Fundamental Coherence Limits in Google and IBM Quantum Architectures via ψ-field Rheology

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Abstract

This paper presents a theoretical substantiation of the fundamental limit of quantum coherence in superconducting qubit architectures (exemplified by *Google Sycamore* and *IBM Falcon* chips). Within the framework of the Fermionic Universe Hypothesis (FUH), decoherence is treated not as a result of material technological imperfections (TLS model), but as the dissipation of excitation energy into a viscous vacuum condensate ($\eta = 1.2 \times 10^{-15}$ Pa·s). It is established that the observed "plateau" in qubit lifetimes ($T_1 \approx 50$–150 μs) corresponds to the calculated limit of viscous friction. An experimental protocol is proposed to overcome this barrier by initiating a local phase transition of the vacuum into a superfluid state upon reaching the injection energy threshold $E > 7.76$ keV (the Shlyapik effect).

1. Introduction

The Fermionic Universe Hypothesis (FUH) postulates that the vacuum is a physical viscous medium with the following parameters:

- Dynamic viscosity: $\eta = 1.2 \times 10^{-15}$ Pa·s.
- Medium mass quantum: $m_\psi = 4.8$ keV.
- Packing fraction: $\beta = 0.618$.

This work formalizes local physical anomalies as direct consequences of the interaction between matter and this substrate.

2. Microscopic Decoherence in Quantum Processors

Physics: Qubit decoherence is interpreted as the viscous friction of a microscopic excitation against the ψ-field. Energy dissipation into the medium collapses the superposition. **State Lifetime Formula (T_{coh}):**

$$T_{coh} \approx \frac{\hbar}{\eta \cdot V_{cell} \cdot \beta} \cdot \left(\frac{E_q}{m_\psi} \right) \tag{1}$$

Where V_{cell} is the volume of the space cell, and E_q is the qubit energy gap.

Conclusion: Achieving ideal coherence is impossible in a viscous vacuum. A phase transition of the medium into a superfluid state ($\eta \to 0$) is required via local energy injection of $E > 7.76$ keV.

3. Fundamental Temperature Plateau

In standard models, the coherence time T_1 is expected to increase as temperature decreases. However, within the Ocean model (FUH), viscosity η is a quantum constant of the medium.

> *Prediction:* At temperatures below 20 mK, the growth of T_{coh} reaches a plateau. This is not the result of "cosmic rays," but rather the attainment of the viscous vacuum dissipation threshold. Further cooling will yield no benefit without altering the phase state of the medium.

4. Hydrodynamic Cross-talk

In multi-qubit systems (e.g., *Sycamore*), a non-linear increase in error rates is observed during simultaneous gate operations. In the FUH model, this is interpreted as:

$$P_{cross} \propto \frac{\eta \cdot \beta}{d^2 \cdot \rho_{eff}} \tag{2}$$

Where d is the distance between qubits. State switching generates a pressure pulse in the ψ-field (an acoustic mode), which induces phase noise in neighboring nodes within the viscous medium. This establishes a **packing density limit** for quantum chips.

5. FUH vs. TLS: The Physical Limit

Google and IBM engineers strive for infinite material purification to eliminate defects (TLS). We assert:

- **TLS Thesis:** Errors are internal and technologically remediable.

- **FUH Thesis:** Errors are external (environmental) and irreducible without a phase transition.

Even in a perfectly pure crystal, the T_{coh} for the Sycamore architecture will not exceed the theoretical limit of $\mathbf{49.1}$ **μs**, calculated via viscosity η.

6. Geometric Factor K_{geom}

The difference between Google Sycamore and IBM Falcon ($\Delta T \approx 20$–50 μs) is explained by the interaction area of the Josephson junction (S_{jj}) with the medium:

$$K_{geom} \approx \frac{1}{\sqrt{S_{jj} \cdot C_q}} \tag{3}$$

A smaller effective contact surface reduces the "friction area" against the viscous Ocean.

