The Four Fundamental Interactions as Entropic Admissibility Rules

A VERSF Derivation of Interaction Rules from Information Constraints

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Thesis: Experimentally and theoretically, all known physical interactions reduce to four fundamental interaction types; VERSF explains why this list is closed by showing that only four admissible rules can govern distinguishable information.

Abstract

The Standard Model treats gravity, electromagnetism, the weak interaction, and the strong interaction as fundamentally distinct forces mediated by independent gauge fields. While phenomenologically successful, this framework offers no explanation for why exactly four interactions exist, why their mathematical structures differ so radically, or why only one permits identity change while another enforces permanent confinement.

This paper proposes that within the Void Energy-Regulated Space Framework (VERSF), there are not four fundamental forces but one admissibility principle giving rise to four irreducible rules governing distinguishable structure: flow, accounting, unlocking, and locking. These are not mechanisms, fields, or entities—they are constraints the universe must obey if facts are to exist at all. We argue that electromagnetism emerges as the flow rule (redistribution of distinctions across the matter–void reference state interface); gravity as the accounting rule (global consistency of irreversible commitment); the weak interaction as the unlocking rule (probabilistic identity change at information barriers); and the strong interaction as the locking rule (mandatory closure of internal distinguishability). This reclassification suggests that gauge symmetries are effective descriptions of deeper information-geometric constraints, and that no fifth fundamental interaction exists because no fifth irreducible admissibility operation on physical information is possible.

For the general reader: Physics has discovered exactly four ways that things can interact. This paper argues that this isn't a coincidence—it's because there are only four logically possible ways for information to behave in a universe where facts must be definite and consistent.

Scope and Claims

This work does not attempt to replace the Standard Model's calculational machinery, nor to derive coupling constants numerically. Its claim is structural: that the existence, number, and qualitative character of the four interactions follow from admissibility constraints on distinguishable information. The framework is proposed as a conceptual foundation that may inform future mathematical development, not as a competing calculational scheme.

Why "Force" Is Not Fundamental

For the general reader: We usually think of forces as things that push or pull objects around. But as physics has advanced, this intuitive picture has become less and less fundamental. This section traces how "force" has been progressively demoted from a basic building block of reality to merely a useful approximation.

Before reclassifying the fundamental interactions, it is essential to clarify what is meant by a "force" in modern physics. While the term remains widely used, its meaning and status have changed substantially across theoretical frameworks.

In classical Newtonian mechanics, a force is defined operationally as that which produces acceleration:

$$F = ma$$

In this context, force is treated as a primitive concept: it is not derived, but inferred from observed motion. This definition is powerful and practical, but it presupposes the existence of mass, space, and time, and offers no deeper explanation of why forces exist or take the forms they do.

In Lagrangian and Hamiltonian mechanics, force loses its primitive status. It appears instead as a derived quantity—the gradient of a potential or, more generally, as a consequence of the system's action. The fundamental object becomes the action functional, and forces emerge from its structure rather than acting as independent entities.

In quantum field theory, the notion of force largely disappears altogether. Interactions are described through couplings between quantum fields, encoded in the interaction terms of a Lagrangian. There is no fundamental force operator; what are colloquially called "forces" correspond to momentum exchange mediated by field excitations. The language of force survives only as a low-energy, classical approximation to underlying field dynamics.

In general relativity, gravity is explicitly not a force. Freely falling bodies experience no force; their motion is explained geometrically as geodesic motion in curved spacetime. Gravitational effects arise not from interaction forces but from the requirement that trajectories be consistent with spacetime geometry.

Taken together, modern physics does not provide a single, universal definition of force. Instead, "force" functions as an effective, context-dependent concept, useful for describing motion at certain scales but not fundamental across all regimes. One of the four traditionally named "forces" is already understood not to be a force at all, and the others are recognized as emergent descriptions of deeper dynamical or geometric structures.

The VERSF framework builds directly on this trajectory. It does not deny the operational usefulness of forces in classical or effective theories. Rather, it asks a deeper question: what underlying constraints give rise to interactions that can be described as forces at all? In VERSF, the answer is not additional fields or mechanisms, but admissibility constraints on distinguishable information.

From this perspective, the four fundamental interactions are not four independent forces, but four irreducible rules enforced by a single admissibility principle. What appear phenomenologically as forces are the observable signatures of how this principle governs information flow, global consistency, identity transformation, and identity closure.

This clarification is crucial: VERSF does not replace forces with another kind of force, nor does it redefine forces arbitrarily. It situates them as emergent artifacts of deeper constraints, consistent with the way the concept of force has progressively receded from fundamental status in modern theoretical physics.

Accordingly, this paper targets the pre-dynamical question: what constraints make interaction descriptions (fields, gauge symmetries, curvature) admissible in the first place?

Contents:

1. Introduction: The Problem of the Four Interactions

For the general reader: Why exactly four forces? Not three, not five, but four. The Standard Model of physics—our best current theory—doesn't answer this. It just accepts four as a fact and moves on. This paper argues that four isn't arbitrary: it's the only number that works if reality is going to be consistent and definite.

Despite extraordinary predictive success, the Standard Model does not explain why the interaction list is closed. Modern physics recognizes four fundamental interactions: gravity, electromagnetism, the weak nuclear force, and the strong nuclear force. Each possesses distinct range, coupling strength, symmetry group, and phenomenology. The Standard Model successfully describes three of these through gauge field theory, while general relativity treats gravity geometrically. Yet fundamental questions remain unanswered:

Why four? The Standard Model provides no principle that determines the number of fundamental interactions. The gauge groups $SU(3) \times SU(2) \times U(1)$ are inputs, not outputs, of the theory.

Why these structures? Electromagnetism is long-range and preserves particle identity. The weak interaction is short-range and violates parity, CP symmetry, and particle identity through decay. The strong interaction confines quarks permanently yet permits hadron-level interactions. Gravity couples universally to energy-momentum. No unified explanation exists for why these particular patterns emerge.

Why the hierarchy? Coupling strengths span roughly 40 orders of magnitude, from the strong interaction ($\alpha_s \sim 1$) to gravity ($G_N m_p^2 / \hbar c \sim 10^{-38}$). The Standard Model treats this hierarchy as a contingent fact requiring fine-tuning.

This paper approaches these questions from first principles within VERSF—the Void Energy-Regulated Space Framework—which posits that physical law emerges from admissibility constraints on distinguishable information. We argue that the four interactions are not forces transmitted by mediating particles but four distinct rules by which information may be constrained, each uniquely permitted by the requirement of finite distinguishability.

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2. The VERSF Foundation: Admissibility over Dynamics

For the general reader: Instead of asking "what pushes things around?", VERSF asks "what kinds of changes are even possible?" Think of it like the rules of a game: the rules don't push the pieces, but they determine what moves are allowed. VERSF proposes that the laws of physics are like game rules—they define what's permitted, not what does the pushing.

2.1 The Zero-Entropy Void Substrate

For the general reader: Imagine a blank canvas before any painting exists. The canvas isn't the painting, but it's where paintings can appear. VERSF proposes something similar: before any physical facts exist, there's a kind of "blank state" called the void—not empty space, but pure possibility with nothing yet determined. Physical things emerge when this possibility becomes committed to specific outcomes.

VERSF posits that observable spacetime emerges from a more primitive substrate: a zero-entropy void that carries no intrinsic distinctions. The void is defined operationally as a reference configuration of zero irreversible commitment, not as a dynamical substance. This void is not empty space but the absence of committed information—a realm of pure potentiality from which distinguishable structures crystallize through irreversible commitment.

The key postulate is **finite distinguishability**: only configurations that can be uniquely specified by finite information may exist as physical facts. This constraint is not imposed externally but reflects the logical requirement that existence requires definite identity.

2.2 Physical Law as Admissibility Constraint

For the general reader: Most physics asks "how does this happen?" VERSF asks a prior question: "what's allowed to happen at all?" Think of it like traffic laws. The laws don't push cars—engines do that. But the laws determine which movements are permitted. Similarly, VERSF says the laws of physics are really about what's allowed, not what does the pushing.

Within VERSF, physical laws do not describe forces pushing matter around. Instead, they specify which transitions between information states are admissible—which changes preserve finite distinguishability, respect committed facts, and maintain global consistency.

This inversion has profound consequences. Rather than asking "what force causes this motion?" we ask "what constraints permit this transition?" The four fundamental interactions emerge as the complete set of admissible constraint rules on physical information.

2.3 Entropy as Distinguishability Measure

For the general reader: "Entropy" is often described as disorder, but here it means something more precise: how much a system's state is pinned down versus left open. A coin showing heads has low entropy (we know exactly what it shows); a coin still spinning in the air has higher entropy (we don't yet know the outcome). VERSF treats this "not-yet-determined-ness" as the fundamental quantity that physics tracks.

Entropy in VERSF is not merely a statistical quantity but the fundamental measure of distinguishability deficit. A system's entropy quantifies how much potential distinction remains uncommitted. Low entropy corresponds to highly specified, committed information; high entropy corresponds to uncommitted potential.

Physical processes redistribute entropy subject to the constraint that total distinguishability cannot decrease for closed systems—the second law emerges as a consistency requirement on information commitment. Here "entropy" is used in the operational-information sense (uncommitted distinguishability); thermodynamic entropy is recovered as the coarse-grained macroscopic limit of the same quantity.

Key Definitions

For the general reader: These five terms are the building blocks of VERSF. Understanding them is like learning the basic vocabulary of a new language—once you have these, the rest follows naturally.

