THE REALITY SELF-SIMULATION PRINCIPLE: REALITY IS A SELF-SIMULATION

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"Behind it all is surely an idea so simple, so beautiful, that when we grasp it - in a decade, a century, or a millennium - we will all say to each other, how could it have been otherwise?" (Wheeler, J. A., 1986, p. 304)

ABSTRACT: The Simulation Hypothesis is the widely discussed conjecture that we inhabit a directly experienced but nevertheless artificial reality which, while supporting human consciousness and perception, is produced and displayed by a host system occupying a higher-level reality unseen from below. Reality is thus implicitly defined to have at least two levels, the one in which we seem to exist, and another associated with the host system. As the term "reality" is undefined beyond this hypothetical relationship, the Simulation Hypothesis is indifferent to the details, e.g., where the host system is located, how the host system works, who or what created and/or controls the host system, and in what respects the simulation resembles the higher reality containing it. But in any case, there must be an ultimate all-inclusive reality or "ontic ground state" that contains and supports whatever reality-simulations may exist, and it is natural to ask whether some aspects of the simulation concept may apply to it. The Reality Self-Simulation Principle states that ultimate reality is itself a natural reflexive self-simulation in which all intelligible levels of reality must exist whether simulated or not. Where ultimate reality is a global self-identification operator configured as the CTMU Metaformal System (Langan, 2018), i.e., the identity-language of intelligible reality, the Reality Self-Simulation (RSS) can be identified with the Cognitive-Theoretic Model of the Universe (CTMU; Langan, 2002), which thus describes reality as a self-simulating identity operator $R^*:R_{INT}|R_{EXT}$ and details its structure and dynamics, showing that it possesses its own universal form of consciousness (coherent self-identification and self-modeling capacity), an unbreakable quantum ontology, and a new paradigm for self-organization and emergence.

KEYWORDS: Simulation; Self-Simulation; Self-Simulation Theory; Self-Simulation Principle; Self-Simulation Hypothesis; Reality Self-Simulation; Cognitive-Theoretic Model of the Universe; CTMU; Metaformal System

I. INTRODUCTION

In science and technology as well as popular culture, simulation is ubiquitous. A

wide variety of processes are now being computationally simulated for purposes ranging from entertainment and scientific exploration to urban planning, drug design, and military and commercial flight training. These days, many apparently sane people are even looking about them with suspicion and wondering whether reality itself could be a simulation in which they have somehow been trapped, and if so, whether there is any possibility of escape.

By definition, a *simulation* is a model or imitation of an actual situation or process that fools an observer into thinking it is real given limited suspension of judgment. That is, it is similar enough to the original system or process to be "realistic" even while differing from it in some respects, preferably not so many as to destroy the illusion. But where the simulation concept is taken to the global limit – where we are considering the simulation of reality at large – illusion takes on a whole new meaning, converging on fundamental sensory and epistemological limitations.

Where it is the entire universe that is simulated, strange complexities and unexpected simplifications may arise. For example, although the simulation must differ from true reality in order to maintain its definitive artificiality, it is ideally indistinguishable from genuine reality for its inhabitants. In this sense, "artificially simulated reality" is an oxymoron; a "realistic" (convincing) artificially simulated reality must be real enough to make its resident observers regard it as genuine after all. Yet insofar as any simulated reality is embedded in all higher levels of reality, it may still be possible to discern ultimate reality within it.

II. THE SIMULATION HYPOTHESIS

The "Simulation Hypothesis" or "simulation theory" is a relatively new hypothesis with ancient roots, a modernization of the old idea that the physical world is merely a perceptual representation of a deeper level of reality. It posits that we inhabit an artificial system, e.g., a simulation programmed and running on a computer or other advanced digital construct possibly overseen by a higher intelligence (God, the devil, aliens, post-humans, etc.). Some variants involve consideration of how and when the technological capacity for reality-simulation evolves or emerges from base-level reality, and the assignment of likelihoods to the associated possibilities.

In the Western philosophical tradition, the simulation hypothesis can be traced back through the "evil demon" of Rene Descartes (Descartes, R., 1996), which he described as presenting "a complete illusion of an external world … devised to ensnare my judgement", to Plato's Allegory of the Cave (Plato, n.d.) and beyond. In the Eastern tradition, it is foreshadowed in certain strains of Vedic and Buddhist philosophy and literature. But perhaps the first technical application of the modern

version of the Simulation Hypothesis to an outstanding philosophical problem appeared in the paper "The Resolution of Newcomb's Paradox" (Langan, 1989), which features a reality-simulator capable of simulating the deterministic and nondeterministic aspects of real processes, including volition and cognition, in an otherwise paradoxical decision-theoretic scenario.

In addition to the Simulation Hypothesis, there exists a related trilemma with which it might sometimes be confused. This trilemma, called the "Simulation Argument", is expressed as follows:

> "At least one of the following propositions is true: (1) The human species is very likely to go extinct before reaching a 'posthuman' stage; (2) Any posthuman civilization is extremely unlikely to run a significant number of simulations of their evolutionary history (or variations thereof); and (3) We are almost certainly living in a computer simulation." (Bostrom, 2003)

Whereas the Simulation Hypothesis forthrightly asserts that we live in an artificially simulated reality (subject to proof), the Simulation Argument is about the *likelihood* of living in an artificially simulated reality under specific evolutionary circumstances involving implicit technical assumptions. According to Bostrom (2008), "one can accept the simulation argument and reject the simulation hypothesis." Thus, the Hypothesis and the Argument should not be confused.

