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Implications of Triads as Primal

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Abstract

Triadic relations are shown to be grounded in fundamental logic and important for overcoming classical metaphysics assumptions, including determinism and space-time actualism. Heisenberg's discovery of quantum physics a century ago has now led to recognizing distinct orders for a logic of possibilities and a logic of actualizations along with seeing space and time as emergent from quantum process. Two fundamental measurement problems, one quantum, one cosmological, are shown to both arise from the presupposition of space-time actualism. Substance thinking and dyadic thinking are now overcome through triadic relations and multiple levels of context that pervade both biological systems (reflected in biosemiotics) and physical systems, illustrated in new possibilist understandings of fundamental quantum process.

1 Triads as Primal

George W. Shields (1951-2020) articulated fundamental logical and philosophical arguments as to why triads are primal within the first section of our joint paper [9]. These arguments are summarized below followed by a survey of implications, from metaphysics to quantum physics. In digital computers, scientific modeling and most applications, a digital, binary logic of circuit state 'on or off', '1' or '0', is used at the most basic level on the assumption that any intermediate state is disallowed, the 'principle of excluded middle.' This yes-no binary description is central to classical physics and a wide range of dyadic and dualistic philosophical arguments and applications from Descartes' mind-body dualism to contemporary artificial intelligence.

The approximations of classical physics have been so successful that many have adopted its corresponding metaphysical claims, including determinism, reductionism, and external (versus internal) relations. These claims are closely tied to a worldview of perceptual objects in which it is presumed that all meaningful statements about reality can be directly linked to events in an objectified, externalized space-time framework. Mechanistic models based on classical physics reinforce such space-time actualism, and the success of relativity theory further encouraged reductions to space-time focused descriptions.

Here, in contrast, I show the breakdown of such dualistic, mechanistic thinking and classical metaphysics, and then summarize how triadic (not dyadic) relations are deeply embedded in fundamental logic. Following that I lay out how considerations of fundamental logic and triads as primal have important implications for the understanding of quantum physics. This is followed by explaining the arrow of time, and results in fundamental ontology focused on unity and plurality. In addition to how the presupposition of space-time actualism impacts two fundamental measurement problems, I briefly review the application of triadic thinking to a more general theory of relations (semiotics or the theory of signs).

2 Breakdown of Classical Metaphysics

Central to the classical metaphysics framework is a view from nowhere, effectively a God's-eye view, conjoined with a container view of space-time [24]. All basic propositions about the real world are then regarded as mappable to statements about particular input-output relations among space-time events.

Our interactions with the world are very often modeled as simply combinations of input-output. This is the essential core of the digital computer world where coded algorithms map specific inputs to specific outputs under the assumption that all well-formed propositions (codable software statements) follow a Boolean (yes-no/on-off/1 or 0) logic. Boolean logic is based on the excluded middle principle noted above, which does not allow for intermediate outcomes such as yes-no-maybe or on-off-indeterminate. Such actualized space-time description appears inevitable from a view from nowhere. The determinacy of the classical physics model encouraged acceptance of the excluded middle doctrine and space-time actualism. Further, the exceptionally good approximations of classical physics for most practical applications encouraged the common acceptance of several classic metaphysics notions, especially (1) local causality and determinism, (2) mechanistic materialism, and (3) space-time actualism. These metaphysical notions have been closely linked, in turn, to (1) treating physical laws as generalizations of excluded-middle algorithms, (2) converting the power of methodological reduction in science into ontological claims of reductive, substance metaphysics, and (3) converting the efficacy of spatialized time-space models into effectively a metaphysical claim that reality is nothing but the interactions of things within and across localized space-time elements.

To varying degrees, the discovery of quantum physics and relativity theory early in the 20th century began to undermine commitments to these classical metaphysics notions through the following developments:
(1) indeterminism in quantum physics (see 'Interpretations of Quantum Physics' below);
(2) process-relational versus substance philosophy; other non-materialist approaches ([5], [6] and [11]);
(3) relational networks of time-space emergence versus space-time substantivalism [11].