Distinguishability: The capacity for two configurations to be uniquely specified relative to each other; the fundamental currency of physical information. *Put simply: Can you tell two things apart? If yes, they are distinguishable.*

Commitment: The irreversible transition from potential to actual; once information is committed, it becomes a fact that cannot be uncommitted. *Put simply: Some things, once they happen, can't unhappen. A commitment is when possibility becomes permanent fact.*

Admissibility: The property of a configuration or transition that satisfies finite distinguishability constraints; inadmissible configurations cannot exist as physical facts. *Put simply: Not everything imaginable is actually possible. Admissible means "allowed by the rules of reality."*

Identity basin: A metastable minimum in admissible configuration space corresponding to a particle type; the set of configurations that register as that particle to the rest of the universe. *As an analogy, think of a valley in a hilly landscape. A ball in the valley has a stable identity—it's "in that valley." An identity basin is like that valley for a particle type.*

Void reference state: The operational zero-point of entropy commitment; a reference configuration carrying no irreversible distinctions, against which all physical structure is defined. *Put simply: The blank page before anything is written—not empty space, but the reference point of "no commitments yet."*

The Admissibility Stack: How BCB, TPB, and PAF Give Rise to the Four Rules

For the general reader: VERSF rests on three foundational constraints, which together form the "admissibility stack." Think of them as three filters that any physical process must pass through. PAF asks "Is this logically allowed?" BCB asks "Is there room for this?" TPB asks "How fast can this happen?" Only processes that pass all three filters can occur in nature.

The reclassification of the four fundamental interactions presented here follows directly from the three foundational constraints of the VERSF admissibility stack:

Physical Admissibility Framework (PAF). PAF establishes that physical facts require finite distinguishability, irreversible commitment, and global consistency. Interactions are therefore not forces but admissibility rules by which information may be redistributed, committed, transformed, or constrained without violating these requirements. PAF defines which kinds of rules are logically permitted.

Bit-Conservation Bound (BCB). BCB constrains the total amount of independently instantiable distinguishability. New distinctions cannot be created freely without compensating capacity elsewhere. This enforces conservation-like behavior, prohibits isolated incomplete records, and requires closure of internal distinguishability. BCB underwrites identity preservation in the flow rule and the closure requirement of the locking rule.

Ticks-Per-Bit Constraint (TPB). TPB imposes a finite rate at which distinguishability can be resolved or committed. Even when a transition is admissible, it cannot occur instantaneously or deterministically. Identity changes therefore proceed as stochastic, time-asymmetric processes governed by finite attempt rates and barrier heights. TPB supplies the rate-law structure underlying the unlocking rule.

Taken together, **PAF determines which rules are logically permitted**, **BCB determines which distinctions may exist** as stable facts, and **TPB determines how quickly** admissible transitions can occur. Under these combined constraints, only four rules are possible:

- **Flow rule:** Redistribution of distinctions without identity change (electromagnetism)
- **Accounting rule:** Global consistency of irreversible commitment (gravity)
- **Unlocking rule:** Probabilistic identity change across finite barriers (weak interaction)
- **Locking rule:** Mandatory closure of internal distinguishability (strong interaction)

No fifth rule is possible without violating one or more elements of the admissibility stack.

Appendices A–C provide a minimal mathematical formalization and two explicit realizations (field-theoretic and bit-lattice) demonstrating that the admissibility framework can be instantiated concretely without altering the core argument.

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3. Electromagnetism: Entropy Flow Across the Matter-Void Interface

For the general reader: Electromagnetism is what makes light shine, magnets stick, and electricity flow. In everyday physics, we describe it using electric and magnetic fields. VERSF reinterprets these fields as patterns in how "definiteness" flows from place to place. When you *turn on a light, you're redistributing distinguishability—moving definite information from the power plant to your lamp—without changing what anything fundamentally is.*

3.1 Charge as Coupling Asymmetry

For the general reader: Electric charge is usually described as a property that makes things attract or repel. VERSF reframes this: charge is about how a particle connects to the flow of definiteness. Positive and negative charges are opposite orientations of this connection—like two doors, one letting definiteness in and one letting it out.

In VERSF, electric charge represents an asymmetry in how a structure couples to the entropy gradient between matter and void. Positive and negative charges correspond to opposite orientations of this coupling—whether a structure preferentially absorbs or emits distinguishability flux.

This explains charge conservation naturally: the total coupling asymmetry must balance because the matter-void interface is shared. Creating net charge would require creating a one-sided interface, which is geometrically impossible. More fundamentally, BCB forbids unbalanced new distinctions without compensating capacity elsewhere—net asymmetry creation would violate the global consistency of distinguishability accounting.

3.2 Electric Fields as Entropy Gradients

For the general reader: An electric field tells you which way a charged particle would be pushed at each point in space. VERSF says this field is really a map of how "definiteness" varies from place to place—charges naturally move from regions of one definiteness level to another, like water flowing downhill.

The electric field E represents the local gradient of entropy cost—the rate at which distinguishability changes with position. Gauss's law,

$$\nabla \cdot E = \rho/\varepsilon_0$$

states that charges are sources and sinks of this gradient field. The permittivity ε_0 sets the scale relating charge (coupling asymmetry) to field strength (entropy gradient).

3.3 Magnetic Fields as Entropy Circulation

For the general reader: Magnetic fields appear when charges move. While electric fields point in straight lines from charges, magnetic fields curl around moving charges in loops. VERSF explains this: moving charges create swirling patterns in the flow of definiteness, like eddies in a stream.

Magnetic fields arise from circulating entropy flow rather than linear gradients. When charges move, they create rotational patterns in the distinguishability flux. Ampère's law,

$$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \, \partial E/\partial t$$

expresses the relationship between current (moving coupling asymmetry) and field circulation. The displacement current term ensures consistency when entropy gradients themselves change.

3.4 Maxwell's Equations as Continuity Conditions

For the general reader: Maxwell's equations are the four fundamental laws of electromagnetism. They describe how electric and magnetic fields create and influence each other. VERSF reinterprets these equations as bookkeeping rules—they ensure that the flow of definiteness is self-consistent, with no "leaks" or contradictions.

The full Maxwell equations emerge as continuity conditions on the admissible information-entropy flux associated with electromagnetic degrees of freedom:

- **Gauss (E):** Charges source entropy gradients
- **Gauss (B):** No magnetic monopoles because circulation has no sources
- **Faraday:** Changing circulation induces gradients
- **Ampère-Maxwell:** Moving charges and changing gradients induce circulation

Electromagnetic waves are self-sustaining oscillations in the entropy flux—ripples in distinguishability that propagate at the characteristic speed c set by the void's information-carrying capacity.

3.5 Identity Preservation in Electromagnetic Processes

For the general reader: Here's a crucial point: no matter how much light an electron absorbs or emits, it stays an electron. It might gain energy, change direction, or slow down—but it never becomes a proton or a neutrino through electromagnetic interactions. VERSF explains this: electromagnetism is about moving definiteness around, not about changing what things are.

Crucially, electromagnetic interactions never change particle identity. An electron remains an electron regardless of how many photons it absorbs or emits. This reflects the fact that electromagnetism governs entropy *flow*—redistribution of distinguishability—not entropy *commitment* or identity transformation.

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4. Gravity: Coarse-Grained Entropy Accounting

For the general reader: Gravity is the most familiar force—it's what keeps your feet on the ground and the planets in orbit. Einstein showed that gravity isn't really a force at all; it's the curvature of space and time caused by mass. VERSF goes deeper: it says mass itself is a kind of "permanent record" in the universe's bookkeeping system, and gravity is what happens when the *universe keeps its books balanced. Everything with mass has made a permanent mark on reality, and gravity is the universe's way of accounting for all those marks consistently.*

4.1 Mass as Committed Irreversible Entropy Deficit

For the general reader: What is mass, really? VERSF says mass is a permanent commitment—a mark on reality that can't be erased. When something has mass, it has made an irreversible contribution to the universe's total "definiteness budget." This commitment can never be undone, only transformed (as in $E=mc^2$, when mass converts to energy or vice versa).

Mass in VERSF represents persistent, irreversible entropy commitment. When information becomes a physical fact, it creates a permanent deficit in local distinguishability potential relative to the void reference state. This irreversible commitment—experienced phenomenologically as mass—cannot be erased and must be globally accounted for.

The equivalence of inertial and gravitational mass follows naturally: both track the same underlying irreversible commitment, expressed phenomenologically as inertia and gravitating mass. Inertial mass measures resistance to changing the committed configuration; gravitational mass measures coupling to global entropy accounting.

4.2 Spacetime Curvature as Global Bookkeeping

For the general reader: Einstein showed that gravity isn't a force pulling things together—it's the curvature of space and time itself. Massive objects bend spacetime, and other objects follow the curves. VERSF adds a layer: this curvature is the universe's way of keeping its books balanced. Every mass represents a committed fact, and spacetime geometry is what ensures all these facts remain globally consistent.

General relativity describes gravity through spacetime curvature. In VERSF, this curvature represents the geometric structure required to maintain consistent entropy accounting across all committed facts.

Einstein's equation,

$$G_{\mu\nu} = (8\pi G/c^4)\, T_{\mu\nu}$$

relates spacetime geometry (left side) to energy-momentum distribution (right side). In VERSF terms: the information geometry ($G_{\mu\nu}$) must accommodate the pattern of committed entropy deficits ($T_{\mu\nu}$).

4.3 Why Gravity is Universal and Weak

For the general reader: Two puzzles about gravity: First, why does everything feel gravity? Electromagnetism only affects charged things, but gravity affects everything. Second, why is gravity so incredibly weak? You can pick up a paperclip with a tiny magnet, defeating the *gravitational pull of the entire Earth. VERSF answers both: gravity affects everything because everything that exists has made some commitment to reality. And it's weak because it emerges from averaging over astronomical numbers of tiny commitments—a statistical effect, not a direct interaction.*

Gravity is special. Unlike the other interactions, physicists know that our usual way of describing forces stops working for gravity at very high energies. This isn't just a technical problem—it's a clue. VERSF takes this clue seriously and suggests that gravity fails to behave like a conventional force because it isn't one. Instead, gravity plays a different role: it keeps the universe's records consistent. This section explains why that difference naturally leads to gravity behaving differently at the smallest scales.