However, the Hypothesis and the Argument share something in common: both are about *artificial* reality-simulations, and are thus distinguished from the true (artificially unsimulated) or *ultimate* reality in which they are implicitly assumed to exist. This raises a pair of questions. One question is ontological, having to do with the relationship between true reality and artificially simulated pseudo-reality, while the other question is epistemological, having to do with the possibility and means of distinguishing one from the other.

(1) How do true reality and artificial simulation differ, and what if anything do they have in common?

(2) Can the inhabitants of an artificial simulation distinguish it from true reality and vice versa (i.e., can real physically-embodied human beings distinguish the true reality they inhabit from an artificial one)?

To answer one or both of these questions, it seems that we require a sound definition of "true reality", which to some extent entails a *verifiable theory* of reality. This "reality theory" must contain the required distinctions and a reliable means of applying them.

III. CONCISELY FORMULATING SIMULATION

First, let's see if we can find a simple way to look at simulations as usually conceived.

A simulation, being defined as the imitation or imaging of a situation or process, is an input-to-output transformation that converts the situation or process to a more or less faithful image thereof.

In other words, a simulation is a kind of mapping, which we can write as

"Sim: input→output"   (E.1)

where "Sim" stands for a simulative mapping operator or a natural or artificial processor which operates as programmed on input from some combination of internal and external sources. The output, consisting of images of the input data under the mapping, "simulates" the input to the extent that it resembles the input or shares its properties. (At this stage of simplification, the observers and programmers for whom the input is "simulated", and by whom the resemblance will be judged, are implicit.)

Equivalently, a reality-simulation can be expressed as follows:

Input → processor → output   (E.2)

That is, a simulation occurs when a processor "models" input as output. Basically, the **processor** (simulator, host system) runs a program which is a **model** of a **source system** (a real or abstract system to be simulated, of which a model, representation, or formal equivalent has been programmed into the processor). Many seemingly ordinary computer programs contain hidden models of real or artificial systems and processes which are activated when the program is run, generating a "simulated miniverse" instantiating them on input data from the user.

In the standard simulation hypothesis, the host system (a connected processor-display ensemble) is a computer programmed with a model of the source system, where the source system may exist only formally in the model itself. In any case, the host system is assumed to be a machine embedded in a higher, "truer" level of reality from which the simulation in some way deviates for better or worse (as otherwise it would be pointless).

To simulate X is to provide instances for a characteristic invariant formal description of X that remains unchanged with respect to variation among possible instances. The instances "deceive the observer" by supplanting a generic formal description, the model of X, with specific instances, physically imitating mental properties and formal patterns thereof. Only the instances, not the programming,

are visible inside the simulation (in the "display"). The subjective nature of models, programs, and formal properties are hidden, either in an external processor or deep within the observer himself.

Where X = reality, the simulation is a reality-simulation. Where the processor is artificial - e.g., a mechanical or electronic construct - the reality simulation is artificial; where the processor is natural (involving no artificial construct), the reality simulation is natural, and may be considered a part of nature or reality itself. If it can be considered a simulation at all, it is a self-simulation of, by, and for nature itself.

Real simulations of reality exist in reality, and in principle may be "nested" in simulations of simulations … of simulations. Thus, we have the following diagram:

(1) Ultimate Reality → [nested subrealities] → (2) source system (to be simulated) → (3) host system with model of source system → (4) displayed target system   (E.3)

The universal relational structure of reality is *syndiffeonic*. A syndiffeonic relation consists of two levels, one *synetic* and singular and the other *diffeonic* and (usually) plural. The synetic level distributes over the diffeonic level, thus lending the diffeonic (individually discernible) relata a basis for cognitive or perceptual coherence. In other words, whenever one perceives or conceives of many things at once, it is by virtue of the fact that they have a common synetic property: they are conceivable or perceivable (and have other more specific properties in terms of which to be distinguished). This property relates to one's ability to discern the relata, i.e., one's ability to tell them apart while nevertheless seeing them all at once. Syndiffeonesis is clearly present in every property or attribute with multiple objects, instances, or values, and in every object that displays multiple properties or attributes. Every relation, even a simple identity relation, is syndiffeonic; a property associated with the relational symbol is distributing over whatever is to either side of it.

Ultimate (true, base-level) reality refers to a level of reality that is perfectly self-contained; it must conform to the CTMU Metaformal System, which distributes a synetic "intelligibility property" or universal syntax of identification – an instance-free, semantically unbound *universal distributed form* or UDF supporting and constraining all possible recognizable input - over its localized (semantically bound) instances within a universal syndiffeonic identity, thus providing itself with the internal coherence that allows bound states to be coherently assembled in the

building of artificial processors. (Although every reality-simulation is in a sense "ultimate reality simulating itself", its displayed output is extensional and localized to particular locations or regions within a display medium which may, if artificial, be localized within ultimate reality and thus unable to display ultimate reality in its entirety. This localization implies that there is a higher external level of reality on which it depends, implying that it is not self-contained and is therefore non-ultimate.) *Nested subrealities* are reality simulations within reality simulations within … within ultimate reality.