3 How triadic (not dyadic) relations are embedded in fundamental logic

On fundamental logical grounds, it can be readily shown that "Hume's phrase 'what is distinguishable is separable' is false and necessarily so" ([9] p.3). In particular, "a cumulative totality A*B entails its parts, say A, but A does not imply the totality A*B. In the case of entailment, then, the 'conditioning' is asymmetrical and the order matters and this mirrors temporal inclusion and creativity." (ibid.) This result derives from an even more fundamental result in logic associated with completing the set of all well-formed formulas of propositional logic involving the works of David Hilbert in the 1920s, and the recognition that Peirce's Theorem, deriving from the logical works of Charles Sanders Peirce (1839-1914), enabled the completion of Hilbert's program. In turn, the Peircean logic of asymmetrical inclusion indicates the fundamentality of asymmetrical triadic relations. As a result, for any real system (not simply a model), any dyadic symmetry is always encompassed by some triadic asymmetry. Such triadicity is well modeled by triquetras, the Celtic icon of movement and triadicities, as laid out by Franses and Griffiths [14].

Shields et al. further show how an analysis of the logic of fundamental process, given this triadic framework, "mirror[s] the general evolution of quantum states...from actual states to potential states rife with quantum superpositions...and a return to actualization. Mathematical modeling of such states would also reflect a triadic structure where the transitions are from Boolean [actualities] to non-Boolean [possibilities] and back to Boolean descriptions" ([9] p.6).

Randall Auxier states that Josiah "Royce [1855-1916] was a creative logician, probably the first to formalize a logic of possibility in his 1878 Primer of Logical Analysis" ([1] p.147). Royce's logic and triadic theory of signs likely influenced Peirce although specific influence is unclear. Royce's logic work focused on how "to generalize Whitehead's universal algebra into a theory of symmetrical groups, specifically tetrads" ([1] p.149). The importance of these logic issues is indicated by how "pluralizing Boole's [dyadic] algebra and getting it to interact with other formal systems has become the very key to developments such as internet search engines and large language models for artificial intelligence, Whitehead's algebra and theory of extensive connections made a crucial contribution to these fields" ([1] p. 149).

4 Interpretations of Quantum Physics

Werner Heisenberg's discovery of quantum physics was an unexpected, genuine discovery. Later analyses clearly showed how it pointed to a real domain of possibility (*potentia*) that is coextensive with our externalized world of time and space events. Given that the triadic logic of relations lies at the most fundamental level of logic and metaphysics, it can then be applied to any model of real physical systems. In the case of current interpretations of quantum physics, all interpretations include a role for deterministic (unitary) evolution of quantum states, which corresponds to how the Schrödinger equation has deterministic form. This aspect of quantum evolution was called Process 2 by John von Neuman. However, quantum measurement always incorporates symmetry-breaking with von Neuman's Process 1, which involves exceptions to such strict entailment.

A standard interpretation of quantum physics, initiated by Niels Bohr, avoids any ontological claim and focuses only on correlations of measurement outcomes. This epistemological approach is consistent with experiments but avoids ontic questions about underlying fundamental processes. Several statistical interpretations similarly evade questions of ontology. In contrast, the ontologically realist many-worlds interpretation treats the wave function as real and interprets the presumed deterministic evolution as branching out to an unlimited number of actualized worlds in conjunction with each and every measurement. Such dramatic ontological overflow is avoided in one interpretation by postulating that consciousness causes collapse of the wave function, but this introduces a complex, subjective feature. Most attempts at a realist or ontic interpretation maintain ongoing deterministic (unitary) wave function evolution and add on some ill-defined 'collapse' process. A sophisticated form of this approach is Rovelli's Relational approach, which maintains deterministic evolution and claims that his version of wave function collapse with outcomes 'relative to observers' can solve the measurement problem. However, as Ruth Kastner explains, this "simply appropriates by fiat the very empirical data that its underlying theory admittedly fails to explain" [21]. All other interpretations that maintain a unitary-only approach (many worlds, consistent histories, modal, de Broglie-Bohm, statistical) are undermined by Kastner's powerful critique.

