The Δτ Firewall Hypothesis

A Logical Framework for Causality Preservation in FTL Scenarios

A surprising number of FTL paradoxes assume Δτ = 0. I explored what happens if we just… don’t. Turns out, causality stays intact. Here’s how

Here Δτ = Cost of any event

Or

A **non-zero** minimum delay inherent to all physical events—measurement, computation, or reaction—bounded below by Planck-scale or other quantum processing constraints (note that Δτ here means any non zero time whether that be Planck, less than Planck or just billions of years)... More details below↓

**Postulate**: No physical process—communication, measurement, or causal reaction—can occur with zero latency. All systems must observe a Δτ > 0, even in idealized FTL or nonlocal configurations.

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I’ve cooked up a theory about why FTL inherently doesn’t break causality and it’s wrong to assume so, as well as that you don’t need to be afraid of developing FTL tech anymore cuz it ain’t breaking causality as far as I know.

Why I used ‘as far as I know’ instead of something like ‘as far current science knows or something’ that because all my knowledge, mental models and frameworks are based on my understanding of world and are only as real as my inner mental framework goes.

Now for the actual part:

PS: I’ve used ai for boring part and formalizing the language a bit so don’t judge me for that.

My takes:

Let’s define what an event is: it’s non zero change in a system.  
what does a change in a system mean: It means that particles or forces have changed the system in non 0 value.

But no particle or force can travel faster than light so as long as change happens and it occupies a non 0 space, it will consume some finite amount of time.

Meaning even though we are discussing FTL we assume light speed constraint stull exist for normal spece time interactions.

As long as faster-than-light scenarios manipulate **spacetime geometry** (e.g., wormholes, metric expansion, Alcubierre drives) *without violating local relativistic constraints*—specifically, without enabling the **local transfer of information or force faster than light**—then **causality remains intact**.

just like how some galaxies are moving away from us faster than light but they don't collapse into paradoxes.

***Basically FTL is allowed but only with spacetime geometry shenanigans not blowing up relativity.***

**FTL here is only considered hypothetical and that too only possible via space manipulation shenanigans not playing inside spacetime, but with it.**

Actual Theory rewritten by AI:

Traditional FTL scenarios in physics are dismissed due to causality paradoxes—particularly those enabled by time dilation across wormhole mouths. This paper proposes a resolution rooted in quantum processing delay: that all physical measurements or responses are fundamentally constrained by a nonzero minimum delay (Δτ), thereby enforcing local temporal order even under exotic spacetime conditions. We introduce a series of logical stress tests that demonstrate how Δτ > 0 suffices to protect causality across all paradox attempts. The result is a simple, yet robust framework that suggests the preservation of causality is an emergent feature of quantum computation, not a hard constraint against FTL.

The Δτ Firewall Hypothesis posits that every physical interaction—be it quantum measurement, signal processing, or actuator response—requires a strictly positive minimum delay (Δτ), and it is this irreducible latency that preserves causality even when information traverses via exotic faster‐than‐light (FTL) conduits such as wormholes. In Test 1 (“Pre-Programmed Zero-Thinking Machine”), a particle sent from Mouth B at t₍B₎=0 emerges at Mouth A at t₍A₎=–Δt and triggers an immediate, hard-wired response after Δτ; that reply, even if “instant,” arrives back at Mouth B at t₍B₎=Δτ>0, so the effect never precedes the cause. In Test 2 (Macroscopic Δt vs. Microscopic Δτ), scaling Δt to one year and Δτ to 10⁻²⁰ s still yields R arriving at t₍B₎=Δτ after the sender’s action. Test 3 (“Feedback Loop”), which plants a pre-existing destroy-P trigger, collapses logically because Δτ enforces that the destroy command can only launch after the original P departure, breaking the would-be paradox loop. Test 4 (Entanglement + Wormhole) confirms that even if measuring an entangled partner at Mouth A collapses the state, the collapse at B can only be registered after (t₍A₎+Δτ)+Δt, preserving local cause-before-effect and preventing any information-bearing superluminal channel. Test 5 (Black Hole Time Dilation Extremes) shows that any attempt to exploit infinite dilation at a singularity is unphysical—event horizons and quantum gravity conspire to forbid traversable wormholes with Δt→∞—so the math itself invalidates the regime. Finally, Test 6 (Planck-Scale Edge Case) demonstrates that even when Δt approaches the Planck time tₚ, the inequality t₍B₎(R)=Δτ>t₍B₎(P)=0 remains intact; scenarios with Δt<tₚ fall into “quantum foam” where spacetime has no coherent meaning, nullifying any paradox. Thus, under every realistic regime the Δτ delay acts as a universal causal lock—only if Δτ could drop to zero or if spacetime admitted a global simultaneity (e.g., an ER=EPR reinterpretation) would paradoxes resurface—but both options contradict established quantum and relativistic principles. In short, causality violations via FTL or wormholes require the impossible assumption of zero‐latency responses; once you recognize that Δτ>0 is as fundamental as c, all classic time-travel paradoxes simply disintegrate.  
  
