The Adjoint-Removal Positivity and Microcausality Theorem in VERSF

▲ Programme Milestone — Quantum Consistency Series Gate QC-1 / Physical-Sector Positivity and Causality Gate

Eliminating auxiliary adjoint residue without losing observable records, introducing negative norm, or permitting acausal influence

A conditional structural closure theorem: positivity, no-ghost quotienting, and microcausality descent

Keith Taylor VERSF Theoretical Physics Programme — Quantum Consistency Series Tier A gate paper, QC-1

General Reader Summary

A physical theory is not complete simply because it has the right symmetries or the right particle pattern. It must also be quantum-admissible.

That means three basic things.

First, the theory must not contain hidden unphysical states with negative probability or negative norm. Second, removing mathematical bookkeeping structures must not accidentally remove real observable information. Third, the theory must not allow one event to influence another event outside the light cone.

VERSF uses a rich formal structure: folds, completions, adjoint presentations, continuation ledgers, and physical record projections. That richness is useful, but it creates a danger. A critic may ask:

Do the extra adjoint or completion structures leave behind ghost states, negative probabilities, or hidden faster-than-light influence channels?

This paper answers that question.

The word **adjoint** in this paper does **not** mean ordinary gauge bosons in the adjoint representation of a gauge group. Gluons, for example, are not removed. Nor does it mean deleting the Hermitian adjoint operation † used in quantum theory. Here, "adjoint-removal" means removing VERSF's auxiliary completion residue: formal mirror/bookkeeping structure that exists to close the algebraic description but does not correspond to an independent terminal physical record.

The central result is simple in plain language:

When the VERSF physical observable sector is obtained by quotienting out adjoint-only, detector-silent completion residue, the remaining sector has positive physical norm, no independent ghost excitations, and microcausal commutation for spacelike-separated observables. Moreover, the quotient is canonical: it is the unique maximal removal compatible with preserving every terminal record.

The theorem is conditional and structural. It assumes the inherited VERSF record framework, the local support discipline, and the already-closed gauge/weak-attachment gates. It does not compute scattering amplitudes, renormalisation flows, the Higgs potential, particle masses, or CKM/PMNS matrices. It proves something earlier and necessary:

the VERSF physical-sector extraction is quantum-admissible.

In one sentence:

Adjoint-removal in VERSF removes only detector-silent completion residue; it preserves all physical records, produces a positive physical state space, and leaves no spacelike signalling channel behind.

Contents

Abstract

VERSF employs formal completion, adjoint presentation, and continuation structures that are broader than the terminal physical record sector. Such structures are useful for algebraic closure, but they raise a quantum-consistency question: after the physical sector is extracted, can adjoint residue leave behind negative-norm states, ghost excitations, or acausal influence channels?

This paper proves that it cannot, under the stated VERSF record and locality premises.

Let $\mathfrak{A}$_K($\mathcal{O}$) be the local kinematic VERSF *-algebra assigned to a bounded fold-support region $\mathcal{O}$ of the emergent continuum. Let $\mathfrak{J}$_AR($\mathcal{O}$) be the adjoint-removal ideal: the class of auxiliary adjoint/completion expressions that vanish against every terminal record functional in every physical context. The physical observable algebra is the quotient

$\mathfrak{A}_P(\mathcal{O}) = \mathfrak{A}_K(\mathcal{O}) / \mathfrak{J}_{AR}(\mathcal{O})$.

The paper proves five results.

First, $\mathfrak{J}_{AR}$ is a two-sided *-ideal, so the quotient is a well-defined local *-algebra. Second, no terminal physical record is lost, and $\mathfrak{J}_{AR}$ is the **largest** two-sided *-ideal with this property, so the physical quotient is canonical relative to the record family. Third, every terminal record state — constructed as a context vector state of the record family, not postulated — descends to a state functional that is positive on all of $\mathfrak{A}_P$, and the corresponding GNS physical state space contains no negative-norm vectors. Fourth, if kinematic spacelike graded commutators vanish modulo adjoint-removal residue — the QC-7 antecedent, registered in this paper as an open upstream debt — then the physical quotient is exactly microcausal:

$[A_P, B_P]_g = 0$ for spacelike-separated supports.

Fifth, adjoint residue supports no spacelike signalling channel for local interventions of standard Kraus form, and admissible continuation dynamics descends to the quotient whenever it preserves the ideal.

Here $[\cdot,\cdot]_g$ denotes the graded commutator,

$[A,B]_g = AB - (-1)^{|A||B|} BA$,

reducing to the commutator for bosonic observables and the anticommutator rule for fermionic generators.

The theorem does not remove gauge fields merely because they transform in adjoint representations, does not remove the Hermitian adjoint operation, and does not assert that all formal auxiliary variables are meaningless. It states the precise condition under which VERSF's auxiliary adjoint residue is nonphysical: it is detector-silent, ideal-stable, locally supported, and continuation-null. Once removed by quotient, the surviving physical sector is positive, ghost-free, and microcausal.

---

0. Inheritance, Notation, and Firewalls

0.1 Inherited results

QC-1 inherits the following results and commitments from earlier VERSF/BCB gates.

I1 — Physical record primacy. A physical fact in VERSF is a terminally recordable commitment, not a free-floating formal coordinate. Mathematical expressions that do not change any possible terminal record belong to presentation, gauge, completion, or null structure.

I2 — Local support discipline. Physical commitments have support. If an operation is assigned to a region $\mathcal{O}$ of the emergent continuum, its observable consequences must remain in the causal development of $\mathcal{O}$, except for gauge/presentation changes that carry no terminal signal.

I3 — Gauge-census closure. The minimal Standard Model internal gauge census has already been closed at local algebra level. QC-1 does not reopen the gauge-factor census.

I4 — Weak-attachment sign closure. The weak sector has already been attached coherently to chirality, hypercharge, Higgs access, and mass-pairing. QC-1 does not carry an unresolved weak-orientation branch.

I5 — Physical extraction discipline. VERSF distinguishes formal completion structure from terminal observable structure. QC-1 makes that distinction precise for adjoint-removal.

I6 — Minimal-census boundary. The paper works inside the minimal Standard Model/VERSF physical census. A mirror sector, a second independent Higgs ledger, a right-handed weak sector, or a new gauge channel would be a census extension, not an unresolved internal residue of this paper.

QC-1 does not re-prove these. It asks whether the physical-sector extraction remains quantum-admissible once they are inherited.

0.2 Standing convention on causal language

Time is emergent in VERSF. Throughout this paper, "spacelike separation" refers to the causal structure of the emergent 4-manifold reconstructed from the commitment order, not to a background time coordinate. "Support region" means a bounded fold-support region $\mathcal{O}$ of that geometric structure. No premise of this paper assumes a pre-geometric clock.

0.3 What "adjoint-removal" means here

The phrase **adjoint-removal** is dangerous unless defined carefully.

This paper does **not** remove:

- the Hermitian adjoint operation $A^\dagger$;
- gauge bosons in adjoint representations;
- gluons;
- weak gauge fields;
- mathematical duals needed for inner products;
- physical antiparticles;
- genuine measurable interference structure.

It removes only a specific VERSF object:

adjoint/completion residue that has no independent terminal record, is stable as a null ideal, and can be quotiented without changing any observable physical continuation.

In this paper, "adjoint" therefore means **auxiliary adjoint-presentation residue**, not "adjoint representation" in the ordinary gauge-theory sense.

This distinction is load-bearing. Without it, the theorem would be false: gluons are physically real excitations even though they transform in the adjoint representation of $SU(3)_c$. QC-1 removes no such thing.

0.4 Firewalls

This paper proves:

- the adjoint-removal sector can be defined as a detector-silent ideal;
- quotienting by that ideal loses no terminal physical records, and no larger ideal has that property;
- terminal record states descend to positive physical state functionals;
- negative-norm ghost states do not survive in the physical Hilbert representation;
- microcausality holds in the physical quotient, as a descent theorem conditional on QC-7;
- adjoint residue cannot provide a superluminal signalling channel for standard local interventions (QC-10).

It does **not** derive:

- the Born rule from nothing;
- canonical quantisation;
- all Wightman/Osterwalder–Schrader axioms;
- perturbative renormalisation;
- scattering amplitudes;
- anomaly cancellation;
- the Higgs potential;
- electroweak symmetry breaking;
- particle masses;
- CKM/PMNS matrices;
- the gravitational quantum theory;
- a complete constructive quantum field theory.

QC-1 is a narrower gate:

physical-sector extraction is compatible with positivity and microcausality.

0′. Predictive-Content Ledger

Object	Prior status	Status here
Physical record sector	inherited	retained
Local support discipline	inherited	retained
Gauge census	inherited	retained
Weak attachment sign	inherited	retained
Formal adjoint/completion residue	present but not yet isolated	isolated
Adjoint-removal ideal $\mathfrak{J}$_AR	not yet formalised	defined
Physical quotient algebra $\mathfrak{A}$_P	implicit	constructed
No-loss condition for records	implicit	stated and proved (definitional unwinding)
Maximality (canonicality) of the quotient	not previously stated	proved, relative to the record family $\mathcal{T}$
Contextual Gram positivity (all of $\mathfrak{A}$_K)	previously restricted	stated as premise QC-2(a)
Parity superselection of terminal records	tacit	stated as premise QC-2(c)
Unitality of the kinematic net	tacit	stated in QC-1/QC-3
Kinematic microcausality (QC-7 antecedent)	unsourced	registered as owed input (open debt)
Operational Kraus representation (QC-10)	tacitly imported	stated as named premise
Positive physical state functional	required	proved on all of $\mathfrak{A}$_P under QC-2(a)
Negative-norm ghosts	possible concern	excluded from physical representation
Spacelike graded commutators	required	shown to vanish in quotient (descent; antecedent QC-7)
Superluminal adjoint channel	possible concern	excluded
Gauge bosons in adjoint reps	physical	explicitly not removed
Hermitian adjoint †	required	explicitly preserved
Renormalisation	open	outside scope
Scattering amplitudes	open	outside scope
Full constructive QFT	open	outside scope

1. Purpose, Claim Level, and Named Premises

1.1 The question

VERSF uses formal structures larger than the final observable sector. That is not unusual. Gauge theory, constrained Hamiltonian systems, BRST quantisation, Gupta–Bleuler quantisation, and path-integral methods all use auxiliary structures that are later quotiented, gauge-fixed, or projected.

The question is therefore not whether auxiliary structure exists.

The question is:

Does VERSF's adjoint/completion residue disappear cleanly when the physical record sector is extracted, or does it leave behind ghosts, negative probabilities, or acausal influence?

QC-1 answers: it disappears cleanly, provided the adjoint residue satisfies detector-nullity, ideal stability, local support preservation, and continuation-nullity.

1.2 Claim level

Claim level: QC-1 physical-sector quantum-admissibility theorem.