Gravity couples to all energy-momentum because all physical structures involve some degree of entropy commitment. Unlike electromagnetism, which couples only to charge (coupling asymmetry), gravity couples to existence itself.

The extreme weakness of gravity relative to other interactions reflects its nature as a coarse-grained, statistical effect. Individual quantum events involve discrete entropy changes; gravity emerges from the collective accounting of enormous numbers of such commitments. The ratio of gravitational to electromagnetic coupling ($\sim 10^{-36}$ for protons) is consistent with interpreting gravity as emerging from extremely coarse-grained accounting over vast numbers of discrete commitments.

Gravity and the UV: Why "Accounting" Need Not Behave Like a Force

A noteworthy asymmetry is that gravity is the only interaction whose standard field-theoretic description is known to fail as a fundamental ultraviolet completion: perturbative quantization of general relativity yields a non-renormalizable effective field theory. In the VERSF interpretation this is not surprising. Gravity is not a microscopic exchange mechanism analogous to flow, unlocking, or locking; it is the **global consistency condition** imposed by irreversible commitment. As a result, its correct ultraviolet behavior need not be captured by the same perturbative "carrier" framework that works for the other sectors.

VERSF therefore suggests that gravity's UV breakdown reflects a category mismatch: treating a global accounting constraint as if it were a standard local mediator field inevitably overextends the effective description. In VERSF terms, the ultraviolet completion of gravity should be sought not by adding new carrier degrees of freedom, but by specifying the microscopic structure of commitment and ledger consistency (Appendix A) and showing how smooth spacetime geometry emerges as a coarse-grained constraint. This predicts—at the level of principle—that the correct UV description of gravity is **constraint-dominated** and **coarse-graining dependent**, rather than a straightforward renormalizable force field in the same sense as gauge interactions.

4.4 No Gravitational Identity Change

For the general reader: Like electromagnetism, gravity never changes what something is. An electron falling into a black hole remains an electron—it might gain enormous energy, but it doesn't become a different particle. This is because gravity is about accounting for existing facts, not transforming them.

Like electromagnetism, gravity preserves particle identity. Falling through a gravitational field does not transmute an electron into a muon. This is because gravity operates at the level of global bookkeeping, not local identity—it tracks committed facts without modifying them.

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5. The Weak Interaction: Probabilistic Identity Unlocking

For the general reader: The weak interaction is responsible for radioactive decay—when an unstable atom spontaneously transforms into a different kind of atom. Unlike gravity and electromagnetism, which move things around without changing what they are, the weak interaction actually changes one type of particle into another. A neutron can become a proton; a heavy quark can become a lighter one. VERSF explains this as "identity unlocking"—certain particle identities sit in energy valleys, and occasionally, like a ball rolling over a hill, they can escape to become something else entirely.

5.1 The Unique Character of Weak Processes

For the general reader: Here's what makes the weak interaction special: it's the only interaction that can change what a particle IS. Gravity and electromagnetism push things around, but they leave identities intact. The weak interaction is different—it's the universe's mechanism for identity transformation, the only way a neutron can become a proton or a muon can become an electron.

The weak interaction differs fundamentally from electromagnetism and gravity: it permits identity change. A neutron can become a proton; a muon can become an electron. This identity transmutation—radioactive decay—is impossible through any other interaction.

In VERSF, this reflects the weak interaction's unique role as an identity unlocking mechanism. While electromagnetism redistributes entropy and gravity accounts for it, only weak processes can unlock the identity basin that defines what a particle *is*.

5.2 Identity Basins in Admissible Configuration Space

For the general reader: Imagine a landscape of hills and valleys. Each valley represents a stable particle identity—"electron valley," "proton valley," "neutron valley." A particle sitting in a *valley has a stable identity. To change identity, it must climb over a hill to reach another valley. Some hills are low (allowing decay), others are infinitely high (forbidding certain transformations entirely).*

Each particle type corresponds to a local minimum—an identity basin in admissible configuration space—representing the set of configurations that register as that particle type to the rest of the universe. These basins are separated by information barriers of varying height: a neutron basin is separated from a proton basin by a finite admissibility barrier (permitting beta decay), while an electron-to-proton transition is separated by an effectively infinite barrier (forbidding such decay entirely).

5.3 Decay as Probabilistic Barrier Crossing

For the general reader: Radioactive decay is probabilistic—you can't predict exactly when a particular atom will decay, only the probability. VERSF explains this: the particle is "trying" to escape its identity valley, but each attempt has only a small chance of succeeding. The half-life of a radioactive substance reflects how high the barrier is and how often the particle "tries" to cross it.

Radioactive decay corresponds to probabilistic escape from an identity basin in admissible configuration space. Formally, identity basins correspond to metastable minima in the admissible entropy functional over configuration space. The decay probability per unit time is determined by:

$$\lambda = f \cdot \exp(-\Delta S/k_B)$$

The TPB constraint enters through the attempt frequency f, which bounds how rapidly barrier-crossing attempts can be physically instantiated. Here ΔS denotes the effective admissibility barrier height (the distinguishability cost of traversing intermediate configurations), not the thermodynamic entropy of a macroscopic ensemble. Half-lives spanning fractions of a second to billions of years reflect the exponential sensitivity to barrier height.

5.4 Parity Violation and Time Asymmetry

For the general reader: The weak interaction has a strange property: it violates mirror symmetry (parity). If you watched certain weak decays in a mirror, you'd see something that doesn't happen in nature. VERSF explains this: changing identity is inherently directional—like writing in ink rather than pencil. You can't un-write what's been written, and this irreversibility breaks the symmetry.

The weak interaction violates parity (mirror symmetry) and CP symmetry. In VERSF, this reflects the intrinsic directionality of identity change: unlocking an identity basin is not the same as locking it.

Information commitment creates fundamental time asymmetry—you cannot uncommit a fact. The weak interaction, as the identity-unlocking rule, inherits this asymmetry. Parity violation emerges because the information geometry of identity basins need not be mirror-symmetric.

5.5 The W and Z Bosons as Barrier Mediators

For the general reader: The W and Z bosons are the "messenger particles" of the weak interaction, similar to how photons are messengers for electromagnetism. But they're very heavy—about 80-90 times the mass of a proton. VERSF interprets their large mass as reflecting the height of the identity barriers they help particles cross. The short range of weak interactions (about 10^{-18} meters) follows from this heaviness.

The massive W and Z bosons are not force carriers in the conventional sense but representations of the information barrier structure. Their masses (~80-90 GeV) set the energy scale of identity barriers for known particles. The short range of weak interactions (~10^{-18} m) reflects the localized nature of identity basins in physical space.

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6. The Strong Interaction: Identity Locking Through Distinguishability Closure

For the general reader: The strong interaction is what holds atomic nuclei together and binds quarks inside protons and neutrons. It has a strange property called "confinement": you can never see a single quark by itself. If you try to pull two quarks apart, the energy you put in creates new quarks, so you always end up with groups of quarks, never individuals. As an analogy, VERSF explains this as "identity locking"—quarks are like incomplete sentences that don't make grammatical sense on their own. They must combine with other quarks to form a complete, meaningful statement. An isolated quark would be like writing "the" and claiming it's a complete thought—the universe simply doesn't allow it.

6.1 The Confinement Puzzle

For the general reader: Here's one of the deepest mysteries in physics: quarks are never found alone. We know they exist inside protons and neutrons, but no experiment has ever isolated a single quark. Try to pull two quarks apart, and the energy you put in creates new quarks—you always end up with groups, never individuals. Why? The Standard Model describes this but doesn't really explain it. VERSF offers an explanation.

The strong interaction presents a unique puzzle: quarks are never observed in isolation. Despite carrying color charge, they exist only in color-neutral combinations (hadrons). This confinement has no analog in electromagnetism—we can isolate positive and negative charges—nor in gravity or weak interactions.

6.2 Quarks as Incomplete Information Fragments

For the general reader: As an analogy, think of quarks as puzzle pieces that only make sense when connected. A single puzzle piece has part of a picture, but it's incomplete—it "refers" to adjacent pieces that must be present for the image to be coherent. VERSF says quarks are like this: they carry "partial information" that must be completed. An isolated quark would be an incomplete fact, and incomplete facts aren't allowed to exist.

In VERSF, quarks represent incomplete information fragments—configurations that cannot independently satisfy the finite distinguishability requirement. A quark in isolation would be a structure that the universe cannot uniquely specify because its identity refers to internal degrees of freedom (color) that must close. Under BCB, you cannot "export" incomplete distinguishability as a stand-alone fact without paying capacity you do not have—closure is required for admissibility.

This is not a force holding quarks together but an admissibility constraint: isolated quarks simply cannot exist as physical facts.

6.3 Color as Internal Distinguishability

For the general reader: Quarks come in three "colors"—red, green, and blue (these are just labels, not actual colors). But here's the rule: the colors must always add up to "white" (neutral). Three quarks of different colors make a proton or neutron. A quark and an antiquark of opposite colors make a meson. But a single colored quark? That would be like having a credit card bill with no account to charge it to—the universe doesn't allow dangling references.

Color charge represents internal distinguishability—distinctions that must be resolved within a composite structure rather than externally. A red quark is distinguishable from a blue quark, but this distinction must close: the composite hadron must be color-neutral, meaning its internal color distinctions sum to zero.

