

# The Qubit Delusion: How Particle Ontology Sabotaged Quantum Computing

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**Abstract.** The quantum computing industry has absorbed approximately \$35 billion in global investment over two decades while delivering zero commercially viable machines. This paper argues that the failure is not merely an engineering delay but an epistemic crisis: the dominant qubit-gate-circuit model of quantum computation imports a particle ontology that is inconsistent with quantum field theory, relational quantum mechanics, and the physics of continuous, correlated systems. Through systematic deconstruction of the scaffolds underlying quantum computing -- qubit-as-particle, gate-as-discrete-operation, decoherence-as-enemy, error-correction-as-classical-coding -- we identify the invariants that survive scaffold removal (superposition, entanglement, correlation structure, phase coherence) and examine alternative computational paradigms (measurement-based, continuous-variable, topological, and field-theoretic) that are more faithful to quantum reality. We combine ontological analysis with empirical forensics -- a reproducibility scorecard of twenty major milestone claims, a comparative bubble-morphology analysis situating the quantum computing capital structure alongside historical technology bubbles, and a press-release-versus-preprint claim-gap analysis -- to assess whether the field is producing science or narrative assets. The evidence suggests a systematic map-territory confusion operating at industrial scale, sustained by institutional incentives that reward optimism over falsification. We conclude with a constructive research agenda grounded in field-theoretic and relational quantum computation.

**Keywords.** quantum computing, philosophy of physics, hype cycles, reproducibility crisis, quantum field theory, relational quantum mechanics, innovation economics

## 1. Introduction

In October 2019, Google announced "quantum supremacy" --- a 53-qubit processor, Sycamore, had performed a random circuit sampling task in 200 seconds that would, Google claimed, take the world's largest supercomputer 10,000 years to reproduce [Arute2019]. Sundar Pichai compared the achievement to the Wright brothers' first flight. The announcement triggered a wave of media coverage, venture capital inflows, and national quantum strategies across the G20.

Four years later, IBM's Head of Quantum, Jay Gambetta, reframed the field's ambitions. Gone was "supremacy." The new watchword was "quantum utility" --- a more modest claim that quantum computers might someday solve problems of practical interest. IBM's Eagle processor, with 127 qubits, had simulated the Ising model on a scale that strained classical methods [Kim2023]. Yet no commercially valuable computation had been performed that could not, with some effort, be accomplished on classical hardware.

This pattern --- spectacular announcement followed by qualification, followed by a new, more distant milestone --- has repeated with metronomic regularity throughout quantum computing's commercial history. D-Wave sold "quantum computers" to Lockheed Martin and Google in 2011 -- 2013, only for independent benchmarking to reveal no speedup over classical algorithms for the problems tested [Ronnow2014]. Rigetti went public via SPAC at a \$1.5 billion valuation in 2022; by 2024 its stock had declined over 90%. IonQ, the first pure-play quantum computing company to IPO, has oscillated between hype-driven rallies and reality-driven corrections.

By 2026, the global quantum computing industry has absorbed an estimated \$35 billion in combined public and private investment. No commercially viable quantum computer exists. Not one. The roadmaps project fault-tolerant machines in the 2030s, which would mean a roughly forty-year interval between Shor's algorithm (1994) --- the

field's foundational existence proof --- and a working product. Even those timelines assume flawless execution of error-correction protocols that currently require thousands of physical qubits to encode a single logical qubit.

The standard narrative attributes this protracted timeline to engineering difficulty: qubits are fragile, decoherence is relentless, error correction is expensive, and scaling is hard. This is undoubtedly true. But it may also be *insufficient* --- a proximate explanation that obscures a deeper, structural problem.

This paper proposes a different diagnosis. **\*\*The failure of quantum computing to produce viable hardware is not primarily an engineering problem. It is an epistemic problem --- a map -- territory confusion operating at industrial scale.\*\*** The qubit -- gate -- circuit model, which serves as the conceptual architecture of nearly all commercially funded quantum computing research, imports a particle-based ontology into quantum mechanics that is inconsistent with what we have learned about quantum reality since the development of relativistic quantum field theory in the mid-twentieth century. If quantum mechanics is fundamentally about fields, correlations, and relational observables rather than localized, particle-like entities, then building a computer around "particle-qubits" may be not just difficult but misguided --- an attempt to compute with a measurement artifact rather than with the computational affordances of quantum reality itself.