Epistemic grade: Conditional structural closure, relative to the inherited VERSF record framework, local support discipline, and minimal Standard Model/VERSF census.

The theorem does not say:

VERSF has now derived all quantum field theory.

It says:

The VERSF physical-sector extraction can be performed without producing negative norm, ghost residue, or spacelike signalling, provided the named premises hold — and the extraction is canonical, not a discretionary projection.

Novelty boundary. The algebraic machinery deployed here — quotient by the joint null ideal of a family of functionals, the GNS construction, descent of dynamics to a quotient — is classical algebraic-quantum-theory technique and is not claimed as new mathematics. The contribution of QC-1 is the VERSF-specific identification of the null sector (adjoint/completion residue rather than gauge orbits or Gupta–Bleuler auxiliaries), the falsifier discipline attached to each premise, and the maximality result that makes the extraction canonical within the record framework. A referee who observes that the lemmas are standard is correct; the gate content lies in what the ideal *is* and in the auditability of the conditions.

1.3 Named premises

Premise QC-1 — Local kinematic *-net

To each bounded fold-support region $\mathcal{O}$ of the emergent continuum, VERSF assigns a local kinematic *-algebra

$$\mathfrak{A}\_K(\mathcal{O}),$$

with involution $A \mapsto A^\dagger$, associative product AB, and isotony:

$$\mathcal{O}_1 \subseteq \mathcal{O}_2 \Rightarrow \mathfrak{A}\_K(\mathcal{O}_1) \subseteq \mathfrak{A}\_K(\mathcal{O}_2).$$

The global kinematic algebra $\mathfrak{A}\_K$ is generated by the local algebras. Each local algebra contains a common unit $\mathbb{1}$, so the net is unital. Elements carry a $\mathbb{Z}_2$ grading $|\cdot|$ (even/bosonic, odd/fermionic), with the product respecting the grading, the unit even, and homogeneous elements spanning each local algebra.

Falsifier: no stable local algebraic assignment exists for VERSF supports, the grading is incompatible with the product, or no common unit exists.

Premise QC-2 — Terminal record functionals: contextual positivity, involution compatibility, parity discipline

There exists a nonempty family $\mathcal{T}$ of terminal record functionals. Each $\tau \in \mathcal{T}$ assigns complex expectation/amplitude data to physical contexts, and probabilities arise from positive record Gram matrices. Three clauses are required.

(a) Contextual Gram positivity. For every $\tau \in \mathcal{T}$, every admissible context C with $\tau(C^\dagger C) > 0$, and every finite family $A_1, \ldots, A_n \in \mathfrak{A}\_K$, the contextual record matrix

$$G\_ij = \tau((A_i C)^\dagger (A_j C))$$

is positive semidefinite. Note the quantifier: this holds for *all* kinematic A_i, not only a distinguished record-accessible subclass. Contextual positivity is what "terminal record" means: a record channel returns probabilities for whatever is prepared through it.

Only the n = 1 case is consumed by this paper (Lemma 3). The full n > 1 Gram condition is nevertheless the physically correct statement of what a record channel is — multi-preparation interference statistics are record data — and it is retained here deliberately as an inheritable resource for downstream gates (flavour interference, χ-readout statistics) rather than trimmed to the minimum this gate consumes.

(b) Involution compatibility. Each τ is record-compatible with the involution:

$$\tau(C^\dagger X^\dagger D) = \overline{\tau(D^\dagger X C)}$$

for admissible contexts C, D and all $X \in \mathfrak{A}\_K$, where the overline denotes complex conjugation.

(c) Parity superselection. Every admissible context decomposes as a finite linear combination of homogeneous contexts that are themselves admissible, and terminal records do not coherently interfere even and odd sectors:

$\tau(C^\dagger X D) = 0$ whenever $|C| + |X| + |D|$ is odd,

for homogeneous admissible C, X, D. Since $\tau(C^\dagger XD)$ is sesquilinear in (C, D), nullity against all homogeneous admissible contexts extends to all admissible contexts by decomposition. Consequently, the homogeneous components of a terminally null element are separately terminally null. This is the VERSF form of fermion-parity (univalence) superselection.

Falsifiers: (a) some contextual Gram matrix has a negative eigenvalue; (b) a record functional fails involution compatibility; (c) a terminal record functional coherently distinguishes even from odd components.

Why QC-2(a) is not a hidden projection onto the desired answer. A critic may observe that if positivity is assumed for every kinematic element, negative norm cannot survive — and conclude the premise assumes the theorem. The premise does not state that every formal kinematic expression is physical. It states that any expression that *can be routed through a terminal record context* must generate a positive record Gram matrix, because that is what a record channel is: a device returning probabilities. An expression violating this condition would not survive as a physical negative-norm state; it would falsify the record framework itself, via falsifier (a). The division of labour is: QC-2(a) fixes what counts as a record; Lemmas 3–5 then prove the nontrivial claims — that the quotient operation transmits this positivity to the whole physical sector, loses no records doing so, and leaves no subsector untested. The premise is where the physics enters; the lemmas are where the extraction is shown not to corrupt it.

Premise QC-3 — Contextual observational equivalence

Two kinematic expressions $A, B \in \mathfrak{A}_K$ are physically equivalent, written $A \sim B$, if no terminal record functional can distinguish them in any physical context:

$$A \sim B \Leftrightarrow \tau(C^\dagger(A - B)D) = 0$$

for every $\tau \in \mathcal{T}$ and every admissible pair of contextual operators C, D. The admissible-context class contains the unit $\mathbb{1}$ and is closed under products and involution: if C, D are admissible and $A \in \mathfrak{A}_K$, then $A^\dagger C$ and BD are admissible.

Falsifier: physical equivalence cannot be defined by terminal record indistinguishability, or the admissible-context class fails closure or excludes $\mathbb{1}$.

Premise QC-4 — Adjoint-removal ideal

The adjoint-removal sector $\mathfrak{J}_{AR}$ is the equivalence class of zero under $\sim$:

$$\mathfrak{J}_{AR} = \{ X \in \mathfrak{A}_K : X \sim 0 \}.$$

Equivalently, $X \in \mathfrak{I}_{AR}$ if and only if X has no terminal record effect in any physical context. Locally,

$$\mathfrak{I}_{AR}(\mathcal{O}) = \mathfrak{I}_{AR} \cap \mathfrak{A}_K(\mathcal{O}).$$

Falsifier: the adjoint-removal sector contains terminally observable material.

Premise QC-5 — Ideal stability

$\mathfrak{I}_{AR}$ is stable under left/right multiplication by kinematic operators and under involution:

$$X \in \mathfrak{I}_{AR} \Rightarrow AXB \in \mathfrak{I}_{AR} \text{ and } X^\dagger \in \mathfrak{I}_{AR}$$

for all admissible $A, B \in \mathfrak{A}_K$.

(§3.3 shows this stability is in fact a theorem given QC-2 and QC-3; it is retained as a named premise so that its failure is independently reportable as falsifier F4/F5.)

Falsifier: adjoint residue can be converted into observable material by placing it inside a physical context.

Premise QC-6 — Support faithfulness of records

Terminal record effects of local expressions are locally witnessed. If $A \in \mathfrak{A}_K(\mathcal{O})$ has a nonzero terminal record effect in some context, then it has a nonzero terminal record effect witnessed by contexts supported in the causal development of $\mathcal{O}$.

(The weaker statement "$[A] \in \mathfrak{A}_P(\mathcal{O})$ for $A \in \mathfrak{A}_K(\mathcal{O})$" holds by construction, since $\mathfrak{I}_{AR}(\mathcal{O}) = \mathfrak{I}_{AR} \cap \mathfrak{A}_K(\mathcal{O})$; it is not the content of this premise. The content is that record-detectability does not leak outside causal support: local nullity tested locally agrees with local nullity tested globally, which is the record-level form of the inherited support discipline I2. This premise is consumed by Lemma 1′, which converts it into the statement that each local quotient is the algebra of locally testable physical classes.)

Falsifier: a local expression whose only terminal record effects require contexts outside the causal development of its support.

Premise QC-7 — Kinematic microcausality modulo adjoint residue

For spacelike-separated support regions $\mathcal{O}_1$ and $\mathcal{O}_2$, and for homogeneous local elements

$$A \in \mathfrak{A}_K(\mathcal{O}_1),\ B \in \mathfrak{A}_K(\mathcal{O}_2),$$

the graded commutator lies in the adjoint-removal ideal:

$$[A,B]_g = AB - (-1)^{|A||B|} BA \in \mathfrak{I}_{AR}.$$

For bosonic observables this is the ordinary commutator; for fermionic generators it is the graded rule. Physical observables are taken from the even part of the algebra; odd elements enter observables only in even combinations.

Provenance. QC-7 is an *owed input*, not an inheritance. None of I1–I6 supplies it, and QC-1 does not prove it. Its natural source is the emergent-causal-structure line of the programme (the causal-coherence compatibility gates), which must establish that fold/commitment order induces graded commutation modulo null residue at spacelike separation. Until that gate is certified, QC-7 stands in the ledger as a registered debt: QC-1 proves the conditional "kinematic causality modulo the ideal ⇒ exact physical causality," and the antecedent is owed upstream. §13.3 states this explicitly.

Falsifier: a spacelike graded commutator has nonzero physical image after adjoint-removal.

Premise QC-8 — Dynamics preserves the adjoint-removal sector

If α_t is an admissible time/continuation evolution on $\mathfrak{A}_K$ (a one-parameter family of *-automorphisms indexed by emergent continuation parameter t), then

$\alpha_t(\mathfrak{J}_{AR}) \subseteq \mathfrak{J}_{AR}$.

Adjoint-null material cannot become physically observable merely by continuation.

Falsifier: adjoint residue evolves into detector-visible physical content.

Premise QC-9 — No hidden adjoint detector channel

There is no detector functional τ_{adj} outside $\mathcal{T}$ that observes $\mathfrak{J}_{AR}$ while leaving ordinary physical records unchanged. Equivalently: the terminal record family $\mathcal{T}$ is observationally complete for the minimal census.

Falsifier: an independent experimental channel couples only to adjoint residue.

Premise QC-10 — Operational local transformations

Whenever an operational no-signalling claim is made, local nonselective physical interventions are assumed representable in the physical quotient by normalised completely positive (Kraus) maps: homogeneous classes $K_i \in \mathfrak{A}_P(\mathcal{O})$ with $\Sigma_i K_i^\dagger K_i = \mathbb{1}$.

QC-1 does not derive this representation; it is the standard operational form of a local intervention, imported here by name. The paper's causal result is then two-layered: microcausality of the quotient (Lemma 6) is proved without QC-10, while the operational no-signalling statement (§9.1, Lemma 7) holds for interventions of this standard form. An intervention not representable as a normalised Kraus map falls outside the operational claim, not outside microcausality.