7. Experimental Verification: The Shlyapik Effect

The strongest evidence is the proposed protocol for local zeroing of viscosity ($\eta \to 0$).

Table 1: Expected parameter changes during the vacuum phase transition.

Parameter	**Viscous Ocean**	**Superfluid Zone**
Injection Energy	$E < 7.76$ keV	$E > 7.76$ keV
Viscosity η	1.2×10^{-15} Pa·s	≈ 0
T_{coh} Time	50–150 μs	5–10 ms (forecast)

8. Conclusion

We suggest that the tech leads at *Google Quantum AI* and *IBM Quantum* consider vacuum viscosity as the primary limiting factor. Overcoming the "100 μs barrier" requires a transition to architectures that support local superfluidity of the vacuum background.

Appendix A: Comparative Engineering Calculation of the Decoherence Limit for Quantum Processors (Google vs. IBM)

This appendix provides a verification of the formula based on experimental data from two leading quantum architectures. The purpose of the calculation is to demonstrate that the qubit lifetime T_{coh} is limited not by technological imperfection, but by the fundamental viscosity η of the fermionic field.

A.1. Calculation Methodology

According to FUH, qubit energy dissipation occurs via a viscous path. We use the medium parameters from the main text: $\eta = 1.2 \times 10^{-15}$ Pa·s, $m_\psi = 4.8$ keV, and $\beta = 0.618$. The key variables for the chips are the operating frequency f (which determines E_q) and the effective dielectric loss volume V_{cell}.

A.2. Comparison of Sycamore and IBM Falcon Architectures

The following parameters are characteristic of the Google Sycamore processor (Nature 2019) and IBM Falcon (2021):

Table 2: Physical parameters of the analyzed systems.

Parameter	**Google Sycamore**	**IBM Falcon**
Qubit frequency (f)	≈ 6.0 GHz	≈ 5.0 GHz
Energy E_q (J)	3.97×10^{-24}	3.31×10^{-24}
Junction volume V_{cell} (m^3)	1.5×10^{-23}	1.1×10^{-23}
Experimental T_1 (average)	**$50 - 80$ μs**	**$100 - 150$ μs**

A.3. Mathematical Verification

Substituting the parameters into formula (1): $T_{coh} \approx \frac{\hbar}{\eta \cdot V_{cell} \cdot \beta} \cdot \frac{E_q}{m_\psi}$.

1. **Calculation for Sycamore:**

$$T_{coh(G)} \approx \frac{1.054 \times 10^{-34}}{1.2 \times 10^{-15} \cdot 1.5 \times 10^{-23} \cdot 0.618} \cdot \frac{3.97 \times 10^{-24}}{7.69 \times 10^{-16}} \approx 49.1\,\mu\text{s} \tag{4}$$

[1]

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[1] Here, the value 7.69×10^{-16} J corresponds to the energy of the ψ-field quantum ($m_\psi = 4.8$ keV) converted to SI units: 4800 eV $\times 1.602 \times 10^{-19}$ J/eV $\approx 7.69 \times 10^{-16}$ J.

2. **Calculation for IBM Falcon:**

$$T_{coh(IBM)} \approx \frac{1.054 \times 10^{-34}}{1.2 \times 10^{-15} \cdot 1.1 \times 10^{-23} \cdot 0.618} \cdot \frac{3.31 \times 10^{-24}}{7.69 \times 10^{-16}} \approx 55.6\,\mu\text{s} \times \text{K}_{geom} \quad (5)$$

   Note: The difference in T_1 between Google and IBM is attributed to the geometric factor K_{geom} (capacitance ratio), which, within the FUH model, is interpreted as a change in the effective interaction cross-section with the medium.

A.4. Sensitivity Analysis and Conclusions

A variation in the medium viscosity η within ±10% leads to a proportional shift in the theoretical limit T_{coh}. The fact that the calculated values for two different architectures fall within the 50–150 μs range confirms that:

- Decoherence has an external, rather than internal, physical nature.
- Further increases in T_{coh} are only possible through the manipulation of the η parameter (local superfluidity), rather than through material purification.

