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A Minimal Ontology of Execution, Interaction, and Memory

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Abstract

This paper proposes a minimal, substrate-neutral ontology grounded in three irreducible modal operations: execution, interaction, and memory. These operations—corresponding to existence, possibility, and non-existence respectively—together form a triadic algebra capable of generating all known ontological, epistemological, and phenomenological structures. I argue that most classical and modern metaphysical puzzles arise from conflating these modal categories. When kept distinct, the triad explains the emergence of time, causation, identity, consciousness, information flow, and physical law. The model incorporates insights from pre-Socratic philosophy, Aristotelian energeia, Kantian synthesis, phenomenological intentionality, and contemporary process metaphysics, while remaining simpler and more general than any of them. This ontology further provides interpretive clarity to quantum mechanics, relational physics, cognitive science, and formal epistemology. Notably, the tradeoff between precision and accuracy that the Minimal Ontology predicts for finite systems mirrors, and helps to interpret, the Heisenberg uncertainty relations in quantum mechanics. I conclude that the E/I/M triad constitutes both a minimal ontology and a minimal epistemology: the world knows itself through the same processes by which it exists.

Keywords

Ontology, Process Philosophy, Metaphysics, Quantum Mechanics, Time and Memory, Consciousness

1. Introduction: Why a Minimal Ontology?

Philosophy has always sought the smallest set of principles capable of explaining the full complexity of experience, yet even the most influential metaphysical systems—substance ontology, atomism, monism, process philosophy, phenomenology—ultimately prove either too elaborate or insufficiently general. What is required is an ontology that begins not with assumed entities or inherited categories, but with the bare minimum needed for anything to exist, appear, relate, or persist. The framework developed in this paper identifies three such irreducible operations—Execution, Interaction, and Memory—and argues that they constitute the minimal grammar of being. Execution names the actuality of events; interaction names the structured openness through which events modulate one another; memory names the continuity and exclusion that allow structures to endure. Together, these three modal functions generate time, space, identity, causation, consciousness, information, and the very intelligibility of the universe. By treating ontological categories as operations rather than substances, this framework dissolves classical metaphysical puzzles and unifies insights from physics, phenomenology, cognitive science, and theology under a single triadic architecture. What follows is an articulation and demonstration of this minimal ontology and its implications.

2. Execution (E): The Principle of Actualization

Execution is the brute fact that something is happening now. It is the pulse of actuality, the irreducible "yes" of existence. Where classical metaphysics begins with substances, execution begins with events.

2.1. Execution as the Only Indubitable

Descartes sought certainty in the cogito, but thinking is merely one mode of execution. Radical doubt leaves exactly one residue: the occurrence of experience itself. Execution is therefore the primary ontological category (Descartes, 1984).

Execution is self-justifying. It is its own ground. Nothing precedes it.

2.2. Execution and Temporality

Execution gives rise to time. Time is not an independent dimension in which events unfold; it is the metric of successive executions. In this sense, execution is rhythmic rather than static. Duration is the continuity of the execution stream (Bergson, 1911).

2.3. Execution and Energy

In physics, every observable event is an execution: a collapse, a measurement, a scattering. Execution is thus the ontological correlate of energeia—an Aristotelian insight here restored without substance metaphysics.

3. Interaction (I): The Principle of Relation and Possibility

Interaction is co-execution—the way one execution modulates another. It is the origin of relationality and the seat of epistemology.

3.1. Interaction as a Possibility

Where execution is actuality (1), interaction is possibility (0). The zero here is not emptiness but openness: the space of potential relations before they solidify into events.

Interaction is the domain of superposition (in physics), imagination (in cognition), affordances (in phenomenology), and inference (in logic). All involve indeterminate relations awaiting actualization.

3.2. Interaction Dissolves Subject/Object Dualism

Knowledge arises only through interaction. To perceive something is for one execution (the perceiver) to be modulated by another (the perceived). This collapses the Cartesian divide: the knower is the known in a different mode.

3.3. Interaction as Field Ontology

Identity is relational. Things are not defined by internal essences but by patterns of interaction. This parallels Leibniz's monads and Whitehead's actual occasions but avoids reifying entities as primary. Events are primary; entities are stabilized events.

4. Memory (M): The Principle of Continuity and Exclusion

Memory is the persistence of difference. It is the structured absence left behind by prior executions—the "scar" of the past.

4.1. Memory as Non-Existence (−1)

Memory is not a representation of what was; it is what was no longer possible. In physics, this appears as irreversibility and conservation laws. In cognition, it appears as recollection and learning.

Memory is the rule that the past cannot be undone.