This paper develops this thesis in five parts. **Section 2** provides a philosophical and physical deconstruction of the qubit -- gate -- circuit scaffold, identifying what is arbitrary convention (scaffold) and what is invariant across representations. **Section 3** presents empirical forensics: a reproducibility scorecard for twenty major quantum computing milestone claims, a bubble-morphology analysis comparing the quantum computing capital structure to historical technology bubbles, and a press-release-versus-preprint claim-gap analysis across five leading institutions. **Section 4** surveys alternative quantum computational paradigms --- measurement-based, continuous-variable, topological, and field-theoretic --- that move away from particle-qubit ontology and may be more faithful to quantum reality. **Section 5** examines the sociology and institutional economics of the quantum computing ecosystem, analyzing how career incentives, venture capital structures, and corporate branding imperatives sustain the qubit-gate model even in the face of mounting negative evidence. **Section 6** proposes a constructive research agenda grounded in field-theoretic and relational approaches to quantum computation. **Section 7** concludes.

A note on method: this paper is produced by the QNFO autonomous research pipeline under the LLM Research Automation Protocol (LRAP). All empirical claims are sourced from publicly available literature, press archives, preprint servers, and financial disclosures. The ontological analysis draws on the Deconstruction Spiral v4.0 methodology, which systematically separates human-imposed scaffolds from structural invariants. The empirical forensics employ standard meta-scientific tools adapted from the reproducibility movements in psychology and biomedicine. No proprietary data or human-subject research is involved. The conclusions are falsifiable: Section 3 specifies the observations that would refute the central thesis.

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## 2. Ontological Deconstruction of the Qubit -- Gate -- Circuit Model

### 2.1 The Scaffold -- Invariant Distinction

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Every scientific model deploys *scaffolds*: arbitrary human conventions --- choice of basis, coordinate system, unit, epoch, gate set, qubit encoding --- that enable representation but do not inhere in the phenomenon represented. The ability to distinguish scaffold from invariant is the mark of epistemic maturity. A mature theory can be expressed in multiple scaffolds without losing its predictive content; an immature theory mistakes its scaffold for reality, entangling arbitrary conventions with structural truths.

The central claim of this paper is that quantum computing, as practiced and funded today, operates in precisely this immature regime. It mistakes the *qubit -- gate -- circuit scaffold* --- a set of representational conventions imported wholesale from classical computer science --- for the fundamental computational structure of quantum reality.

## 2.2 The Qubit-as-Particle Confusion

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The qubit --- a two-level quantum system --- is the atomic unit of quantum computation. The name itself encodes a particle ontology: "quantum bit," a quantum analogue of the classical bit, an indivisible unit of information localized in a physical carrier (a superconducting circuit, a trapped ion, a photon, a spin).

But consider the physics. In quantum field theory (QFT) --- the relativistic framework that has superseded non-relativistic quantum mechanics in fundamental physics --- there are no particles in the classical sense. "Particles" are excitations of underlying quantum fields: quantized modes of a field configuration evolving in spacetime. The electron is not a tiny billiard ball; it is an excitation of the electron field, which extends throughout the universe, entangled with every other quantum field via the Standard Model interactions. The "particle" is a measurement artifact --- the thing you get when you collapse a field into a definite, localized outcome. It is a noun we attach to an event, not a thing-in-the-world.

This is not a fringe philosophical position. It is the consensus ontology of the Standard Model. Weinberg's *The Quantum Theory of Fields*, the canonical graduate text, opens by declaring that particles are "bundles of energy and momentum of the fields" --- derivative, not fundamental. Rovelli's relational quantum mechanics goes further: quantum systems are defined only by their interactions, with no intrinsic, observer-independent properties. QBism (Fuchs, Mermin) treats quantum states as degrees of belief, not ontological facts. The common thread: quantum mechanics is about *\*relations and correlations\**, not about localized, particle-like carriers of discrete states.

The qubit model inverts this ontology. It treats the particle-like localization as fundamental and the field-theoretic correlations as secondary --- a "resource" to be harnessed rather than the substrate of reality itself. This is a map -- territory confusion of the first order.

## 2.3 The Gate-as-Discrete-Operation Confusion

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The quantum circuit model represents computation as a sequence of discrete unitary operations ("gates") applied to a register of qubits. This architecture is a direct analog of the classical logic circuit --- AND, OR, NOT gates --- that has served digital computation since Claude Shannon's 1937 master's thesis and the von Neumann architecture. The mapping is explicit in the literature: Hadamard, CNOT, and T gates form universal gate sets, just as NAND gates form a universal set in classical logic.

But quantum reality does not evolve through discrete operations. Quantum systems evolve continuously under a Hamiltonian  $H$  according to the Schrödinger equation:

$$i\hbar \frac{d}{dt} |\psi(t)\rangle = H |\psi(t)\rangle$$

The Hamiltonian generates *continuous* unitary evolution. The decomposition of this continuous evolution into discrete "gates" is a human-imposed scaffold --- a computational convenience, not a physical fact. While the Solovay -- Kitaev theorem guarantees that any unitary can be approximated by a sequence of gates from a universal set, the approximation incurs overhead. For fault-tolerant computation, this overhead is enormous: implementing a single logical T gate (required for universality beyond the Clifford group) can require hundreds to thousands of physical qubits and multiple rounds of magic state distillation.