The three colors and their anticolors correspond to the minimal structure permitting complete closure. SU(3) symmetry emerges as the symmetry group of this internal distinguishability space.

6.4 Confinement as Identity Closure

For the general reader: When you try to separate quarks, it's like stretching a rubber band—the further you pull, the more energy it takes. Eventually, the "rubber band" snaps, but instead of getting free quarks, the energy creates new quark-antiquark pairs. The new quarks immediately pair up with the originals, so you end up with two hadrons instead of free quarks. VERSF explains: the "rubber band" is the information cost of maintaining coherence during separation. Snap it, and the universe immediately "heals" the incomplete information by creating new pieces.

Confinement is thus an identity constraint, not a force. As quarks separate, the effective linear potential can be understood as the rising information cost of maintaining admissibility as separation approaches closure failure. Before reaching inadmissibility, the energy invested creates new quark-antiquark pairs, maintaining closure.

The "string" of color flux between separating quarks represents the information cost of maintaining admissibility during separation. String breaking (hadronization) occurs when this cost exceeds the mass-energy of new quark pairs.

6.5 Asymptotic Freedom and Commitment Proximity

For the general reader: Here's a paradox: at very short distances (probed at high energies), quarks behave almost like free particles—they barely interact. This is called "asymptotic freedom." But at larger distances, they're tightly bound. VERSF explains: when quarks are close together, their "completion requirements" are nearly satisfied locally—they're practically complete already. It's only when they try to separate that the incompleteness becomes critical.

At short distances (high energies), quarks behave as nearly free particles—asymptotic freedom. In VERSF, this reflects the fact that when quarks are close, their internal distinguishability requirements are nearly satisfied locally. Only as they separate does the closure constraint become stringent.

6.6 Strong Decays as Failed Identity Basins

For the general reader: Some particles decay almost instantly through the strong interaction—in about 10^{-24} seconds (a trillionth of a trillionth of a second). These aren't identity changes like weak decays; they're more like unstable configurations that never quite settled down. As an analogy, imagine a valley so shallow it's almost flat—a ball placed there rolls away immediately. These particles never established stable identities in the first place.

Some hadrons decay via the strong interaction (e.g., $\Delta \rightarrow \pi N$ in $\sim 10^{-24}$ s). Unlike weak decays, these do not involve identity unlocking but rather represent configurations that never established stable identity basins. They are admissible momentarily but not persistently—the identity basin is too shallow to trap the configuration.

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7. Unification: From Four Interactions to Four Admissibility Rules

For the general reader: Physicists have long dreamed of "unifying" the forces—showing that they're all aspects of one deeper thing. Most attempts try to find a bigger mathematical structure that contains all four. VERSF takes a different approach: instead of unifying the forces into one *super-force, it explains why there are exactly four in the first place. The answer is that there are only four kinds of questions you can ask about how information behaves: Can it move? Must it be consistent? Can it change identity? Must it combine to exist? Each question corresponds to one interaction.*

7.1 Conventional vs. VERSF Explanations

For the general reader: This table compares how conventional physics and VERSF explain the same phenomena. The key difference: conventional physics describes HOW interactions work (very successfully), while VERSF explains WHY these particular interactions exist and no others.

Aspect	Conventional Framework (SM + GR)	VERSF Framework
Ontology	Forces mediated by gauge bosons / curvature	Admissibility rules on information
Fundamental question answered	How do interactions behave?	Why do only these interactions exist?
Number of interactions	Postulated (4)	Derived (4 irreducible rules)
Electromagnetism	U(1) gauge field, photon exchange	Flow rule: redistribution of distinctions
Gravity	Spacetime curvature sourced by energy	Accounting rule: global consistency of commitment
Weak interaction	SU(2) gauge interaction, W/Z bosons	Unlocking rule: probabilistic identity change
Strong interaction	SU(3) color force, gluon exchange	Locking rule: mandatory distinguishability closure
Identity change	Occurs only via weak sector (structural feature of SM Lagrangian)	Required by admissibility geometry
Confinement	Dynamical property of non-abelian gauge fields	Consequence of inadmissible isolated identities
Coupling hierarchy	Empirical parameters	Reflect distinct constraint geometries
Unification strategy	Embed forces in larger symmetry group	Derive rules from single admissibility principle

In the conventional framework, the four interactions are described by distinct dynamical mechanisms whose form is fixed by symmetry principles and empirical input. These descriptions are extraordinarily successful at prediction, yet they do not explain why precisely four interactions exist, why their qualitative roles differ so sharply, or why identity change and confinement appear in only specific sectors. The VERSF framework operates at a different explanatory level: it does not replace gauge dynamics or curvature descriptions, but identifies the admissibility constraints that make such dynamics possible in the first place. From this perspective, the Standard Model and general relativity emerge as effective theories describing the quantum and geometric realization of deeper information-theoretic constraints.

7.2 The Complete Classification

For the general reader: This is the heart of the paper. Four questions—and only four—can be asked about how information behaves in a consistent universe. Each question corresponds to one interaction. There's no room for a fifth question, which is why there's no fifth force.

This is a classification at the level of admissibility; it is compatible with the Standard Model's field dynamics, which describe how these rules are instantiated in quantum field language.

VERSF reclassifies the four fundamental interactions as four irreducible rules arising from a single admissibility principle:

The Admissibility Principle: Finite distinguishable information can exist only if its creation, persistence, transformation, and composition obey admissibility constraints.

From this single principle, the four rules follow logically, because any admissible fact must answer four questions:

Question	Rule	What It Governs	Conventional Name
Can distinctions move without changing identity?	**Flow**	Redistribution of existing distinctions	Electromagnetism
How are committed distinctions globally consistent?	**Accounting**	Global consistency of committed distinctions	Gravity
Can identities change, and if so, how?	**Unlocking**	Probabilistic identity change	Weak interaction
Can partial identities exist alone, or must they close?	**Locking**	Mandatory closure of incomplete identity	Strong interaction

These are not mechanisms, not fields, and not entities. They are constraints required for stable, recordable facts. The rules are:

- Not interchangeable (each governs a distinct aspect of information)
- Not reducible to one another (flow ≠ accounting ≠ unlocking ≠ locking)
- Not contingent on energy scale (they hold universally)
- Always in force simultaneously (all four constrain every physical process)

7.3 Why Exactly Four Rules

For the general reader: Information can move. It must stay consistent. It can change identity. It must be complete. That's it—those are the only four things information can "do." Any other operation you can imagine either reduces to one of these four or creates contradictions. This is why physics has found exactly four interactions, and why decades of searching for a fifth have come up empty.

Proposition (Admissible Interaction Completeness): *Any physically admissible interaction must correspond to one of the four rules: flow, accounting, unlocking, or locking. No additional rule is possible without violating finite distinguishability or irreversible commitment.*

The four rules exhaust the questions that can be asked about admissible information:

1. **Flow:** Can information move between already-committed structures without changing their identity? This is electromagnetism.
2. **Accounting:** How is committed information kept globally consistent? This is gravity.
3. **Unlocking:** Can finite barriers be probabilistically crossed, permitting identity change? This is the weak interaction.
4. **Locking:** Can some information exist only in closed combinations? This is the strong interaction.

There is no fifth rule because there is no fifth question you can ask about information that doesn't collapse into one of these. Information can move (flow), must be consistent (accounting), can change identity under constraints (unlocking), or must close to exist (locking). Any proposed fifth interaction would either reduce to one of these four or violate finite distinguishability.

This logical closure is consistent with extensive empirical searches. Precision tests of the gravitational inverse-square law place stringent bounds on deviations down to sub-millimeter scales. Collider experiments place strong limits on additional force-mediating particles beyond the Standard Model gauge bosons. Precision electroweak measurements and flavor physics tightly constrain any additional couplings. The absence of a fifth interaction is not merely a contingent empirical fact but reflects the underlying completeness of the admissibility structure.

7.3.1 Proof by Exhaustion: Why Any Proposed Rule Reduces to Four (or Contradicts Facts)

A compact way to state the closure claim is as a proof by exhaustion over the kinds of transformations an interaction could implement on distinguishable information. Consider any physically meaningful "operation" $\mathcal{O}$ that purports to describe a fundamental interaction. For $\mathcal{O}$ to be physically substantive, it must produce a distinguishable difference in the world (otherwise it is operationally null). Any such difference falls into one of the following mutually exclusive categories:

1. **Redistribution with identity preserved.**
   The system changes state while remaining within the same identity class (no reclassification of "what it is"). This is precisely the **flow** rule: admissible redistribution of distinctions without identity change.
2. **Global consistency of committed facts.**
   The operation does not merely move distinctions but constrains how committed distinctions can coexist across the whole system/history. This is the **accounting** rule: global ledger consistency of irreversible commitment. Any rule that allows inconsistent commitment (e.g., "rewrite history," "uncommit facts," or "contradict previously recorded distinctions") destroys the very notion of a fact and is therefore inadmissible.
3. **Identity change (reclassification).**
   The operation changes what the system *is*—i.e., it crosses from one identity basin to another. This is the **unlocking** rule: probabilistic basin escape across finite barriers (rate-limited under TPB). A "deterministic identity change at will" would violate finite throughput and the observed stability hierarchy of identities.
4. **Closure requirements on partial structure.**
   The operation concerns whether incomplete fragments can exist as stand-alone facts. If the existence of a fragment requires completion (closure), the operative constraint is the **locking** rule. If incomplete fragments could exist freely, then internal dangling degrees of freedom would generate unbounded, context-dependent distinguishability and break admissibility.

No fifth irreducible category exists. Any proposed interaction rule either (i) falls into one of the four categories above, or (ii) is operationally null (produces no distinguishable change), or (iii) violates the requirements for stable facts (e.g., allows inconsistent history, unbounded distinguishability, or uncontrolled identity reclassification). This completes the closure argument at the level of admissible operations.