This failure of unitary-only approaches is further reinforced by recognizing the fundamentality of triadic relations. The former are like a 'bucket brigade' in which a sequence of dyadic (input-output) bucket-passing relations result in a fully determinate final output without any essential reference to possibilities or context. Each input plus an algorithmically-determined trajectory fully specifies the output, and the 'bucket brigade' sequencing continues in a fully local causal way [19]. In contrast, more fundamental triadic relations, which include the dyadic as a limit, incorporate input, output and context. Such triadic asymmetry includes simple input-output dyadic symmetry and yet provides for possible alternative and active outputs (prehensive and active 'out-take'). Applying the fundamental logic of triadic relations necessarily involves a higher level non-unitary interaction of input to out-take. Indeed, such more general relations appear in quantum field theory, which includes the concepts of emission and absorption, and provides for active emitters and active absorbers. Each emitter provides offer waves, enabling a possible transfer of energy, but only one such offer-accept transaction can be actualized, which results in Von Neuman's Process 1 with its non-unitary measurement transition. The inevitable context of multiple possible absorbers and active acceptance (actualization) by one specific absorber among others then fleshes out the logically required triadic asymmetry, which includes the simple input-output dyadic. Improperly assuming the latter representation as the full reality corresponds to the framework of deterministic unitary-only accounts, none of which have been able to resolve the quantum measurement problem.

Ruth Kastner has explicitly shown how non-unitary interactions with both emitters and active absorbers provide a realist account of Von Neumann's Process 1 and a quantitatively correct basis for the measurement process and the Born rule, which links the deterministic mathematical description of a quantum system (its wave function) with probabilistic results of actual measurements [20]. Further, Kastner shows how the fine structure constant, the fundamental coupling constant for electromagnetism, represents the basic probability of the occurrence of radiation. Her very successful approach to resolving the famed quantum measurement problem builds on a well-established theory for direct interactions between field sources without invoking mediating fields ([20] p. 99). Critics of Kastner's possibilist approach almost always presuppose space-time actualism and, assuming this, argue that her advanced propagation solutions represent unreal (retro-causal) movements into the past. In contrast, Kastner is very clear that quantum possibilities are not spacetime entities; such advanced solutions are functioning within a possibilist quantum pre-space, and not within and among actualized space-time events ([19], [20]). In my view, by avoiding ad hoc features, vague references to wave function projection or collapse, or some reduction to only pure states or only unitarity, Kastner has achieved, through her possibilist interpretation, the most clear, elegant and quantitative interpretation of quantum physics available. Her approach also enables a robust affirmation of dualities without dualism[1]: unitary and non-unitary, Boolean and non-Boolean[2], Yang and Yin.

A recent confluence of possibilist interpretations of quantum physics is illustrated by the seminal paper "Taking Heisenberg's Potentia Seriously" [22], which argues in support of Heisenberg's own possibilist understanding of his unique discovery a century ago. This paper is highlighted in my essay "Orders of Possibility and Actuality" [12], which shows how the hypothesis of distinct orders for pre-space *potentia* and actualized space-time events resolves a number of both scientific and philosophical problems, especially unstated assumptions, such as determinism and space-time actualism, associated with classical metaphysics.

5 On the Arrow of Time

Given that the Schrödinger equation has deterministic form and is time symmetric, it is then unclear why time appears to move in only one direction, namely from past to future. Efforts to resolve this arrow of time problem typically turn to thermodynamic or statistical arguments. Drossel and Ellis [8], for example, utilize these arguments, imbedded within a spacetime actualist framework, and conclude that "the arrow of time...in the end derives from cosmology." While maintaining local-global context, possibilist understandings of fundamental quantum process affirm both symmetry and asymmetry and yet avoid appeals to cosmic scale. Everywhere/everywhen, at the transition from pre-space potentia to actualizations, both time and space constantly emerge from fundamental quantum process (both unitary and non-unitary; both Boolean and non-Boolean). Such fundamental process drives the arrow of (always emergent) time and space relations of actualized events. As stated by Kastner, "basic physical laws are symmetrical with respect to both space and time but describe only potentialities, and... actual events and processes arise because of symmetry breaking...[yielding] the 'arrow of time...[T]he actual breaks the symmetry of the potential'" ([18] p. 201–202).

This analysis also helps to clarify issues of emergence and causation as well because "at the intersection of semiotics, information theory, process

[1] This theme is the focus of my paper Duality without Dualism [10]

[2] Concerning Boolean and non-Boolean logics, see Conclusion; ([26], [11])

thought, and quantum physics lies the need to distinguish two fundamental types of relation: (1) relations with a synchronic focus as required for the analysis of emergence and semiotics, and (2) relations with a diachronic focus as required for the analysis of fundamental quantum process and causation" ([11] p.104); see Chapters 3 and 4 of my *Untying the Gordian Knot* for details.