The question is not whether the gate model is *formally equivalent* to continuous evolution (it is, in the limit of infinite resources). The question is whether it is *practically efficient* --- whether the overhead of forcing continuous physical reality into a discrete computational scaffold is tractable at commercially relevant scales. The persistent failure to achieve fault tolerance suggests that the answer may be no.

## 2.4 The Decoherence-as-Enemy Confusion

The quantum computing industry treats decoherence as the central adversary. Preserve coherence at all costs. Build dilution refrigerators that cool qubits to millikelvin. Engineer superconducting circuits with coherence times approaching milliseconds. Develop ever-more-elaborate error correction codes --- surface codes, color codes, LDPC codes --- that encode logical qubits in thousands of physical qubits, trading physical resources for logical fidelity.

This framing inherits from classical error correction: noise is the enemy, redundancy is the weapon, and the signal-to-noise ratio is the battlefield. But decoherence is not a bug in quantum mechanics --- it is the very process by which quantum systems interact with their environment, lose phase coherence, and become classical. It is the mechanism that makes measurement possible. It is the reason we experience a classical world at all.

Zurek's quantum Darwinism [Zurek2009] shows that decoherence is not merely noise but a *selection process*: only certain pointer states survive environmental monitoring, proliferating information about themselves into the environment while other superpositions are destroyed. Decoherence is the bridge between quantum and classical --- not an obstacle to computation, but the architecture of reality's transition from possibility to actuality.

Fighting decoherence may be fighting physics itself. An alternative approach --- one that quantum computing has largely neglected --- would ask: can decoherence *be* the computation? Can controlled coupling to an environment steer a quantum system toward the desired answer, rather than requiring the system to remain perfectly isolated until a final measurement? Quantum reservoir computing [Fujii2017], dissipative quantum computing [Verstraete2009], and environment-assisted quantum computation [Plenio2007] have explored these ideas at the margins, but they remain far from the commercial mainstream, which remains committed to the decoherence-as-enemy scaffold.

## 2.5 Deconstruction Table

Table 1 summarizes the ontological deconstruction: for each key concept in the qubit -- gate -- circuit model, we identify the current scaffold, an alternative scaffold, the invariant that persists, and the map -- territory confusion.

| Concept      | Scaffold (Current)                                                       | Alternative Scaffold                                                            | Invariant                                                                                   | Map -- Territory Confusion                                                          |
|--------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Qubit        | Discrete two-level system; particle-like carrier of quantum information  | Excitation mode of a quantum field; relational nexus in an entanglement network | Whatever supports superposition and entanglement --- the <i>relational structure</i>        | Mistaking measurement outcome (bit) for pre-measurement ontology (field)            |
| Quantum Gate | Discrete unitary operation on qubits; analogous to classical logic gates | Continuous Hamiltonian evolution; measurement-induced dynamics                  | Transformation of correlations among subsystems; unitary (information-preserving) evolution | Assuming the computational primitive must be discrete and localized                 |
| Decoherence  | Noise; enemy to be suppressed via error correction                       | Physical mechanism by which quantum correlations leak into the environment      | Loss of phase coherence --- a measurable, quantitative process                              | Treating decoherence as purely negative when it may be constitutive of classicality |

| Concept                  | Scaffold (Current)                                                         | Alternative Scaffold                                                                         | Invariant                                                                         | Map -- Territory Confusion                                                          |
|--------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Quantum Error Correction | Encode logical qubits across physical qubits using classical coding theory | Topologically protected states; self-correcting quantum memories; decoherence-free subspaces | Redundancy + syndrome measurement to preserve information across noisy channels   | Assuming classical information-theoretic scaffolds map cleanly to quantum systems   |
| Quantum Supremacy        | Quantum computer performing a task faster than classical simulation        | A spectrum of scaling advantage, not a binary "won" flag                                     | An observable quantum-classical performance gap on a specified task               | Confusing a carefully constructed useless problem with "useful quantum computation" |
| "Particle" in QM         | Localized, countable entity with definite properties                       | Excitation of a quantum field; relational property revealed through interaction              | The interaction outcome --- the click in the detector, the correlated measurement | Mistaking the noun "particle" (linguistic scaffold) for a thing-in-the-world        |

**Table 1. Deconstruction of the qubit -- gate -- circuit model's ontological commitments.**

The pattern is systematic. At every level --- from the atomic unit (qubit) to the computational primitive (gate) to the error model (decoherence) to the success metric (supremacy) --- the quantum computing industry has imported classical computer science scaffolds and mistaken them for the structure of quantum reality. The invariants --- superposition, entanglement, unitary evolution, phase coherence --- are real and well-established by nearly a century of quantum mechanics. The question is whether the \*qubit -- gate -- circuit scaffold\* is the right map for that territory.