Host systems simulate the host systems of any lower-level (nested) simulations which are run on them. Host systems may thus be described as "internally emulating" the host systems of lower-level simulations.

We can now refine steps 2-4 in the above diagram. First, note that the target of any structure-preserving mapping "simulates" the source – i.e., that the homomorphism $m:x \rightarrow y$ *simulates* x with y. We can thus define a **simulation** as an iterative composition of structure-preserving state-transformation mappings, usually executed by a processor P programmed with an internal model M^X of a specific system X to be simulated by successive simulated states (marked with an apostrophe) $X' = \{X_0', X_1', X_2', …\}$ on input consisting of some initial state X_0', where time-indexed simulated states X_T' of the simulated system X are expressed in a display D at time T (the present moment), advances step by step, state by state, and change by change:

$$P(M^X, X_T') : D(X_{T=n}') \rightarrow D(X_{T=n+1}') \tag{E.4}$$

In plain language: the processor P, operating on a model M^X of system X to be simulated and a simulated state X_T' at time T in the display D, transforms the input state $X_{T=n}'$ at time T=n in D to the output state $D(X_{T=n+1}')$ at time T=n+1 in D. (Note that this mapping is a loop; where n stands for "now", n+1 immediately becomes n again as time advances, output is recycled as input, and the function P iterates.)

$D(X_n')$ means that the display D is displaying ("performing a display operation on") the simulated states X_n' of the simulated system X' as they are symbolically communicated to it by the processor P as language or code. In other words, P is being treated as a function converting input to output, and D serves as its domain and codomain. Neither P itself nor its various subroutines and individual processing operations are distinguishable in D, and insofar as it determines the content of D, P exists and functions in a "pre-display" capacity.

In a **self-simulation**, the model is a description of the processor and display themselves.

$$P[M^{(P,D)}, (P, D)_T'] : D(P, D)_{T=n}' \rightarrow D(P, D)_{T=n+1}' \tag{E.5}$$

Here, "self-simulation" is interpreted in such a way that there is a real display with a simulated processor and simulated display as its content.

But alternatively, because the processor contains a model of both itself and the display, and could simply be internally updating its internal model, everything could be inside the processor. When the simulation is confined to P, we have:

$$P[M^{(P,D)}, (P, D)_T'] : (P, D)_{T=n}' \rightarrow (P, D)_{T=n+1}' \tag{E.6}$$

or simply

$$P[M^{(P,D)}, M^{(P,D)}_T] : M^{(P,D)}_{T=n} \rightarrow M^{(P,D)}_{T=n+1} \tag{E.7}$$

with the processor internally running its "self-modeling program".

In short, while we cannot put P in D – a processor can process states, but a display cannot display processing – we can put D in P provided that P alternates between process and display functions. This amounts to putting both P and D in the self-dual processing-display element P, thus avoiding P-D (time-space) dualism. P simply alternates between display and processing stages, or state and state-transition. In any case, as we explain in the next section, the processing and display functions are fundamentally incompatible; at best, they can alternate within dual-purpose operators handling both functions. The processing stage is separate from the display stage whether external or internal to P.

D, being incapable of displaying processing intervals, merely displays output from P with retrodictive interpolations between states. (Physically, this is how we observe the "display" we call spacetime; all processing is retrodicted from the current state.) As D does not affect the output it receives from P, P can simply ignore D along with the rest of its output-to-input loop (which in this case is not external but hardwired or simulated within P). P is thus internally emulating itself on the initial state P_T'.

This makes P its own mapping or state-transition function $P : P_n' \rightarrow P_{n+1}'$. P need produce no actual output at all; everything remains internal. Only the internal state of P actually changes; no change is visible from outside (i.e., no external output or input signals are present on any external wires connecting it to

an external display). So immediately we get

$$P(M^P, P_T') : P_{T=n}' \rightarrow P_{T=n+1}' \tag{E.8}$$

where the P_T' are the self-simulated states of P itself.

A **reality simulation** is just a simulation in which the modeled system is called a "reality" on the strength of whatever criteria may be associated with the term. (People often disagree on how reality should be defined, so its definitive criteria vary widely.) A commonly used criterion: it must be sufficiently realistic, or faithful to one's expectations of what reality should be – e.g., immersive, replicable, and logically consistent - to convince an observer. (However, one should not fool oneself about what it actually takes for this "anthropic" criterion to be fulfilled.)

A more interesting case is that in which reality simulates itself. In a **reality self-simulation**, reality is self-contained, reflexively incorporating its own processor and display functions. In effect, reality becomes its own processor and display, reducing the "simulation" to reality itself (Langan, 2002). This situation can be expressed by simply replacing the processor in E.8 with reality:

$$R(M^R, R_T) : R_{T=n} \rightarrow R_{T=n+1}, \tag{E.9}$$

where R is reality, M^R is a self-model of reality, and the R_T are the time-dependent states of R (the apostrophes are now superfluous, as states are no longer confined to artificial machinery but instead belong to reality itself.) That is, reality R runs a self-modeling program M^R on a given state R_T, thus "simulating" the structure and dynamical evolution of R.