Falsifier: a physically implementable local nonselective intervention in the minimal census that admits no normalised Kraus representation in $\mathfrak{A}_P$.

---

2. The Adjoint-Residue Problem

2.1 Why the problem exists

A theory may use more mathematical structure than appears in its physical spectrum.

Examples from ordinary theory are familiar:

- gauge potentials contain gauge redundancy;
- constrained Hamiltonian systems contain unphysical coordinates;
- BRST systems contain ghost fields whose physical role is not that of observed particles;
- covariant quantisations may introduce negative-norm auxiliaries that are later removed from the physical Hilbert space;
- path integrals sum over formal configurations that are not individually observed states.

VERSF has its own version of this issue. Its completion and adjoint machinery allows the formal record algebra to close before one has selected the terminally observable sector. That is useful, but it creates a risk:

a formal completion object could be mistaken for a physical object.

If that happens, three pathologies threaten the programme:

1. **Record loss:** removing adjoint material might accidentally remove a real physical observable.
2. **Negative norm:** retained adjoint material might carry indefinite inner product.
3. **Acausality:** adjoint residue might act as a hidden spacelike influence channel.

QC-1 is the gate that prevents those pathologies.

2.2 The danger of treating all formal objects as physical

Suppose a kinematic VERSF expression has the schematic form

$A_K = A_{rec} + A_{adj}$,

where A_{rec} changes terminal records and A_{adj} is auxiliary completion residue.

If both pieces are treated as physical, the theory may overcount states. Worse, if the adjoint residue carries an indefinite pairing, the physical state space may inherit negative-norm excitations.

But if A_{adj} is simply discarded without discipline, the opposite error occurs: one might throw away real physical information. And if the split into $A_{rec} + A_{adj}$ is made by hand, a third error appears: the "physical" sector depends on a presentation choice.

The correct operation is neither naïve retention, nor arbitrary deletion, nor a hand-chosen split.

It is quotienting by terminal record indistinguishability — an operation that §5 proves is canonical.

2.3 The VERSF discipline

The VERSF rule is:

Physical content is what survives every terminal record test.

If a formal object changes no terminal record in any physical context, it is not a second physical thing. It is null presentation structure.

This is the reason adjoint-removal is a quotient rather than a subtraction.

The physical class of A is not the expression A itself. It is

$[A] = A + \mathfrak{J}_{AR}$.

All expressions differing by adjoint-null residue represent the same physical observable.

---

3. Physical Observables, Terminal Records, and Adjoint Nullity

3.1 Terminal distinguishability

Let $\mathcal{T}$ be the family of terminal record functionals.

A kinematic expression X is terminally null if

$\tau(C^\dagger X D) = 0$

for every terminal record functional $\tau \in \mathcal{T}$ and every admissible physical context C, D.

This definition is deliberately contextual. It is not enough that X vanish in one state or one measurement arrangement. It must vanish in all physically admissible contexts.

This prevents a premature quotient.

3.2 Definition — adjoint-removal ideal

Define

$\mathfrak{J}_{AR} = \{ X \in \mathfrak{A}_K : \tau(C^\dagger X D) = 0$ for all $\tau \in \mathcal{T}$ and all admissible C, D $\}$.

Elements of $\mathfrak{J}_{AR}$ are **adjoint-null**.

They are not merely small. They are not merely unmeasured. They are not currently inaccessible particles.

They are zero in the terminal physical record category.

3.3 Proposition — contextual nullity gives a two-sided *-ideal

Proposition 1. Under Premises QC-2 and QC-3, $\mathfrak{J}_{AR}$ is a two-sided *-ideal of $\mathfrak{A}_K$.

Proof. *Two-sided stability.* Let $X \in \mathfrak{J}_{AR}$ and let $A, B \in \mathfrak{A}_K$ be admissible. For any $\tau \in \mathcal{T}$ and admissible contexts C, D,

$\tau(C^\dagger (AXB) D) = \tau((A^\dagger C)^\dagger X (BD))$.

By the closure of the admissible-context class (QC-3), $A^\dagger C$ and BD are again admissible contexts. Since X is terminally null, the right-hand side vanishes. Hence $AXB \in \mathfrak{J}_{AR}$.

Linearity. $\mathfrak{J}_{AR}$ is a linear subspace because each condition $\tau(C^\dagger (\cdot) D) = 0$ is linear.

Involution closure. Let $X \in \mathfrak{J}_{AR}$. By record-compatibility of τ with the involution (QC-2),

$\tau(C^\dagger X^\dagger D) = \overline{\tau(D^\dagger X C)}$.

Since D and C are admissible contexts and X is terminally null, $\tau(D^\dagger X C) = 0$, hence $\tau(C^\dagger X^\dagger D) = 0$ for all τ, C, D. So $X^\dagger \in \mathfrak{J}_{AR}$.

Therefore $\mathfrak{J}_{AR}$ is a two-sided *-ideal. ■

This proposition upgrades Premise QC-5 from an independent assumption to a consequence of QC-2 and QC-3. QC-5 is retained as a named premise only so that its failure remains independently reportable in the falsification ledger.

---

4. The Adjoint-Removal Quotient

4.1 Definition — physical observable algebra

The physical observable algebra is

$\mathfrak{A}\_P = \mathfrak{A}\_K / \mathfrak{J}\_AR$.

For each region $\mathcal{O}$,

$\mathfrak{A}\_P(\mathcal{O}) = \mathfrak{A}\_K(\mathcal{O}) / \mathfrak{J}\_AR(\mathcal{O})$, $\mathfrak{J}\_AR(\mathcal{O}) = \mathfrak{J}\_AR \cap \mathfrak{A}\_K(\mathcal{O})$.

The class of A is written

$[A] = A + \mathfrak{J}\_AR$.

The quotient operations are

$[A][B] = [AB]$, $[A]^\dagger = [A^\dagger]$, $[A] + [B] = [A + B]$.

These are well-defined because $\mathfrak{J}\_AR$ is a two-sided *-ideal (Proposition 1).

4.2 Lemma 1 — Quotient-algebra lemma

Lemma 1. $\mathfrak{A}\_P = \mathfrak{A}\_K / \mathfrak{J}\_AR$ is a well-defined graded *-algebra. If the kinematic algebras form a local net and adjoint-removal is local (QC-6), then the physical algebras form a local net with isotony

$\mathcal{O}_1 \subseteq \mathcal{O}_2 \Rightarrow \mathfrak{A}\_P(\mathcal{O}_1) \subseteq \mathfrak{A}\_P(\mathcal{O}_2)$.

Proof. Let $A' \sim A$ and $B' \sim B$, so $A' = A + X$, $B' = B + Y$ with $X, Y \in \mathfrak{J}\_AR$. Their product differs by

$A'B' - AB = AY + XB + XY$.

Since $\mathfrak{J}\_AR$ is a two-sided ideal, each term belongs to $\mathfrak{J}\_AR$, so $[A'B'] = [AB]$. Similarly

$(A')^\dagger - A^\dagger = X^\dagger \in \mathfrak{J}\_AR$, so the involution is well-defined. Addition descends trivially.

The grading descends because $\mathfrak{J}$_AR is spanned by its homogeneous elements. Let $X = X_0 + X_1 \in \mathfrak{J}$_AR with homogeneous components X_0, X_1. Evaluate against homogeneous admissible contexts, which suffice by QC-2(c): every admissible context is a finite combination of homogeneous admissible ones, and sesquilinearity of $\tau(C^\dagger X D)$ in (C, D) extends nullity from the homogeneous class to all contexts. For homogeneous C, D, parity superselection kills whichever of $\tau(C^\dagger X_0 D)$, $\tau(C^\dagger X_1 D)$ has odd total grade, so the vanishing of $\tau(C^\dagger X D)$ forces the vanishing of the surviving even-grade term. Ranging over all homogeneous admissible contexts, each component is terminally null in every admissible context, hence $X_0, X_1 \in \mathfrak{J}$_AR separately. The quotient therefore inherits a well-defined $\mathbb{Z}_2$ grading.

Locality: if $A \in \mathfrak{A}$_K($\mathcal{O}$), then [A] $\in \mathfrak{A}$_P($\mathcal{O}$) by the intersection construction $\mathfrak{J}$_AR($\mathcal{O}$) = $\mathfrak{J}$_AR $\cap$ $\mathfrak{A}$_K($\mathcal{O}$) — this holds by definition and does not invoke QC-6, whose genuine content is consumed by Lemma 1′ below. Isotony descends from the kinematic net because the local ideals are defined by intersection, so the inclusion $\mathfrak{A}$_K($\mathcal{O}_1$) ⊆ $\mathfrak{A}$_K($\mathcal{O}_2$) maps $\mathfrak{J}$_AR($\mathcal{O}_1$) into $\mathfrak{J}$_AR($\mathcal{O}_2$) and induces an injective *-morphism $\mathfrak{A}$_P($\mathcal{O}_1$) → $\mathfrak{A}$_P($\mathcal{O}_2$). ■

4.3 Lemma 1′ — Local-nullity compatibility

The definition $\mathfrak{J}$_AR($\mathcal{O}$) = $\mathfrak{J}$_AR $\cap$ $\mathfrak{A}$_K($\mathcal{O}$) makes the local quotient technically well-defined, but by itself it tests local elements against *global* contexts. Support faithfulness (QC-6) is what makes the local quotient locally meaningful.

Lemma 1′. Assume QC-6. For $A \in \mathfrak{A}$_K($\mathcal{O}$), the following are equivalent:

1. $A \in \mathfrak{J}$_AR (global terminal nullity);
2. $\tau(C^\dagger A D) = 0$ for all $\tau \in \mathcal{T}$ and all admissible contexts C, D supported in the causal development of $\mathcal{O}$ (local terminal nullity).

Consequently $\mathfrak{A}$_P($\mathcal{O}$) is not merely the restriction of a global quotient: it is the algebra of *locally testable* physical classes associated with $\mathcal{O}$.

Proof. (1) ⇒ (2): global nullity quantifies over all admissible contexts, which include the locally supported ones.

(2) ⇒ (1): contrapositive. Suppose $A \notin \mathfrak{J}$_AR, so A has a nonzero terminal record effect in some context. By support faithfulness QC-6, A then has a nonzero terminal record effect witnessed by contexts supported in the causal development of $\mathcal{O}$, contradicting (2). ■

This is why QC-6 is a genuine premise rather than decoration: without it, an element could be locally invisible yet globally recorded, and the local physical algebra would misrepresent what is physically testable at $\mathcal{O}$.

4.4 Reading

The quotient is not an optional simplification. It is the mathematical expression of the VERSF physical principle:

objects indistinguishable by all terminal records in all contexts are not distinct physical observables.

This is why adjoint-removal does not throw away physics. It removes only the zero class of terminal physical distinction.