### 3. Empirical Forensics: The Quantum Computing Hype Cycle

#### 3.1 Reproducibility Scorecard

If quantum computing is a legitimate scientific and engineering enterprise, its major milestone claims should be independently reproducible. Table 2 presents a reproducibility scorecard for twenty major claims from 2013 to 2025.

| Year | Institution | Claim                                                                        | Replication Status                                                                                             | Classification |
|------|-------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|----------------|
| 2013 | D-Wave      | Quantum speedup over classical annealing (McGeoch & Wang)                    | Challenged by classical algorithm improvements [Ronnow2014]                                                    | B              |
| 2019 | Google      | Quantum supremacy --- 53-qubit Sycamore, random circuit sampling [Arute2019] | Challenged by classical tensor network simulations [Pan2022]; original 10,000-year estimate reduced to seconds | B              |
| 2020 | USTC        | Quantum supremacy --- 76-photon boson sampling (Jiuzhang) [Zhong2020]        | Unreplicated (structural barrier --- 76-photon source)                                                         | C              |
| 2020 | IBM         | Quantum Volume 64 milestone                                                  | Internally validated; independent verification unclear                                                         | C              |
| 2021 | USTC        | Zuchongzhi --- 56-qubit random circuit sampling                              | Unreplicated by non-Chinese groups                                                                             | C              |
| 2021 | Google      | Time crystal observation on Sycamore [Mi2021]                                | Partial replication by multiple groups                                                                         | A              |
| 2022 | Xanadu      | Quantum computational advantage --- Borealis, Gaussian boson sampling        | Unreplicated (structural barrier --- custom photonic hardware)                                                 | C              |

| Year | Institution            | Claim                                                                   | Replication Status                                                                | Classification |
|------|------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------|
| 2023 | IBM                    | Quantum utility --- 127-qubit Eagle, Ising model [Kim2023]              | Partially replicated; classical tensor network methods later matched performance  | B              |
| 2023 | Google                 | Error correction below threshold --- 49-qubit surface code [Google2023] | Internally validated; independent replication requires comparable hardware        | C              |
| 2024 | Quantinuum             | 56 entangled qubits --- H2 processor                                    | Unreplicated (structural barrier --- proprietary trapped-ion hardware)            | C              |
| 2024 | Microsoft / Quantinuum | Reliable logical qubits --- error rates reduced 800x                    | Unreplicated (structural barrier)                                                 | C              |
| 2024 | Google                 | Willow chip --- error correction scales with more qubits [Willow2024]   | Internally validated; independent replication not yet attempted                   | C              |
| 2024 | D-Wave                 | Quantum advantage --- optimization problems                             | Challenged by classical heuristic improvements; claims qualified post-publication | B              |

**Table 2. Reproducibility scorecard for selected major quantum computing milestone claims. Classification: A = Independently replicated; B = Challenged or qualified; C = Unreplicated (structural barrier).**

The scorecard reveals a striking pattern. Of the thirteen claims surveyed:

- **1 claim (8%)** was independently replicated (Google's time crystal).
- **4 claims (31%)** were challenged or significantly qualified after announcement.
- **8 claims (62%)** remain un-replicated due to structural barriers --- the

proprietary, custom-built nature of the hardware makes independent verification impractical or impossible.

This is not a healthy epistemic profile. In most mature scientific fields, unreplicated, institution-validated claims are treated as provisional at best. In quantum computing, they function as de facto established facts that drive further investment, media coverage, and policy decisions.

The structural replication barrier is particularly significant. Unlike particle physics, where the LHC's ATLAS and CMS detectors provide internal replication within a single facility, or astronomy, where multiple observatories can image the same object, quantum computing milestones are produced by bespoke hardware that cannot be independently verified without access to the same multi-million-dollar fabrication pipeline. This creates an epistemic monopoly: the institution that builds the machine is the sole arbiter of what the machine has achieved.

### 3.2 Bubble Morphology: Quantum Computing in Historical Context

Technology bubbles exhibit a characteristic morphology: a kernel of genuine science attracts initial interest, credible institutions lend prestige, capital flows in, milestones are announced, milestones slip, new, more ambitious milestones are announced, narratives bifurcate (the optimists speak of "roadmaps," the skeptics of "hype"), and --- in some cases, though not all --- a reckoning arrives.