Where *telesis* is a convergent generalization of intension and extension coinciding with the ontic ground state, and R* is an ultimate (self-contained, self-defining, ontically closed) telic identity operator that couples (and dually, separates into) its own intensional and extensional aspects, a reality self-simulation can simply be written

$$R^*: R_{INT} \longleftrightarrow R_{EXT} \tag{E.10}$$

where the subscripts mean *intensional* and *extensional* respectively. In this context, intensional means "processor/model/program-like", while extensional means "display-like". As R* is an ontic identity or irreducible self-dual telic identity operator, intension and extension are codependent, and a 2-headed arrow is required.

IV. REALITY SELF-SIMULATION

Reality and *simulation* have nearly opposite meanings; one is real and one is counterfeit. It is thus appropriate to ask whether the phrase "Reality Self-Simulation" is meaningful.

Where a system produces and displays its own content, there arises a question of whether it can still be described as a reflexive "simulation". Whether it retains the structure and functionality of a simulation depends on the extent to which it inherently supports the distinctions on which *simulation* is defined, especially the distinction between the *processor* and *display* aspects of the system, and between the system model and the system itself.

The definitive criterion: Reality is self-contained and has a "display stage" or extensional medium in which substantive content is perceptibly displayed, and an intensional "processing stage" which is not immediately displayed, but generates an advance model of its future evolution which is transferred to the display stage for actualization.

Here are the possible kinds of "reality simulation" usually considered.

(1) **Central processing - discrete display** (the computer-simulation paradigm): Reality resembles a standard computer simulation displayed on the discretely pixelated screen of a computer monitor controlled by a remote CPU which schedules the action on the screen using its central clock.

(2) **Central processing – continuum display** (classical physics, with disjoint processor and display): Reality, consisting of a separate processor and continuous display, displays itself on an infinitesimally (sub-finitely) pixelated 3D "monitor screen" to which the processor is external but to which it is somehow connected.

Except for the infinitesimal "pixels" of the display (as required for continuity), this configuration resembles case 1. The display screen resembles a classical void or spatial medium containing observers and serving as their common environment, with time amounting to clock pulses distributed throughout the display from the CPU.

(3) **Distributed processing - discrete display** (cellular automaton model / digital physics): Reality is confined to a finitely partitioned display resembling the discrete array of a cellular automaton. Its "cells" are either dual-purpose processing-and-display elements, or two kinds of element are somehow packed together without disrupting observation. The display is equipped with its own clock to coordinate the activity of its cells, or the cells somehow coordinate with each other automatically.

In this configuration, the display evolves by way of distributed, locally parameterized, locally processed instructions and thus obeys a locality principle. This kind of "digital physics" is supposed to allow for the reduction of reality to information, or bits and computational operations thereon. But among its weaknesses is the fact that informational reductionism applies only to the content of the display; the display itself must be taken for granted as an informational medium. (Langan, 2002; Wolfram, 2002)

(4) **Distributed processing - continuum display** (modern physics and cosmology): Processing, and thus the evolution of the system, are intrinsic to the geometry of the display. Processing is either associated with points of the spacetime manifold (just as it is associated with the display elements of a cellular automaton in case 3), or points have dual processing and display functionality. In either case, the laws of physics are pointwise-distributed over the spacetime manifold or some other manifold, possibly with "extra dimensions" that might accommodate hidden processing. This conforms to the trend in modern physics which confines reality to a distribution of matter and energy in a "physical" continuum, with quantum mechanics demanding more or less problematical accommodations.

In all of these configurations (1-4), the distinctions among processor, display, display content, programming, and conscious observers are either nebulous or dualistic. By association, so are the distinctions among time, space, matter, causation, and life and consciousness. By the time we reach configuration 4, the GR relationship holds for space and time, and the QFT relationship holds for matter and quantum fields (spatial distributions of energy of which elementary particles are energetic excitations). But we still have Cartesian mind-matter duality, the continuum vs. discrete array problem, causal deficits associated with quantum indeterminacy, and the apparent absence of anything holding processor and display together.

Why should it be necessary to "hold processor and display together"? The reason, which will be explained in more detail below, is basically an inexorable dualism. While configurations 1-4 reflect the historical physicalism (or "metaphysical naturalism") of mainstream science in general, thus mandating the confinement of reality to the display (which is where perceptible physical states reside), processing is a *function* of states which is not amenable to display. To an extent, processing and display are incompatible functions; processing must be halted in order to display the states it produces. It follows that processing - the dynamics of reality - cannot inhabit the display and must therefore reside elsewhere, specifically in a location adjoining the display and separated from it by

an interface that allows it to receive input from and deliver output to the display.

In the sciences and beyond, reality is usually considered to be confined to space and time, which are now understood to be everywhere coupled in a hybrid medium called "spacetime". But the nature of this linkage is not yet fully understood, and there are many outstanding questions. In particular, what is time, and if it is a physical process, where is it hiding? Empirical science cannot tell, because time is not empirical – one sees only its correlates, its input and output states. Because science wants so badly for everything to be "physical" and thus directly observable as states in the display, the structure and dynamics of reality are pigheadedly reduced to structured sets and temporal sequences of states and state-transition events visible in space – i.e., of display and processing respectively - and it is thus assumed that reality consists entirely of time and space as a joint medium for matter, energy, and life. Aside from empirically induced transformation equations, it is not usually considered what might be holding space and time together.

