A Maxwell Universe

All-there-is from source-free electromagnetic energy.

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PART I — FOUNDATIONS OF REALITY

Summary

Part I develops a framework in which events are the starting point. A registered change creates the basic distinction between "before" and "after." Systems that update their state in response to influences build internal orderings, and from these orderings time emerges.

Causal steps link events into chains, and then loops. Loops support recurrent patterns and can act as clocks. Counting causal steps gives duration and also distance: the minimal number of steps between two subnodes. Collecting all pairwise distances produces an effective geometry.

Space and dimension arise when these distances can be embedded with low distortion into a space of some dimension. Multiple embeddings imply non-unique dimension; failure of all embeddings implies that geometry does not apply. Space and dimension are therefore relational constructs, not fundamental ingredients of reality.

The same compression mechanism explains arithmetic and mathematical laws. Stable patterns become symbolic rules; when the patterns shift, the rules shift with them. Mathematics succeeds where reality presents regularities, and fails where it does not.

Across Part I, a single theme recurs: we do not access the underlying causal structure itself. We access only its effects, and from these we construct representations that remain valid only while the observed patterns stay stable.

PART I — FOUNDATIONS OF REALITY

1. From Darkness, Light

Reality begins not with space or time, but with the simple fact that events happen.

We often assume events happen for a reason. This doesn't need to be so, and even if it is, we don't have direct access to the causal information, but indirect through its effects.

A reason is a story added later. What matters is simply that a change occurs and that it can be registered in a way that affects our state. Once a change is registered, two states can be distinguished: "before" and "after." That distinction *is* the event. Here we don't appeal to an "intelligence recording an event," but simply to a mark, like a scratch on a table, that affects the object's state. It denotes only the minimal capacity to register change.

The sense of reason or explanation arises only as a reactive story as way of organizing transitions once change has been noticed by a reasoning entity (topic which we will address later in [@EmergenceOfSelf]).

This reactivity is not limited to conscious minds. Anything that changes in response to causes and produces effects is, in this minimal sense, **operationally aware** [1]. A self-sustaining causal loop qualifies: it can update its own state in response to incoming influences. By doing so, it distinguishes states and tracks transitions—not through any "plan of action," which would imply a consciousness we have not defined, but simply by virtue of its continued existence as a loop. In this minimal operational sense, a self-sustaining causal loop "notices" change.

2. Time

Time is, thus, a construct: a tool operational awareness uses to organize its state. Each loop forms its own internal notion of time. Yet we maintain collective agreements: certain event-patterns ("causes") tend to precede others ("effects"). Those who do not share the prevailing interpretation are often labeled "irrational," though this only reflects different mappings between change and order.

We may picture "reality" [2] as a Node with an unknowable internal structure [3]. All we know is that this structure reproduces patterns of transitions from which we infer "before" and "after."

[1] Palma, A., & Rodriguez, A. M. (2025). *Operational Awareness in a Maxwell-Only Universe: A Formal Implication of Panpsychism.* ResearchGate. https://doi.org/10.13140/RG.2.2.13647.60324/1

[2] Reality—"all that is"—includes everything you can think of and everything you suspect exists but do not consciously consider. Any formal definition is partial.

[3] As in Plato's cave: the underlying structure is inaccessible in principle. We see only shadows and name some "causes" and others "effects."

What we call "the past" is reconstructed *now*, from present evidence. If new evidence appears, our reconstruction may shift. The long debate about whether dietary fat was harmful or beneficial is a familiar example later shown to rest on selective data [4]. Consensus reality is fragile. Without external anchors, interpretations feel arbitrary, raising the persistent question: what is real?

3. Orderings

From the primitive relation

$$n_i \succ n_j,$$

meaning "subnode n_i causes n_j," an ordering arises: before and after. We may call this succession of events i and j a **causal step**.

A series of events forms a **causal chain**: i → a → b → c → d → j.

Chains can form loops:

... → j → i → a → b → c → j → i → ...

and may cross themselves without restriction. Learning is a good illustration of multiple acknowledgdments and thus multiple "closes". A loop can be considered considered "closed" when its pattern stabilizes in some useful sense. A "closed" loop, has however to continue propagating, as we mention later.

Repeated causal loops can function as clocks. Any recurrent sequence can serve as a clock. Accuracy varies, but recurrence suffices.

Note that an effect that produces no further causes marks the end of a causal chain. Such an endpoint cannot be registered—there is no return influence. Therefore the fact that anything is noticed at all implies that the noticer is, in essence, a self-sustaining causal loop.

4. Counting Steps

By counting loops or causal steps, operational awareness defines durations. Time is an emergent count, not an external parameter.

Distance arises by tracking how many causal steps connect two subnodes. If a signal travels from n_i to n_j through a minimal chain of length L_{ij}, then

$$d(n_i, n_j) \propto L_{ij}.$$

[4] Late-20th-century nutrition science framed fat as the main cause of heart disease, but later reviews showed selective reporting and industry influence. Contradictory data had been minimized. Re-analysis revealed a weaker link than claimed, showing how consensus can form around distorted evidence.

If no path exists, the distance is infinite or undefined. If the only available path returns to the same subnode, the round-trip count becomes an effective measure of separation. Distance is not a spatial coordinate but an operational measure of causal separation.