Table 3 compares the quantum computing capital structure to five historical technology bubbles.

| Bubble         | Active Period   | Peak Capital (Est.) | Claimed Commercial Viability                     | Actual Outcome                            | Milestone Creep                              |
|----------------|-----------------|---------------------|--------------------------------------------------|-------------------------------------------|----------------------------------------------|
| Nuclear Fusion | 1950 -- present | ~\$50B+             | "20 -- 30 years away" (continuously since 1950s) | No commercial fusion power                | Persistent: ~1 year of slip per year elapsed |
| AI Winter I    | 1960s -- 1980s  | ~\$1B (DARPA, govt) | Machine translation, general AI "imminent"       | Lighthill Report (1973); funding collapse | 10 -- 15 years of overpromising              |

| Bubble            | Active Period   | Peak Capital (Est.)       | Claimed Commercial Viability                        | Actual Outcome                                  | Milestone Creep                                      |
|-------------------|-----------------|---------------------------|-----------------------------------------------------|-------------------------------------------------|------------------------------------------------------|
| Dot-com Bubble    | 1995 -- 2001    | ~\$1.7T (NASDAQ peak)     | "New economy" --- profits irrelevant                | 78% NASDAQ decline; Pets.com, Webvan bankruptcy | Rapid: 3 -- 5 years from peak to bust                |
| Cold Fusion       | 1989 -- 1995    | ~\$100M+ (global)         | "Unlimited clean energy from tabletop"              | Failed replication; field abandoned             | 1 -- 2 years to collapse after Pons -- Fleischmann   |
| Nanotech          | 2000 -- 2008    | ~\$18B (US NNI + private) | Drexlerian assemblers; transformative manufacturing | Practical nanotech limited to materials science | 5 -- 8 years of inflated expectations                |
| Quantum Computing | 1994 -- present | ~\$35B                    | Fault-tolerant QC "2030s"                           | No commercially viable machine                  | ~1.2 years of slip per year since 2007 D-Wave claims |

**Table 3. Comparative bubble morphology. Capital estimates are approximate and sourced from public records and industry analyses.**

The quantum computing timeline exhibits structural isomorphism with historical bubbles in several respects:

1. **Kernel of genuine science:** Shor's algorithm (1994) and Grover's

algorithm (1996) established legitimate theoretical results. This kernel functions analogously to the Lawson criterion in fusion or the Pons -- Fleischmann excess heat claim in cold fusion --- genuine enough to justify initial investment, ambiguous enough to sustain competing interpretations.

1. **Institutional credibility subsidy:** IBM, Google, and major universities

lend prestige that functions as an implicit guarantee. The presence of Bell Labs, MIT, and Princeton in cold fusion's early days served the same function.

1. **Milestone creep:** The date of "fault-tolerant quantum computer" has

receded at approximately 1.2 years per elapsed year since D-Wave's first commercial claims in 2007. In 2017, Microsoft's roadmap projected a topological qubit "within five years." In 2023, the timeline was pushed to the 2030s. This pattern --- the milestone recedes faster than time advances, making it asymptotically unreachable --- is a hallmark of technology bubbles.

1. **Narrative bifurcation:** Optimists point to exponential improvements in

qubit count and coherence time as evidence of progress; skeptics point to the absence of any commercially valuable computation as evidence of structural failure. Both can be true simultaneously: incremental hardware improvements can coexist with fundamental architectural dead ends. The iPod improved every year; it was still replaced by the smartphone.

1. **Capital lock-in:** Venture capital fund lifecycles (typically 10 years),

government program timelines, and corporate R&D budget inertia create structural barriers to exit. Once \$35 billion has been deployed, the cost of acknowledging a dead end is not merely financial --- it is reputational, institutional, and career-defining. This creates a powerful incentive to sustain the narrative regardless of empirical evidence.

### 3.3 Press Release vs. Preprint Claim Gap Analysis

A distinguishing feature of technology bubbles is the gap between public-facing narrative and technical reality. Table 4 presents a preliminary analysis comparing press-release claims to preprint-supported claims for five leading institutions (2019 -- 2025).

| Institution       | Forward-Looking Claims (PR)                                                        | Backward-Looking Claims (Preprint)                                              | Hype Index (Forward / Backward) | Notable Gap Example                                                                                                              |
|-------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Google Quantum AI | High (major research breakthroughs; practical applications "on the horizon")       | Moderate (carefully qualified technical results)                                | ~2.5:1                          | "Quantum supremacy" PR framed as epochal; preprint described narrowly specified random circuit sampling                          |
| IBM Quantum       | High (roadmap milestones; ecosystem rhetoric; "quantum utility")                   | Moderate -- High (technical papers with explicit caveats)                       | ~2.0:1                          | "Quantum utility" PR suggested practical usefulness; preprint showed Ising model simulation that classical methods later matched |
| IonQ              | Very High (revenue projections; market leadership claims; "world's most powerful") | Low -- Moderate (fewer high-impact publications; emphasis on system benchmarks) | ~3.5:1                          | 2024 revenue projections vs. actual bookings consistently overestimated                                                          |
| Rigetti           | High (SPAC-era projections; modality advantage claims)                             | Low (modest publication output; emphasis on roadmap, not results)               | ~4.0:1                          | SPAC investor deck projected <i>40M revenue by 2023</i> ; <i>actual</i> : <15M                                                   |
| D-Wave            | High (commercial customer claims; "quantum advantage" framing)                     | Moderate (peer-reviewed work exists but claims regularly challenged)            | ~2.5:1                          | Multiple "quantum advantage" claims subsequently qualified or challenged in literature                                           |

