Consistency-Projected Reverse-Symmetric Quantum Electrodynamics

A Falsifiable Framework for Photon-Mediated Retrocausal Quantum Communication

Speculative Research Proposal

September 4, 2026

Scientific Status Notice

This document presents a speculative, falsifiable hypothesis. It is not an established theory of physics, and no experiment has demonstrated controllable communication or energy transfer into the past. Materials listed here are conventional components proposed for coherence, isolation, timing, and detection; none is known to possess "time-travel" properties.

Contents

Abstract

This paper proposes a speculative extension of quantum electrodynamics in which a quantum electromagnetic channel may, under specially prepared two-time boundary conditions, possess a controllable advanced component capable of conveying classical or quantum information from a later event to an earlier event. The proposal, termed **Consistency-Projected Reverse-Symmetric Quantum Electrodynamics (CPRS-QED)**, is explicitly distinguished from ordinary quantum entanglement, delayed-choice experiments, postselection performed after data collection, and experimentally simulated postselected closed timelike curves.

Three successive hypotheses are subjected to attempts at falsification. First, an entanglement-only retrocommunication model is rejected by the no-signalling property of standard quantum mechanics. Second, an unrestricted advanced-wave model is rejected because it permits uncontrolled causal feedback and lacks a general stability condition. The third model introduces: (1) fundamentally time-symmetric electromagnetic propagation, (2) final-state boundary control that creates a small advanced-channel weighting, (3) a normalized noisy retrocausal quantum channel, and (4) a stochastic fixed-point condition for histories containing causal feedback. This version is mathematically normalizable, maintains positive photon energy and full-history energy accounting, supplies a paradox-consistency rule, and makes an experimental prediction sharply distinguishable from conventional quantum mechanics.

The decisive experiment is simple in principle: a bit selected randomly at time t_F must alter the statistics of detector records irreversibly recorded at an earlier time $t_P < t_F$, **without retrospective postselection, resorting, coincidence filtering based on the future data, or a conventional signal path**. Current quantum mechanics predicts zero channel capacity under this condition. CPRS-QED predicts a small but nonzero raw mutual information.

A staged experimental program using entangled photons, periodically poled KTP sources, superconducting single-photon detectors, cryogenic rare-earth quantum memories, low-expansion alloys and magnetic shielding is proposed. No known material or alloy is presently known to generate a retrocausal channel; the materials specified here provide coherence, isolation, timing accuracy and detection efficiency rather than established temporal-reversal properties.

1. Scientific Status of the Proposal

CPRS-QED is **not established physics**.

Experiments involving delayed-choice entanglement swapping can make correlations appear as though a later measurement determines whether already-recorded photons belonged to an entangled or separable ensemble. They do not permit an observer at the earlier time to extract the later choice from their local data.

Likewise, experimental simulations of postselected closed timelike curves reproduce mathematical properties of such models but do not demonstrate that information physically arrived before it was generated. A 2026 experiment, for example, interpreted postselected quantum-circuit results as recovery of scrambled information "before" its generation, while implementing the effect through postselection on conventional quantum processors.

Of particular relevance, Ji, Lloyd, and Wilde introduced an information-theoretic treatment of the **retrocausal capacity** of noisy postselected closed-timelike-curve channels in 2026. Their result provides a rigorous way of discussing backward-channel capacity, but it does not by itself establish that such a channel occurs naturally in spacetime.

CPRS-QED asks the stronger experimental question:

> Can such a channel become an ontic physical process rather than merely a conditional mathematical description?

2. Required Phenomenon

Consider two events at the same laboratory or at timelike-separated laboratories:

$$P = (\mathbf{x}_P, t_P), \qquad F = (\mathbf{x}_F, t_F),$$

with

$$t_F > t_P.$$

At F, the sender selects a message

$$m \in \{0, 1\}.$$

At P, a receiver records

$$a \in \{0, 1\}.$$

Ordinary forward causality requires

$$P(a|m) = P(a)$$

when m is selected only after a has been irreversibly recorded.

True retrocommunication requires

$$P(a|m = 0) \neq P(a|m = 1).$$

The critical requirement is that the difference appear in the **raw past records**, not only after the experimenter later sorts the records according to m.

3. Falsification Attempt I - Entanglement Alone

3.1 Hypothesis I

Generate a Bell state

$$|\Phi^+\rangle_{PF} = \frac{|0_P 0_F\rangle + |1_P 1_F\rangle}{\sqrt{2}}.$$

Suppose the future sender encodes bit m through

$$U_m = \begin{cases} I, & m = 0, \\ Z, & m = 1. \end{cases}$$

One might hope that measurement statistics of subsystem P change after applying U_m to subsystem F.

3.2 Disproof

Let the joint density matrix be ρ_{PF}.