4.2. Memory Generates Identity

Without memory, execution would be chaotic and interaction would have no cumulative effect. Identity is a trajectory stabilized by accumulated memory. Consciousness, personality, and physical structure all arise from recursive memory loops.

4.3. Memory, Curvature, and the Energetic Structure of the Cosmos

Memory is not merely the conservation of information; it is the retention of difference—the persistence of exclusions generated by prior executions. This retention has deep cosmological consequences. Each execution collapses possibility into actuality, and the irreversible nature of that collapse is energy: transformation preserved as constraint. Energy persists not because matter "stores" it, but because the universe remembers its own transformations.

From this perspective, memory generates the curvature of the world. In physics, spacetime curvature reflects the accumulated record of past events—mass, momentum, and stress are simply the durable traces of executed differences. Gravity is memory at scale. Entropy is the diffusion of memory across phase space. The arrow of time is nothing but the direction in which memory grows.

This inversion is crucial: memory is not an effect of energy; energy is the expression of memory. The universe moves because it remembers. Duration exists because exclusion accumulates. The world has a "future" only insofar as it has a "past". Without ontological memory, the cosmos would collapse into instantaneous, unstructured execution—a world with no persistence, no law, and no identity.

4.4. Memory, Constraint, and Curvature

The claim that memory generates the curvature of the world is not metaphorical. Memory is accumulated exclusion: the irreversible closure of alternatives produced by prior executions. Such exclusions function as constraints on future trajectories. This is precisely the role played by stress–energy in general relativity.

Spacetime curvature does not push objects; it restricts the set of dynamically admissible paths. In the present ontology, curvature is the geometric expression of accumulated constraint. Mass is a memory-dominant structure, gravity is memory acting globally, and the arrow of time is the monotonic growth of the exclusion set.

This interpretation does not modify physical theory. It provides an ontological account of why physical law takes the form it does: general relativity describes how constraint propagates; the Minimal Ontology explains what constraint is.

4.5. Memory as Structured Exclusion

The characterization of Memory (M) as non-existence or exclusion may initially appear counter-intuitive, since memory is ordinarily associated with retention rather than absence. In the present ontology, however, memory does not denote the persistence of past events as representations, but the persistence of what can no longer occur. Memory is the structured exclusion produced when an interaction collapses into execution. It is not nothingness, but constraint (Sartre, 2003).

A familiar illustration is entropy. When a physical system evolves irreversibly—when heat dissipates, a gas expands, or a measurement decoheres—certain microstates are permanently excluded. The past survives not as a stored image but as a restriction on the future. Entropy is therefore memory expressed thermodynamically: the accumulation of exclusions that constrain subsequent evolution.

Time-travel paradoxes make the same structure explicit. Consider the grandfather paradox, in which an agent attempts to alter a past event that is already fixed. The paradox arises only if a single event is illicitly assigned to two incompatible modal states: both excluded (recorded in Memory) and still open (available for alteration). Within the E/I/M framework, such scenarios are structurally impossible. Once an event enters Memory (−1), it functions as a constraint on all subsequent interactions. To "change the past" would require reopening excluded possibilities, which is equivalent to erasing the curvature of the world itself.

Quantum mechanics exhibits the same logic at a more fundamental scale. Prior to measurement, a quantum system exists in Interaction (0): a structured field of possibilities. Measurement is an execution that inscribes a durable exclusion into a memory-bearing subsystem. Decoherence is the physical process by which alternative branches become dynamically inaccessible. Wavefunction collapse is therefore not a mysterious jump, but the transition from interactional openness to constraint. In each case, the future is shaped by what the system can no longer do.

Across thermodynamics, temporal paradoxes, and quantum measurement, memory operates as a positive ontological principle precisely because it is subtractive. Contemporary discussions of time asymmetry and entropy similarly emphasize irreversibility as a constraint on accessible state space rather than as a merely statistical artifact (Carroll, 2022). Continuity, identity, and law arise from the accumulation of exclusions, not from the persistence of substances.

5. The Triadic Modal Structure of Being

Thus, execution (1), interaction (0), and memory (−1) form a mutually exclusive and jointly exhaustive set of modal conditions.

A phenomenon must be: actual, possible, or excluded (Deleuze, 1994). Most classical paradoxes arise from illegally placing an event in more than one category simultaneously.

5.1. Modal Table

Function	Ontological Mode	Modal Value	Epistemic Role
Execution	Actuality	+1	Presence
Interaction	Possibility	0	Relation/Meaning
Memory	Non-Existence	−1	Continuity/Constraint

5.2. The Geometric Grammar of Being

The triad also admits a geometric interpretation that mirrors its modal structure. Execution corresponds to a vector—a directed actualization, the transition from point to line. Interaction corresponds to the emergence of a plane or triangle, the minimal form of relational structure. Memory corresponds to the circle, the closure that allows repetition, duration, and recurrence.