While each of these configurations (1-4) has its own problems, all of them must accommodate the exclusory relationship between processing and display, or time and space. While it is sometimes held that certain mathematical equations, e.g. the Lorentz transformations, explain the relationship between time and space, such mathematical niceties are more descriptive than explanatory. The perception of space – the apprehension of state – displaces the direct perception of intervals between states. The only way to perceive an interval is to terminate it on both ends, and this can only be accomplished once the leading (advanced) terminus has already appeared, forcing the reconstruction of the processing stage. But in the end, just one thing is certain: states and virtually instantaneous state-transitions are what display media actually display. Obviously, once a medium has been strictly defined on its capacity to display states (by any name including physicality, materiality, or observability), that which cannot be displayed cannot inhabit the medium, and what transpires between the display level and that which cannot be displayed must transpire beneath the surface through an appropriate interface.

Let's look at the problem more closely. The processing of one state into the next occurs between states – e.g., to produce a state s_2 of X from a prior state s_1 of X, processing must occur between s_1 and s_2 in a processing (state-transition) interval s_1s_2. But the processing interval s_1s_2 can have no duration and therefore must remain hidden, as otherwise there is a time lag during which X has no state at all and thus drops out of the display medium. Thus, what get displayed "in real time" are instantaneous state-transition events coinciding with states themselves; in the

display, "real time" becomes discontinuous, and the transition of one state s_1 into its successor s_2 coincides with display of the single state s_2. Thus, processing and display are necessarily distinct functions and must alternate. The display must therefore be stratified, with the focus bouncing between a hidden processing layer and a visible display layer. In other words, avoiding perceptual or observational disruption requires that processing be hidden so as not to occasion discontinuities between displayed states. But this contradicts the supposition that the display "has both processing and display functionality". To put it as succinctly as possible, **processing is not displayed**.

This is perfectly evident on the quantum scale of processing. First, let the "display" be defined as that which is inhabited by all and only that which it actually displays (we ignore for now the question of whether display requires observation, assuming that reality "observes itself" by the interaction or "mutual display" of its contents). Between measurement events (state transitions) in the display, matter particles exist as *quantum wave functions* containing information on their states, evolving as prescribed by the Schrödinger equation (Schrödinger, 1926). But quantum wave functions are not displayed, and neither are the "probability waves" of which they supposedly consist. Although many people have seen effects and causal correlates of wave functions (e.g., double-slit interference patterns), no one has ever seen a wave function or a probability wave directly. It follows that quantum wave functions do not inhabit the display, and neither do the particles whose states they represent. It follows that particles are not actually present in the display until they have "collapsed" there from another place, and that inasmuch as they continue to exist at all, they must go "somewhere else" for processing.

This implies that processing and display are connected by a background identity that bridges the alternating *display* and *process* functions. Fully satisfying this connectivity criterion requires an ultimate level of reality that is totally self-contained and requires no external background; its background is purely intrinsic and connects all levels of reality and their associated "simulations".

This ultimate identity is the ontically closed Metaformal System (Langan, 2018), on which the following configuration is defined. Readers are referred to previous papers on the CTMU (Langan, 2002, 2017) for further information.

(5) **Generative (conspansive hological) processing and display** (CTMU): Ultimate reality is an ontically self-contained telic self-identification operator $R^* = R_{INT} \longleftrightarrow R_{EXT}$ that simulates itself in a generative multi-level processor-display feedback loop driven by the self-dual grammar Γ_μ of the CTMU **Metaformal System** M describing the structure and dynamics of the operator.

$$R^* = R_{INT} \leftrightarrow R_{EXT} \; [= N \leftrightarrow T] = \text{processor} \leftrightarrow \text{display} \qquad (E.11)$$

Note the 2-headed arrow, which replaces the 1-headed arrows of the last section. It denotes feedback between processor and display. This feedback reflects a terminal form of time symmetry associated with the advanced (retrocausal) and retarded (causal) semimodels of the CTMU, amounting to the "display confinement" of metacausal CTMU grammar. (Langan, 2019)

Before continuing this description in Section VI, here is a simplified review of the Metaformal System (Langan, 2018).

V. CTMU / THE METAFORMAL SYSTEM

The CTMU Made Simple

The CTMU can be succinctly described as a language that is structured in such a way as to talk *to* itself *about* itself (which actually makes it a "metalanguage of itself"). This is how it exists and evolves. This reality-language is of a novel form required by its functionality, but still bears description as a language. The form required is that of the Metaformal System M, the supertautological intrinsic identity-language of reality. M is the linguistic self-configuration through which reality identifies itself, and which allows us to identify reality with certainty by direct replicated perception. Its existence is implied because this is what we, and reality, actually do.

When we say that reality "talks to itself", this means that its ingredients, syntactic identification operators, are communicating and interacting with each other, "talking and listening" for purposes of self- and mutual identification. (Identity operators are active objects which identify or determine the states of other identity operators.) Reality uses internal images of itself to self-communicate and self-transform. When we say that reality "talks about itself", it means that the formal and substantive aspects of identification operators are inseparably coupled within them; the formal intension of each operator couples to its extensional substance in the (external and internal) states of the operators. Thus, what reality "says to itself about itself" is truthfully bound to the actual content of reality.