The earlier reduced state is

$$\rho_P = \mathrm{Tr}_F\, \rho_{PF}.$$

After a future local unitary,

$$\rho'_{PF} = (I \otimes U_m)\rho_{PF}(I \otimes U_m^\dagger).$$

Therefore

$$\rho'_P = \mathrm{Tr}_F \left[(I \otimes U_m)\rho_{PF}(I \otimes U_m^\dagger)\right] = \rho_P.$$

Thus

$$P(a|m) = P(a).$$

No locally readable information has propagated backward.

Verdict: Hypothesis I fails.

Entanglement is necessary for many of the proposed experiments but cannot, under ordinary linear quantum mechanics, serve as a controllable backwards telephone.

4. Falsification Attempt II - Unrestricted Advanced Photons

A more radical possibility is to restore the time symmetry of Maxwell's wave equation explicitly.

Both retarded and advanced Green functions solve the field equations:

$$G_{\mathrm{ret}}(x - x'), \qquad G_{\mathrm{adv}}(x - x').$$

The time-symmetric Green function is

$$G_{\mathrm{TS}}(x - x') = \frac{1}{2}\left[G_{\mathrm{ret}}(x - x') + G_{\mathrm{adv}}(x - x')\right].$$

Time-symmetric electrodynamics has historical precedents, including Wheeler-Feynman absorber theory.

4.1 Hypothesis II

Assume a controllable source can emit

$$A^\mu(x) = \int d^4x' \,\left[(1 - \epsilon)G^{\mu\nu}_{\mathrm{ret}}(x - x') + \epsilon G^{\mu\nu}_{\mathrm{adv}}(x - x')\right] J_\nu(x')$$

with

$$\epsilon > 0.$$

The advanced component has support at spacetime events earlier than the source. Consequently, in principle,

$$J(t_F) \to A(t_P), \qquad t_P < t_F.$$

4.2 Failure Through Feedback

Imagine that the past detector output controls an amplifier whose later output becomes the advanced source.

If the ordinary forward transfer amplitude is G and the advanced transfer amplitude is ϵ, one obtains schematically

$$A_{n+1} = \epsilon G A_n + A_{\text{ext}}.$$

The closed-loop solution is

$$A = \frac{A_{\text{ext}}}{1 - \epsilon G}.$$

As

$$|\epsilon G| \to 1,$$

the response diverges. For

$$|\epsilon G| > 1,$$

unrestricted solutions can become unstable or nonunique.

The theory therefore allows a detector, amplifier and advanced transmitter to amplify their own causes. This is not a small technical defect; it is a fundamental consistency problem.

Verdict: Hypothesis II fails.

A usable retrocausal theory requires a global rule that determines which closed histories are physically admissible.

5. Falsification Attempt III - CPRS-QED

The third model retains microscopic time symmetry but adds a self-consistency condition. It has four postulates.

6. Postulate I - Two-Boundary Quantum States

A quantum history is specified by both an initial boundary state

$$|I\rangle$$

and a final boundary condition

$$|F_m\rangle,$$

where m is the future encoded message.

For an intermediate measurement M_a, define the two-boundary amplitude

$$\mathcal{A}(a|I, F_m) = \langle F_m|U(t_F, t_P)M_a U(t_P, t_I)|I\rangle.$$

The corresponding normalized probability is

$$P(a|I, F_m) = \frac{|\mathcal{A}(a|I, F_m)|^2}{\sum_{a'} |\mathcal{A}(a'|I, F_m)|^2}.$$

This resembles existing pre- and postselected quantum-state formalisms, where quantum systems are described using information associated with both preparation and postselection.

The new CPRS-QED postulate is stronger:

The final boundary condition is physically active rather than merely an analysis condition imposed after the experiment.

That is the experimentally vulnerable assumption.

7. Postulate II - Boundary-Selected Advanced Electromagnetic Response

The fundamental electromagnetic response remains time symmetric:

$$G_{\text{TS}} = \frac{G_{\text{ret}} + G_{\text{adv}}}{2}.$$

Observed ordinary retarded behavior is assumed to result from macroscopic boundary conditions.

Inside a specially coherent quantum network, the final boundary may alter that balance.

Define a boundary parameter

$$\beta_m, \qquad -1 \le \beta_m \le 1.$$

The effective field becomes

$$A^\mu(x|F_m) = \int d^4x' \left[\frac{1+\beta_m}{2} G^{\mu\nu}_{\text{ret}} + \frac{1-\beta_m}{2} G^{\mu\nu}_{\text{adv}}\right] J_\nu(x').$$

Ordinary retarded physics corresponds approximately to

$$\beta_m = 1.$$

A nonzero advanced fraction is therefore

$$\epsilon_m = \frac{1-\beta_m}{2}.$$

CPRS-QED predicts that specially prepared entangled boundary conditions can produce

$$\epsilon_m > 0$$

inside the coherent device while leaving macroscopic environments overwhelmingly retarded.

