. Measurement and recording can, in principle, be implemented reversibly; the unavoidable thermodynamic cost typically enters when one resets or compresses the device's memory. More importantly, Landauer's principle suggests a **directionality**: processes that increase entropy can *destroy* information (e.g. decoherence), whereas processes that *gain* information must pay an energy/entropy price.

In the context of collapse, one might conjecture that as a quantum superposition spreads and entangles with an environment, at some point the cost of further information proliferation triggers a transition. This extrapolates Landauer's erasure bound well beyond its proven domain: no existing theorem links information gain or mere entanglement directly to collapse, so ITC treats this as a speculative physical analogy rather than a consequence of Landauer's principle. Collapse then ensues, accompanied by the dissipation of the system's quantum uncertainty as thermodynamic entropy in the environment.

2.4 Quantum Darwinism and Redundant Information

Quantum Darwinism (QD), developed by Zurek and colleagues [3], describes how the classical world arises from the quantum substrate via the selective proliferation of information. The environment plays the role of a communication channel that carries imprints of the quantum system's state. Many fragments of the environment redundantly encode the state of the system; only certain preferred **pointer states**—robust against decoherence—can survive this imprinting. QD thus explains effective collapse as a result of decoherence plus amplification of information.

Zurek has argued, using an "environment-assisted invariance" principle (envariance), that the probabilities of outcomes follow the usual $|\psi|^2$ weighting [10, 11]. This derivation remains debated—Schlosshauer and Fine have identified implicit assumptions that some view as equivalent to the Born rule itself [12]—but envariance nonetheless provides an important information-theoretic route to quantum probabilities. The ITC theory is compatible with QD, but goes a step further in positing a concrete criterion for *when* the quantum-to-classical transition happens: when the informational redundancy or acquired information exceeds a threshold I_c.

Experiments have begun to support QD. Unden et al. demonstrated that information about a nitrogen-vacancy center's electron spin becomes redundantly encoded in nearby ^{13}C nuclear spins [13]. Additional tests include photonic demonstrations [14] and superconducting circuits [15].

2.5 Grinbaum's Algorithmic Complexity Criterion

Alexei Grinbaum has proposed a perspective that explicitly invokes **algorithmic complexity** in defining when a quantum system's behavior becomes effectively classical [16]. He introduces a condition based on Kolmogorov complexity that yields an observer-independent *element of reality*: any physical system that is to be considered an objective element of reality must have a description that is simple enough to be identical for all observers who are not too dissimilar. To formalize this, he defines observers as *system identification algorithms* and imposes a condition on the growth of Kolmogorov complexity across a family of observers. Grinbaum also entertained the **universal observer hypothesis** (tracing the idea back to Everett, 1957): that even a very small system with memory could serve as a "quantum observer" if it meets the information-theoretic requirements.

Strictly speaking, Kolmogorov complexity is uncomputable and depends on the chosen description language; here it is used as a conceptual proxy rather than an operationally measurable quantity. The collapse in ITC can be viewed as a dynamical enforcement of a complexity criterion—when $K(\psi)$ exceeds some critical value K_c, the state reduces to a simpler mixture or eigenstate.

2.6 The Diósi–Penrose Gravitational Collapse Model

Another instructive comparison for ITC is the **Diósi–Penrose (DP) objective collapse model**, which posits that superpositions collapse when the *gravitational self-energy* difference between the superposed states reaches a critical threshold [17, 18]. Specifically, Penrose argues that superpositions of two mass distributions differing by gravitational self-energy ΔE_G will collapse on a timescale $\tau \sim \hbar/\Delta E_G$. Like ITC, the DP model introduces a physical threshold—in its case gravitational rather than informational—beyond which superpositions become unsustainable. The DP model has been subjected to experimental tests, most notably through optomechanical proposals and spontaneous radiation searches [19]. One could speculate that in a regime where gravitational self-energy and information content are correlated (e.g., more massive objects encode more spatial information in their superposition), the DP and ITC thresholds may be related—a connection worth exploring in future work.