7.4 Why Any "Extra Rule" Collapses

For the general reader: If the four rules really are complete, then any "fifth rule" we try to invent should either turn out to be one of the existing four in disguise, or it should break reality. This section tests that claim by trying to invent new rules and watching them fail.

A useful test of completeness is to attempt to construct a fifth rule and observe what happens. In every case, one of two outcomes occurs: the proposed rule reduces to a special case of the existing four, or it violates the requirements for facts to exist at all.

"A rule for creating something from nothing." This apparent novelty immediately collapses. If something appears without changing identity, that is flow. If something appears with identity change, that is unlocking. If it appears without any constraints, conservation and consistency fail—reality becomes incoherent. "Creation" is either flow, unlocking, or inadmissible.

"A rule for erasing or rewriting the past." If the past can be altered or erased, facts cease to be facts. If the past must remain consistent, that is exactly accounting. There is no stable middle ground: either history is consistent, or reality has no memory.

"A rule for partial or fuzzy identity." If partial identities are allowed to exist freely, identity becomes meaningless. If partial identities must close, that is locking. If partial identities can resolve into new identities, that is unlocking. No intermediate option is stable.

"A rule for interaction without influence." If nothing changes, nothing happened—there is no rule to describe. If something changes without identity change, that is flow. If something changes identity, that is unlocking. A rule that produces no distinguishable change is not a rule but an absence.

"A rule for non-local effects." Non-local correlations (including quantum entanglement) may change where constraints are manifested, but they do not introduce a new admissibility operation. Non-local interactions still must preserve identity (flow), preserve consistency (accounting), change identity (unlocking), or enforce closure (locking). Non-locality changes where rules apply, not what rules exist.

The pattern is general: any proposed interaction must answer four questions—Does something move without changing what it is? Does the universe remain consistent? Can something change what it is? Must something close to exist?—and these questions exhaust the logical space. The four rules are not chosen; they are the only ways distinguishable information can behave without the framework of facts collapsing entirely.

7.5 Gauge Symmetries as Effective Descriptions

For the general reader: "Gauge symmetry" is a technical term for a deep pattern in physics: certain changes you could make to your mathematical description leave all the actual physics unchanged. These symmetries are usually treated as fundamental. VERSF suggests they're not fundamental at all—they're just the mathematical fingerprints of the deeper admissibility rules.

The gauge groups U(1), SU(2), and SU(3) are not fundamental but effective descriptions of the geometry of each admissibility rule. The appearance of these specific groups reflects the minimal symmetry groups consistent with each admissibility rule for known particle content:

- **U(1):** The symmetry of phase (coupling orientation) in entropy flow
- **SU(2):** The symmetry of identity basins in information space
- **SU(3):** The symmetry of internal distinguishability closure

The non-abelian structure of SU(2) and SU(3) reflects the richer geometry required for identity operations compared to simple flow.

Why These Groups (and Not Others)?

If gauge symmetries are effective fingerprints of admissibility geometry, it is natural to ask why the observed groups are $U(1)$, $SU(2)$, and $SU(3)$, rather than alternatives such as $U(1) \times U(1)$for flow or $SU(4)$for locking. VERSF's claim is not that the groups are chosen arbitrarily, but that the minimal symmetry compatible with each rule and **known particle content** is selected.

- **Flow (electromagnetism) → $U(1)$.**
  The flow rule concerns a single conserved coupling orientation (phase-like degree) associated with identity-preserving redistribution. The minimal continuous symmetry for a conserved phase is $U(1)$. A $U(1) \times U(1)$structure would generically imply two independent, long-range conserved coupling phases, i.e., two distinct flow channels with separate conserved charges. Empirically we do not observe an additional long-range gauge field of this type, and within VERSF it would represent an extra independent flow operation rather than a refinement of the same one.
- **Unlocking (weak) → $SU(2)$.**
  Unlocking acts on a minimal two-component structure of identity alternatives in the chiral sector (left-handed doublets). $SU(2)$is the minimal non-abelian symmetry supporting such doublet structure and the observed pattern of parity violation. A larger group such as $SU(3)$or $SU(4)$would imply additional generators (additional unlocking channels) and therefore additional identity transformations beyond what is observed, unless they are dynamically broken back to $SU(2)$.
- **Locking (strong) → $SU(3)$.**
  Locking enforces closure of internal distinguishability. For quarks, three-valued internal distinguishability is the minimal structure that supports the observed baryon/meson closure patterns and color singlet constraints. $SU(3)$is the minimal non-abelian group acting on a three-component internal space with a singlet closure condition. $SU(4)$would generically entail additional internal degrees of freedom and corresponding new confining sectors or hadron families, absent in observations unless strongly broken/decoupled.

In short, VERSF treats gauge groups as the **minimal effective symmetries** consistent with each admissibility rule *and with the empirically realized inventory of stable identities and closure patterns*. Alternative groups are not logically forbidden, but they would correspond to additional independent flow channels, additional unlocking pathways, or higher-dimensional internal closure spaces—i.e., new interaction content not observed.

7.6 The Hierarchy Problem Reframed

For the general reader: One of the great puzzles of physics is why the forces have such wildly different strengths. Gravity is incredibly weak compared to the other forces—about 10^{36} times weaker than electromagnetism when comparing how they affect individual particles. The Standard Model has no explanation for this; the numbers are just plugged in. VERSF suggests these huge differences reflect the different "geometries" of each rule—they're not arbitrary but emerge from how each rule operates.

The vast differences in coupling strength are no longer mysterious:

- **Electromagnetism ($\alpha \sim 1/137$):** Sets the scale of entropy flow per interaction
- **Weak ($G_F \sim 10^{-5}$ GeV^{-2}):** Reflects the height of typical identity barriers
- **Strong ($\alpha_s \sim 1$):** Reflects the stringency of closure requirements

- **Gravity ($G\_N \sim 10^{-38}$ in natural units):** Reflects the coarse-graining over enormous numbers of discrete commitments

These are not arbitrary parameters but consequences of the distinct geometries of each admissibility rule.

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8. Implications and Empirical Connections

For the general reader: A good theory doesn't just reorganize what we already know—it should also explain specific puzzles and suggest new things to look for. This section shows how VERSF naturally explains several features of particle physics that the Standard Model simply takes as given, and points toward experiments that might distinguish VERSF from conventional approaches.

8.1 Predictions and Post-dictions

For the general reader: A theory isn't just judged by what it explains—it's also judged by what it predicts. Here are some things VERSF naturally explains that the Standard Model takes as unexplained facts.

The VERSF reclassification offers several empirical connections:

Why no proton decay: The proton is the lightest baryon, and baryon number corresponds to a topological invariant of the closure constraint. Proton decay would require unlocking this closure, but no finite information barrier connects it to lighter configurations.

Why neutrinos are light: Neutrinos participate only weakly in non-gravitational interactions, and in VERSF they are therefore minimally involved in identity-preserving flow and closure constraints. Their small masses are consistent with minimal irreversible commitment in the non-gravitational sectors. Neutrinos still gravitate—because accounting applies to all energy–momentum—but gravitational coupling is universal and does not by itself set particle rest mass. In VERSF terms, gravity "accounts for" whatever commitment exists; it does not *create* identity commitment. Hence neutrinos can couple gravitationally while remaining light.

Why photons and gluons are massless: These mediate flow (photon) and closure (gluon) rather than representing committed structures. Masslessness reflects zero persistent entropy commitment.

8.2 Testable Differences from Standard Model

For the general reader: Where might VERSF make different predictions than conventional physics? The differences would likely show up in extreme conditions—near black holes, in the *very early universe, or at energies far beyond current particle accelerators. These are the frontiers where the theories might diverge.*

While VERSF reproduces Standard Model predictions in established regimes, differences may emerge:

- **Quantum gravity regime:** VERSF predicts that gravity emerges from entropy accounting, not from graviton exchange. Tests of gravity at quantum scales may distinguish these pictures.
- **Early universe:** The VERSF framework suggests modified early-universe dynamics where entropy constraints dominate before gauge symmetries emerge.
- **Black hole information:** VERSF provides a natural framework for information conservation through entropy accounting, potentially resolving the black hole information paradox.

8.3 Connections to Existing Programs

For the general reader: VERSF doesn't appear out of nowhere—it connects to several respected research programs that have been exploring similar ideas from different angles. These connections suggest VERSF is part of a larger shift in how physicists think about the foundations of reality.

The VERSF approach resonates with several established research programs:

- **Verlinde's entropic gravity:** VERSF generalizes entropic gravity to all four interactions
- **Wheeler's "it from bit":** VERSF provides concrete mechanisms for how "it" emerges from "bit"
- **Holographic principle:** Entropy bounds in VERSF connect naturally to holographic constraints

8.4 A Concrete Empirical Discriminant

For the general reader: A good theory needs to make predictions that can be tested. Here is a specific experiment that could distinguish VERSF from conventional physics. It's not easy to do, but it's within reach of current technology—and the result would tell us something definitive.

8.4.1 Prediction: Gravity-Coupled Decoherence Depends on Irreversible Commitment

VERSF premise: Gravity is an accounting rule tied to irreversible commitment (ledger consistency), not a fundamental exchange force. This suggests that when a system is placed into a spatial superposition, the "gravitational back-reaction" relevant to coherence is controlled not only by mass distribution, but by how much irreversible commitment the system undergoes during the experiment.

Proposed discriminant experiment: Use matter-wave interferometry (or optomechanical superposition tests) with two cases that have:

- the same mass distribution to experimental precision,
- but different internal irreversible entropy production during the interferometer time T.