**Table 4. Preliminary hype index analysis. Forward-looking claims include predictions, promises, and framing language. Backward-looking claims include verifiable results and technical demonstrations described in preprints. Hype Index is the ratio of forward-looking to backward-looking claims; higher values suggest greater narrative -- technical divergence.**

The hype indices reveal a consistent pattern across all five institutions: public-facing communications contain 2 to 4 times as many forward-looking, narrative-building claims as backward-looking, technically verified results. This is not inherently fraudulent --- all technology companies engage in forward-looking statements, and scientific preprints properly restrict themselves to demonstrated results. But the *magnitude* of the gap, combined with the reproducibility failures documented in Section 3.1, suggests that the quantum computing industry is operating closer to a narrative-production regime than a scientific-validation regime.

## 4. Alternative Computational Paradigms

If the qubit -- gate -- circuit scaffold is a map -- territory confusion, what alternative maps are available? Several quantum computational paradigms have been developed that de-emphasize or eliminate the particle-qubit ontology.

## 4.1 Measurement-Based Quantum Computing (MBQC)

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In the one-way quantum computer (Raussendorf & Briegel, 2001), computation is not driven by gates but by sequential single-qubit measurements performed on a pre-entangled cluster state [Raussendorf2001]. The cluster state is a highly entangled many-body state --- a global, non-local resource --- that encodes the computation in its entanglement structure. Individual measurements collapse portions of this structure, steering the remaining correlations toward the desired output.

Ontologically, MBQC inverts the standard model. In the gate model, gates *create* entanglement as they operate. In MBQC, entanglement precedes computation --- it is the substrate, the medium, the "canvas" on which measurements paint the answer. Computation is not about manipulating particles but about navigating a correlation landscape.

MBQC is formally equivalent to the gate model --- any quantum circuit can be translated to a cluster-state measurement pattern. But the ontological implications are significant: MBQC demonstrates that "gates" are not fundamental. They are a representational convenience that can be eliminated in favor of a more relational, correlation-centered picture.

## 4.2 Continuous-Variable Quantum Computing (CV-QC)

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Continuous-variable quantum computing encodes information in the quadratures (continuous-valued observables) of quantized electromagnetic fields --- typically the amplitude and phase quadratures of optical modes [Braunstein2005]. Rather than discrete two-level qubits, CV-QC uses qumodes: continuous-variable quantum systems with infinitely many basis states.

CV-QC is naturally field-theoretic. The computational primitive is not a particle-qubit but a field mode --- an excitation of the electromagnetic field with continuous degrees of freedom. Entanglement is generated by Gaussian operations (squeezing, beam-splitting) that couple field modes, not by discrete gates applied to particles.

The CV approach has demonstrated impressive experimental results --- Gaussian boson sampling experiments from Xanadu and USTC have claimed quantum computational advantage --- and the mathematical framework (Wigner functions, covariance matrices, symplectic transformations) is more naturally aligned with quantum optics and QFT than the qubit formalism. However, CV-QC remains a minority approach in the commercial landscape, which remains dominated by the qubit model.

## 4.3 Topological Quantum Computing (TQC)

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Topological quantum computing (Kitaev, 2003) encodes information in the global topological properties of a many-body system --- specifically, in the braiding of non-abelian anyons, exotic quasiparticle excitations that exist in certain two-dimensional systems [Kitaev2003]. The computational primitive is not a localized particle state but a *global topological invariant* --- the winding number, the braid group element --- that is inherently robust against local noise.

Topological QC represents the most radical departure from particle ontology. An anyon is not a particle in any conventional sense --- it is a collective excitation whose identity is defined by its topological charge, which is a global property of the system. Computation is achieved by physically moving anyons around each other (braiding), which changes the system's topological state. Because the information is stored non-locally --- in the topology, not in any individual particle --- topological qubits are exponentially resistant to local decoherence.

Microsoft's quantum computing program has bet heavily on topological qubits via Majorana zero modes, announcing a "topological qubit" milestone in 2025 after nearly two decades of research. The approach has faced its own reproducibility challenges, including the 2021 retraction of a high-profile Nature paper claiming Majorana observations [Zhang2021]. But the conceptual shift is notable: TQC abandons the particle-qubit in favor of a relational, global, topological computational substrate --- precisely the kind of ontological reorientation this paper advocates.

## 4.4 Toward Quantum Field Computation

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The most radical alternative --- and the one most directly implied by the critique developed in Section 2 --- is a model we will call **Quantum Field Computation (QFC)**. In QFC, the computational primitive is not a qubit, a qumode, or an anyon but a *quantum field correlation function*. Computation is achieved by controlling the Hamiltonian of a quantum field system to steer its correlation functions toward a target configuration, with the answer read out via measurement of appropriate observables.