(Note: Other speculative information-threshold or entropy-gradient mechanisms for collapse have recently been proposed in the literature, including deterministic models driven by local entropy landscapes. These remain largely unverified and lack peer-reviewed experimental support compared to the stochastic frameworks discussed above; they are not treated further here, but their existence illustrates the breadth of current interest in information-based collapse.)

2.7 QBism and Relational Quantum Mechanics

Not all information-based interpretations posit objective collapse; some instead reconceptualize what the quantum state *is*. The brief sketches here follow the standard expositions and are intended only to set conceptual context.

QBism, championed by Fuchs, Mermin, and Schack [20, 21], interprets the wavefunction as an expression of an agent's subjective beliefs about measurement outcomes. Collapse is literally Bayesian updating—no physical "jump" occurs. As Fuchs puts it: "*Whose information?*" — "*Mine!*" — "*Information about what?*" — "*The consequences (for me) of my actions upon the physical system!*" The significance for ITC is mostly philosophical: QBism reminds us that collapse can be seen as information processing.

Relational Quantum Mechanics (RQM), proposed by Rovelli [22], posits that the values of quantum variables are always relative to some observing system. Rovelli writes: "*all systems are assumed to be equivalent, there is no observer-observed distinction, and the theory describes only the information that systems have about each other.*" ITC can be seen as adding a quantitative criterion to RQM: beyond a certain cumulative information, a fact becomes objective (relative to *all* observers), and that is when a global collapse occurs.

In summary, QBism and RQM reinforce that quantum mechanics is deeply concerned with information and its distribution. ITC attempts to embed an objective collapse mechanism into this information-centric worldview.

3 Information-Triggered Collapse: Theoretical Framework

3.1 Postulates and Quantum Dynamics with ITC

We formulate ITC as a set of modifications to the standard quantum postulates.

1. **State Space and Unitary Evolution (Unmodified).** Physical systems are described by state vectors in a Hilbert space $\mathcal{H}$ (or density operators on $\mathcal{H}$). In the absence of a collapse-triggering condition, the state $|\Psi(t)\rangle$ evolves according to $i\hbar\frac{d}{dt}|\Psi\rangle = \hat{H}|\Psi\rangle$.

2. **Information Measure.** We associate to each quantum state $|\Psi\rangle$ an information measure $I(|\Psi\rangle)$, intended to quantify the total information content or complexity of the state. While Kolmogorov complexity $K(\Psi)$ provides a rigorous theoretical upper bound on description length, it is formally uncomputable. For operational purposes, we propose that $I(|\Psi\rangle)$ be approximated by the von Neumann entropy of

the reduced density matrix (entanglement entropy) or the quantum mutual information between the system and its environment. For a pure state $|\Psi\rangle = \sum_i c_i |u_i\rangle$, one can define

$$I(|\Psi\rangle) = -\sum_i p_i \log_2 p_i \,, \qquad p_i = |c_i|^2 \,, \tag{2}$$

the Shannon entropy of the state's probability distribution in the preferred basis. We only require that $I(|\Psi\rangle)$ increases with the number of effectively distinguishable outcomes.

3. **Informational Threshold Postulate.** There exists a critical information content I_c (which may be a fundamental constant of nature or a function of system parameters such as mass, volume, or energy density—analogous to the mass-proportional coupling in CSL models) which we call the **collapse threshold**. Its precise form is an open question for the theory. If $I(|\Psi(t)\rangle)$ remains below I_c, quantum evolution is entirely unitary. **When $I(|\Psi(t)\rangle) \geq I_c$, a dynamical collapse is induced**, projecting the state onto a substate of significantly lower information content.

4. **Collapse Dynamics.** When $I = I_c$ is reached, the unitary dynamics is interrupted by a stochastic reduction. The collapse selects outcome $|u_j\rangle$ with probability $\Pr(j) = f(p_j, K_j)$, where we will argue for $f(p_j, K_j) = p_j$ (the Born rule) by invoking a principle of minimal algorithmic information (Sec. 3.2). The collapse is assumed to be instantaneous (or very rapid) and non-unitary.