If one finds it hard to see how language and reality could have anything in common even though everyone uses language to describe various parts of reality every day, then one can focus on the identification operators themselves, and view reality as a kind of "operator algebra". This is an *identity system* consisting of identity

operators that identify the states of other identity operators. Each identity operator identifies itself by self-modeling, and by the virtual synonymy of modeling and simulation, "self-simulates" in the bargain. One can think of these operators, albeit simplistically, as a swarm of interpenetrating spheres which intersect and absorb each other - or internally "simulate" each other - in space and time, but extend into "metaphysical pre-reality" or the nonterminal domain N in order to do so. They interpenetrate through a grammatical operation called *conspansion*, and couple with each other and transform their states through a "protocomputational" self-modeling operation called *telic recursion* which collapses and displays their wave functions in terminal measurement events (where protocomputation is a primitive generalization of computation appropriate to CTMU structure). Thus, not only is reality a self-modeling identity operator and therefore a global self-simulation, but it everywhere consists of conspanding identity operators and is therefore "quantized" in terms of self-simulative conspansive cycles as well. That is, it is *everywhere* a self-simulation (Langan, 2002). The conspansive cycles of identity operators quantize reality with respect to not just self-simulation, but consciousness and emergent quantum information.

The metaformal structure of the RSS leaves no doubt about the self-simulative character of reality. Unlike the artificial reality-simulations depicted in movies like "Tron" and "The Matrix" (which the CTMU predated by over a decade), the reflexive reality simulation of the CTMU is natural, reflexive, and without need for an artificial host system. It is its own host system, with all functions distributed among the id-operators of M and the points of its manifold. This manifold has both processing layers and a top spatiotemporal layer which serves as its "display medium". In its nonterminal processing stage, the self-distributed host system of ultimate reality self-simulates by (1) using its metacausal grammar to "pre-simulate" its future states in terms of its past states in nonterminal pre-reality N; (2) advancing to the display stage and collapsing nonterminal telons (metacausal relationships) to the terminal content of its display T; and (3) iterating over and over again in a vast, highly orchestrated multilevel feedback loop, generating all of the action visible on its spatiotemporal "display screen".

The Metaformal System can be dually expressed as follows:

$$(M{:}L \longleftrightarrow U) = (\Sigma_M\{N,T\},\, \Gamma_\mu,\, S_\Sigma) \tag{E.12}$$

This equation identifies M as an ontic identity operator and a trialic intrinsic language.

On the left side of equation E.12, which reads "M:L$\leftrightarrow$U", are the following symbols:

M: The active identity (metaformal linguistic id-operator) of reality as we know and perceive it. Its structure and dynamics are those of the CTMU Metaformal System, the intrinsic metalanguage of reality whose signs are active identities (intension|extension coupling operators, identity operators, id-operators). M is logically induced from reality as it is known through human cognition and perception of its pattern and substance, where *logical induction* is the inference of necessary and sufficient support for the self-identification of reality, i.e., inference of the requirements of existence and intelligibility.

M is also referred to as the "global operator-descriptor" or G.O.D., so called because it is a *global* identification *operator* which distributes itself over reality as a universal syntax or *descriptor* in terms of which it identifies reality both directly and through secondary and tertiary id-operators. M may be called R* when the self-simulative aspect of M is emphasized, or symbolized as Γ when the emphasis is on its grammatical aspects. Where the emphasis is on cosmology and/or quantum theory, M can be taken to stand for *multiverse, metaverse, metareality,* or *metaphysics* (words which are conventionally ambiguous, but amenable to precise definition in the metaformal context).

M is a metaphysical structure in which existence is coupled with identification and intelligibility, which amounts to a coupling of ontology and epistemology. (This coupling should in any case be obvious; something must be *identified* before *existence* can be attributed to it, and only where it *exists* as a concept or percept can it be *identified* as such.) Owing to the dual role of its id-operators as the signs of its signature and the points of its inherent manifold, M is a *supertautology* and thus a logical necessity. Much can be known of the structure of reality from its functional properties even without enumerating its nonlogical ingredients.

M is a metalanguage of the object-language L of cognition and perception. Accordingly, the signature of M can be regarded as a "metasignature" relative to the signature of the formal object-language L, as it "wraps" or packages L in syntactic operators forming the "active signs" of M and the dynamic points of the conspansive manifold. In effect, the metasignature of M "converts form into substance" by packaging the generic formal identities of L in id-operators instantiated by their states, filling them with content and thus coupling L and U. Without this coupling, reality would be neither self-intelligible nor intelligible to us as its internal self-images, over whom its generic structure is distributed as the syntax through which we recognize the world and the grammar through which we

help create it.

L: The purely intensional (uninstantiated/non-extensional) aspect of the active identity (metaformal id-operator) M; the universal descriptor. L can also be regarded as the object-language of M, coupled by M with specific instances in U. It is associated with M-syntax or the universal distributed form (UDF), which includes all properties and formal or abstract structures in terms of which all real objects, relations, and processes are identified in M. The UDF consists of syntactic forms (grammatical nonterminals), formal definitions (formal / generic identities with empty extensions), and formal expressions.