6 On Plurality and Unity

The radical diversity of specific actualizations exemplifies pluralistic philosophies, which often focus exclusively on an order of actuality. The complementary, co-extensive order of possibility, highlighted in [22], [11], [12]), is yet more radically pluralistic with vast multi-dimensional realms of *potentia.* The natural order of actualizations is entirely contingent. Now suppose that the realms of *potentia* are entirely contingent as well; then everything, without exception, is contingent. However, philosopher Lorenz Puntel argues that "The thesis that everything is contingent entails not only the assumption of the possibility of absolute nothingness but also an additional assumption: that beings could somehow emerge from absolute nothingness into the dimension of being...But the thought of even a possible emergence of beings from the unthinkable 'dimension' of absolute nothingness...is a simply senseless, impossible pseudo-thought: no being of any sort whatsoever could come from absolute nothingness" ([27], p.445). For this reason, the realms of *potentia* arguably require a grounding in some non-contingent actuality ([27], p. 446). As part of his ontology, Whitehead was a proponent "of what Hartshorne calls the 'essential argumentative kernel' of the Ontological Argument...'Something exists' is a necessary...truth. This is Hartshorne's 'Principle Zero' (P-Zero). This truth is a precondition for all coherent thinking, a position corroborated by the doctrine of [Whitehead and Russell's] *Principia Mathematica* that the universe of discourse cannot be empty" ([30],p. 228).

Mechanistic, substance philosophies often moved to a reductive pluralism of only contingent actualities. In contrast, Spinoza represents the opposite reduction to a monism of only one substance in all reality, God or Nature. The above logical argument points to a fundamental unity within the order of *potentia* so that, among ultimacies, we have both unity and plurality. Implications of this fundamental duality without dualism are laid out by

Andrew Davis in *Mind, Value, and Cosmos: On the Relational Nature of Ultimacy* [6].

7 Two fundamental measurement problems–one common source

A container view of space and time, or space-time actualism, is widely implicit (if not explicit) in many scientific descriptions and models. This God's-eye view approach to time and space[3] relations was explicit throughout two centuries during which highly-successful Newtonian models and classical physics dominated the physical sciences up through the early 20th century. After the introduction of Einstein's General Theory of Relativity (GTR) in 1915, time and space relations (previously fixed within the cosmic arena) became variable and interdependent. Indeed, the geometry and the physics came to be treated as co-extensive in GTR models. Matter and energy warp the fabric of spacetime whose curvature determines in turn the motion of matter and energy. Gravity is then not a force but the result of objects following 'straight' paths (geodesics) in a curved, four-dimensional spacetime. Throughout the last century, numerous efforts have been forwarded to develop a unified theory combining both gravity and quantum physics under the assumption that GTR is equally fundamental to the quantum physics. These efforts towards a unified theory have largely failed. Further, GTR's combining of geometry and physics leads, unfortunately, to a cosmological problem of measurement as developed in detail by Gary Herstein (2006) in his *Whitehead and the Measurement Problem of Cosmology* ([15] and [2]) as follows:

"If the structure of space is a contingent aspect of physical influences, then we must first know the nature and distribution of those physical factors before we can know the geometry of any spatial region. But in order to know this distribution of physical factors, we must be able to make accurate and reliable spatial measurements properly to place and relate

[3]Time and space relations of actualized events are constrained by relativity physics; however, reference to 'spacetime' often presupposes space-time actualism. To avoid such spatialization, being mindful of Milic Capek's extensive critique of the fallacy of spatialization ([4] Ch. XI), we here avoid 'spacetime' language and refer instead to 'time-space' or 'time and space' actualizations or emergence.

those contingent, physical influences upon any given point of space. But in order to make accurate and reliable spatial measurements, we must have a robust understanding of the geometry of the spaces in and through which we are measuring. Only with the latter can we understand the effects on our standard unit of measurement of the non-uniform and contingent projective relations of those spaces, and thereby establish a logically meaningful system of conjugacy with the things to be measured. Yet such a robust understanding of the geometry of space is precisely what we do not have, and cannot establish, for it is exactly what G[T]R refuses to grant us" ([2] p.103-104).