Example implementations:

- A cryogenic, ultra-low dissipation internal state vs. a deliberately "heated" internal state (controlled phonon population), while keeping center-of-mass trajectories identical.
- A mechanical resonator prepared in two internal dissipation regimes (same geometry/mass).

VERSF signature: VERSF predicts an additional dephasing/decoherence contribution proportional to an irreversible commitment rate $\dot{S}_{irr}$ (or an operationally measurable proxy such as internal entropy production or dissipated heat divided by temperature).

A minimal parameterization:

$$\Gamma_{VERSF} = \Gamma_{std} + \eta\,(k_B/\hbar)\,\dot{S}_{irr}$$

where:

- Γ_{std} includes known environmental decoherence sources (gas collisions, blackbody radiation, vibrations, etc.),
- η is a dimensionless coupling of "ledger noise" to commitment (to be bounded experimentally).

Key point: In standard GR+QFT treatments, once conventional decoherence sources are controlled, there is no generic prediction that coherence loss must scale with internal entropy production when mass distribution is held fixed. In VERSF, this scaling is natural because accounting is tied to irreversible commitment.

Falsifiability: If experiments improve to the regime where they can vary $\dot{S}_{irr}$ by a known factor while keeping Γ_{std} constant, then:

- observing no change in interference visibility places an upper bound on η,
- observing a systematic visibility loss proportional to $\dot{S}_{irr}$ supports the VERSF accounting–commitment link.

This is a true discriminant: it is not "VERSF can explain whatever happens." It predicts a specific scaling to look for.

8.4.2 Secondary Discriminant: Phase Variance Scaling

A closely related test is to compare gravitationally induced phase noise (not just mean phase shift) between two internal dissipation regimes. VERSF suggests that accounting fluctuations (ledger noise) should increase with irreversible commitment, yielding a measurable excess phase variance:

$$\mathrm{Var}(\varphi)_{\mathrm{VERSF}} = \mathrm{Var}(\varphi)_{\mathrm{std}} + \eta' \dot{S}_{\mathrm{irr}} T$$

This provides an independent check: if both decoherence rate and phase variance show the predicted scaling with internal entropy production, the case for VERSF's accounting-commitment link becomes substantially stronger.

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9. Discussion: Forces as Phenomenological Artifacts

For the general reader: This section steps back to consider what it really means if VERSF is correct. The claim isn't that forces don't exist in any sense—clearly, magnets attract and gravity pulls. The claim is that these "forces" are how the deeper rules appear to us at our scale, much like how "temperature" is how the random motion of trillions of molecules appears to us. Temperature is real and useful, but it's not fundamental—it emerges from something deeper. VERSF says the same is true of forces.

9.1 The Illusion of Force

For the general reader: When two electrons repel each other, it feels like there's a force pushing them apart. But VERSF suggests this is an illusion—like how it feels like there's a "force" pushing you back in your seat when a car accelerates, when really it's just geometry (you're trying to go straight while the car curves under you). The "force" is how deeper constraints appear at our scale.

The concept of "force" is a phenomenological description useful for classical mechanics but potentially misleading at the fundamental level. VERSF suggests that what we experience as forces are actually the constraints imposed by admissibility requirements.

An electron "repels" another electron not because a force pushes them apart but because configurations with overlapping entropy gradients are increasingly costly. The apparent force is a shadow of the underlying admissibility constraint.

9.2 Why Forces Appear Mediated

For the general reader: Modern physics describes forces as being "carried" by particles—photons carry electromagnetism, W and Z bosons carry the weak force, gluons carry the strong *force. VERSF doesn't deny this picture but says it's incomplete: these "carrier particles" are really quantum descriptions of how the admissibility constraints operate, not the fundamental explanation.*

The Standard Model describes forces as mediated by exchange particles: photons, W/Z bosons, gluons, and (hypothetically) gravitons. In VERSF, these "mediators" represent quantum descriptions of the constraint geometry:

- **Photons:** Quanta of entropy flow
- **W/Z bosons:** Quanta of identity barrier structure
- **Gluons:** Quanta of closure constraint
- **Gravitons:** Quanta of accounting geometry (if they exist)

The mediator picture is not wrong but incomplete—it describes the quantum mechanics of constraints without identifying what is being constrained.

9.3 Exchange Particles as Calculational Artifacts, Not Literal Carriers

For the general reader: When physicists say a photon "carries" the electromagnetic force between two electrons, this is a useful picture for calculations—but it's not literally true. The photon in the calculation isn't a real particle traveling through space; it's a mathematical term in an equation. This distinction matters because it reveals that "force carriers" are descriptions of how fields interact, not the fundamental explanation.

In quantum field theory it is common to speak of interactions as being "mediated" or "carried" by particles such as photons, gluons, or W and Z bosons. This language originates from perturbative calculations, where interaction terms are expanded into Feynman diagrams and internal lines are interpreted as particle exchange. However, these internal lines do not represent physical particles propagating through space in the usual sense. Virtual quanta are off-shell contributions to correlation functions; they do not obey the dispersion relations or localization properties of real particles and cannot be observed as independent entities.

From a fundamental perspective, quantum field theory is built from fields and their couplings, not from force-carrying particles. What is physically primary is the structure of the interaction terms in the action and the constraints imposed by symmetry and conservation laws. The "exchange particle" picture is therefore a calculational representation of how coupled fields redistribute energy–momentum and quantum numbers, not a literal mechanism by which forces are transmitted. This distinction is already explicit in general relativity, where gravity is not mediated by particle exchange at all but arises from geometric consistency conditions on spacetime.

The VERSF framework extends this insight: interactions are not fundamentally conveyed by particles, but by admissibility constraints on how distinguishable information may be redistributed, committed, transformed, or composed. Gauge fields and their quantized excitations are effective realizations of these constraints within quantum field theory, rather than the underlying origin of interaction itself.

9.4 Implications for Unification

For the general reader: Physicists have long sought a "unified theory" that combines all forces into one. Most attempts try to find a bigger mathematical structure that contains all four forces. VERSF suggests a different approach: maybe the forces don't unify INTO each other—maybe they all emerge FROM something simpler. The unity isn't at high energies; it's at the level of the rules themselves.

Conventional unification programs seek a single gauge group containing all interactions (GUTs, string theory). VERSF suggests a different path: unification through the common substrate of admissibility constraints rather than through symmetry embedding.

The four interactions may not unify into one at high energies but rather emerge as distinct rules from a single underlying requirement—finite distinguishability.

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10. Conclusion

For the general reader: The central message of this paper is simple: physics has found exactly four fundamental interactions not because of historical accident or incomplete searching, but because four is the only number possible. The universe runs on information, and there are exactly four things that information can do: flow without changing, stay globally consistent, change identity, or require completion. That's it. That's why we have electromagnetism, gravity, the weak force, and the strong force—and why we'll never find a fifth.

The four fundamental interactions of physics—gravity, electromagnetism, the weak interaction, and the strong interaction—need not be accepted as primitive facts about the universe. Within the VERSF framework, there are not four forces but one admissibility principle giving rise to four irreducible rules:

1. **The Flow Rule** (electromagnetism) governs how distinctions may be redistributed between committed structures without changing identity.
2. **The Accounting Rule** (gravity) enforces global consistency of all committed facts across spacetime.
3. **The Unlocking Rule** (weak interaction) enables probabilistic identity change across finite barriers in admissible configuration space.
4. **The Locking Rule** (strong interaction) requires mandatory closure of internal distinguishability for partial identities to exist as facts.

These are not mechanisms, fields, or optional behaviors—they are constraints the universe must obey if finite distinguishable information is to exist at all.

This reclassification answers questions the Standard Model leaves open: why four interactions exist (they exhaust the questions that can be asked about admissible information), why their structures differ (they govern different aspects of information constraint), and why their coupling strengths vary (they reflect different constraint geometries).

Future work within this framework will develop the mathematical formalism of admissibility constraints, derive specific predictions for quantum gravity experiments, and explore connections to established approaches including holography, entropic gravity, and quantum information theory.

The fundamental forces may not be forces at all—but the four rules that information must obey to become fact.

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Appendix A: A Minimal Formalization of Admissibility, Identity Basins, and the Four Rules

For the general reader: This appendix provides the mathematical scaffolding for the ideas in the main paper. Don't worry if the equations look intimidating—the key ideas are explained in words alongside each formula. The goal is to show that VERSF's claims can be expressed in precise mathematical language, not to derive everything from first principles.

A.1 Configuration Space and Admissible Facts

Let X denote the space of physically specifiable configurations (coarse-grained microstates, field configurations, or information states). A configuration $x \in X$ is physically admissible if it can be specified with finite operational distinguishability and can persist as a recordable fact.

We represent the "cost" of existing as a stable fact by an admissibility functional:

$$A[x] = S\_commit[x] + \lambda \, C[x] + \mu \, R[x]$$

For the general reader: Think of A[x] as a "price tag" for a configuration to exist as a fact. The price has three components: how much has been irreversibly committed (S_commit), whether the configuration is complete or has dangling pieces (C), and whether it can be operationally distinguished from other configurations (R).

Interpretation (minimal):

- **S_commit[x]:** Irreversible commitment cost (how much distinguishability has been irreversibly fixed as fact).
- **C[x]:** Closure constraint functional (penalizes "dangling" internal distinctions that cannot form complete records).
- **R[x]:** Operational resolvability/finite-precision cost (encodes PAF-style finite distinguishability and bounded readout/reset).
- **$\lambda, \mu > 0$:** Weights (placeholders that can later be tied to TPB/BCB scales).

A configuration is admissible if A[x] is finite. Inadmissible configurations are represented by $A[x] = \infty$ (hard constraints).

This formalism is intentionally abstract: it is a container in which different physical realizations can be encoded.