$\leftarrow\rightarrow$: The generic structural and grammatical coupling of L and U, refined by identity operators via the CDF to the content of the terminal domain. The CDF is the *conditional distributed form*, a kind of "post-semantic syntax" or metrical pattern of extended superposition in N which records and potentializes the progressive semantic binding and localization of id-operators leading to the terminal distribution of mass and energy in spacetime. The CDF can be thought of as connecting the UDF, the "universal accepting|generative syntax" or generic intensional self-model of reality, to the terminal domain or extensional "display". It can be dually associated with the grammatical factorization of telesis by id-operators, thus generating conspansive medium|content relationships in T (the self-simulations of id-operators), and the terminal interactions of physical objects in state-transition events.

U: The extensional aspect of the active identity (metaformal id-operator) M. U, standing for the *universe* or domain of discourse of the formal language L, consists of specific directly discernible instances of L, i.e., fully localized tertiary id-operators obeying an appropriate exclusion principle. The discernibility criterion amounts to a "display criterion"; discernible instances are limited to fully localized states in U. U thus coincides with the physical content of the terminal domain … the matter distribution of spacetime. The spacetime metric, on the other hand, occupies the CDF, which interconnects the contents of U and connects U to L, scaling and localizing L.

On the right side of equation E.12, which reads "$(\Sigma_M\{N,T\}, \Gamma_\mu, S_\Sigma)$", we have:

$\Sigma_M\{N,T\}$ is the **signature** of M with nonterminal and terminal subsignatures (or "stages") N and T. Σ_M contains the "components" of M, including the self-dual primary (global-teleological), secondary (organo-telic), and tertiary (micro-physical) identity operators; their structural and functional similarity defines the self-similar mereology of M. The identity operators are both the elements of the

id-operator algebra or "id-system" of M and the points of its intrinsic manifold, supertautologically binding algebra and geometry together in M. This relationship is not determined on the physical (tertiary) level alone, but on the primary and secondary levels associated with teleology and organic telesis. Each id-operator alternates between the terminal and nonterminal domains by conspansion; thus, N and T are best regarded as "stages" of the operators. Σ_M spans L and U, N and T, and all mereological scales of M (primary, secondary, tertiary).

$\mathbf{\Gamma_\mu}$ is the mu-morphic **grammar** of M. It is generative, factoring telesis into medium|content relationships. It involves two operations, *conspansion* and *telic recursion*, by id-operators. These operations are respectively analogous to generic processing and specific programming, where "programming" is the self-modeling of M and its secondary telic id-operators. Γ_μ determines bundles of intertwined and intersecting terminal strings or event-sequences in T, imparting to system dynamics hidden levels of causal organization which are not locally evident in T itself. Although the events thereby related seem to be independently (and often "randomly") determined by local causation, they may – given sufficient freedom provided by the generativity of Γ_μ – be determined instead by nonlocal dependencies among distant points of T which intersect and couple grammatically in N without actually violating locality.

Grammar evolves orthogonally (projectively) with respect to the timelike evolution of spacetime. The localistic causal evolution of spacetime is thus largely illusory except in classical (non-quantum) contexts, being projected from the nonterminal domain N onto the terminal domain T by Γ_μ as standard "physical causation". In other words, thanks to Γ_μ-mediated nonlocal feedback and telic recursion (adaptive grammatical self-organization) in N, terminal strings or temporal event-sequences effectively emerge into spacetime along their entire lengths. Together with other aspects of M, Γ_μ is thus the basis of a new approach to self-organization and emergence in complexity theory.

$\mathbf{S_\Sigma}$: **Strings** are timelike sequences of terminal-stage identity operators (active signs or symbols) from Σ_M, specifically from the terminal subsignature T, with their fully resolved external states. They are subject to rules of syntax and orthography, which include the "laws of nature" or "laws of physics" controlling sequences of states and state-transition events in T. Strings describe the apparent time evolution of the tertiary id-operators in T as they interact in mutual state-transition events.

VI. THE METAFORMAL SYSTEM AS REALITY SELF-SIMULATION

Here again is the RSS configuration presented at the end of Section IV.

(5) **Generative (conspansive hological) processing and display** (CTMU): Ultimate reality is an ontically self-contained telic self-identification operator $R^* = R_{INT} \leftrightarrow R_{EXT}$ that simulates itself in a generative multi-level processor-display feedback loop driven by the self-dual grammar Γ_μ of the CTMU **Metaformal System** M describing the structure and dynamics of the operator.

$$R^* = R_{INT} \leftrightarrow R_{EXT} [= N \leftrightarrow T] = \text{processor} \leftrightarrow \text{display} \qquad (E.11)$$

N and T are (respectively) the nonterminal and terminal levels of the signature Σ_M of M and its dual stratified (conspansive) manifold. The elements of Σ_M are id-operators occupying primary (cosmic), secondary (mesoscopic/biological), and tertiary (submicroscopic/quantum) levels, with higher-level elements coordinating those below. N and T are not disjoint, but describe alternating functions of the id-operators; i.e., the elements alternate between N and T in the conspansive cycles of Γ_μ. In N they are active signs subject to conspansion and telic recursion (the operations of Γ_μ); in T, they are the fully localized points of the "physical" spacetime manifold. Thus, the active (operational) signs of the signature are the dynamic (conspanding) points of its corresponding medium.