In the case of quantum physics as discussed above, the commitment to space-time actualism displaces any distinction between the orders of pre-space *potentia* and actualized time-space events. This is especially clear with the many-worlds interpretation. With both measurement problems, one in quantum physics and one in cosmology, holding on to space-time actualism contributes to the problem: for GTR, equating the physics with an ontologized geometric framework without grounding that framework in a workable basis for measurement; for quantum interpretations, maintaining deterministic approaches that apply only to space-time actualizations and failing to recognize the context of an order of pre-space *potentia*. Finally, it has been recently shown that GTR can be derived from quantum field theory, which indicates that it is derivative to quantum physics and not a fundamental theory ([29]). This result may also explain the ongoing failure of proposed unified field theories that attempt to incorporate GTR. In a sense, we already have such a unified theory provided that one denies the assumption of space-time actualism and affirms a possibilist framework that incorporates both the orders of pre-space *potentia* and actualized time-space events.

Although GTR overcame the classical metaphysics assumption of a fixed space-time container for events, the deployment of variable geometries co-extensive with the physics still retained space-time actualism. This variability and GTR's powerful tensor formalism has enabled the Big Bang research program to flexibly interpret a very wide range of anomalous observations; however, its in-advance predictions have been exceptionally limited as I have noted in "Cosmic Agnosticism" (Eastman 2009), and clear falsifications have recently appeared with observations of NASA's James Webb Space Telescope (JWST). Alternatives should now be more seriously considered; for example, Eric Lerner's model, which successfully predicted (in advance) JWST observations of fully-formed early galaxies ([23]; [28]). In addition, Lerner has also shown that galactic size data are best fit with predictions of a non-expanding universe "with no free parameters. But predictions based on the expanding universe hypothesis provide no acceptable fit to the same data, despite having an additional free parameter" ([23], p. 3190; also see 'Science' at lppfusion.com).

8 Consequences for Semiotics

C. S. Peirce introduced the fundamental categories of firstness, secondness, and thirdness which, respectively, denote possibility or ideas, then givenness or actuality, and finally mediation and generalities. Peirce determined as well that all higher order relations can be analyzed in terms of triadic or lower-level relations, which corresponds to the logic argument in the section above on triadic relations.

Peirce's theory of signs or semiotics was triadic, including the sign, an object and an interpretant or interpretive context. One example could be a bone as pointing to 'dinosaur' as the object with the interpretive context being a geological stone formation containing what used to be a normal bone. Going beyond typical dyads of input-output in science, Peircean semiotics indicates that real systems (not simply models of such) inevitably involve some form of input-output-context[4] triad.

John Deely laid out a major role for the Latin age in his 1000-page intellectual history *Four Ages of Understanding*. Within that history, Deely highlighted the discovery of semiotics by John Poinsot in his *Treatise on Signs* of 1632. In the late 19th century, Peirce independently re-discovered these semiotic relations and went beyond Poinsot by "extending semiotic understanding beyond the sphere of cognitive phenomena to the whole of nature itself as a network virtually semiosic in character" [7]. Peirce's extension of semiosis (triadic relationality) to all of nature is compatible with our argument that triads are primal. Although most semiotic analyses are carried out with an epistemological focus, many works in biosemiotics have emphasized as well implications for ontology, including an emphasis on triadic thinking. In particular, Jesper Hoffmeyer states that "It is only due

[4] Alicia Juarrero ([17]) provides an extensive analysis of context and constraints in complex systems.

to the many insights laboriously procured through this (standard dyadic) methodology that enough genuine knowledge is now in place to suggest the hypothesis that such mechanistic and dyadic logic itself, in a more profound analysis, should be seen as subsumed under a more biologically primitive, interactive (triadic) logic" ([16], p. 315)..."evolution has worked an interactive, triadic logic into the organization of life processes [viz. human genome example]...Dyadic modeling (and dyadic thinking) simply does not suffice as an explanatory strategy here... the more we learn about the biosemiotic logic that organizes the processes of life, the more we must expect that a triadic and semiotic understanding will replace the mechanistic and dyadic models of biochemistry" ([16], p. 317).