A.2 Identity Basins as Metastable Minima

For the general reader: Remember the "valleys in a landscape" analogy for particle identities? This section makes that precise. An identity basin is literally a valley in the admissibility *landscape—a region where configurations naturally settle because moving away would cost more.*

Define an identity basin for particle/type label i as a region $B_i \subset X$ around a local minimum x_i^* of A:

$x_i \in \mathrm{argmin}_{x \in B_i} A[x]$, with $\delta^2 A[x_i] > 0$**

Metastability means there exists a barrier $\Delta A_{i\to j}$ between basins:

$\Delta A_{i\to j} = \min_\gamma \max_t A[\gamma(t)] - A[x_i]^*$

where γ ranges over admissible paths from B_i to B_j.

- "Stable identity" = deep basin (large ΔA).
- "Forbidden identity change" = effectively infinite barrier.

A.3 Dynamics as Admissible Evolution Plus Constraints

For the general reader: This section describes how things can change over time while respecting admissibility. There are two kinds of change: smooth flow within an identity (like an electron moving) and jumps between identities (like radioactive decay).

Let p(x,t) be a distribution over X. The most general coarse-grained evolution consistent with admissibility can be expressed as:

$$\partial t\, p = -\nabla\cdot J + \Sigma_{\{i\neq j\}} (W_{j\to i}\, p_j - W_{i\to j}\, p_i)$$

where:

- **J(x,t)** is a current on X (continuous redistribution).
- **$W_{i\to j}$** are transition rates between basins (discrete identity change channels).

Admissibility imposes three generic constraints:

1. **Hard closure:** If $C[x] = \infty$, then $p(x,t) = 0$ (locking).
2. **Global ledger consistency:** The net irreversible commitment must satisfy a conservation/consistency condition (accounting).
3. **Finite throughput:** Transitions are rate-limited by TPB (unlocking is stochastic and time-asymmetric).

A.4 The Four Rules as a Completeness Decomposition

For the general reader: Here's where the four rules emerge mathematically. Any admissible change must fall into one of exactly four categories—there's no fifth option.

With these ingredients, the four rules appear as the only irreducible categories of admissible evolution:

(i) Flow rule (continuous redistribution without identity change)

Within a basin B_i, evolution can occur via currents J that rearrange configuration without leaving the basin:

$x(t) \in B_i \Longrightarrow$ identity preserved.

This is the admissible analog of "interaction that changes motion/field values but not particle type."

(ii) Accounting rule (global consistency constraint on committed facts)

Introduce a commitment density σ(x,t) and a ledger L(t) such that:

$$\dot{L}(t) = \int_X \sigma(x,t)\, dx, \text{ with } \sigma \geq 0$$

with a global consistency constraint coupling local evolution to the ledger (e.g., via a Lagrange multiplier field enforcing consistency). This expresses that facts, once committed, must be globally consistent and cannot be "unwound."

(iii) Unlocking rule (stochastic basin transitions with TPB-limited attempts)

Transitions between basins occur with rates of Arrhenius/Kramers form:

$$W_{i\to j} = f_i \exp(-\Delta A_{i\to j}/k_A)$$

where f_i is an attempt frequency and k_A is an admissibility scale parameter (analogous to k_B in thermodynamics), setting the barrier sensitivity of identity transitions. In VERSF language, TPB bounds f_i by limiting how quickly distinguishability can be resolved/committed:

$$f_i \leq f_{max}(\text{TPB})$$

This yields probabilistic identity change and naturally supports half-life phenomena.

(iv) Locking rule (closure constraint: incomplete identities cannot exist alone)

If "partial identities" correspond to configurations violating closure:

$$C[x] = \infty \text{ for isolated fragments}$$

then isolated fragments are simply not admissible facts. Physical states must satisfy $C[x] = 0$ (or finite)—a closure requirement that forces compositeness.

A.5 Proposition: Formal Completeness Sketch

Proposition (Admissible Interaction Completeness—formal sketch).

Under (a) finite admissibility functional A, (b) basin decomposition of identity, (c) ledger consistency of irreversible commitment, and (d) finite throughput (TPB), any admissible interaction process decomposes into: (1) intra-basin redistribution (flow), (2) global ledger consistency constraints (accounting), (3) stochastic inter-basin transitions (unlocking), and/or (4) hard closure constraints excluding certain configurations (locking). No fifth irreducible admissibility operation exists.

Sketch of why: Any change must either (i) remain within the same identity basin (hence flow), or (ii) move between basins (unlocking), while (iii) respecting global constraints induced by irreversible commitment (accounting). Any configuration that cannot satisfy closure is excluded (locking). Any proposed "new" rule is either a special case of these (e.g., a particular current field J, a particular transition W, or a particular constraint C) or violates admissibility (infinite A).

Appendix B: Translation Layer—How Each Rule Maps onto Standard Structures

For the general reader: This appendix shows how each VERSF rule connects to the actual mathematics physicists use every day. It's like a dictionary between two languages—VERSF on one side, conventional physics on the other. The point is to show that VERSF isn't replacing established physics; it's explaining why established physics takes the form it does.

This appendix is deliberately schematic: it shows how each VERSF rule corresponds to a standard physics structure (Lagrangian term, constraint, or state condition) without claiming a full derivation of coupling values.

B.1 Baseline: Standard Model + GR as an "Effective Realization"

The conventional "interaction content" is encoded in:

$$\mathbf{L\_SM = L\_gauge + L\_fermion + L\_Higgs + L\_Yukawa}$$

and GR in:

$$\mathbf{S\_GR = (1/16\pi G) \int d^4x \sqrt{(-g)}\, R + \int d^4x \sqrt{(-g)}\, L\_matter}$$

VERSF's claim is: these are realizations of deeper admissibility rules (flow/accounting/unlocking/locking).

B.2 Flow Rule → U(1) Gauge Structure + Continuity

VERSF statement: Redistribution of distinctions without changing identity.

Standard correspondences:

A conserved current j^μ and continuity equation:

$$\partial_\mu j^\mu = 0$$

U(1) gauge field A_μ coupling:

$$L_{EM} = -(1/4) F_{\mu\nu} F^{\mu\nu} + j^\mu A_\mu$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

Interpretation: Gauge redundancy reflects bookkeeping freedom in describing flow; identity preservation corresponds to remaining within a basin class while momentum/energy redistribute.

B.3 Accounting Rule → GR Constraint Structure + Stress-Energy Bookkeeping

VERSF statement: Global consistency of irreversible commitment (ledger consistency).

Standard correspondences:

Einstein field equation as global consistency:

$$G_{\mu\nu} = (8\pi G/c^4) T_{\mu\nu}$$

Bianchi identity implies local conservation:

$$\nabla_\mu G^{\mu\nu} = 0 \Rightarrow \nabla_\mu T^{\mu\nu} = 0$$

Interpretation: What GR encodes as geometric constraint can be read as a global consistency condition on committed structure; universality follows because all physical records contribute to $T_{\mu\nu}$.

B.4 Unlocking Rule → SU(2)_L + Flavor Change via Yukawa/CKM

VERSF statement: Probabilistic identity change via barrier crossing; time-asymmetry and parity violation as natural features of identity change.

Standard correspondences:

Weak gauge sector:

$$\mathbf{L_{weak} = -(1/4)\, W^a_{\mu\nu} W_a^{\mu\nu} + \bar{\psi}_L \gamma^\mu (\partial_\mu - ig\, \tau^a W^a_\mu) \psi_L}$$

Flavor/identity change encoded through Yukawa couplings and mixing matrices (CKM/PMNS), producing transitions such as β-decay channels.

Interpretation: "Unlocking" corresponds to leaving one basin class for another; the SM implements this via chiral SU(2) structure and mixing, which naturally violates parity (left-handed coupling).

B.5 Locking Rule → SU(3)_c Gauss Law + Physical-State Constraint (Color Singlets)

VERSF statement: Incomplete identities cannot exist alone; closure is mandatory.

Standard correspondences:

QCD Yang–Mills:

$$\mathbf{L_{QCD} = -(1/4)\, G^a_{\mu\nu} G_a^{\mu\nu} + \bar{q} \gamma^\mu (\partial_\mu - ig_s T^a G^a_\mu) q}$$

Gauss law constraint in gauge theory selects physical states; in QCD, physical asymptotic states are color singlets.

Confinement as area-law behavior (effective long-range linear potential) in nonperturbative regimes.

Interpretation: The state constraint ("only closed/color-neutral states are admissible") matches VERSF's locking rule; confinement is the dynamical realization of a closure requirement.

B.6 Translation Table

VERSF Rule	What It Restricts	Standard Structure	Where It Lives
Flow	Redistribution w/o identity change	U(1), conserved currents	Continuity + $j^\mu A_\mu$

VERSF Rule	What It Restricts	Standard Structure	Where It Lives
Accounting	Global consistency of committed facts	GR geometry + $\nabla_\mu T^{\mu\nu} = 0$	Einstein–Hilbert + constraints
Unlocking	Identity changes (decays, flavor change)	$SU(2)_L$ + Yukawa mixing	Weak sector + CKM/PMNS
Locking	Closure: incomplete fragments forbidden	$SU(3)_c$ + physical-state constraint	QCD + confinement/nonperturbative

This mapping is the "translation layer": it shows exactly what structures in established theory correspond to each rule-class, without yet deriving numerical coupling values from first principles.

Appendix C: A Constructive Bit-Lattice Realization of A[x]

For the general reader: The previous appendix was abstract—it gave the mathematical shape of admissibility without specifying what the pieces are made of. This appendix goes concrete: it builds admissibility out of actual bits on a lattice, the kind of thing you could simulate on a computer. This isn't meant to be "the" fundamental theory—it's a proof of concept showing that VERSF's ideas can be made fully precise and testable in a simplified setting.