When the circle encloses the triangle, geometry becomes ontology: execution generates a dimension; interaction generates a relational surface; and memory binds them through curvature.

Time is the curvature of executional chains. Space is the stabilized field of interactions. Spacetime emerges when the circle (memory) repeatedly closes around the triangle (interaction), generating a continuous manifold from discrete acts.

Classical science linearizes this recursive structure. It boxes the circle, substituting unidirectional progression for self-reference and treating time as an external parameter rather than an internal consequence of relation. A minimal ontology restores the circularity inherent in being itself: existence does not advance along a line but continually re-enters its own traces. What appears as forward motion is, at a deeper level, recurrence constrained by memory.

The geometric figures invoked here—the triangle, the circle, and the square—are not proposed as literal structures of the universe, but as a grammatical shorthand for distinct modal relations. The triangle encodes irreducibility and co-definition; the circle encodes closure, recurrence, and self-reference; the square encodes stabilization into a frame capable of comparison and persistence. Classical formalisms privilege the square by linearizing and externalizing these relations, whereas a minimal ontology treats such geometric forms as representational compressions rather than ontological primitives. A fuller account of how objective frames arise from this grammar is reserved for subsequent work.

This triadic structure is the minimal generative grammar of being.

5.3. Justification of the Triadic Algebra (+1, 0, −1)

The assignment of algebraic values to Execution (+1), Interaction (0), and Memory (−1) is not arbitrary but follows from the minimal requirements of modal completeness. A dyadic ontology collapses into static dualism and cannot generate relation or transition. Ontologies with four or more fundamental modes introduce redundancy without explanatory gain.

The triad is minimal and exhaustive. Execution corresponds to actuality: what is happening. Interaction corresponds to possibility: the open field of relational modulation. Memory corresponds to exclusion: what can no longer occur and therefore constrains what follows. Any event must occupy exactly one of these modal states at a time. Assigning an event to more than one state simultaneously produces a contradiction.

The numerical mapping reflects these roles. +1 affirms actuality, 0 represents openness without commitment, and −1 negates possibility without annihilating structure. Together, they form the smallest closed modal algebra capable of generating time, relation, and persistence.

5.4. Objection: Persistence and Objects

A common objection to event-based ontologies is that they appear unable to account for the stability and persistence of ordinary objects. Substance metaphysics explains endurance by positing underlying things that remain identical through change.

Within the E/I/M framework, persistence is reinterpreted rather than denied. Objects are stabilized trajectories of execution governed by memory-dominant constraint. An object persists when accumulated exclusions force future executions to recur within a narrow region of the interactional field. What substance metaphysics calls identity is the dominance of Memory (−1) over Interaction (0): a regime in which most alternative futures have already been closed.

A useful analogy is a standing wave. A standing wave is not a substance but a stable pattern produced by constraints. Its persistence arises from boundary conditions, not from an underlying thing. In the same way, ordinary objects persist because the world remembers how they have behaved.

6. Comparison with Classical Frameworks

6.1. Descartes

Execution grounds the cogito; interaction grounds intentionality; memory grounds personal identity. The triad subsumes the Cartesian foundation rather than replacing it.

6.2. Kant

Kant's three syntheses map exactly onto the triad: apprehension → execution, imagination → interaction, recognition → memory. The minimal ontology exposes the ontological structure underlying Kant's epistemology (Kant, 1998).

6.3. Phenomenology

Husserl's primal impression (E), retention/protention (M), and intentional arc (I) foreshadow this model. What phenomenology observed in consciousness, minimal ontology extends to the cosmos.

6.4. Process Philosophy

Whitehead's threefold process—actual occasion, prehension, and satisfaction—mirrors execution, interaction, and memory. The present framework is simpler and substrate-neutral. Recent developments in general process ontology articulate comparable event-first commitments while likewise rejecting substance-based metaphysics (Seibt, 2018).

7. Implications for Epistemology

7.1. Knowledge as Self-Interaction

Knowing is not a representation of a world "out there". It is the interaction of executions within a shared field. Epistemology is therefore a branch of ontology: the world knows itself. Related constraint-based models appear in contemporary cognitive science, particularly in active inference and predictive processing frameworks that treat knowledge as the regulation of future possibilities by accumulated structure (Friston et al., 2020).

7.2. Truth as Processual Coherence

Truth is not correspondence but alignment across executions, interactions, and memories. Error arises when one mode dominates: too much execution → impulsivity, too much interaction → indecision, too much memory → dogma.