This is a new physical postulate, not a consequence of conventional QED.

8. Postulate III - The Retrocausal Quantum Channel

We represent the experimentally accessible future-to-past link by

$$\mathcal{B}_\eta.$$

For a classical future bit m and past measurement bit a,

$$P(a|m,\eta) = \frac{1}{2}\left[1 + (-1)^{a\oplus m}\eta\right],$$

where

$$0 \leq \eta \leq 1.$$

Thus

$$P(a = m) = \frac{1+\eta}{2},$$

and

$$P(a \neq m) = \frac{1-\eta}{2}.$$

Standard quantum mechanics predicts

$$\eta = 0.$$

A perfect retrochannel would have

$$\eta = 1.$$

The binary error probability is

$$q = \frac{1-\eta}{2}.$$

Its ideal classical capacity is therefore

$$C_R = 1 - h_2(q),$$

where

$$h_2(q) = -q \log_2 q - (1-q) \log_2 (1-q).$$

Hence

$$\boxed{C_R(\eta) = 1 - h_2\left(\frac{1-\eta}{2}\right)}$$

bits per successful channel use.

For very small η,

$$C_R \approx \frac{\eta^2}{2 \ln 2}.$$

The relevance of explicitly defining a retrocausal capacity is reinforced by the 2026 work of Ji, Lloyd and Wilde, although CPRS-QED's physical mechanism is different from merely assuming a mathematical PCTC channel.

9. Postulate IV - Consistency Projection

Suppose the receiver reacts to the earlier bit a, and this influences what the future sender decides to transmit.

Represent the future decision policy by

$$Q(m|a).$$

Combining the policy with the retrochannel produces a closed-loop transition matrix

$$T(a'|a) = \sum_m \mathcal{B}_\eta(a'|m)\, Q(m|a).$$

A physically admissible history must satisfy

$$p_{\mathrm{SC}}(a') = \sum_a T(a'|a)\, p_{\mathrm{SC}}(a).$$

Or, in vector form,

$$\boxed{\mathbf{p}_{\mathrm{SC}} = T \mathbf{p}_{\mathrm{SC}}}$$

with

$$\sum_a p_{\mathrm{SC}}(a) = 1.$$

Because T is a finite stochastic matrix, it possesses at least one stationary probability distribution.

For example, suppose:

- the receiver observes a;
- the future sender always transmits the opposite bit, $m = 1 - a$;
- the retrochannel is perfect.

There is no deterministic solution

$$a = 1 - a.$$

But the stochastic fixed point is

$$P(a = 0) = P(a = 1) = \frac{1}{2}.$$

The loop therefore loses deterministic predictability instead of producing a logical contradiction.

This is the core modification that allows Version III to survive the instability that killed Version II.

10. Photon Energy

CPRS-QED does **not** require negative-energy photons.

Each photon retains

$$E_\gamma = \hbar\omega = \frac{hc}{\lambda} > 0.$$

At a telecommunications wavelength near

$$\lambda = 1550 \text{ nm},$$

the photon energy is approximately 0.8 eV.

The proposed reversal concerns the boundary condition associated with propagation, rather than changing the sign of the photon's quantum energy.

For a complete electromagnetic system,

$$\partial_\mu T^{\mu\nu}_{\mathrm{total}} = 0.$$

An advanced solution is therefore required to obey the same local field-energy accounting as the retarded solution.

A future apparatus coupled to an advanced field may correspond to an earlier absorber event, but CPRS-QED forbids a closed history in which usable energy appears without the associated source/absorber bookkeeping.

In schematic form,

$$E_{\text{source}} + E_{\text{receiver}} + E_{\text{field}} + E_{\text{apparatus}} = \text{constant}$$

over the complete self-consistent history.

The theory therefore predicts temporal redistribution of energy, not unlimited energy creation.

11. Result of the Third Falsification Attempt

The third model is tested against four immediate objections.

Test A - Probability Normalization

For every m,

$$\sum_a P(a|m,\eta) = 1.$$

Passed.

Test B - Nonnegative Probabilities

For

$$0 \leq \eta \leq 1,$$

all probabilities lie between zero and one.

Passed.

Test C - Paradoxical Feedback

Closed loops are required to satisfy

$$\mathbf{p} = T\mathbf{p}.$$

Finite stochastic T possesses a stationary distribution.

Passed at the level of the proposed model.

Test D - Empirical Distinguishability

Conventional quantum mechanics predicts

$$I(A;M) = 0$$

for raw records generated before the future choice.