5. **Preferred Basis and Environment Coupling.** The preferred basis is determined by the dynamics of information acquisition—the **pointer basis** of the system as defined by its coupling to the environment [23]. ITC does not pick an a priori fixed basis; like decoherence, it emerges from the interaction context.

These postulates modify standard quantum theory only when a state becomes very complex. Most microscopic experiments produce $I(|\Psi\rangle) \ll I_c$, so ITC predicts no deviation. Macroscopic superpositions produce enormous I, so ITC predicts rapid collapse.

ITC has similarities to GRW [24] and CSL in that it introduces a new process breaking unitarity. However, unlike GRW (with collapse rate $\lambda \sim 10^{-16}\,\mathrm{s}^{-1}$ per particle), ITC uses information content as the trigger. Superluminal signaling is prevented because observers cannot choose to exceed the threshold in one branch versus another; the outcomes are random. Consistency with special relativity is maintained via the No-Communication Theorem.

3.2 Heuristic Motivation of Born's Rule from Algorithmic Complexity

One of the most important requirements is that ITC reproduces Born's rule $P_i = |c_i|^2$ to high accuracy, since Born's rule has been confirmed in stringent tests of higher-order interference [25, 26]. This heuristic motivation is inspired by Zurek's envariance [11] and Solomonoff's universal prior [27], but tailored to ITC.

Suppose $|\Psi\rangle = \sum_i c_i |u_i\rangle$ has reached I_c. Each branch $|u_i\rangle$ has algorithmic information content K_i. The **universal a priori probability** (Solomonoff–Levin distribution) assigns to any bitstring x a probability approximately $P(x) \propto 2^{-K_U(x)}$ (more precisely, via Levin's Coding Theorem, $-\log_2 M(x) = K(x) + O(1)$). Simpler outcomes are exponentially more likely a priori.

A natural hypothesis is that the probability of a given branch is proportional to 2^{-K_i}. However, the amplitudes c_i already encode much of the needed information. The *effective complexity* of a branch includes the Shannon self-information $\ell_i = -\log_2 p_i$ (the "surprise" of outcome i). If Nature minimizes the algorithmic complexity of the realized world, it biases outcomes by a factor $2^{-\ell_i} = p_i$. Multiplying the intrinsic and coding-theoretic factors:

$$P(i) \;\propto\; 2^{-K_i} \cdot p_i \,. \tag{3}$$

If the intrinsic complexities K_i are not wildly different (as in typical experiments where all outcomes are macroscopically similar), then 2^{-K_i} is approximately constant and can be absorbed into normalization:

$$P(i) \;\propto\; p_i = |c_i|^2 \,, \tag{4}$$

which is the Born rule.

We note an important subtlety: interpreting $-\log_2 p_i$ as a "surprise" inherently presumes $|c_i|^2$ acts as a prior probability weight, which is precisely what we are trying to motivate. However, treating the quantum amplitude-squared as a fundamental *pre-measure of informational volume*—analogous to the Haar measure on state space—allows us to map the state to an optimal prefix-free code. This reasoning is thus best understood as a consistency argument rather than a logically independent derivation.

Under a typicality assumption—where the intrinsic descriptive complexities K_i of macroscopically distinct branches are not systematically correlated with their Born weights p_i—the factor 2^{-K_i} becomes approximately constant, yielding $P(i) \propto |c_i|^2$. This aligns with Zurek's envariance derivation [11], providing an independent information-theoretic route to the Born rule.

In summary, algorithmic probability and quantum probability coincide up to details of branch complexity:

$$P(i) = \frac{2^{-K_i}}{\sum_j 2^{-K_j}} \approx \frac{|c_i|^2}{\sum_j |c_j|^2} = |c_i|^2 \,. \tag{5}$$

3.3 Collapse as an Informational Phase Transition

The wavefunction's evolution can be understood as a **phase transition triggered by information**. When $I(|\Psi\rangle)$ is low, superposition is maintained (coherent phase). As I grows, the state approaches a critical point. At $I = I_c$, coherence between branches breaks down and the system "chooses" a branch (classical phase).