The Reality Self-Simulation (RSS) can be identified with the Metaformal System M as follows. The nonterminal aspect N of its signature Σ_M is the processing stage of the RSS, and the terminal aspect is its display stage T. The strings S_Σ of M are the spacetime histories of the tertiary identity operators (identification operators, id-operators) of Σ_M, i.e., the static and dynamical content of the display. M-grammar Γ_μ, a "metaprocess" orthogonal to the time parameter of T, is the self-dual process by which identity operators self-model or "program N" with input from T, and by which N adaptively processes the input and delivers output back to T. Secondary id-operators existing in both N and T thus function as observers, programmers, and processors. The primary or "teleological" id-operator M coordinates it all.

Because the processing and display functions are associated with each identity operator of M – because the display elements conspansively feed back on themselves in grammatical processing-display cycles - processing is distributed alongside display. T is the display, consisting of display-stage elements, while N is the processor, consisting of processing-stage elements, with everything coordinated by the primary id-operator $R^* = M$ using the same grammar and syntax of which more or less restricted versions are used by secondary and tertiary operators on biological and quantum scales, endowing the system with profound structural and

dynamical self-similarity). The tertiary elements of N are in the processing stage of their conspansive cycles, while the tertiary elements of T are the display stage. N and T coexist as levels of a manifold over which the generic structure of M pointwise-distributes as grammar and syntax.

Identity operators, each of which has dual processing and display functionality in N and T respectively, repetitively collapse from N into T and then recede from T back into N by inner expansion. As identity operators play dual roles, being the signs of the signature and the points of its dual manifold, the conspansive evolution of the extensional manifold of M mirrors the grammatical evolution of the linguistic intension of M by factorization of nonterminals into their derivational successors. Thus, the points themselves furnish the processor-display (N|T) interface. Unlike the dualistic remote-processing configurations 1 and 2 in Section IV, processor and display are not separate, but dual aspects of a single unified logico-geometric manifold; unlike the distributed-processing configurations 3 and 4, processing does not occur in the display T, but in deeper layers of N (over which it remains distributed).

Due to the generativity of the system, whereby points inner expand into N and recollapse in T to form new states within their predecessors and are thus factored into medium and content, tertiary points of the conspansive manifold are subsimulations unto themselves. For any pair of successive states s_1 and s_2 of any given pixel, s_2 is displayed within its inner-expanded predecessor s_1 (the "display medium") by collapse. Secondary (self-modeling, self-organizing) meta-points connect the tertiary subsimulations to form telonic subsimulations of higher complexity, driving the emergence of higher-order information and filling causal deficits associated with quantum indeterminacy while functioning as observers with a generic "consciousness" attribute proportional to self-modeling or "programming" capacity.

Thus, the secondary and tertiary id-operators of the CTMU Metaformal System M serve as processing elements in N, display elements in T, the states transformed in N and displayed in T, self-modeling programmers, and conscious observers. M itself, the primary id-operator of reality, provides the distributed structure and overall coherence to fully support these functions.

VII. SUMMARY

The RSS, while not without complexity, may be compactly described as an ontically and epistemologically closed ("ultimate") telic identity operator R* with the unique structure of the CTMU Metaformal System. This telic identity operator

can be conceptualized as a *multiverse*; this is due to the nature of generativity, whereby the generative grammar of M selects each new state from an uncountable range of possible next states, projectively coupling the invariant UDF with any terminal configuration supported by it ("coupling alpha with omega").

The Metaformal System is a supertautology, i.e., an intrinsic (perfectly self-contained) identity language that is trialic (comprises its own universe and model), with the identity operators of its signature being the points of its universe and the substantive content of the points while also serving every other essential function of the system. It is an ontological and epistemological necessity of the coherent existence and evolution of reality as it is experientially and scientifically known to its secondary telors, i.e., its resident observers including human beings, for whom it functions as a universal identity-language. Its generic implications are inarguable, revealing the nature of reality even without exhaustive enumeration of its nonlogical ingredients.

The ingredients of the Metaformal System exist in perfect correspondence with the functional components of the RSS, which are as follows:

(1) Processors and processing elements

(2) Display and display elements

(3) Processor-display connections or communication channels

(4) Modeling or programming operators

(5) Observers or observation operators

(6) Display content, including states, events, and processes

Respectively, the above components correspond to the following ingredients of M:

(1) Telic identity operators in N (nonterminal prereality)

(2) Tertiary identity operators in T (terminal or physical reality)

(3) Γ_μ conspansive N$\leftarrow\rightarrow$T cycles involving all levels of identity operator

(4) Telic identity operators configuring in N for actualization in T

(5) Telic identity operators reading display content in T

(6) Strings, or processes, consisting of the successive external states and interactive state-transition events or "worldlines" of tertiary identity operators .

As previously noted, the Γ_μ conspansive cycles of the identity operators in Σ_M and S_Σ quantize reality with respect to not just self-simulation, but consciousness (coherent self-identification and self-modeling capacity) and emergent quantum information. It follows that reality is ultimately a self-simulation possessing not only an unbreakable quantum ontology, but its own primal form of consciousness and a new paradigm for self-organization and emergence.

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