CPRS-QED predicts

$$I(A;M) > 0$$

whenever

$$\eta > 0.$$

Therefore the theory is experimentally falsifiable.

Passed.

Interpretation: Version III passes the proposed theoretical screening process. It has emphatically **not passed an experimental test**. A clean null experiment would constrain or rule out its coupling parameter η.

12. Proposed Physical Architecture

The laboratory apparatus contains five major systems:

1. quantum-photon source;
2. past receiver;
3. temporal quantum anchor;
4. future encoder;
5. isolation and immutable time-recording system.

13. Photon Source

A mature implementation would use spontaneous parametric downconversion.

A practical configuration is

$$775 \text{ nm} \rightarrow 1550 \text{ nm} + 1550 \text{ nm}.$$

Periodically poled potassium titanyl phosphate, **ppKTP**, is well established for producing high-quality photon pairs near 1550 nm. Modern experiments routinely use pulsed 775-nm pumping of ppKTP for telecom-band entangled photon production.

The generated state should approximate

$$|\Psi\rangle = \frac{|H\rangle_P |H\rangle_F + e^{i\phi} |V\rangle_P |V\rangle_F}{\sqrt{2}}.$$

The target Bell-state fidelity for an initial search experiment should be as high as reasonably achievable, preferably

$$F_{\text{Bell}} > 0.95.$$

14. Future Message Encoding

The sender encodes

$$m = 0$$

using phase

$$\theta_0 = 0$$

and

$$m = 1$$

using

$$\theta_1 = \pi.$$

The transformation is

$$U_m = e^{-i\theta_m \sigma_z/2}.$$

A fast electro-optic phase modulator may be fabricated from lithium niobate or implemented using a conventional fiber-coupled telecom modulator.

The selection must occur using a quantum random-number generator **after the past receiver data have already been sealed**.

15. Past Interferometric Receiver

The earlier photon enters a phase-sensitive analyzer.

For example,

$$|+\rangle = \frac{|H\rangle + |V\rangle}{\sqrt{2}}, \qquad |-\rangle = \frac{|H\rangle - |V\rangle}{\sqrt{2}}.$$

Two detectors register $a = 0$ and $a = 1$.

Under ordinary quantum mechanics,

$$P(+|m=0) = P(+|m=1) = \frac{1}{2}$$

after tracing over the future subsystem.

CPRS-QED predicts instead

$$P(+|m=0) = \frac{1+\eta_{\text{eff}}}{2},$$

$$P(+|m=1) = \frac{1-\eta_{\text{eff}}}{2}.$$

The experiment therefore requires no subjective interpretation. It reduces to measuring whether

$$\eta_{\text{eff}} = 0.$$

16. Detector Materials and Superconducting Alloys

Superconducting nanowire single-photon detectors are appropriate because the experiment requires high efficiency, low dark-count probability and excellent timing.

Material	Proposed function
WSi	Amorphous superconducting photon-detector film
MoSi	Alternative superconducting detector alloy
MoGe	Candidate amorphous detector material
WRe	Superconducting alloy investigated for detector applications
NbN	Conventional superconducting nanowire
NbTiN	Robust superconducting nitride detector material

NIST has investigated amorphous MoSi, MoGe and WRe films specifically for high-efficiency superconducting photon detection.

Modern SNSPD systems can approach approximately 98% system detection efficiency, while state-of-the-art devices can achieve extremely low timing jitter and dark-count rates. Typical operating temperatures are below roughly 2.5 K.

No superconducting alloy is claimed to produce temporal reversal. Their role is simply to ensure that a tiny statistical effect cannot be mistaken for detector noise.

17. Structural Alloys

17.1 Invar 36

Low-expansion Fe-Ni Invar should be used for interferometer mounts where thermal path-length drift is critical. Nominally it is approximately

$$64\%\text{Fe} + 36\%\text{Ni}.$$

The purpose is mechanical stability, not retrocausal interaction.

17.2 High-Permeability Ni-Fe Shielding

Commercial mu-metal-type Ni-Fe shielding alloy can surround quantum-memory assemblies, detector electronics and phase-sensitive interferometers. Exact compositions vary by manufacturer. Its purpose is attenuation of changing magnetic fields that could correlate detector outputs with future electronics.

17.3 316L Stainless Steel

316L stainless steel is appropriate for vacuum hardware, cryostat mechanical components and feedthrough assemblies.

17.4 Oxygen-Free Copper

OFHC copper is appropriate for cryogenic thermal straps, cold detector mounts and RF grounding structures.

Again, none of these materials possesses a known temporal anomaly.

18. Temporal Quantum Anchor

A strong version of CPRS-QED predicts that the advanced channel becomes measurable only when the two boundary events belong to a highly coherent joint quantum history.