A crucial constraint on the mathematical formulation is that any modification to the Schrödinger equation must be *stochastic*: Gisin proved rigorously that deterministic nonlinear extensions inevitably allow superluminal signaling [28]. Using Itô calculus, the state evolution could be described by:

$$d\,|\Psi_t\rangle = \left[-\tfrac{i}{\hbar}\hat{H}\,dt - \tfrac{\gamma}{2}\,\Theta(I-I_c)\,(\hat{F}-\langle\hat{F}\rangle_t)^2\,dt + \sqrt{\gamma}\,\Theta(I-I_c)\,(\hat{F}-\langle\hat{F}\rangle_t)\,dW_t\right]|\Psi_t\rangle \;, \tag{6}$$

where Θ is the Heaviside step function turning on when $I > I_c$, $\hat{F}$ is the pointer observable, γ is a collapse rate parameter, and dW_t is a stochastic Wiener process. The stochastic noise term ensures the no-signaling theorem is respected while recovering Born rule statistics. In the pre-critical regime $\Theta = 0$ and we have normal Schrödinger evolution. For a relativistic extension, one could draw on Tumulka's framework [29].

A single isolated particle in a double-slit apparatus has $I \leq 1$ bit, far below I_c. Adding a macroscopic detector rapidly proliferates information, pushing I toward I_c and forcing collapse. ITC thus qualitatively agrees with decoherence theory but adds a quantitative threshold and an objective collapse.

4 Experimental Predictions and Tests

4.1 Macroscopic Superposition Tests

ITC Prediction 1: There is a maximum size/complexity of superposition that can be sustained. Matter-wave interferometry has observed interference with molecules comprising up to ∼2000 atoms (∼25,000 amu) [30], with no anomalous loss of coherence. This places a lower bound on I_c. Future experiments with 10^6 amu nanocrystals may push the bound further.

For ITC-relevant tests, one should create states with **volume-law entanglement** (e.g., highly scrambled outputs of deep pseudo-random circuits), where entanglement entropy scales linearly to $\sim N$ bits. A simple GHZ "cat state" $\frac{1}{\sqrt{2}}(|00\ldots0\rangle + |11\ldots1\rangle)$

has only 1 ebit of entanglement entropy across any bipartition regardless of N, so it would not trigger ITC in isolation. Current GHZ records are $\mathcal{O}(10^2)$ qubits [31].

ITC Prediction 2: Interference visibility or coherence time will drop precipitously when crossing the threshold—akin to a sharp phase transition. Experiments such as MAQRO [32] aim to detect spontaneous collapse at mesoscopic scales.

Multi-slit experiments have constrained any higher-order (third-order) interference term—quantified by the Sorkin parameter—to below $\sim 10^{-3}$ of expected pairwise interference [26], improving upon the earlier bound of 10^{-2} [25]. ITC respects these bounds because typical lab states have $I \ll I_c$.

4.2 Controlled Information Manipulation

ITC predicts that collapse triggered by exceeding I_c is effectively irreversible: reversibility would require reducing the informational entropy of the entire causally connected region below I_c—a thermodynamic impossibility. A quantum eraser experiment where sufficient information was recorded to trigger collapse should therefore show *no recovery* of interference, unlike standard QM predictions.

A more practical test could involve **weak measurements**. According to ITC, a series of weak measurements that cumulatively acquire information could trigger collapse when the total info crosses I_c, manifesting as a non-linear effect where information gathering has a memory.

4.3 Connection to Entropy and Thermodynamics

A collapsing wavefunction should produce a slight excess of entropy or energy in the environment. If ΔI bits of information are lost, then $\Delta E \geq k_B T_{\text{env}} \ln 2 \cdot \Delta I$ energy must be dumped into the environment. Existing experiments constraining CSL via X-ray emission from Germanium [19, 33] already limit the rate of such energy release. For ITC to remain viable, I_c must be sufficiently high that spontaneous emissions evade current detection limits.

Cosmological implications are also possible: if inflaton fluctuations underwent ITC collapse at horizon crossing, this could seed classical density perturbations.