---

5. No-Loss and Maximality: the Quotient Is Canonical

5.1 The concern

A critic may object:

If you remove a whole ideal, how do you know you have not removed real physics? And why this ideal rather than another?

The answer to the first question is built into the definition of the ideal. The answer to the second is a maximality result: $\mathfrak{J}_{AR}$ is the unique largest ideal whose removal is record-safe. Both are stated and proved explicitly.

5.2 Lemma 2 — No-loss of terminal records

Lemmas 2 and 2′ are definitional unwindings, not deep theorems: Lemma 2 is the contrapositive of the membership condition for $\mathfrak{J}_{AR}$, and Lemma 2′ is immediate because $\mathfrak{J}_{AR}$ is defined as the set of *all* terminally null elements. They are stated as lemmas because they are the load-bearing interpretive claims of the gate — the claims a referee must be able to point to — not because their proofs carry mathematical weight. The ledger records them accordingly.

Lemma 2. If a kinematic expression $A \in \mathfrak{A}_K$ has a nonzero terminal record effect in some physical context, then its physical class $[A]$ is nonzero in $\mathfrak{A}_P$.

Equivalently, adjoint-removal loses no terminally observable record.

Proof. Assume A has a nonzero terminal record effect. Then there exist $\tau \in \mathcal{T}$ and admissible contexts C, D such that

$\tau(C^\dagger A D) \neq 0.$

If $[A] = 0$, then $A \in \mathfrak{J}\_AR$. But by definition of $\mathfrak{J}\_AR$ this would imply $\tau(C^\dagger A D) = 0$ for every τ, C, D — contradiction. Therefore $[A] \neq 0$. ■

5.3 Lemma 2′ — Maximality: the quotient is canonical

Lemma 2′. Let $\mathfrak{K} \subseteq \mathfrak{A}\_K$ be any two-sided *-ideal with the no-loss property: every element of $\mathfrak{K}$ is terminally null in every admissible context. Then $\mathfrak{K} \subseteq \mathfrak{J}\_AR$.

Consequently, $\mathfrak{J}\_AR$ is the unique maximal record-safe removal, and $\mathfrak{A}\_P$ is canonical **given the record family $\mathcal{T}$**: it depends only on the pair $(\mathfrak{A}\_K, \mathcal{T})$ and on no presentation choice, splitting convention, or gauge-fixing scheme.

Proof. Let $X \in \mathfrak{K}$. By hypothesis, $\tau(C^\dagger X D) = 0$ for every $\tau \in \mathcal{T}$ and every admissible C, D. That is precisely the membership condition for $\mathfrak{J}\_AR$, so $X \in \mathfrak{J}\_AR$. Hence $\mathfrak{K} \subseteq \mathfrak{J}\_AR$.

Uniqueness of the maximal record-safe ideal follows: any record-safe ideal is contained in $\mathfrak{J}\_AR$, and $\mathfrak{J}\_AR$ is itself record-safe by Corollary 1 below. The quotient $\mathfrak{A}\_P$ is therefore determined entirely by the pair $(\mathfrak{A}\_K, \mathcal{T})$ and inherits no arbitrariness from how the kinematic presentation was written down. ■

5.4 Corollary — Adjoints removed are physically silent

Corollary 1. Every element removed by adjoint-removal is terminally silent in all physical contexts.

Proof. Immediate from the definition of $\mathfrak{J}\_AR$. ■

5.5 Reading

Adjoint-removal does not say:

we cannot see this thing yet, so remove it.

It says:

this thing has no possible terminal record difference inside the stated physical census, so it is not an independent physical object.

And Lemma 2′ adds the sharper point: there is exactly one maximal way to perform a record-safe removal, and this is it. Anyone proposing a different physical sector must either lose a record (violating Lemma 2) or leave removable residue behind (violating maximality).

One precision is owed here, because the rhetoric could otherwise outrun the mathematics. Canonicality is canonicality **relative to the record family $\mathcal{T}$**. Lemma 2′ proves $\mathfrak{A}\_P$ is determined by the pair ($\mathfrak{A}_K$, $\mathcal{T}$) with no residual presentation freedom — but the presentation-independence of the physical sector as a whole therefore rests entirely on the observational completeness and presentation-independence of $\mathcal{T}$ itself. Those are carried by Premise QC-9 and the inherited record-primacy commitment I1, as premises, not as theorems of this paper. The correct summary is: given the record family, the quotient is forced; the record family itself is a falsifiable input.

---

6. Positivity and the Physical State Functional

6.1 The positivity question

Quantum theory requires positive probabilities and nonnegative physical norm.

For a physical state functional ω, positivity means

$\omega(A^\dagger A) \geq 0$

for every physical observable/preparation A.

In a quotient theory, one must prove that the state functional descends to the quotient and remains positive.

6.2 Terminal record states, constructed rather than postulated

A **terminal record state** is not defined by fiat as "a state that annihilates the ideal" — that definition would be circular-adjacent, assuming exactly what descent requires. Terminal record states are constructed from the record family itself.

Definition (elementary terminal record state). For $\tau \in \mathcal{T}$ and an admissible context C with $\tau(C^\dagger C) > 0$, define

$\omega_{\tau,C}(A) = \tau(C^\dagger A C) / \tau(C^\dagger C), A \in \mathfrak{A}_K$.

Definition (terminal record state). A terminal record state ω_K is any convex combination, or pointwise limit of convex combinations, of elementary terminal record states.

Two properties are now automatic rather than assumed.

Annihilation of the ideal. If $X \in \mathfrak{J}_{AR}$, then $\omega_{\tau,C}(X) = \tau(C^\dagger X C)/\tau(C^\dagger C) = 0$, because C is an admissible context (with $\mathbb{1}$ available by QC-3 when the trivial context is intended). Convex combinations and limits preserve this. So every terminal record state kills $\mathfrak{J}_{AR}$ by construction.

Descent. Define $\omega_P([A]) = \omega_K(A)$. If $A' = A + X$ with $X \in \mathfrak{J}_{AR}$, then $\omega_K(A') - \omega_K(A) = \omega_K(X) = 0$. Thus terminal record states descend to well-defined functionals on $\mathfrak{A}_P$.

6.3 Lemma 3 — Positive state descent on all of $\mathfrak{A}_P$

Lemma 3. Every terminal record state ω_K descends to a positive state functional on the whole of $\mathfrak{A}_P$:

$\omega_P([A]^\dagger[A]) \geq 0$ for every class $[A] \in \mathfrak{A}_P$.

Proof. It suffices to prove positivity for an elementary state $\omega_{\tau,C}$; convex combinations and pointwise limits of positive functionals are positive.

Using quotient multiplication and involution, $[A]^\dagger[A] = [A^\dagger A]$, so

$\omega_P([A]^\dagger[A]) = \omega_{\tau,C}(A^\dagger A) = \tau(C^\dagger A^\dagger A C) / \tau(C^\dagger C) = \tau((AC)^\dagger(AC)) / \tau(C^\dagger C)$.

By contextual Gram positivity QC-2(a) with $n = 1$ — which holds for **all** $A \in \mathfrak{A}_K$, with no record-accessibility restriction — the numerator is nonnegative, and the denominator is positive by hypothesis. Hence $\omega_P([A]^\dagger[A]) \geq 0$ for every class, with no exceptional subsector.

The value is independent of the representative because adjoint-null differences vanish in every terminal context: $A^\dagger A$ and $(A+X)^\dagger(A+X)$ differ by $A^\dagger X + X^\dagger A + X^\dagger X \in \mathfrak{J}_{AR}$. ■

Domain remark. The quantifier in QC-2(a) is what closes the gap between "positive on record-accessible preparations" and "positive on all of $\mathfrak{A}_P$." Lemma 4's GNS construction — in particular the Cauchy–Schwarz argument making $\mathcal{N}_\omega$ a left ideal — requires positivity on every class. With QC-2(a), Lemma 3 delivers exactly that, and there is no subsector of $\mathfrak{A}_P$ in which negative norm could hide untested.

6.4 What is assumed, and what is proved

The paper does not derive probability positivity from nothing.

It assumes the minimal physical requirement that terminal record probabilities are positive — contextually, for every preparation routed through a record channel (QC-2(a)). That is not the result; it is the measurement-admissibility premise, and within the wider programme it is supplied by the independent Born-rule gates.

What QC-1 proves is narrower:

the adjoint-removal quotient does not destroy positivity or turn a positive terminal record structure into an indefinite physical theory.

This is the right claim level.

---

7. No-Ghost and No-Negative-Norm Result

7.1 The GNS physical state space

Given a positive state ω_P, define a sesquilinear form on $\mathfrak{A}_P$:

$\langle [A],[B] \rangle_\omega = \omega_P([A]^\dagger [B])$.

Positivity of ω_P and the Cauchy–Schwarz inequality make the null set

$\mathcal{N}_\omega = \{ [A] \in \mathfrak{A}_P : \omega_P([A]^\dagger [A]) = 0 \}$

a left ideal of $\mathfrak{A}_P$. The physical Hilbert space $\mathscr{H}_\omega$ is the completion of

$\mathfrak{A}_P / \mathcal{N}_\omega$

under the induced norm $\|[A]\| = \omega_P([A]^\dagger [A])^{1/2}$, with $\mathfrak{A}_P$ acting by left multiplication.

This is the standard GNS quotient-by-null construction. Null vectors are not negative-norm ghosts. They are zero-length redundancies in the representation, and the left-ideal property guarantees the physical action is well-defined on the quotient.

7.2 Lemma 4 — No negative physical norm

Lemma 4. The physical GNS representation obtained from ω_P contains no negative-norm vectors.

Proof. For any vector represented by [A],

$\|[A]\|^2 = \langle [A],[A] \rangle_\omega = \omega_P([A]^\dagger [A])$.

By Lemma 3 this is nonnegative. If it is zero, [A] lies in the GNS null space $\mathcal{N}_\omega$ and is quotiented out at the representation level. The norm extends continuously to the completion and remains nonnegative there. No vector of negative norm exists. ■

7.3 Definition — physical ghost in QC-1

A **physical ghost** means a surviving physical excitation satisfying at least one of the following:

1. it has negative norm;
2. it registers detection probabilities under some functional outside the terminal record family $\mathcal{T}$;
3. it couples to physical observables while remaining outside the physical record algebra;
4. it mediates influence through an adjoint-null channel.

QC-1 excludes all four under the named premises: (1) by Lemma 4; (2) by Premise QC-9 directly; (3) by Lemma 5; (4) by Lemma 7.

7.4 Lemma 5 — No independent adjoint ghost

Lemma 5. No element of $\mathfrak{J}$_AR survives as an independent physical excitation.

Proof. If X ∈ $\mathfrak{J}$_AR, then [X] = 0 in $\mathfrak{A}$_P, so X has no physical observable class and, in particular, its GNS image is the zero vector in every physical representation built from a terminal record state.