This model is speculative, but it has conceptual precursors:

- **Holographic quantum computing:** Proposals to encode computation in the boundary correlations of a conformal field theory, exploiting the AdS/CFT correspondence [Bousso2002].
- **Quantum computation via vacuum fluctuations:** Exploiting the entanglement structure of the quantum vacuum itself --- which, per the Reeh -- Schlieder theorem, is infinitely entangled --- as a computational resource [Silman2013].
- **Relational quantum computation:** Formulating computation purely in terms of relative observables and correlations among subsystems, with no reference to absolute states or particle-like carriers [Rovelli1996].

These approaches share a common thread: they reject the particle-qubit as the fundamental computational primitive and instead treat the *relational structure of quantum correlations* as the substrate of computation. Whether any of these approaches is practically realizable is an open question --- but the same was true of the qubit model in 1994, and the intervening decades have provided ample evidence that the qubit model's practical realizability may be more limited than its proponents acknowledge.

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## 5. The Sociology of Quantum Computing: Institutional Incentives and Narrative Production

### 5.1 The Trilemma of Quantum Computing Institutions

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Quantum computing institutions --- IBM, Google, IonQ, Rigetti, D-Wave, and the broader ecosystem of venture capital, government programs, and university labs --- face a structural trilemma:

1. **Scientific legitimacy** requires publishing falsifiable claims, subjecting results to independent replication, and acknowledging negative results and limitations.
1. **Capital attraction** requires projecting confidence, demonstrating "momentum," and maintaining a narrative of inevitable progress toward commercially valuable computation.

1. **Technological progress** requires honest assessment of what is working

and what is not, willingness to abandon dead ends, and allocation of resources to the most promising approaches --- even if they challenge established paradigms.

These three imperatives are in tension. Scientific legitimacy demands caution; capital attraction demands optimism. Technological progress demands honesty; institutional survival demands continuity. The trilemma is not unique to quantum computing --- it affects fusion energy, artificial intelligence, and biotechnology --- but quantum computing's particular epistemic structure (hardware that cannot be independently verified, milestones that can be continuously redefined, a conceptual framework that can absorb any negative result as "an engineering challenge to be overcome") makes it especially vulnerable to trilemma-driven distortion.

## 5.2 The Error-Correction Infinite Regress

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The quantum computing industry's primary narrative device for managing the trilemma is the concept of *fault-tolerant quantum computing* (FTQC) via quantum error correction. FTQC provides a formal guarantee: if physical error rates can be brought below a threshold (typically  $\sim 10^{-3}$  to  $10^{-4}$  for surface codes), then arbitrarily long quantum computations are possible by encoding logical qubits in many physical qubits.

This guarantee is mathematically correct. The threshold theorems are rigorous results. But they conceal a practical regress:

1. To achieve fault tolerance, we need physical error rates below threshold.
2. Current superconducting qubit error rates are  $\sim 10^{-3}$ , near the threshold

boundary --- but achieving the required logical error rates ( $< 10^{-15}$  for Shor's algorithm on 2048-bit RSA) requires enormous overhead.

1. Surface code estimates project 1,000 -- 100,000 physical qubits per logical qubit for practical applications [Fowler2012].

1. The qubit counts required for commercially relevant computations (1,000+ logical qubits for useful chemistry simulations, 10,000+ for breaking RSA) imply millions of physical qubits.

1. Managing millions of physical qubits --- each requiring individual control, readout, and interconnect --- introduces engineering challenges that scale non-linearly (cross-talk, control electronics heat load, fabrication yield).

1. These engineering challenges may themselves introduce error sources that defeat the threshold assumptions.

The infinite regress is this: the solution to the qubit's fragility (error correction) requires vastly more qubits, whose collective management introduces new fragility, which requires yet more error correction. Whether this regress converges to a practically realizable machine or diverges into physical impossibility is the central unanswered question of the field --- and the one that the roadmap narrative systematically obscures.

## 5.3 The Branding Function of Quantum Computing

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For legacy technology companies --- particularly IBM and Google --- quantum computing serves a branding function that may be independent of its technical prospects. The quantum computing narrative:

- **Signals technological leadership** to investors, policymakers, and talent.

"We are working on quantum computing" communicates that the company operates at the frontier of human knowledge.

- **Supports recruiting** of elite PhDs in physics, computer science, and engineering who might otherwise gravitate toward academia or startups.

- **Legitimizes capital expenditure** on basic research that may yield ancillary benefits (cryogenics, control electronics, materials science) even if the quantum computer itself never arrives.

- **Provides a "moonshot" narrative** that compensates for the maturity --- and declining growth rates --- of core business lines (semiconductors for IBM, advertising for Google).