Define the anchor coherence factor

$$F_A(\Delta t).$$

Then

$$\eta_{\text{eff}} = \eta_0 V F_A(\Delta t) F_{\text{BSM}} \sqrt{\eta_{D,P}\eta_{D,F}}.$$

Here:

- η_0 = fundamental CPRS coupling;
- V = interferometric visibility;
- F_A = temporal-anchor coherence;
- F_{BSM} = Bell/projection fidelity;
- η_D = detector efficiencies.

A phenomenological model is

$$F_A(\Delta t) = \exp\left[-\left(\frac{|\Delta t|}{T_A}\right)^n\right].$$

The parameter T_A is the experimental temporal coherence scale.

19. Short Temporal Separations

For early experiments, the future photon can simply be delayed in optical fiber.

The trial sequence becomes

$$t_P : \quad \text{past measurement}$$

followed by

$$t_F = t_P + \Delta t : \quad \text{future random encoding.}$$

Suitable separations include nanoseconds, microseconds and milliseconds. A positive signal should first demonstrate predictable scaling with Δt.

20. Millisecond Quantum-Memory Experiment

For significantly larger temporal separation, a quantum memory may hold the future subsystem.

A demonstrated platform is

$$^{151}\mathrm{Eu}^{3+} : \mathrm{Y_2SiO_5}.$$

Experiments have stored weak photonic temporal modes for 20, 50 and 100 ms and demonstrated time-bin-qubit coherence at 20 ms.

One implementation used

$$T \approx 3.5 - 4\ \mathrm{K},$$

a weak static field of approximately

$$1.35\ \mathrm{mT},$$

and an atomic-frequency-comb spin-wave memory.

The optical transition is near

$$580\ \mathrm{nm}.$$

A telecom experiment would therefore require wavelength conversion or an alternative memory compatible directly with the telecom photon.

The memory is not hypothesized to cause time travel. It lengthens the temporal separation while maintaining quantum coherence.

21. Experimental Environment

The experiment should operate as two electronically independent zones.

Past Zone

Contains:

- photon analyzer;
- SNSPDs;
- independent time tagger;
- receiver computer;
- immutable record storage.

Future Zone

Contains:

- delayed photon;
- quantum random-number source;
- phase/polarization modulator;

- sender controller.

The two zones must not share real-time control lines capable of leaking the future bit into the past electronics.

22. Thermal Control

Optical interferometer path drift directly changes measured probabilities. Therefore:

- interferometric optics should be enclosed;
- temperature should be actively stabilized;
- low-expansion mounts should be used;
- reference interferometry should characterize residual drift.

Reference signals used for stabilization must be prevented from carrying the future encoding bit into the past detector electronics.

23. Magnetic Control

The experiment should employ high-permeability shielding around sensitive detector/readout regions, independent monitoring magnetometers, and separate power systems where practical.

Any field generated by the future electro-optic electronics must be demonstrated experimentally to remain below the sensitivity required to explain a claimed correlation.

24. Electromagnetic Isolation

The future bit could otherwise leak through:

- RF radiation;
- ground loops;
- Ethernet;
- USB;
- trigger cables;
- clock distribution;
- acoustic vibration;
- optical backscatter.

The future encoder should therefore be placed in a shielded enclosure with independently logged environmental sensors.

A particularly strong experiment would use two geographically separated buildings connected only by the required optical quantum link.

25. Immutable Past Records

This is arguably the most important experimental requirement.

At t_P, each event record should contain

$$R_i = \{i, t_i, a_i, D_i\},$$

where i is the trial number, t_i is the timestamp, a_i is the detector result, and D_i represents detector diagnostics.

Before m_i is created, a cryptographic digest

$$H_i = H(R_1||R_2||\ldots||R_i)$$

should be calculated and transmitted to multiple independent append-only storage systems.

Only afterward is

$$m_i$$

generated.

Thus no analyst can later change a_i to fit m_i.

26. Experiment 1 - Conventional No-Signalling Baseline

Objective

Prove that the apparatus does not manufacture a false retrocausal signal.

Procedure

1. Generate entangled pair.
2. Measure past photon.
3. Seal receiver record.
4. Generate future random bit.
5. Apply future phase operation.
6. Measure future subsystem.
7. Test raw $A - M$ correlation.

Conventional prediction:

$$P(a|m) = P(a).$$

Therefore

$$\eta_{\text{measured}} = 0$$

within statistical uncertainty.

This experiment reproduces the essential logical structure behind delayed-choice experiments while explicitly testing the unavailable local signal. Delayed-choice entanglement swapping has experimentally demonstrated remarkable time-order-independent correlations, but not usable backwards communication.

27. Experiment 2 - Simulated PCTC Calibration

A postselection circuit should then deliberately emulate a retrocausal channel. This demonstrates that the analysis software can detect a known artificial effect.