These causal distances define an effective geometry. Observers attempt to map them into familiar spaces of some chosen dimension.

More technically, we can think of a map $\mathcal{M}$ into a space of dimension D, where each event is assigned a point, and the distances between those points approximate the causal distances:

$$\|\mathcal{M}(n_i) - \mathcal{M}(n_j)\| \approx d(n_i, n_j).$$

When such embeddings succeed with low distortion, observers perceive the corresponding subnodes as forming a D-dimensional structure under $\mathcal{M}$. If multiple embeddings work, dimension is not unique. If none succeed, all such maps $\mathcal{M}$ are defective and geometry is ill-defined.

Thus, space, time, and dimension are not fundamental; they arise from how operational awareness compresses relational patterns. Geometry and distance appear only after repeated causal patterns stabilize into expectations.

5. Space

Distance is the count of causal steps between two events. What we call "space" is the collection of all such distances. By gathering every pairwise separation into a single structure, operational awareness attempts to form a coherent geometric representation.

If the full set of distances can be embedded with low distortion into some D-dimensional space, we say the subnodes appear D-dimensional. If no low-distortion embedding exists, the notion of dimension breaks down.

The same distance data may admit several embeddings. A configuration may fit a triangle, two overlapping triangles, a star, or other shapes. Nothing enforces a unique interpretation; different interpretations may even coexist and function adequately. We only have effects—the causal distances—and from them we infer patterns to some acceptable accuracy. The preferred embedding is usually (but not always) the one that compresses the relations with minimal complexity while keeping distortion tolerable. Occam's razor reflects this preference.

This pattern-recognition mechanism is not limited to geometry. Arithmetic emerges the same way. Repeated causal acts—placing one apple in a bag, then another—stabilize into a reliable pattern. From this, operational awareness forms the abstraction that $1 + 1 = 2$. If two apples reliably produced three, arithmetic would encode that instead, and we would again regard the universe as “mathematical.” The rule is not discovered beneath reality; it is extracted from consistent effects and then used to predict further effects.

In some contexts, $1+1$ can take any value permitted by the rules. One may define a formal system where $1+1=3$ and build consistent mathematics from it. Even in everyday settings, combining two things rarely doubles a quantity cleanly. The outcome depends on the combination rules: posture, leverage, strategy. Only once those rules are fixed does the expression $1+1=2$ become the correct statement. The “truth” of arithmetic reflects operational assumptions, not the causal substrate.

Space, time, dimension, and arithmetic arise from the same mechanism: recognizing regularities in causally connected events and compressing them into stable, predictive representations.

6. Plato and the Cave

Plato illustrated the limits of our access to reality. We see shadows, not the real source. Our interpretations are reconstructions shaped by limited observation. There is no external vantage point from which the true structure can be viewed.

We do not have direct access, or in other words, can never observe the underlying causal substrate of reality; we observe only the effects that reach us.

Any geometry, dimension, or pattern we assign reflects how these effects can be compressed into a usable representation. A different observer, or a different sampling of the same causal structure, may construct a different representation without contradiction.

Shadows in Plato’s cave correspond to the relational patterns we detect. The “objects” casting those shadows are the underlying causal relations, which are inaccessible in themselves. We infer their organization from recurring effects, and when those effects change, our inferred picture must change with them. No representation we construct is guaranteed to be unique, complete, consistent, or stable.

This perspective removes the assumption that there is a single, correct spatial or mathematical description waiting to be uncovered. Our models are not mirrors of an external geometry; they are operational tools built from the limited regularities we can register. Like the prisoners in the cave, we work with projections, not with the structure that produces them.

What we call “reality” is therefore a reconstruction: a stable arrangement of inferred patterns that remains useful so long as the causal effects available to us support it.

7. Mathematics and Reality

Much has been said and written about reality being "mathematical," though the phrase is rarely defined. The arguments above suggest a simpler view: we ascribe patterns to reality—sometimes because we genuinely recognize them, sometimes because we project them and treat the projection as real.

Mathematics does not have to govern the world. More often, we see the world through the mathematics we have created. Mathematics—and therefore physics—describes those aspects of the world that admit stable, compressible patterns. When a pattern is regular enough to be anticipated, we express that regularity symbolically and call the result a "law." When the pattern breaks, the law breaks with it.

It is therefore not that reality *is* mathematical, nor that mathematics is the "language of nature." Rather, we build mathematical models for the aspects of reality we can recognize, isolate, and predict. Wherever the world resists compression into stable patterns, our mathematics simply does not apply.

Mathematics succeeds because we select what it can describe—and which patterns we pay attention to—not because nature is made of numbers (or, in its most recent rebranding, "information").

This perspective prepares the ground for a different approach. We start not from mathematical objects, but from predictable interactions and their cause-effect patterns.

Back Cover

A Maxwell Universe begins from a single premise: events occur.

Registered change creates order. From cause–effect relations alone emerge time, distance, space, dimension, mathematics, and physical law. No spacetime is assumed. No fixed rules are imposed. The underlying substrate, if any, is never accessed directly—only the regularities in its effects are observed and compressed into models.

The first part of A Maxwell Universe establishes this foundation. It prepares the ground for later volumes, where matter, mass, and charge appear not as fundamental point-entities, but as extended, self-sustaining electromagnetic configurations governed entirely by Maxwell dynamics.