Existing experiments place a lower bound on I_c that is quite high. Arndt et al.'s buckyball (C_{60}) interference [34] involves center-of-mass superposition entropy of $\sim$1 bit; future 10^9 amu tests could probe $I_c \approx 10^3$–10^6 bits if internal modes entangle. All evidence points to quantum mechanics being intact at these scales.

Table 1: Comparison of ITC with major objective collapse models and information-centric interpretations.

Model	Trigger	Objective?	Born Rule	Testability
GRW / CSL	Spontaneous per particle	Yes	Postulated	Radiation, optomech
Diósi–Penrose	Grav. self-energy	Yes	Postulated	Optomech., radiatio
ITC (this work)	**Info. threshold I_c**	**Yes**	**Heuristic**	**Macro. superpos.**
Quantum Darwinism	Redundant env. records	Effective	Via envariance	NV centers, photoni
QBism	Agent's belief update	No	Normative	N/A

5 Discussion and Implications

5.1 Resolution of the Measurement Problem

ITC offers a clear (if speculative) resolution: it posits an ontologically objective criterion—the information threshold I_c—that delineates when a measurement is completed. The Schrödinger cat paradox is resolved because a cat, by virtue of being a macroscopic information-rich system, will blow past I_c almost immediately. ITC formalizes the intuitive notion that "large, thermodynamically irreversible amplification has happened, so the outcome is decided."

Within ITC, the Wigner's friend scenario is resolved by the information threshold: if the friend's measurement generates $I \geq I_c$, an objective collapse occurs, rendering the outcome factual for all subsequent observers.

5.2 Comparison with Other Interpretations

ITC is a **dynamical collapse theory** (like GRW/CSL) that synthesizes decoherence with objective collapse. Table 1 summarizes how ITC relates to major interpretations.

Compared to **Many-Worlds**, ITC enforces a single branch and directly uses standard probability concepts. Compared to **Bohmian mechanics**, ITC is indeterministic with no hidden variables beyond a threshold. Compared to **GRW** [24], ITC uses a collective information criterion rather than independent per-particle collapses; it would predict no spontaneous collapse radiation for an isolated atom, thus evading constraints from Germanium experiments [19, 33].

5.3 Implications for Quantum Computing

If ITC is true, it has implications for quantum computer scalability—contingent on the unknown value of I_c. If I_c is sufficiently large (e.g., near the Bekenstein bound for the device), no practical limitation arises. A quantum computer with N qubits in a volume-law entangled state has $\sim N$ bits of entanglement entropy; if N surpasses I_c, the computer collapses. Conversely, a future 10^6-qubit quantum computer operating successfully would indicate no ITC effect up to $\sim 10^6$ bits.

5.4 Conceptual and Philosophical Impact

If ITC were correct, it would underscore that information is a physical entity on par with energy in dictating dynamics, resonating with the holographic principle [35] and Penrose's gravity-induced collapse conjecture [18]. ITC connects collapse to the Second Law of thermodynamics: collapse occurs when further unitary evolution would require more entropy capacity than available. The intuitive narrative is: **"When enough bits are in play, quantum bits turn into classical bits."**

6 Conclusion and Outlook

This work is theoretical and does not claim empirical support beyond inspiration from existing physics.

We have presented a theoretical framework in which quantum wavefunction collapse is an **emergent phenomenon triggered by information**. When a quantum system contains more than I_c bits of information, a non-unitary collapse occurs, selecting a single branch with probability given by the Born rule motivated from algorithmic complexity. ITC offers a falsifiable resolution to the measurement problem.

Open questions include: the precise value (or functional form) of I_c; the dynamics of the collapse transition; relativistic and field-theoretic generalization (possibly following Tumulka's framework [29]); connection to rigorous entanglement measures (von Neumann entropy, quantum mutual information, quantum discord); experimental implementation of toy models via quantum simulators [36]; and the philosophical implications of information as a dynamical agent.

Whether or not ITC in this precise form is correct, the dialogue between quantum foundations and information theory seems destined to play a crucial role in our understanding of reality. As Wheeler suggested, information may point the way to a deeper unity of physics—potentially becoming a quantitative law of nature that triggers collapse, once enough bits say so.

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