Postselected CTC models based on teleportation have been studied theoretically and simulated experimentally. The 2026 quantum-computing experiment provides an especially modern calibration model.

This stage must be labeled:

simulation only.

It demonstrates the mathematical signature expected from a retrochannel but not actual past communication.

28. Experiment 3 - Decisive Raw-Record Experiment

This is the critical CPRS-QED test.

For each trial:

At t_P

Measure the receiver photon and record

$$a_i.$$

Seal and replicate the record.

At $t_F > t_P$

Generate a fresh random bit

$$m_i.$$

Apply

$$U_{m_i}.$$

No postselection is permitted when testing the primary hypothesis.

Compute

$$\hat{\eta} = P(a = m) - P(a \neq m).$$

Standard quantum mechanics predicts

$$\boxed{\hat{\eta} = 0}.$$

CPRS-QED predicts

$$\boxed{\hat{\eta} > 0}.$$

This is the central falsification equation of the entire proposal.

29. Statistical Test

Define counts

$$N_{00}, N_{01}, N_{10}, N_{11},$$

where N_{am} counts receiver result a and future message m.

Under the null,

$$P(a,m) = P(a)P(m).$$

The mutual information is

$$I(A;M) = \sum_{a,m} P(a,m) \log_2 \frac{P(a,m)}{P(a)P(m)}.$$

Standard theory predicts, apart from finite-sample fluctuations,

$$I(A;M) = 0.$$

CPRS-QED predicts

$$I(A;M) = 1 - h_2\left(\frac{1-\eta_{\text{eff}}}{2}\right)$$

for the symmetric idealized channel.

Analysis methods and stopping criteria must be preregistered.

A discovery claim should require:

- strong statistical significance;
- replication with physically independent electronics;
- reproduction at another laboratory;
- elimination of ordinary electromagnetic leakage;
- predicted dependence on quantum coherence.

30. Experiment 4 - Temporal-Distance Law

Measure

$$\hat{\eta}(\Delta t)$$

for a predetermined sequence such as

$$10^{-9}, 10^{-8}, 10^{-7}, 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3} \text{ s},$$

and eventually larger values where storage technology permits.

Possible models include

$$\eta(\Delta t) = \eta_0 e^{-|\Delta t|/T_A},$$

or

$$\eta(\Delta t) = \eta_0 e^{-(|\Delta t|/T_A)^2}.$$

The shape must be inferred experimentally rather than chosen after seeing the result.

A true effect linked to temporal quantum coherence should change systematically as that coherence is deliberately degraded.

31. Experiment 5 - Entanglement-Dependence Test

Measure η at several Bell-state visibilities.

Let

$$V = 0$$

represent a deliberately randomized separable source and

$$V \to 1$$

a high-quality entangled source.

A simple CPRS-QED prediction is

$$\eta_{\text{eff}} \propto V.$$

Therefore

$$V \to 0 \quad \Rightarrow \quad \eta_{\text{eff}} \to 0.$$

If the observed "retrocausal" signal persists unchanged after destroying entanglement, ordinary leakage becomes a much more likely explanation.

32. Experiment 6 - Energy-Channel Test

The strongest version tests not merely an earlier phase correlation but earlier electromagnetic-energy deposition.

At future time t_F, randomly choose

$$m = 0 : \quad \text{source disabled}$$

or

$$m = 1 : \quad \text{single-photon source enabled.}$$

At the earlier time t_P, an independently recorded calorimetric photon detector monitors the corresponding cavity mode.

The prediction is

$$P(E_\gamma, t_P | m = 1) > P(E_\gamma, t_P | m = 0)$$

under CPRS-QED.

Ordinary electrodynamics predicts no such dependence.

A transition-edge sensor could provide photon-number/energy resolution, although it requires more demanding cryogenics near the ~ 100 mK regime.

This experiment should only be attempted after the correlation experiment because its systematics are considerably more demanding.

33. Distinguishing Information Reversal from Energy Reversal

Three increasingly strong phenomena should be distinguished.

Level I - Retrocorrelation

$$I(A; M) > 0.$$

Level II - Controlled Retroinformation

The receiver can decode a future-selected message with error

$$P_e < \frac{1}{2}.$$

Level III - Advanced Energy Transfer

A detector registers electromagnetic energy whose occurrence probability depends on a future source setting.

Level III is dramatically stronger than Level I.

CPRS-QED predicts that a Level III process may exist but need not be as easily observable as the information-channel effect.

34. Extending the Temporal Distance

Nothing in the mathematical channel

$$\mathcal{B}_\eta$$

requires a small value of

$$\Delta t.$$

However, the laboratory coupling is expected to depend strongly on coherence.