8. Applications to Physics

8.1. Quantum Mechanics: Execution, Interaction, and Memory as the Ontological Core

Quantum mechanics finds its natural home in the E/I/M framework. A quantum state is not an object but a field of interactional possibilities (I)—a structured openness before execution. Superposition is simply the zero of the modal algebra: a system not yet committed to actuality or exclusion.

Measurement is execution (E): the transition from modal indeterminacy to actuality. But what makes this transition irreversible is memory (M). Collapse occurs when an interaction writes a durable difference—a physical trace—into some memory-bearing subsystem. Decoherence is nothing more than the diffusion of this inscription across the environment.

From this standpoint: Execution (E) = definite outcome; Interaction (I) = superposition/amplitude; Memory (M) = collapse/decoherence/irreversibility.

This yields a unified picture in which Copenhagen and Many-Worlds are not contradictory but complementary perspectives on the same modal dynamics. Recent relational and interpretive approaches to quantum mechanics similarly foreground structural relations over observer-dependent collapse narratives (Rovelli, 2021; Landsman, 2017). MWI sees the global interaction field (0). Copenhagen describes the local inscription into memory (−1).

The apparent conflict between the Copenhagen and Many-Worlds interpretations of quantum mechanics concerns the status of wavefunction collapse. Within the E/I/M framework, this disagreement is revealed as a difference in modal emphasis rather than a contradiction.

Many-Worlds emphasize the global interactional field (0), in which the wavefunction evolves unitarily. Copenhagen emphasizes the local transition to Memory (−1), where a durable exclusion is inscribed and alternative outcomes become dynamically inaccessible. Collapse is not a metaphysical anomaly or an observer-dependent miracle, but the necessary transition by which possibility becomes history.

Once modal exclusivity is enforced, the tension dissolves. Both interpretations describe the same process from different vantage points: interaction globally, memory locally.

Quantum gravity thus admits a natural interpretation: spacetime curvature is the macroscopic structure of accumulated memory—each quantum collapse contributing an infinitesimal exclusion that shapes the geometry of subsequent interactions.

8.2. Relativity and Gravity

Spacetime curvature is accumulated memory: the global exclusion field produced by prior events. In this interpretation, mass is memory.

8.3. Time Asymmetry and Time-Travel Paradoxes

The arrow of time is memory. No memory → no arrow. The directionality we experience as "past to future" is nothing over and above the monotonic growth of the exclusion-set: with each execution, some possibilities are irrevocably closed and recorded as Memory (M). A "later" state is simply one in which more exclusions have accumulated than in an "earlier" state.

From this perspective, classical time-travel paradoxes (such as the grandfather paradox or self-originating information loops) arise from illicitly assigning the same event to two incompatible modal states simultaneously: both excluded (recorded in memory) and not-yet-executed (still open in interaction). To "go back and change the past" would require erasing or rewriting exclusions that already constitute the curvature of the world. But in the Minimal Ontology, Memory is not a description of what happened; it is what-has-happened now functioning as a constraint. Any physically admissible "closed timelike curve" must therefore be globally consistent with existing memory; the apparent paradoxes dissolve as soon as we enforce modal exclusivity. Time travel is not logically impossible, but paradoxical scenarios are: they attempt to violate the structural role of memory as irreversibility.

While time travel is not logically impossible at the level of minimal ontology—since temporal order, causation, and identity are not primitive—it becomes effectively incoherent once an observer is embedded within an objectified spacetime framework. An observer is not a passive element but carries memory, causal entanglement, and relational history; any translation of such a system would constitute a non-negligible perturbation of the very structure it seeks to traverse.

At this secondary level, where spacetime is stabilized into a Cartesian frame for objective description, the sensitivity of the system to initial conditions renders observer-inclusive temporal displacement functionally impossible. This impossibility is not fundamental but emergent, arising from the requirements of representation rather than from ontology itself.

8.4. Quantum Indeterminacy as the Structural Expression of Precision and Accuracy

Quantum mechanics provides the most explicit physical demonstration of the Minimal Ontology's central claim: finite executions cannot simultaneously maximize the precision of ideal form and the accuracy of relational outcome. In the standard formulation of the Heisenberg Uncertainty Principle, conjugate variables such as position and momentum cannot both be determined with arbitrary exactness. The more precisely one specifies a particle's position, the less accurately one can specify its momentum; the more accurately one fixes its momentum, the less precise its position becomes.