9 Conclusion

Virtually unlimited networks of input–output–context quantum processes, grounded in unlimited successions[5] of fundamental emission-absorption process[6], enable the ongoing emergence of event actualizations (possibilities-probabilities-actualities). Kastner ([19]) helpfully summarizes this as weaving the world. Instead of a spatialized arena or container of events, temporal and spatial relations of events emerge from such fundamental process everywhere/everywhen, concurrently bridging the orders of pre-space *potentia* and newly emergent time and space actualized events. Constraints within these networks of possibilist quantum process provide a basis for physical relations discovered and applied in physics, exemplified by the use of least action principals to derive basic equations such as Newton's for classical physics or Schrödinger's for quantum physics ([11], p. 138-139).

The common notion that physical "laws" require strict input-output entailment arose from Enlightenment deism and God's "laws" and then led to the classical metaphysics notion of absolute determinism. The mechanist and substance-thinking of classical metaphysics became ever more entrenched with the great success of Newtonian physics throughout the 19th century, bolstered as well by the industrial revolution. The fixed space-time

[5]An extensive analysis of the concept of succession is provided by Jorge Nobo ([25] Ch. 17)

[6]Details of emission and absorption in quantum field theory are provided by Kastner ([20] Ch. 5)

container view of classical physics was upended by Einstein's relativity theories early in the 20th century; however, Einstein's GTR maintained both determinism and space-time actualism with ontologized, dynamical geometric forms. The most important break with classical physics and metaphysics came with Werner Heisenberg's discovery of quantum physics in 1925. Throughout the past century, numerous interpretations of quantum physics have developed and, as yet, by many accounts, seemingly without any clear closure. However, within the past two decades, there have emerged several possibilist interpretations that have enabled major advancements.

Knowledge of any time-space actualized region involves a particular Boolean point of view; yet there is no global Boolean description. Building on earlier work by Jeffrey Bub on non-Boolean logics ([3]), quantum chemist Hans Primas shows how locally-applicable partial Boolean algebras can be woven together to enable a useable Boolean manifold, a structured family of partially overlapping Boolean algebras. "The locally Euclidean geometric structure of the globally non-Euclidean theory of general relativity is an apt analogy for the locally Boolean behavior of globally non-Boolean descriptions. The proper tool for a mathematical formulation of the analogy are Boolean manifolds. Algebraically, Boolean contexts play an analogous role as Euclidean spaces play for geometric manifolds" ([26], p. 44). Michael Epperson and Elias Zafiris ([13]) developed an extensive category-theory framework for understanding quantum physics, which deploys both a (Boolean) logic of actualizations and a (non-Boolean) logic of *potentia* including, as laid out independently by Ruth Kastner, unlimited successions of possibility to probability to actuality. Kastner further showed how frameworks that are based only on unitarily evolving processes (as described by the Schrödinger equation with its deterministic form; von Neumann's Process 2) cannot, in principle, resolve the measurement problem due to the inevitable presence of some non-unitary process (von Neumann's Process 1) in conjunction with non-Boolean actualizations. In her 2024 paper, Kastner [21] demonstrates that both unitary and non-unitary descriptions are essential just as Primas had demonstrated the need for both Boolean and non-Boolean process.

Eastman [12] calls attention to the importance of the joint paper by Kastner, Kauffman and Epperson [22], which builds on the confluence of three independent research programs, and argues for a possibilist understanding of fundamental quantum physics. Combining these results with Schlatter and Kastner [29] on gravity physics as derivative from quantum field theory, one then has a unique combination of unitary and non-unitary, Boolean and non-Boolean, local and global. Further, there is always a global context for any finite system in process of actualization, such being the pre-space, quantum substratum providing possibilist context; once again, triads of input-output-context. If an input-output pair could be fully isolated, then they could be determinate Boolean-only, unitary-only embodiments of classical determinism and local causality. However, any input-output pair (in process of actualizing) is always and inevitably within a context of fundamental quantum process bridging pre-space *potentia* to particular time-space event actualizations.

Triadic relations have a key role at the most fundamental levels for both biological systems and physical systems. For the former, Hoffmeyer emphasizes the "biosemiotic logic that organizes the processes of life" ([16], p. 317). For the latter, we have linked together triadic relations from fundamental logic to the best current understandings of quantum physics. Triadic relations and context are not only important for the sciences but also central to any metaphysics adequate to a new natural philosophy for the 21st century.

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