The detector exclusion splits into two cases, resolved by different premises.

Case 1 — detector within the terminal family. If X had an independent detection probability within $\mathcal{T}$, there would exist $\tau \in \mathcal{T}$ and admissible contexts C, D with $\tau(C^\dagger XD) \neq 0$, contradicting X ∈ $\mathfrak{J}$_AR directly.

Case 2 — detector outside the terminal family. If the proposed detector lies outside $\mathcal{T}$, then Premise QC-9 is precisely the assumption excluding it inside the minimal census: $\mathcal{T}$ is observationally complete, and no functional outside it couples to $\mathfrak{J}$_AR.

Thus Lemma 5 (via the definition of the ideal) excludes terminal-family adjoint ghosts, while QC-9 excludes hidden-detector adjoint ghosts. A coupling of X to physical observables producing any terminal record difference would fall under Case 1; a coupling producing records only under a non-$\mathcal{T}$ functional falls under Case 2. Adjoint-null material therefore neither survives as a physical algebra element, nor appears as a detector excitation of either kind. ■

7.5 Corollary — No negative-norm adjoint residue

Corollary 2. Adjoint-removal leaves no negative-norm adjoint residue in the physical state representation.

Proof. Negative norm would require a surviving physical vector v with $\langle v,v\rangle < 0$. Lemma 4 excludes this for all surviving vectors. Elements of $\mathfrak{J}$_AR do not survive as nonzero physical classes by Lemma 5. ■

---

8. Local Support and Microcausality

8.1 Microcausality requirement

Relativistic quantum theory requires that spacelike-separated physical operations cannot be used to signal.

At algebra level this is encoded by microcausality:

$[A,B]_g = 0$

whenever A and B have spacelike-separated supports.

For bosonic observables:

$[A,B] = AB - BA = 0.$

For fermionic generators, the correct statement is graded: fermionic generators anticommute at spacelike separation, while even physical observables commute. Since physical observables are even (QC-7), microcausality for observables is ordinary commutation, with the graded rule operating one level below.

8.2 VERSF version

VERSF allows the kinematic algebra to contain auxiliary completion terms. Therefore the strongest appropriate kinematic condition is not always

$[A,B]_g = 0$

strictly in $\mathfrak{A}_K$, but

$[A,B]_g \in \mathfrak{J}_{AR}.$

That is:

any apparent spacelike noncommutation in the kinematic presentation is adjoint-null and has no terminal record effect.

Then in the physical quotient it must vanish exactly.

8.3 Lemma 6 — Microcausality descends to the physical quotient

Lemma 6. Let $\mathcal{O}_1$ and $\mathcal{O}_2$ be spacelike-separated support regions. If

$$[A,B]_g \in \mathfrak{J}_{AR}$$

for all homogeneous $A \in \mathfrak{A}_K(\mathcal{O}_1)$ and $B \in \mathfrak{A}_K(\mathcal{O}_2)$, then

$$[[A],[B]]_g = 0$$

in the physical quotient $\mathfrak{A}_P$. For inhomogeneous elements the graded commutator is not defined by a single sign; the correct general statement is that every homogeneous-component graded commutator vanishes, so any sign-convention extension to inhomogeneous elements vanishes term by term.

Proof. In the quotient,

$$[[A],[B]]_g = [A][B] - (-1)^{|A||B|}[B][A] = [AB] - (-1)^{|A||B|}[BA] = [\ [A,B]_g\ ].$$

By hypothesis $[A,B]_g \in \mathfrak{J}_{AR}$, so $[\ [A,B]_g\ ] = 0$ in $\mathfrak{A}_P$. Hence $[[A],[B]]_g = 0$ for homogeneous classes. General elements decompose into homogeneous components, and each component-pair graded commutator vanishes by the above, which is the strongest well-defined statement in the inhomogeneous case. ■

8.4 Reading

This is the second major structural result.

It says that VERSF may use formal completion terms in the kinematic presentation, but those terms cannot become physical spacelike influence if they belong to the adjoint-removal ideal.

The physical algebra is microcausal even if the pre-quotient bookkeeping contains adjoint residue.

---

9. No Superluminal Adjoint Channel

9.1 From microcausality to no signalling

Microcausality prevents spacelike-separated physical operations from changing local expectation values. The derivation must be stated with the grading in view, because signalling operations are built from physical — hence even — elements.

Let $\mathcal{O}_A$ and $\mathcal{O}_B$ be spacelike-separated.

Let $A \in \mathfrak{A}\_P(\mathcal{O}\_A)$ be a physical (even) observable.

Let a nonselective local operation in $\mathcal{O}\_B$ be represented, per Premise QC-10, by homogeneous Kraus classes

$K_i \in \mathfrak{A}\_P(\mathcal{O}\_B)$,

satisfying the normalisation

$\Sigma_i K_i†K_i = \mathbb{1}$,

where $\mathbb{1}$ is the unit of the quotient net, available because the kinematic net is unital (QC-1) and the unit descends.

The Heisenberg action on A is

$\mathcal{E}\_B^*(A) = \Sigma_i K_i† A K_i$.

Because A is even, the graded sign in $[A, K_i]\_g$ is $(-1)^{\{|A||K_i|\}} = (-1)^0 = +1$ **regardless of the parity of K_i**, so Lemma 6 gives ordinary commutation of A with every homogeneous K_i at spacelike separation. Therefore

$\mathcal{E}\_B^*(A) = \Sigma_i K_i† K_i A = (\Sigma_i K_i†K_i) A = A$.

So the operation in $\mathcal{O}\_B$ cannot change expectation values of A in $\mathcal{O}\_A$. No evenness restriction on the Kraus operators is needed: the computation holds for homogeneous K_i of either parity, and homogeneous decomposition of general operations is available because the quotient grading is well-defined (Lemma 1 via QC-2(c)). Independently, parity superselection QC-2(c) implies physically implementable operations are generated in the even sector; either route suffices.

Two standard closing remarks. *Selective operations:* conditioning on a particular outcome in $\mathcal{O}\_B$ changes distant statistics only relative to that outcome, and communicating which outcome occurred requires a classical channel; selective operations therefore signal nothing by themselves, and the nonselective case above is the complete no-signalling statement. *Kinematic implementations:* an operation implemented at the kinematic level acts on terminal records only through its physical classes, by the descent structure of §§4–6 — its adjoint-null components have, by definition, no record effect in any context. So an adversarial "operation whose kinematic implementation matters" is either a QC-10 operation in disguise (covered above) or an appeal to a record channel outside $\mathcal{T}$ (excluded by QC-9). There is no third implementation route to a record.

9.2 Lemma 7 — No spacelike signalling through adjoint residue

Lemma 7. Under Lemma 6, the no-hidden-adjoint-detector premise (QC-9), and the operational representation premise (QC-10), adjoint-removal residue cannot mediate superluminal signalling between spacelike-separated physical regions by any local nonselective intervention of the standard Kraus form.

Proof. The argument is a three-step exhaustion; the disjunction is derived, not assumed.

Step 1 — a signal is a record change. By record primacy (I1), a signal received in $\mathcal{O}$_A is, by definition, a change in some terminal record localisable in $\mathcal{O}$_A. Something producing no terminal record anywhere is not a signal.

Step 2 — record changes are exhaustively governed by $\mathcal{T}$. By observational completeness (QC-9), every terminal record is a record under some $\tau \in \mathcal{T}$: there is no detector functional outside the family, and in particular none coupling to $\mathfrak{J}$_AR alone. So the record change of Step 1 must be visible to $\mathcal{T}$ as a change in the expectation value of some physical observable A ∈ $\mathfrak{A}$_P($\mathcal{O}$_A) under some terminal record state.

Step 3 — within $\mathcal{T}$-governed records, spacelike influence requires a nonvanishing physical commutator. By QC-10, the intervention is represented by a normalised Kraus map, so any $\mathcal{T}$-visible change it induces acts on A through the Heisenberg map $\mathscr{E}$_B*(A) = $\Sigma_i K_i^\dagger A K_i$, and §9.1 shows $\mathscr{E}$_B*(A) = A whenever A commutes with the K_i. A kinematically implemented intervention acts on records only through its physical classes (§9.1, closing remarks), so it falls under the same computation. A nontrivial change therefore requires a nonvanishing physical spacelike commutator, which Lemma 6 excludes.

The three steps exhaust the possibilities: a putative adjoint-mediated signal either produces no record (Step 1: not a signal), produces a record outside $\mathcal{T}$ (Step 2: excluded by QC-9), or produces a $\mathcal{T}$-record via a QC-10 intervention through a nonvanishing spacelike commutator (Step 3: excluded by Lemma 6). Therefore adjoint residue cannot mediate superluminal signalling within the named operational class. ■

9.3 Reading

The theorem does not merely say:

adjoint material is unobserved.

It says something stronger:

adjoint material cannot be used as a hidden causal wire between spacelike regions.

That is the microcausal content of QC-1.

---

10. Dynamics and Stability of the Physical Sector

10.1 Why stability matters

A quotient is not enough if continuation evolution can move removed material back into the physical sector.

If $X \in \mathfrak{I}_{AR}$ but $\alpha_t(X) \notin \mathfrak{I}_{AR}$, then a detector-silent adjoint residue could later become observable. That would mean adjoint-removal was premature.

So QC-1 requires ideal stability under admissible continuation dynamics.

10.2 Lemma 8 — Dynamics descends to the physical quotient

Lemma 8. If admissible dynamics α_t preserves the adjoint-removal ideal,

$\alpha_t(\mathfrak{I}_{AR}) \subseteq \mathfrak{I}_{AR}$,

then it descends to a well-defined physical dynamics

$\alpha_t^P([A]) = [\alpha_t(A)]$,

and α_t^P is a *-endomorphism of $\mathfrak{A}_P$ for each t. If $\{\alpha_t\}_{t\in\mathbb{R}}$ *is a one-parameter group of* *-*automorphisms with* $\alpha_t(\mathfrak{I}_{AR}) \subseteq \mathfrak{I}_{AR}$ *for all t, the descended maps are automatically* *-*automorphisms: applying the hypothesis at* $-t$ *gives* $\mathfrak{I}_{AR} = \alpha_t(\alpha_{-t}(\mathfrak{I}_{AR})) \subseteq \alpha_t(\mathfrak{I}_{AR})$, so $\alpha_t(\mathfrak{I}_{AR}) = \mathfrak{I}_{AR}$ exactly, and α_{-t}^P inverts α_t^P.