This appendix provides a fully concrete, simulatable realization of the admissibility functional in terms of bits on a lattice. This demonstrates that VERSF concepts are not merely philosophical but can be instantiated in precise computational terms.

C.1 The Microstate

Let the microstate be a binary string with additional structure:

$$x \equiv \{b_i\}_{i=1}^N, \text{ where } b_i \in \{0, 1\}$$

with additional "record" bits r_j (which track what has been irreversibly committed) and optional gauge-like constraint tags c_i (for modeling color-like internal degrees of freedom).

For the general reader: Think of this as a very long row of switches, each either ON (1) or OFF (0). Some switches are "data" (the actual physical configuration), some are "records" (the universe's memory of what happened), and some are "tags" (like color labels that must balance out).

C.2 The Concrete Admissibility Functional

The admissibility cost takes the explicit form:

$$A[x] = \alpha K(x) + \lambda C_{closure}(x) + \mu R_{capacity}(x) + \nu T_{ticks}(x)$$

Each term is now fully specified:

(1) K(x): Algorithmic/Description Complexity (Finite Distinguishability)

For the general reader: How many bits does it take to describe this configuration? Simple, repetitive patterns are cheap; random-looking patterns are expensive. This captures PAF's requirement that physical facts must be finitely specifiable.

Let $K(x)$ be an MDL-style (Minimum Description Length) description length: the number of bits needed to specify the configuration relative to a reference codebook.

Concrete implementable proxy:

$$K(x) \approx L(\text{compress}(x))$$

That is, the compressed length under a standard compressor (LZ-style, gzip, etc.). This is a working stand-in for Kolmogorov complexity, which is uncomputable in general but can be approximated operationally.

(2) C_closure(x): Closure Constraint (Locking)

For the general reader: This enforces "no incomplete fragments." If you have a red quark, you must have enough other quarks nearby to make the colors sum to neutral. An isolated colored object is simply forbidden—its cost is infinite.

Define "fragments" as patterns that must appear in closed combinations. For color-like tags c_i that must sum to zero across any isolated cluster:

$$C_{closure}(x) = 0 \text{ if } \Sigma_{i \in \text{cluster}} c_i = 0 \text{ for all clusters } C_{closure}(x) = \infty \text{ otherwise}$$

This literally enforces "no isolated color"—a confinement-like admissibility constraint that emerges from the structure of the functional, not from dynamics.

(3) R_capacity(x): BCB Finite Capacity

For the general reader: The universe has a finite "budget" for how much distinct information can exist. If a configuration would require more bits than the budget allows, it's simply not permitted. This is BCB made concrete.

Let B_{max} be the total distinguishability budget (a fundamental parameter). Define:

$R\_capacity(x) = 0$ if $K(x) \leq B\_max$ $R\_capacity(x) = \infty$ if $K(x) > B\_max$

This is a hard BCB constraint: configurations exceeding the bit budget are inadmissible, full stop.

(4) T_ticks(x): TPB Time Cost

For the general reader: Every irreversible change costs "ticks"—discrete units of processing time. You can't commit new facts to the universe's record faster than the tick rate allows. This makes TPB literal and countable.

Let each irreversible record update consume ticks. Define explicit tick accounting:

$T\_ticks(x) = \tau_0 \cdot N\_commit(x)$

where N_commit is the number of record-bit flips required to make the state a fact (the minimal number of record updates needed to stabilize and broadcast the distinction).

This makes TPB operational: you cannot "unlock" identity faster than you can pay ticks for commitments. The attempt frequency f in decay rates is literally bounded by how fast ticks can be consumed.

C.3 Where the Four Rules Live in This Model

For the general reader: Here's the payoff—each of the four rules corresponds to a specific feature of this bit-lattice model:

Rule	Lattice Realization
Flow	Transformations $x \to x'$ that preserve identity tags and require no record flips: N_commit = 0. Bits rearrange without new commitments.
Accounting	The cumulative tick/commit ledger T_ticks plus record bits r_j enforce history consistency. The total must balance globally.
Unlocking	Rare transitions that require paying many ticks and surmounting a large ΔA barrier. Identity change = expensive record updates.
Locking	Hard closure constraint C_closure forbids isolated fragments. Incomplete patterns have infinite cost.

C.4 Simulatability

For the general reader: Unlike many theories in fundamental physics, this model can actually be run on a computer. You could write a program that tracks bits, enforces the constraints, and watches what happens. This is a proof of concept that VERSF isn't just philosophy—it's operational.

This model is fully concrete and can be simulated:

1. **Initialize** a lattice of bits with identity tags and record bits.
2. **Propose** transitions (bit flips, rearrangements).
3. **Evaluate** A[x] for the proposed new state.
4. **Accept** transitions with finite A[x]; reject those with A[x] = ∞.
5. **Track** tick consumption for any transitions involving record updates.

The dynamics that emerge from this simple setup exhibit:

- Conservation-like behavior (from BCB capacity limits)
- Confinement-like behavior (from closure constraints)
- Rate-limited identity change (from tick costs)
- Free rearrangement within identity classes (from zero-cost flow moves)

This is not claimed to be the actual microscopic structure of reality—but it demonstrates that VERSF's conceptual framework can be instantiated in a precise, falsifiable, computable form.

Appendix D: Exhaustion of Admissible Interaction Rules

For the general reader: The main paper argues that there are exactly four fundamental interactions because there are only four logically possible ways information can behave in a universe where facts must be definite and consistent. This appendix makes that argument explicit. It shows, step by step, that any conceivable interaction either reduces to one of the four rules already identified—or leads to contradiction.

D.1 Definitions and Admissibility Assumptions

We begin by restating the minimal assumptions already established in the main text.

A **physical fact** is a configuration that:

1. Is **finitely distinguishable** (Physical Admissibility Framework, PAF),
2. Involves **irreversible commitment** to a record,
3. Remains **globally consistent** with all other committed facts,
4. Persists under admissible evolution.

An **interaction rule** is defined as an admissible operation that changes the relational state of one or more physical facts.

We assume the admissibility stack:

- **PAF** (finite distinguishability, irreversible commitment),
- **BCB** (finite distinguishability capacity),
- **TPB** (finite rate of commitment).

Any admissible interaction rule must respect all three.

D.2 The Exhaustive Question Set

Any proposed interaction rule must answer at least one of the following questions about distinguishable information. We show that these questions are **mutually exclusive** and **jointly exhaustive**.

Q1. Can distinguishable structure be redistributed without changing identity?

If **yes**, the operation is a **flow rule**.

This includes:

- motion,
- momentum exchange,
- field propagation,
- gauge-mediated interactions.

Identity basins are preserved; only relational configuration changes. This exhausts all admissible operations that modify *where* or *how* information is arranged without altering *what* the information is.

If **no**, proceed to Q2.

Q2. Must committed facts remain globally consistent?

If **yes**, the operation enforces an **accounting rule**.

This includes:

- conservation laws,
- global stress–energy consistency,
- geometric constraint enforcement (as in general relativity).

If committed facts were allowed to become mutually inconsistent, physical records would lose meaning. Any admissible universe must therefore enforce accounting.

If **no**, the operation violates global consistency and is inadmissible.

Q3. Can identity itself change?

If **yes**, the operation is an **unlocking rule**.

Identity change must be:

- probabilistic (TPB),
- barrier-limited (finite admissibility barriers),
- time-asymmetric (irreversible commitment).

This includes:

- radioactive decay,
- particle transmutation,
- flavor change.

If **no**, proceed to Q4.

Q4. Can partial or incomplete identities exist as standalone facts?

If **no**, the operation enforces a **locking rule**.

This forbids configurations whose internal distinguishability cannot close (e.g. isolated color charge). Closure is required for finite distinguishability and admissibility.

If **yes**, identity becomes ill-defined and violates PAF; such configurations are inadmissible.

D.3 Mutual Exclusivity

Each rule governs a distinct logical aspect of information:

- **Flow**: redistribution without identity change
- **Accounting**: global consistency of committed facts
- **Unlocking**: identity change across admissibility barriers
- **Locking**: closure requirements for admissible identity

No rule can substitute for another:

- Flow cannot change identity.
- Accounting does not move or transform identity.
- Unlocking does not enforce closure.
- Locking does not redistribute or transform facts.

Thus, the rules are **irreducible**.

D.4 Collapse of Proposed "Fifth Rules"

Any proposed additional interaction rule must fall into one of two categories:

1. **Reduction:**
   The rule reduces to a special case of flow, accounting, unlocking, or locking.

Examples:

- “Creation from nothing” → unlocking or inadmissible
- “Erasure of the past” → violation of accounting
- “Non-local influence” → flow or accounting applied non-locally

2. **Contradiction:**
   The rule violates finite distinguishability, irreversible commitment, or global consistency, and is therefore inadmissible.

There is no third option.

D.5 Proposition (Admissible Interaction Completeness)

Proposition.
Under PAF, BCB, and TPB, any physically admissible interaction operation decomposes into one or more of the following:

1. *Intra-identity redistribution (flow),*
2. *Global consistency enforcement (accounting),*
3. *Stochastic identity transition (unlocking),*
4. *Hard closure constraints excluding incomplete identities (locking).*

No fifth irreducible admissibility operation exists.

Sketch of proof:
Any admissible change must either preserve identity or not; if not, it must cross a finite barrier. Any configuration must either be complete or forbidden. All committed facts must remain globally consistent. These conditions exhaust the logical space of admissible information behavior.

D.6 Role Within the Main Argument

This appendix formally underwrites the paper’s central claim:

The four fundamental interactions are not four forces, but the complete set of admissible operations on distinguishable information.

The Standard Model and general relativity are effective realizations of these operations, not their origin.