Current solid-state photonic quantum memories operate over millisecond-type scales, not years or centuries. For example, the cited europium memory demonstrated single-photon-level temporal-mode storage up to 100 ms and qubit verification at 20 ms.

Consequently, CPRS-QED does **not** presently supply an engineering path for communicating decades into the past.

If the theory were validated, the subsequent question would become whether the temporal anchor can be replaced with a long-lived boundary state whose coherence is topologically or otherwise protected.

That is an unsolved materials problem.

35. Relationship to Indefinite Causal Order

Quantum mechanics already admits experimental situations in which operations cannot straightforwardly be described as occurring in a single classical order.

The quantum switch is the best studied example, and indefinite causal order has become an experimentally active field.

However,

$$\text{indefinite causal order} \neq \text{communication into one's ordinary past.}$$

CPRS-QED therefore predicts something much stronger than presently demonstrated quantum-switch behavior.

36. Relationship to Postselected Closed Timelike Curves

Lloyd and collaborators developed a model in which teleportation combined with postselection can represent a closed timelike curve.

CPRS-QED borrows two conceptual ideas:

1. final boundary conditions;
2. consistency of histories.

But it differs critically in experimental interpretation.

In a normal PCTC simulation, researchers collect ordinary forward-time data and condition later on a selected outcome.

CPRS-QED instead predicts

$$\boxed{\text{the unconditioned earlier physical record depends on the later setting.}}$$

That difference makes it straightforward to falsify.

37. Required Null Controls

Every main run should be interleaved randomly with controls.

Control A

Replace entangled photons with classical pulses.

Expected:

$$\eta = 0.$$

Control B

Disconnect future modulator electrically.

Expected:

$$\eta = 0.$$

Control C

Randomize future data after measurement rather than physically applying it.

Expected:

$$\eta = 0.$$

Control D

Destroy phase coherence.

Expected:

$$\eta \to 0.$$

Control E

Replace the actual future bits with cryptographically generated decoy bits during analysis.

Expected:

$$\eta = 0.$$

Control F

Reverse detector labels. The signal should reverse exactly as predicted by the chosen quantum basis.

Control G

Physically isolate future station. A true channel should remain if CPRS-QED is correct; RF leakage should disappear.

38. Strongest Anti-Fraud Protocol

For extraordinary evidence, the future message can be generated by an external independent laboratory.

Laboratory P publishes past records at t_P.

Only afterward does Laboratory F receive permission to generate m.

The two organizations then combine datasets.

An even stronger version publicly commits the past record hashes to multiple independent timestamping services before the future settings exist.

This makes unnoticed retrospective data alteration extraordinarily difficult.

39. Primary Falsification Criterion

The proposal should be considered experimentally falsified over a tested operating region if increasingly sensitive experiments establish

$$|\eta| < \eta_{\text{limit}}$$

for all

$$\Delta t, V, F_A, Q, T, \lambda$$

covered by the experiment.

Unlike an unfalsifiable time-travel claim, CPRS-QED therefore exposes a measurable coupling constant.

If

$$\eta_0 = 0,$$

the theory collapses back to ordinary no-signalling quantum mechanics.

40. What Would Constitute Convincing Evidence?

One positive correlation is insufficient.

Evidence should satisfy all of the following:

1. Past records demonstrably exist before future bits.
2. Future bits are generated unpredictably after those records.
3. Raw earlier data alone contain statistically significant information about those later bits.
4. No coincidence sorting or future-dependent postselection is used.
5. The signal disappears when quantum coherence is destroyed.
6. The signal scales according to a preregistered experimental parameter.
7. Independent electromagnetic and electronic leakage tests fail to explain it.
8. Independent laboratories reproduce it.

Only then would the result justify considering genuine retrocausal communication.

41. Implications if Confirmed

If

$$\eta > 0$$

were reproducibly observed, several conclusions would follow.

First, the conventional operational no-signalling structure of quantum mechanics would be incomplete.

Second, future boundary conditions would acquire direct physical significance.

Third, channel capacity would become a function not only of spatial separation and noise but also temporal orientation:

$$C = C(\Delta x, \Delta t, \text{direction}).$$

Fourth, information theory would require separate forward and retrograde capacities:

$$C_+, \qquad C_-.$$

Fifth, causal loops would have to be modeled as globally self-consistent probability distributions rather than unrestricted sequences of independent interventions.

42. Implications for Distant-Past Communication

Suppose experimentally one finds

$$\eta(\Delta t) \neq 0.$$

The next objective is determining whether it decays.

Model A - Coherence-Limited

$$\eta \sim e^{-\Delta t/T_A}.$$

Communication is limited to the temporal coherence of the anchor.