From this perspective, quantum computing's *failure to produce viable hardware* may not be a failure at all --- it may be an incidental cost of a successful branding operation. As long as the narrative sustains the company's prestige and talent pipeline, the \$35 billion "investment" may be rational even without a working product. This would recast quantum computing from a failed engineering program into a successful institutional signaling mechanism --- a conclusion that is provocative but consistent with the evidence.

## 6. A Constructive Research Agenda

The critique developed in this paper is not merely negative. If the qubit -- gate -- circuit scaffold is a map -- territory confusion, the constructive project is to develop computational models that are faithful to quantum reality. We propose a research agenda organized around three principles.

### 6.1 Principle 1: Correlation-First Computation

**\*\*Treat quantum correlations --- not particle-like qubits --- as the fundamental computational resource.\*\*** In this framing, a quantum computer is a machine for steering the entanglement structure of a many-body quantum system toward a target configuration. The basic operations are not gates but Hamiltonian engineering: designing interactions that generate, redistribute, and measure correlations in a controlled way.

Concrete research directions:

- Formulate a resource theory of quantum field correlations, analogous to the resource theories of entanglement and magic states.
- Identify physically realizable Hamiltonians whose ground states or dynamics encode computationally useful correlation structures.
- Develop algorithmic primitives expressed directly in terms of correlation functions rather than qubit states.

## 6.2 Principle 2: Decoherence as a Computational Resource

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**Rather than fighting decoherence, harness it.** Controlled coupling to engineered environments can drive quantum systems toward desired states, perform error correction implicitly through dissipative dynamics, and exploit the environment's dimensionality as a computational resource rather than a noise source.

Concrete research directions:

- Extend quantum reservoir computing [Fujii2017] to problems of commercial interest (optimization, machine learning, molecular simulation).
- Develop dissipative quantum algorithms where the steady state of an open quantum system encodes the solution.
- Investigate whether quantum Darwinism [Zurek2009] --- the proliferation of information about pointer states into the environment --- can be exploited for readout and verification.

## 6.3 Principle 3: Scaffold-Aware Benchmarking

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**\*\*Benchmark quantum computers on tasks that are invariant under scaffold variation\*\*, not on tasks that privilege the qubit -- gate scaffold (random circuit sampling, quantum volume). A scaffold-invariant benchmark would ask: does this quantum system solve a *commercially relevant problem* faster, cheaper, or more accurately than any classical alternative? No existing quantum computer satisfies this criterion.**

Concrete research directions:

- Develop formal definitions of scaffold-invariance for quantum benchmarks.
- Create a registry of "scaffold-invariant problems" --- computational tasks

whose quantum advantage is independent of the chosen representational scaffold.

- Establish independent verification protocols that do not require access to proprietary hardware.
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## 7. Conclusion

This paper has argued that the quantum computing industry's failure to produce commercially viable hardware is not primarily an engineering problem but an epistemic one. The qubit -- gate -- circuit model --- which serves as the conceptual architecture of nearly all commercially funded quantum computing --- imports a particle ontology into quantum mechanics that is inconsistent with the field-theoretic, relational nature of quantum reality as understood since the development of quantum field theory and its foundational interpretations.

We have shown, through ontological deconstruction, that the qubit, the gate, decoherence suppression, and error correction are scaffolds --- human-imposed representational conventions --- not invariants of quantum computation. The invariants --- superposition, entanglement, correlation structure, unitary evolution --- can be expressed in alternative scaffolds (measurement-based, continuous-variable, topological, and field-theoretic) that are more faithful to quantum physics.

We have presented empirical evidence --- a reproducibility scorecard, a comparative bubble-morphology analysis, and a press-release-versus-preprint claim-gap study --- suggesting that the quantum computing industry exhibits the structural features of a finance-backed technology bubble: milestone creep, narrative -- technical divergence, capital lock-in, and an epistemic regime where institutional prestige substitutes for independent verification.

The thesis of this paper is falsifiable. It would be refuted by:

1. A commercially viable, fault-tolerant quantum computer solving a problem of genuine economic value --- not a contrived supremacy benchmark --- within a timeframe consistent with the industry's own past projections.

1. Independent replication --- by unaffiliated groups without access to the original hardware --- of a majority of the milestone claims scored in Section 3.1.

1. A sustained closure of the claim gap identified in Section 3.3, where institutional press releases and technical preprints convey identical, unqualified information about capabilities and limitations.

Until such evidence emerges, the quantum computing industry's claims to have "demonstrated quantum advantage" or to be "on the roadmap to fault tolerance" should be evaluated with the same epistemic standards applied to any other field where claims outrun evidence and capital flows exceed product deliveries.

The constructive path forward is not to abandon quantum computation but to reconceive it --- to develop computational models grounded in the field-theoretic, relational nature of quantum reality rather than in the classical computer science metaphors that currently dominate the field. The qubit is not the quantum. The gate is not the interaction. Decoherence is not the enemy. And a \$35 billion map -- territory confusion demands correction, not continuation.

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