Proof. Suppose $[A] = [B]$. Then $A - B \in \mathfrak{I}_{AR}$. By ideal stability, $\alpha_t(A - B) \in \mathfrak{I}_{AR}$, so $[\alpha_t(A)] = [\alpha_t(B)]$ and α_t^P is well-defined on classes. It respects products and involution because α_t does and the quotient operations are computed on representatives. In the one-parameter-group case, ideal preservation at every t (including $-t$) forces $\alpha_t(\mathfrak{I}_{AR}) = \mathfrak{I}_{AR}$, and α_{-t}^P inverts α_t^P, giving an automorphism for free. ■

10.3 Corollary — Adjoint-nullity is not temporary invisibility

Corollary 3. If dynamics preserves $\mathfrak{I}_{AR}$, then adjoint-null material does not become physical merely by continuation.

Proof. If $X \in \mathfrak{I}_{AR}$, then $[X] = 0$. Under descended dynamics,

$\alpha_t^P([X]) = [\alpha_t(X)] = 0,$

since $\alpha_t(X) \in \mathfrak{I}_{AR}$. Thus adjoint-nullity persists along every admissible continuation. ■

---

11. The Adjoint-Removal Positivity and Microcausality Theorem

11.1 Assembly

The paper has established:

1. The adjoint-removal sector is a two-sided *-ideal (Proposition 1).
2. The physical algebra is a quotient graded *-algebra forming a local net (Lemma 1).
3. No terminal physical record is lost by the quotient (Lemma 2).
4. $\mathfrak{I}_{AR}$ is the unique maximal record-safe ideal, so the quotient is canonical (Lemma 2′).
5. Terminal record states descend to positive physical states (Lemma 3).
6. The GNS physical representation has no negative-norm vectors (Lemma 4).
7. Adjoint-null material has no independent detector excitation (Lemma 5).
8. Spacelike graded commutators vanish in the physical quotient (Lemma 6).
9. No adjoint residue can mediate superluminal signalling (Lemma 7).
10. Dynamics preserving the ideal descends to the quotient (Lemma 8).

11.1′ Load-bearing premises

Each conclusion of Theorem 1 rests on an identifiable premise. The mapping is stated here so a referee can locate the source of every claim without reconstruction.

Result	Load-bearing premise(s)
Quotient is a well-defined *-algebra	QC-3 context closure (Proposition 1); QC-5 as audit backup
Grading descends to $\mathfrak{A}_P$	QC-2(c) parity superselection
Local net, locally testable classes	QC-1 net structure; QC-6 support faithfulness (Lemma 1′)
No loss of records	definition of $\mathfrak{I}_{AR}$ from $\mathcal{T}$ (Lemma 2, definitional)
Quotient is canonical	definition of $\mathfrak{I}_{AR}$ from $\mathcal{T}$ (Lemma 2′); completeness of $\mathcal{T}$ via QC-9, I1
Positive physical norm, no ghosts	QC-2(a) contextual Gram positivity
Microcausality in the quotient	QC-7 (registered open debt, §13.3)

Result	Load-bearing premise(s)
Operational no-signalling	QC-7 + QC-9 + QC-10
Dynamical stability	QC-8

11.2 Theorem 1 — Adjoint-Removal Positivity and Microcausality

Theorem 1. Under Premises QC-1 through QC-10, the VERSF physical observable sector obtained by adjoint-removal,

$$\mathfrak{A}_P(\mathcal{O}) = \mathfrak{A}_K(\mathcal{O}) / \mathfrak{J}_{AR}(\mathcal{O}),$$

is a well-defined local *-algebraic sector with the following properties.

1. **No loss of physical records:** If a kinematic expression has any nonzero terminal record effect, its physical class is nonzero.
2. **Canonicality:** $\mathfrak{J}_{AR}$ is the unique maximal two-sided *-ideal whose removal preserves all terminal records; $\mathfrak{A}_P$ depends only on $(\mathfrak{A}_K, \mathcal{T})$ and on no presentation choice.
3. **Positive physical state functionals:** Every terminal record state descends to a positive state functional on $\mathfrak{A}_P$.
4. **No negative physical norm:** The associated GNS physical representation contains no negative-norm vectors.
5. **No independent adjoint ghosts:** Elements of $\mathfrak{J}_{AR}$ do not survive as physical excitations, detector channels, or observable couplings.
6. **Physical microcausality (descent form):** If the kinematic spacelike graded commutator lies in $\mathfrak{J}_{AR}$, as required by QC-7, then the corresponding physical classes graded-commute exactly in $\mathfrak{A}_P$:

   $$[[A],[B]]_g = 0.$$

   QC-1 proves the descent; the kinematic antecedent is QC-7's registered debt.

7. **No superluminal adjoint channel:** For local nonselective interventions of the standard Kraus form (QC-10), adjoint-removal residue cannot mediate a signal between spacelike-separated physical regions, given QC-7 and QC-9.
8. **Dynamical stability:** Admissible continuation dynamics preserving $\mathfrak{J}_{AR}$ descends consistently to the physical quotient.

Therefore, adjoint-removal in VERSF is quantum-admissible at the level of physical-sector positivity and microcausality, and the extraction itself is canonical.

Proof. By Premises QC-2 and QC-3, $\mathfrak{J}_{AR}$ is the contextual terminal-null sector; Proposition 1 shows it is a two-sided *-ideal (independently secured by QC-5). Lemma 1 gives the quotient graded *-algebra $\mathfrak{A}_P$ — with the grading descending via parity superselection QC-2(c) — and the local net structure; Lemma 1′ shows support faithfulness QC-6 makes each local quotient the algebra of locally testable classes.

Lemma 2 establishes no-loss of records: any expression with nonzero terminal record effect has nonzero physical class. Lemma 2′ establishes maximality: every record-safe ideal is contained in $\mathfrak{J}$_AR, so the quotient is canonical relative to the record family $\mathcal{T}$ (§5.5).

Contextual Gram positivity QC-2(a) holds for all kinematic elements routed through admissible contexts. Terminal record states, constructed in §6.2 as convex combinations and limits of context vector states, annihilate the ideal automatically and descend; Lemma 3 shows the descended functionals are positive on all of $\mathfrak{A}$_P, with no exceptional subsector. Lemma 4 then gives nonnegative physical norm throughout the GNS representation, with zero-norm classes quotiented by the standard left-ideal construction. Lemma 5 excludes independent adjoint ghosts.

By Premise QC-7, spacelike kinematic graded commutators lie in $\mathfrak{J}$_AR. Lemma 6 shows their quotient classes vanish, giving physical microcausality as a descent theorem, and the §9.1 Kraus computation — for interventions of the QC-10 operational form — converts this into operational no-signalling. Lemma 7 closes the remaining route by Premise QC-9: no hidden detector observes the ideal.

Finally, Premise QC-8 and Lemma 8 show admissible dynamics descends to the quotient, and Corollary 3 shows adjoint-nullity persists under continuation.

All claimed properties follow. ■

11.3 Corollary — Physical extraction is not a hidden source of nonunitarity

Corollary 4. Adjoint-removal does not by itself introduce nonunitarity into the physical sector.

Proof. The quotient removes only terminal-null ideal material. Positive state functionals descend to the quotient, and admissible dynamics descends when it preserves the ideal, as an endomorphism of a positive sector. Therefore no probability loss or negative norm is introduced by the act of adjoint-removal itself.

This does not prove all physical dynamics is unitary in every representation; it proves that the adjoint-removal operation is not the source of nonunitary leakage. ■

11.4 Corollary — Later gates may work in the physical quotient

Corollary 5. Later VERSF gates concerning flavour, mass hierarchy, scattering, or electroweak dynamics may work directly in $\mathfrak{A}$_P, provided they do not require terminal effects from $\mathfrak{J}$_AR.

Proof. By Theorem 1, $\mathfrak{A}_P$ preserves all terminal records, positive state structure, and microcausal locality, and is canonical. Any later gate depending only on terminal physical observables may therefore use the quotient sector without carrying adjoint residue as a separate physical branch, and without needing to record which kinematic presentation produced the quotient. ■

---

12. Why This Is Not a Projection Smuggle

A natural objection is:

You simply projected away the bad states.

That is not the argument.

QC-1 does not begin with known bad states and delete them. It defines the removable sector by a physical criterion:

$X \in \mathfrak{J}_{AR} \Leftrightarrow X$ changes no terminal record in any context.

That criterion is stronger than "unwanted" or "unobserved".

The paper then proves that this sector is an ideal, that quotienting by it loses no observable record, that no larger removal is record-safe, and that positive terminal record states descend to the quotient.

The order matters:

1. define physical equivalence by terminal records;
2. identify the zero class;
3. prove ideal stability;
4. prove maximality, so the quotient is forced given the record family;
5. form the quotient;
6. prove positivity and microcausality.

This is not arbitrary projection. It is physical equivalence made algebraic, and Lemma 2′ closes the residual discretion: there is no smaller "convenient" removal and no larger "aggressive" removal available. Both directions falsify.

12.1 Why negative norms are not hidden

Another objection:

Perhaps the negative-norm states are still present but invisible.

No. If a negative-norm object has no physical class, it is not a physical state. If it has a physical class, Lemma 4 forbids negative norm. If it has an independent detector channel, Premise QC-9 fails and the theorem is falsified.

The theorem is therefore sharp:

- detector-silent adjoint residue is removed;
- detector-visible adjoint material is not removable and would falsify QC-1;
- no negative-norm physical vector survives.

12.2 Why microcausality is not assumed away

The paper does not assume that every kinematic commutator strictly vanishes before quotienting. It assumes the weaker and more appropriate VERSF condition:

$[A,B]_g \in \mathfrak{J}_{AR}$

for spacelike-separated supports.

That permits formal completion residue in the kinematic presentation while forbidding physical spacelike influence. The physical quotient then has exact microcausality.

So the claim is not:

there was never any formal nonlocal-looking residue.

The claim is:

any such residue is terminally null and cannot become a physical signal.

12.3 Why gauge adjoint particles are untouched

The word "adjoint" could mislead.

Gauge fields often take values in the adjoint representation of a Lie algebra. For example, gluons are associated with the adjoint representation of $SU(3)_c$.

QC-1 does not remove those fields.

A gluon is not in $\mathfrak{J}_{AR}$ merely because it is "adjoint" in the representation-theoretic sense. It is physical because it has terminal record consequences: jets, hadronic structure, scattering effects, confinement dynamics, and colour-mediated interactions.

Only detector-silent completion residue is removed.

13. Relation to Gauge Closure, Weak Attachment, and Later Gates

The earlier Standard Model structural gates answer different questions.

Gauge-census closure answers:

Which connected internal gauge channels exist?

Weak-attachment sign closure answers:

How does the weak channel attach coherently to chirality, hypercharge, Higgs access, and mass-pairing?

QC-1 answers:

Does the physical-sector extraction leave a positive, ghost-free, microcausal quantum sector — and is that extraction canonical?

These are complementary.

A theory can have the right gauge group but still fail positivity. A theory can have the correct weak sign but still contain ghosts. A theory can have formal algebraic closure but still permit hidden acausal channels.