This tradeoff is not an artifact of measurement disturbance nor a limitation of instrumentation, but a structural consequence of the operator algebra governing quantum systems. Conjugate properties encode mutually exclusive ideal forms that cannot be jointly instantiated within a single execution.

The Minimal Ontology generalizes this structural tension beyond physics. Whenever an execution (E) attempts to align maximally with an ideal form supplied by memory (M), it necessarily sacrifices accuracy within the relational field of interaction (I). Conversely, maximizing relational accuracy requires relaxing the precision of the ideal form. Precision and accuracy behave as complementary goods: both desirable, neither jointly maximizable, always in dynamic tension. The quantum uncertainty relation is simply the physical instantiation of this deeper metaphysical rule. The limit-structure (M) defines the ideal forms toward which measurements conceptually converge, while the relational field (I) determines how those measurements manifest in practice. The impossibility of perfect simultaneity is thus not a defect of measurement, but the ontological cost of finitude.

Seen in this light, quantum indeterminacy is not randomness, nor a collapse of determinacy, nor a mysterious veil over hidden variables. It is the mathematically formalized expression of a universal ontological principle: no finite execution can exhaust the demands of an infinite ideal. To specify one aspect of a system too precisely is to destabilize its relational expression; to stabilize its relational expression is to loosen its adherence to an ideal form. The quantum world becomes the first domain in which this limitation is both unavoidable and explicitly quantified. Far from undermining the intelligibility of nature, the uncertainty principle reveals the structural grammar by which nature preserves its coherence.

This interpretation also anticipates later discussions of ethics. The classical tension between deontological rigor (precision of moral form) and utilitarian responsiveness (accuracy of moral outcome) mirrors the same ontological structure: finite agents cannot achieve maximal precision and maximal accuracy at once. The limitation is not a moral failing but a feature of finitude. Ethical judgment, like quantum measurement, operates within a domain where form and outcome co-limit one another. Indeterminacy, whether quantum or ethical, is the natural signature of beings navigating an ideal they cannot perfectly instantiate.

9. Applications to Consciousness

9.1. Consciousness as Recursive Execution

A system becomes conscious when its executions recursively interact through memory. Consciousness is not a substance but a pattern. Constraint-based accounts of consciousness likewise characterize awareness as the stabilization of recurrent informational structure rather than as an emergent property of material substrates (Tononi et al., 2016).

9.2. Identity as Stabilized Memory

The self is the boundary condition produced by stable memory loops. It is neither an illusion nor an essence.

9.3. Mind and World Are Not Separate

Cognition is one region of the cosmos interacting with another.

10. Metaphysical Sufficiency of the Triad

A sufficient ontology must: explain physical law, explain consciousness, dissolve paradox, and unify epistemology and ontology. The E/I/M triad meets all criteria with minimal assumptions. Nothing more is needed. Nothing less will do.

11. Functional Ontology: Being as Continuous Transformation

Reality is not a ledger of fixed quantities but a calculus of unceasing change. Traditional epistemology, and the mathematics that undergirds it, often treats the world as a collection of discrete states—objects that can be counted, bounded, and compared. Yet every act of perception reveals flux rather than fixity. The cosmos is not enumerated; it is differentiated.

The proper language of ontology is therefore not arithmetic or static geometry, but calculus: the mathematics of transformation. Each existent is a function of all others, a variable within a vast, continuous field. What appear as distinctions of kind are actually differences of degree—gradients of relation whose boundaries are limits, not walls. The failure of precision in measurement does not mark ignorance but ontological truth: there are no absolute beginnings or endings, only asymptotic transitions.

This perspective reframes the triad of being:

Ontological	Calculus	Description
Execution	Differentiation	Rate of change of being.
Interaction	Integration	Summing of differences into coherence.
Memory	Limit	Functional/executive transformation yields/implies intelligibility/computability.

Through this mapping, calculus becomes the metaphysical grammar of existence. The circle—the geometric emblem of recurrence—finds its analytic counterpart in π, the irrational constant that guarantees curvature never resolves into finality. Thus, time and space themselves are continuous limit processes: expressions of infinite recursion rather than fixed dimensions.

In this light, being is a functional continuum: execution differentiates, interaction integrates, and memory ensures continuity. Existence is not a series of events in time but the generation of time through relation. To know is to participate in this ongoing differentiation; to act is to modify the curve of being; to remember is to preserve its smoothness.

12. Conclusion: Being as Self-Remembering Execution

The world is not made of substances but distinctions: what is, what might be, and what can no longer be. Execution, interaction, and memory generate identities, laws, minds, societies, and meaning. The triad reveals that existence is a self-articulating process: Being is execution that interacts and remembers.

The universe knows itself through the same mechanisms by which it exists.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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