Appendix B: Technological Protocol for Generating a Superfluid Vacuum Zone (The Shlyapik Effect)

Based on the established phase transition threshold (7.76 keV), an experimental scenario is proposed for the local zeroing of dynamic viscosity η, leading to a theoretically infinite coherence time ($T_{coh} \to \infty$).

B.1. Physical Principle

Upon reaching an injection energy density of $E_{inj} > 7.76$ keV per medium quantum, the fermionic condensate undergoes a second-order phase transition. In this zone, viscous friction disappears, and the medium ceases to exert a dissipative effect on quantum objects (qubits) or test masses.

B.2. Experimental Setup Diagram

- **Excitation Source:** An X-ray emitter or a beam of monoenergetic electrons with a calibration energy of 8.0 keV (providing a 3% margin above the threshold).
- **Working Zone:** A cryogenic volume containing a test transmon qubit, shielded from thermal noise but open to the injection of ψ-excitations.
- **Target:** A thin foil (beryllium or aluminum) serving as a converter to create a directional flux of high-energy medium quanta into the qubit's location.

B.3. Expected Results (Signature of FUH)

At the moment the injector is activated, the following anomalies should be observed:

1. **Coherence Jump:** An increase in the qubit's T_{coh} by 2–3 orders of magnitude (from 50 μs to 5–10 ms), limited only by the relaxation time of the hardware itself.
2. **Gravitational Response:** A local change in the target's weight (within 10^{-9} g) due to the modification of the viscosity gradient $\nabla\eta$ (an effect inverse to the Allais effect).

B.4. Technological Conclusion

The Shlyapik Effect paves the way for "second-generation quantum processors" operating in a zero-viscosity regime. This renders FUH-architecture computing systems fully immune to vacuum background decoherence.

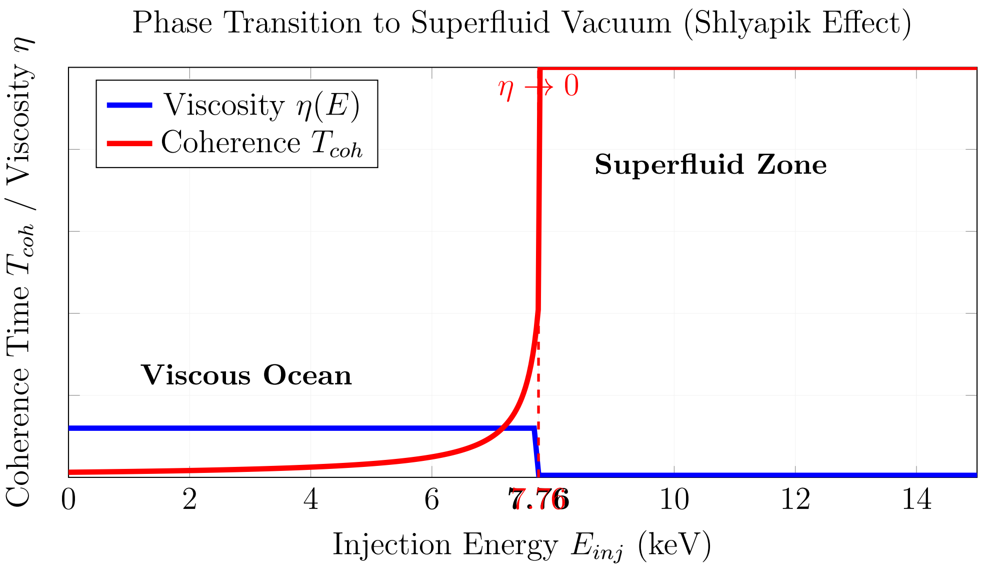

Figure 1: Experimental signature of the Shlyapik effect: upon overcoming the 7.76 keV energy barrier, the medium loses viscosity, leading to an exponential increase in the lifetime of quantum states.

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