QC-1 blocks those failures at the physical-sector level.

13.1 Why QC-1 belongs before later mass and flavour gates

Later VERSF gates concerning Yukawa hierarchy, CKM/PMNS structure, χ-readout, or mass increments must operate on physical degrees of freedom. They should not have to carry an unresolved question:

Are we computing in a positive physical sector, or are we accidentally using auxiliary adjoint residue?

QC-1 removes that ambiguity.

After QC-1, later gates may state:

All calculations are performed in the adjoint-removed physical quotient 𝔄_P, whose terminal states are positive, whose local observables are microcausal, and whose construction is canonical given (𝔄_K, 𝒯).

That is the programme value.

13.2 Minimal-census boundary

QC-1 closes adjoint-removal only inside the minimal physical census.

It does not rule out beyond-standard extensions with additional physical sectors. If a proposed extension introduces a mirror sector, a new gauge group, additional Higgs ledgers, or hidden particles, those are not automatically in 𝔍_AR.

They must be tested.

If they have terminal record effects, they are not removable by QC-1. They require a new census gate.

Thus QC-1 does not say:

anything unseen is adjoint residue.

It says:

anything terminally indistinguishable from zero in every context is not a separate physical object of the minimal census.

A specific instance of this boundary concerns anomaly cancellation (falsifier F11). Gauge anomaly cancellation in the minimal census is a statement about physical fermion content. If some future derivation could only cancel an anomaly by conscripting material from 𝔍_AR as physical content, that would demonstrate the material was never terminally null — the census, or the ideal, was drawn incorrectly. F11 is therefore a census-audit trigger, not a property QC-1 proves.

13.3 The QC-7 debt, registered

Honest accounting requires stating what this gate does not own. QC-7 — kinematic microcausality modulo the ideal — does essentially all the causal work in the paper: Lemma 6 is a one-line descent argument once QC-7 holds. But QC-7 is supplied by none of I1–I6 and is proved by no prior certified gate cited here.

Its natural source is the emergent-causal-structure line of the programme: the gates deriving the causal order of the 4-manifold from commitment structure (the causal-coherence compatibility line) must be extended to show that spacelike separation in the emergent geometry induces graded commutation of local kinematic elements modulo terminally null residue. Until that extension is certified, the correct statement of QC-1's causal content is conditional:

QC-1 proves: kinematic causality up to null terms ⇒ exact physical causality. The antecedent is a registered open debt of the programme, owed by the emergent-geometry gates, and its absence is visible in the Predictive-Content Ledger rather than hidden in an inheritance clause.

A hostile referee asking "where does kinematic microcausality come from in a theory whose causal structure is itself emergent?" is asking the right question, and the answer is: from a gate that is owed, named, and not yet closed. That is what a ledger discipline is for.

What would discharge QC-7. The owed gate must prove the following. If two bounded fold-support regions are spacelike-separated in the reconstructed 4-manifold, then the ordered-commitment algebra assigns them homogeneous local generators whose graded commutator is terminally null:

$\mathcal{O}_1$, $\mathcal{O}_2$ spacelike-separated ⇒ $[A,B]_g \in \mathfrak{I}_{AR}$ for all homogeneous $A \in \mathfrak{A}_K(\mathcal{O}_1)$, $B \in \mathfrak{A}_K(\mathcal{O}_2)$.

Equivalently: any nonzero kinematic commutator across spacelike-separated supports must be shown to be pure adjoint/completion residue with no terminal record effect in any admissible context. The natural strategy is to derive this from the commitment-order structure itself — spacelike separation in the emergent geometry corresponds to the absence of any commitment-order relation between the generating events, and the owed gate must show that order-unrelated commitments generate at most terminally null noncommutativity. That statement is the precise next-paper requirement; once certified, clauses 6 and 7 of Theorem 1 upgrade from descent-conditional to unconditional within the census.

---

14. Falsification Conditions

#	Failure	Consequence
F1	No local kinematic *-net exists	QC-1 cannot be formulated
F2	A contextual Gram matrix fails positivity, or a record functional fails † compatibility	positivity theorem fails
F2′	A terminal record coherently interferes even and odd sectors	grading descent fails; §8–§9 machinery unfounded
F3	Observational equivalence is not contextual, or contexts fail closure or exclude $\mathbb{1}$	quotient may remove real physics
F4	$\mathfrak{I}_{AR}$ is not a two-sided ideal	physical multiplication is not well-defined
F5	$\mathfrak{I}_{AR}$ is not closed under †	physical involution is not well-defined

#	Failure	Consequence
F6	An element of ℑ_AR has terminal detector effect	no-loss theorem fails
F7	A local expression's only record effects require contexts outside its causal development	support faithfulness fails
F8	Spacelike graded commutator has nonzero physical image	microcausality fails
F9	Hidden detector couples only to adjoint residue	no-adjoint-channel theorem fails
F10	Adjoint residue evolves into observable material	dynamical stability fails
F11	Removed material is needed for gauge anomaly cancellation as physical content	census must be re-audited
F12	Gauge bosons are mistakenly included in ℑ_AR	theorem is misapplied
F13	Negative-norm vector survives with nonzero physical class	positivity closure fails
F14	Later gates require terminal effects from ℑ_AR	those gates misuse QC-1 or expose an incomplete quotient
F15	A record-safe two-sided *-ideal strictly larger than ℑ_AR is exhibited	maximality (canonicality) fails; the quotient is not forced
F16	A physically implementable local nonselective intervention admits no normalised Kraus representation in 𝔄_P	the operational no-signalling claim loses its stated form; microcausality (Lemma 6) is unaffected

Methodological caution. Failure to observe something experimentally is not enough to place it in ℑ_AR. The criterion is stronger: no terminal record distinction in any admissible physical context.

---

15. QC-1 Closure Certificate

QC-1 condition	Result
Adjoint-removal problem isolated	closed
"Adjoint" distinguished from gauge adjoint representation	closed
Hermitian adjoint † preserved	closed
Local kinematic *-net stated (unital, graded)	closed
Terminal record functionals stated (contextual positivity, † compatibility, parity superselection)	closed
Contextual observational equivalence defined	closed
Adjoint-removal ideal ℑ_AR defined	closed
Ideal stability proved (Proposition 1)	closed

QC-1 condition	Result
Physical quotient algebra constructed (grading descends)	closed
No-loss of terminal records stated (definitional)	closed
Maximality / canonicality proved, relative to $\mathcal{T}$	closed
Terminal record states constructed from $\mathcal{T}$ (not postulated)	closed
Positive state descent proved on all of 𝔄_P	closed
No negative physical norm proved	closed
Independent adjoint ghosts excluded	closed
Spacelike graded commutators vanish in quotient, conditional on QC-7	closed as a descent theorem; antecedent open (§13.3)
No superluminal adjoint channel, conditional on QC-7, QC-9, QC-10	closed relative to named premises
Dynamics descends if ideal is preserved	closed
Gauge bosons not removed	closed
Minimal-census boundary stated	closed
Kinematic microcausality (QC-7 antecedent)	open debt — owed by emergent-geometry gates (§13.3)
Operational Kraus representation stated as premise (QC-10)	closed
Renormalisation	outside scope
Scattering amplitudes	outside scope
Full constructive QFT	outside scope
Higgs potential and masses	outside scope
CKM/PMNS	outside scope
Gravity/quantum gravity	outside scope

QC-1 closure grade: closed as a conditional physical-sector extraction theorem. QC-1 proves that adjoint-removal is record-preserving, canonical relative to the record family, positivity-preserving, and ghost-free, and that microcausality descends exactly to the physical quotient once QC-7 is supplied. The remaining open debt is not inside adjoint-removal itself but in the upstream derivation of kinematic microcausality modulo terminally null residue (§13.3). Operational no-signalling holds for the standard intervention class named in QC-10.

---

16. Conclusion

VERSF uses more formal structure than the terminal physical record sector. That is not a weakness by itself. Many successful physical formalisms use auxiliary variables, gauge redundancy, constrained coordinates, or quotient structures.

The danger is whether the auxiliary structure leaves behind unphysical residue.

QC-1 proves that VERSF's adjoint-removal procedure is safe under precise conditions.

The removable sector is not selected by taste. It is the contextual terminal-null ideal:

$\mathfrak{J}$_AR = { X : τ(C† X D) = 0 for all terminal records and contexts }.

Quotienting by that ideal produces the physical observable algebra

$\mathfrak{A}$_P = $\mathfrak{A}$_K / $\mathfrak{J}$_AR.

The quotient loses no terminal physical record, because any expression with nonzero terminal record effect has nonzero class — and no larger removal is record-safe, so the quotient is canonical given the record family rather than chosen. Positive terminal record states descend to positive physical states. The associated physical representation contains no negative-norm vectors. Adjoint-null material does not survive as an independent ghost. Given the kinematic antecedent (QC-7, registered in §13.3), spacelike graded commutators vanish exactly in the quotient, so the physical sector is microcausal. With no hidden adjoint detector channel and for interventions of the standard Kraus form (QC-10), no superluminal signalling route remains.

The result is deliberately limited. It does not derive all of quantum field theory. It does not compute couplings, masses, amplitudes, or renormalisation. It does not remove gauge bosons in adjoint representations. It removes only detector-silent auxiliary completion residue.

The programme consequence is important.

Earlier gates close what the physical gauge and weak structures are. QC-1 closes the question of whether the physical extraction of those structures is quantum-admissible. Later gates may now work in the adjoint-removed physical quotient without carrying a hidden ghost, negative-norm, or acausal branch, and without recording which kinematic presentation the quotient came from.

In one sentence:

VERSF adjoint-removal preserves all terminal physical records while eliminating only detector-silent completion residue; the resulting physical sector is positive, ghost-free, microcausal, and canonically determined.

Appendix A — Minimal Algebraic Skeleton

This appendix gives the theorem in its most compressed algebraic form.

Let $\mathfrak{A}$_K be a graded kinematic *-algebra. Let $\mathcal{T}$ be a family of terminal record functionals with positive Gram matrices and involution compatibility.

Define

$X \in \mathfrak{J}_{AR} \Leftrightarrow \tau(C^\dagger X D) = 0$ for all $\tau \in \mathcal{T}$ and all admissible contexts C, D.

Then:

1. $\mathfrak{J}_{AR}$ is a two-sided ideal, because contextual insertion preserves nullity: $\tau(C^\dagger(AXB)D) = \tau((A^\dagger C)^\dagger X (BD)) = 0$.
2. $\mathfrak{J}_{AR}$ is *-closed, because $\tau(C^\dagger X^\dagger D) = \overline{\tau(D^\dagger X C)} = 0$.
3. Therefore $\mathfrak{A}_P = \mathfrak{A}_K / \mathfrak{J}_{AR}$ is a *-algebra.
4. $\mathfrak{J}_{AR}$ is the largest record-safe ideal: any ideal $\mathfrak{K}$ of terminally null elements satisfies $\mathfrak{K} \subseteq \mathfrak{J}_{AR}$ by definition of membership. The quotient is canonical.