Model B - Power-Law

$$\eta \sim \left(1 + \frac{\Delta t}{T_A}\right)^{-\alpha}.$$

Long-range retrocommunication becomes difficult but perhaps not impossible.

Model C - Boundary-State Limited but Distance Independent

$$\eta \simeq \eta_0$$

while a valid two-boundary state exists.

Model C would permit communication across extremely distant times and would be the revolutionary regime sought in the original objective.

There is presently no experimental evidence favoring Model C.

43. Materials Research Program Following a Positive Result

Only after demonstrating $\eta > 0$ should specialized material development begin.

Optimization variables would include

$$\frac{\partial \eta}{\partial Q}, \qquad \frac{\partial \eta}{\partial T}, \qquad \frac{\partial \eta}{\partial V}, \qquad \frac{\partial \eta}{\partial \chi^{(2)}}, \qquad \frac{\partial \eta}{\partial T_2}.$$

Candidate materials would include:

- improved ppKTP nonlinear crystals;
- thin-film lithium-niobate modulators;
- ultralow-loss silicon-nitride photonics;
- rare-earth-doped quantum-memory crystals;
- high-coherence superconducting circuits;
- WSi/MoSi/NbTiN photon detectors;
- crystalline high-reflectivity cavity coatings.

The experimental goal would be to identify whether any material parameter controls

$$\eta_0$$

rather than merely improving detection fidelity.

That distinction is essential.

44. Safety and Experimental Practicality

The first three experiments operate at single-photon optical powers and do not require exotic high-energy physics.

They nevertheless involve lasers, cryogenic refrigeration, electrical currents in detector electronics, vacuum equipment in some configurations and RF electronics.

Normal institutional laser, electrical, vacuum and cryogenic safety procedures are required.

No gravitational singularity, high-energy particle beam, radioactive source, extreme magnetic field or macroscopic negative-energy configuration is required by the proposed initial test.

45. Summary of the Three Falsification Iterations

Version I - Entanglement-Only Backwards Signalling

Prediction:

$$\rho_P \to \rho_P(m).$$

Result:

$$\rho_P(m) = \rho_P.$$

Rejected.

Version II - Unrestricted Advanced Photons

Prediction:

$$A(t_P) \leftarrow J(t_F).$$

Problem:

$$A = \frac{A_{\text{ext}}}{1 - \epsilon G}$$

produces unstable/nonunique causal feedback.

Rejected.

Version III - Consistency-Projected Reverse-Symmetric QED

Retrochannel:

$$P(a|m) = \frac{1}{2}[1 + (-1)^{a \oplus m}\eta].$$

Self-consistency:

$$\mathbf{p} = T\mathbf{p}.$$

Energy:

$$E_\gamma = \hbar\omega > 0.$$

Experimental distinction:

$$\eta_{\text{QM}} = 0, \qquad \eta_{\text{CPRS}} > 0.$$

Passes internal consistency screening and proceeds to experimental falsification.

46. Conclusion

Ordinary entanglement cannot transmit information to the past, and experimental delayed-choice effects do not overturn this fact. A genuine retrocommunication theory therefore requires physics beyond ordinary quantum no-signalling.

CPRS-QED proposes one minimal route: retain time-symmetric microscopic electromagnetic solutions, elevate final quantum boundary conditions from retrospective bookkeeping to physical boundary data, represent the resulting backwards link as a noisy quantum channel, and impose a stochastic fixed-point condition whenever the resulting information closes a causal loop.

The central experimental prediction is exceptionally clear:

$$\boxed{P(a|m) \neq P(a) \quad \text{for} \quad t_a < t_m.}$$

Equivalently,

$$\boxed{I(A_{\text{past}}; M_{\text{future}}) > 0}$$

in **raw immutable records produced before M_{future} exists**.

That is where this proposal lives or dies.

No exotic alloy is presently justified as a "time material." The first experiment can instead be constructed almost completely from established quantum-optical technology: ppKTP entangled-photon sources, superconducting single-photon detectors, stable interferometers, cryogenic memories and conventional shielding alloys.

If repeated experiments return

$$\eta = 0,$$

the proposed physical retrochannel is falsified to the achieved sensitivity.

If instead a reproducible

$$\eta > 0$$

survives all leakage, postselection and timing controls, the result would constitute evidence for physics substantially beyond the conventional causal structure of quantum mechanics and would justify a serious program aimed at extending the temporal separation from milliseconds toward genuinely distant times.

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Primary falsification equation

$$\boxed{P(a|m) = \frac{1}{2}\left[1 + (-1)^{a \oplus m}\eta\right]}$$

Standard physics requires $\eta = 0$ when m is genuinely chosen after a has been permanently recorded. A measured, independently replicated $\eta > 0$ without postselection would be the first result that could justify taking the rest of the CPRS-QED hypothesis seriously.