Human Language:

Alright, here’s the deal with faster-than-light travel and why it *actually* doesn’t wreck causality like sci-fi movies say—if you accept one crucial fact: **nothing happens instantly.** Every action, detection, or response takes at least a tiny, unavoidable amount of time—call it Δτ—which is basically the universe’s “minimum reaction time,” sitting somewhere near the Planck scale (think 10⁻⁴³ seconds, basically the shortest flicker of a cosmic eye). Now, imagine you have a wormhole connecting two points, Mouth A and Mouth B. You send a particle from Mouth B at time zero. Because of weird time dilation effects in the wormhole, that particle arrives at Mouth A at a *negative* time (like in the past of B’s clock). But here’s the kicker: the moment Mouth A detects the particle, it can’t instantly shoot a response back—it has to wait Δτ to process and trigger the reaction. So, that reply zooms back and shows up at Mouth B just *after* the particle was originally sent, preserving the order: cause → effect, no time travel paradox. Even if you crank the time dilation to a whole year or more, Δτ still stops you from sending info into the past because the delay at detection can’t be beat. Try to build a “destroy the particle before it even arrives” feedback loop? Nah, the loop breaks because the response physically *can’t* get there before the particle leaves—Δτ keeps time honest. What about quantum entanglement, where measuring one particle instantaneously affects the other? Doesn’t help break causality either, because the actual *measurement* requires that same tiny delay, and no usable information travels faster than light anyway. Even wild cases like putting one wormhole end near a black hole with crazy time dilation don’t let you cheat causality—physics and quantum gravity toss in hard limits that stop infinite time shifts from becoming a thing. And if you try to shrink all this down to the Planck scale? Spacetime itself gets fuzzy and unpredictable, so the idea of a paradox just doesn’t make sense anymore. Bottom line: that tiniest delay Δτ is like the universe’s “no cheating” card—unless you assume zero delay, which no known physics supports, causality stays safe. So, those classic “time travel paradoxes” need a major rewrite, because once you accept that real physical processes aren’t instantaneous, all the crazy paradox scenarios fall apart. It’s like the universe is playing chess, and Δτ makes sure you can’t move your pieces back in time no matter how hard you try.  
  
TL DR in my language:

Suppose there are two guys Alice and bob.

Alice on earth where t = 12:00.

Bob’s moving at .5c and when he passes earth his clock gets synced with Alice so at the exact moment bob’s

T is also 12:00.

Now after some time…

Bob’s current clock is 12:30 but Alice’s is 1:00.

Bob sends Alice an instantaneous message ‘sup bro’ at 12:31 and Alice receives it at 1:01 and now assuming Alice is a human or a sci-fi machine she’ll need at least Δt time to process the message and reply back, meaning now assuming that travel back of information is also instantaneous Bob will receive that message at 12:31 + Δt time.

(Alice’s current time is 1:01 + Δt)

Now to test causality we verify that is the time at which bob sent the message earlier than when he received the reply?

Bob sent at 12:31 and received at 12:31 + Δt .

Causality’s preserved.

**Conclusion:**  
The Δτ Firewall isn’t a rejection of relativity—it’s a refinement of causality. So long as reality has processing costs, paradoxes remain fiction. It’s not faster-than-light that breaks the universe—it’s lazy math or rather **thinking**.

**Key Papers Proving Non-Zero Interaction Time**

**1. Nearly-Instantaneous Alternatives in Quantum Mechanics**

Micanek & Hartle (1996) analyze how **real measurements are extended in time**, not point-like events. They find that below a certain timescale, interference effects emerge—so you *can’t* treat measurement as instantaneous without breaking QM [en.wikipedia.org+15arxiv.org+15link.springer.com+15](https://arxiv.org/abs/quant-ph/9602023?utm_source=chatgpt.com).

**2. Fundamental Bound on Time Measurement (IOP, 2020)**

This rigorous paper shows that **uncertainty in time measurement is irreducible**, based on the uncertainty principle and relativistic frame effects. You *can't* achieve perfect time precision—an intrinsic Δt > 0 exists .

**3. Time-of-Arrival Cannot Be Instantaneous (Aharonov et al., 1997)**

This study formally demonstrates that **you cannot define or measure the exact instant a particle arrives**—the uncertainty in arrival time scales inversely with the particle’s energy. Instantaneous detection is physically impossible [royalsocietypublishing.org+15arxiv.org+15link.springer.com+15](https://arxiv.org/abs/quant-ph/9709031?utm_source=chatgpt.com).

**Additional Evidence from Measurement Theory**

* **Quantum Trajectory Theory** and **Quanta Magazine** report that even quantum jumps (state collapses) occur *smoothly over time*, not instantaneously [en.wikipedia.org+2quantamagazine.org+2reddit.com+2](https://www.quantamagazine.org/quantum-leaps-long-assumed-to-be-instantaneous-take-time-20190605/?utm_source=chatgpt.com).
* Texts on the **Quantum Zeno effect** emphasize that treating measurements as continuous or infinitely frequent (Δτ→0) leads to paradoxes—REAL measurement devices operate with finite delay [iopscience.iop.org+15arxiv.org+15link.springer.com+15](https://arxiv.org/abs/quant-ph/0411145?utm_source=chatgpt.com).
* Studies on **time measurement in QM (MDPI)** derive minimum time bounds Δt ≥ ħ/ΔE from first principles of decoherence and energy-time inequalities .
* Research on the **quantum speed limit** (e.g., UC Berkeley, 2015) proves there's a minimum possible time for a quantum state transition, derived from the energy-time uncertainty principle [news.berkeley.edu](https://news.berkeley.edu/2015/01/22/scientists-set-quantum-speed-limit/?utm_source=chatgpt.com).