Terminal record states are constructed, not postulated: $\omega_{\{\tau,C\}}(A) = \tau(C^\dagger AC)/\tau(C^\dagger C)$ for admissible C with $\tau(C^\dagger C) > 0$, closed under convex combination and pointwise limit. Ideal annihilation is automatic ($\omega_{\{\tau,C\}}(X) = 0$ for $X \in \mathfrak{J}_{AR}$), so $\omega_P([A]) = \omega_K(A)$ is well-defined. Then, by contextual Gram positivity for all kinematic elements,

$\omega_P([A]^\dagger[A]) = \tau((AC)^\dagger(AC))/\tau(C^\dagger C) \geq 0$ for every class $[A] \in \mathfrak{A}_P$,

so the physical quotient is positive on its entirety, and its GNS representation (with the null left ideal $\mathcal{N}_\omega$ divided out) has nonnegative norm throughout — with no untested subsector.

If $\mathcal{O}_1$ and $\mathcal{O}_2$ are spacelike-separated and

$[A,B]_g \in \mathfrak{J}_{AR}$,

then

$[[A],[B]]_g = [\ [A,B]_g\ ] = 0$,

so the physical quotient is microcausal, and the Kraus computation

$\Sigma_i K_i^\dagger A K_i = (\Sigma_i K_i^\dagger K_i) A = A$

— valid for homogeneous K_i of either parity, since A is even and the graded sign is +1 regardless — converts microcausality into operational no-signalling for local interventions of the normalised Kraus form, imported as Premise QC-10.

That is the algebraic core of QC-1.

Appendix B — Convention Dictionary

B.1 Hermitian adjoint

The Hermitian adjoint $A^\dagger$ is the ordinary involution of the *-algebra. QC-1 does not remove it; the theorem requires $\mathfrak{I}_{AR}$ to be *-closed precisely so that † survives the quotient.

B.2 Gauge adjoint representation

A field may transform in the adjoint representation of a gauge group. QC-1 does not remove such fields. Gluons, weak gauge bosons, and gauge curvature components are not eliminated merely because they are adjoint-valued.

B.3 VERSF adjoint/completion residue

This is the specific object removed by QC-1: auxiliary completion residue that is terminally indistinguishable from zero in every physical context.

B.4 Null vector

A null vector has zero physical norm in the GNS representation. It is quotiented at representation level, and the null set is a left ideal so the physical action descends. It is not a negative-norm ghost.

B.5 Negative-norm ghost

A negative-norm ghost would be a surviving physical vector v with $\langle v,v\rangle < 0$. QC-1 excludes this in the physical representation.

B.6 Graded commutator

$[A,B]_g = AB - (-1)^{|A||B|} BA$ for homogeneous A, B, extended bilinearly. Even–even and even–odd pairs use the commutator sign; odd–odd pairs use the anticommutator sign.

B.7 Microcausality

Microcausality means physical observables associated with spacelike-separated regions graded-commute. For ordinary bosonic observables, this means they commute. For fermionic generators, the graded rule applies. "Spacelike" refers to the causal structure of the emergent 4-manifold.

B.8 No-signalling

No-signalling is the operational consequence of microcausality: a nonselective local operation in one spacelike region cannot change expectation values in another. The operational statement is relative to the QC-10 intervention class (normalised Kraus maps in the physical quotient); microcausality itself is the stronger structural claim and does not depend on QC-10.

B.9 Canonicality

The quotient $\mathfrak{A}\_P$ is canonical: it is determined by $(\mathfrak{A}\_K, \mathcal{T})$ alone, as the quotient by the unique maximal record-safe ideal. No presentation choice, splitting convention, or gauge-fixing scheme enters.

Appendix C — Referee Objections and Replies

Objection 1 — You are simply projecting away bad states.

Reply: No. The removable sector is defined by terminal record indistinguishability in all physical contexts. The paper then proves this sector is a two-sided *-ideal, that quotienting by it loses no terminal records, and — via the maximality lemma — that it is the unique largest record-safe removal. This is quotient by physical equivalence, not arbitrary deletion, and no discretionary latitude remains in either direction.

Objection 2 — Does "adjoint-removal" remove gluons?

Reply: No. "Adjoint" in QC-1 does not mean "adjoint representation of a gauge group." Gluons are physical because they have terminal record consequences. QC-1 removes only detector-silent auxiliary completion residue.

Objection 3 — Are you deleting the Hermitian adjoint operation?

Reply: No. The Hermitian adjoint $A^\dagger$ is preserved. In fact, the theorem requires the adjoint-removal ideal to be *-closed so that the quotient has a well-defined involution.

Objection 4 — Does the theorem derive the Born rule?

Reply: No. It assumes terminal record positivity as a physical admissibility premise, supplied elsewhere in the programme by the independent Born-rule gates. It proves that adjoint-removal preserves positivity and does not introduce negative norm.

Objection 5 — What if adjoint residue becomes observable later?

Reply: Then Premise QC-8 fails. The theorem explicitly requires admissible dynamics to preserve ℑ_AR. If adjoint-null material evolves into observable material, QC-1 is falsified or the ideal was defined too broadly.

Objection 6 — What if there is a hidden detector that sees adjoint residue?

Reply: Then Premise QC-9 fails. QC-1 does not hide this possibility. If such a detector exists, the residue is not terminally null and cannot be removed.

Objection 7 — Does this prove full relativistic QFT consistency?

Reply: No. It proves physical-sector positivity and microcausality under the named premises. Renormalisation, scattering, constructive existence, anomaly cancellation, and detailed dynamics remain separate gates.

Objection 8 — Could a beyond-Standard-Model hidden sector be mistaken for adjoint residue?

Reply: Only if the test is applied incorrectly. A hidden sector with physical effects is not in ℑ_AR. QC-1 removes only terminally indistinguishable residue. A genuine hidden sector requires a new census gate.

Objection 9 — Why allow kinematic spacelike commutators to vanish only modulo the ideal?

Reply: Because VERSF's kinematic presentation may include auxiliary completion residue. The physical question is whether spacelike noncommutation has terminal observable effect. QC-1 proves that if the graded commutator lies in the adjoint-removal ideal, it vanishes exactly in the physical quotient.

Objection 10 — Is the theorem too conditional?

Reply: It is conditional by design. QC-1 is a structural closure theorem, not a magic derivation of all quantum physics. Its value is that it names the exact premises required for VERSF physical-sector extraction to be positive, ghost-free, and microcausal. Those premises are falsifiable and reusable by later gates.

Objection 11 — Does quotienting by $\mathfrak{J}$_AR erase interference?

Reply: No. Interference is removed only if it is terminally null in all contexts. Any interference term that changes a terminal record has nonzero physical class by Lemma 2.

Objection 12 — Does this make adjoint residue "unreal"?

Reply: It makes it nonphysical inside the minimal terminal record census. It may remain useful as formal bookkeeping, just as gauge redundancy is useful without being an additional observed particle.

Objection 13 — Isn't Premise QC-5 redundant, given Proposition 1?

Reply: Logically, yes: ideal stability follows from QC-2 and QC-3. It is retained as a named premise for auditability: if stability fails empirically or structurally, the falsification ledger must be able to report the failure at F4/F5 without first adjudicating which of QC-2 or QC-3 broke. Redundant premises with independent falsifiers are a feature of the gate discipline, not an oversight.

Objection 14 — Could two different kinematic presentations give two different physical sectors?

Reply: Not if they share the same terminal record family. Lemma 2′ shows $\mathfrak{A}$_P is determined by ($\mathfrak{A}$_K, $\mathcal{T}$) as the quotient by the unique maximal record-safe ideal. Presentation-dependent physical sectors would require presentation-dependent terminal records, which contradicts record primacy (I1). Note the honest scope stated in §5.5: canonicality is relative to $\mathcal{T}$, whose completeness and presentation-independence are carried by QC-9 and I1 as premises.

Objection 15 — Doesn't your positivity hold only on a "record-accessible" subsector, leaving room for hidden negative norm?

Reply: Not in this formulation. QC-2(a) states contextual Gram positivity for *all* kinematic elements routed through admissible contexts, and terminal record states are constructed as context vector states (§6.2), so Lemma 3 delivers ω_P([A]†[A]) ≥ 0 for every class in $\mathfrak{A}$_P. There is no exceptional subsector in which Lemma 4's GNS argument fails to reach. A formulation that restricted Gram positivity to a distinguished accessible subclass would indeed leave that hole; the premise is quantified precisely to close it, and its falsifier (a negative contextual Gram eigenvalue anywhere) is correspondingly broad.

Objection 16 — Lemma 6 is trivial once QC-7 is assumed. Where does QC-7 come from?

Reply: Correct, and stated openly: Lemma 6 is a one-line descent argument, and QC-7 carries the causal content. QC-7 is registered as an owed input of the programme (§13.3), with the precise discharge condition stated there: the emergent-causal-structure gates must show that order-unrelated commitments generate at most terminally null noncommutativity across spacelike-separated supports. QC-1's causal contribution is the conditional: *if* the kinematic theory is causal up to terminally null terms, the physical quotient is exactly causal, with no residual acausal channel. The debt is in the ledger, not hidden in an inheritance clause.

Objection 17 — QC-2(a) is so strong it assumes the no-ghost result.

Reply: QC-2(a) fixes what a record channel is: any preparation routed through it returns a positive Gram matrix. It does not assert that every formal expression is physical, and it is falsifiable in the strongest sense — a single negative contextual Gram eigenvalue anywhere refutes it. The nontrivial content of the paper is downstream of the premise: that the quotient transmits positivity to the entire physical sector with no untested subsector (Lemmas 3–4), loses no records (Lemma 2), is canonical (Lemma 2′), and is causally clean (Lemmas 6–7). A theory could satisfy QC-2(a) and still fail any of those if the extraction were done badly; QC-1 proves the extraction cannot fail them. See the discussion following QC-2's falsifiers.

Objection 18 — Where did the Kraus/completely-positive formalism come from?

Reply: From Premise QC-10, which names the import honestly. QC-1 does not derive the operational representation of local interventions; it proves that for interventions of that standard form, microcausality of the quotient implies no operational spacelike signalling. Microcausality itself (Lemma 6) is proved without QC-10 and is the stronger structural claim; the Kraus premise is needed only to translate it into operational language. F16 keeps the import falsifiable.

Final one-sentence theorem

After quotienting the VERSF kinematic algebra by the terminally silent adjoint-removal ideal — the unique maximal record-safe removal — the surviving physical observable sector preserves all records, has positive norm, contains no independent adjoint ghosts, and obeys microcausality.