A Further Review of 'Orch OR' Theory: The Universe in Consciousness

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ABSTRACT

According to Hameroff and Penrose's 2014 review of their 'Orch OR' theory, "The nature of consciousness, the mechanism by which it occurs in the brain, and its ultimate place… are unknown." We propose that these issues are unknowable in their ultra-reductive approach. Their review completely left out the *holistic* view of consciousness as primary, even though it has been the most enduring view throughout history. Also, their review overlooked recent theories of an ontologically real nonlocal information field, a major step toward the holistic view. Reductive assumptions about physicalism, quantum wavefunction reduction, the mind/brain relationship, panpsychism, and the structure of the universe are reconsidered in light of the holistic view.

Key Words:'Orch OR theory, reductive models, quantum mind, consciousness as primary, holistic Vedic account
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Introduction

Stuart Hameroff and Sir Roger Penrose, developers of 'Orch OR' theory, begin their 2014 review article (Hameroff and Penrose, 2014), "*Consciousness in the universe – A review of the 'Orch OR' theory"*, with what might seem to be a noncontroversial, straightforward statement (pp. 39-40):

"Consciousness implies awareness: subjective, phenomenal experience of internal and external worlds…a sense of self, feelings, choice, control of voluntary behavior, memory, thought, language, and…internally-generated images and geometric patterns. But what consciousness actually *is* remains unknown…. Three general possibilities regarding the origin and place of consciousness in the universe have been commonly expressed…

(A) Science/Materialism, with consciousness having no distinctive role…

(B) Dualism/Spirituality, with consciousness… being outside science…

(C) Science, with consciousness as an essential ingredient of physical laws not yet fully understood..."

They are to be congratulated for a deeper view of consciousness as "an intrinsic feature of physical laws," and for attempting to reconcile (A) and (B) in (C). It also is commendable that they extend their theory of consciousness to the Planck scale as the most fundamental, 'finest-grained' metric of physical spacetime. However, their theory remains a *reductive* model of consciousness as built of primitive proto-conscious moments of experience. And none of their three 'general possibilities' properly characterize the *holistic* view of consciousness as *primary,* even though it has been the most enduring view throughout history.

This holistic view is associated with the ancient Vedic knowledge tradition that is said long ago to have addressed 'the nature of consciousness, its relation to the brain, and its ultimate place' as *the basis of the universe—*

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opposite Hameroff and Penrose's view of '*consciousness in the universe*.' From the holistic perspective, the fragmented reductive physicalist view is a severe misunderstanding of consciousness. Because some terms are the same, it is crucial to clarify the profound differences in these views and corresponding meanings of terms.

The holistic Vedic meaning of consciousness

Veda is the oldest continuous knowledge system. Here we apply its re-clarification by Maharishi Mahesh Yogi as *Maharishi Vedic Science and Technology.* In that *completely holistic* account, consciousness is not awareness *of* an object of experience or momentary proto-conscious 'flickerings', does not supervene on the physical or emerge from complexity, and is not accounted for by classical or quantum models of the brain. In distinct contrast, consciousness is primary to all of nature, the *completely unified field of universal Being*. It is phenomenally localized in individual beings as various states of consciousness and objects that appear inert in the ordinary waking state of consciousness.

We first summarize Hameroff and Penrose's theory of consciousness and their related speculations about free will and evolution. This is included to help clarify the key concepts in order to contrast them more effectively with the holistic view. Direct quotes are used to minimize potential discrepancies in the review. We then explain our concerns, and also briefly summarize progress toward the holistic view and its empirical validation.

Review of 'Orch OR' theory

In introducing their fragmented reductive theory, Hameroff and Penrose (2014) state that:

"Consciousness has often been argued to be a sequence of discrete moments. William James…described the "specious present, the short duration of which we are immediately and incessantly sensible…. Stroud… described consciousness as a series of discrete events, like sequential frames of a movie…. Consciousness is also seen as sequences of discrete events in Buddhism, trained meditators describing distinct "flickerings" in their experience of pure undifferentiated awareness…. For example Sarvaastivaadins… described 6,480,000 "moments' per 20 ms (50 Hz). The best measurable correlate of consciousness through modern science is gamma synchrony electro-encephalography (EEG), 30 to 90 Hz coherent neuronal membrane activities occurring across various synchronized brain regions…. Thus, we may argue that consciousness consists of discrete events at varying frequencies occurring across brain regions, for example 40 conscious moments per second, synchronized among neurons in frontal and parietal cortex". (p. 41)

In considering free will, Hameroff and Penrose (2014) note that

"As shown by Gödel's theorem, Penrose…described how the mental quality of 'understanding' cannot be encapsulated by any computational system and must derive from some 'non-computable' effect. Moreover, the neurocomputational approach to volition, where algorithmic computation completely determines all thought processes, appears to preclude any possibility for independent causal agency, or free will." (p. 41.)

Thus conscious choices require *non-computable* probabilistic principles, associated with quantum theory. They relate quantum theory to a discrete 'element of energy' with its limiting frequency as the Planck scale (10^{-33} cm, 10^{-44} sec.), the finest-grained unit of physical nature. The 'Orch OR' theory of consciousness extends neurobiology below the 'gap-junction' neural network all the way to ultramicroscopic, *non-computable* quantum gravity dynamics at the Planck scale. A core issue in quantum theory is how to get from the abstract mathematical quantum wavefunction (such as the Schrödinger equation) to a definite object in the real physical world. As Hameroff points out: "The mechanism by which quantum superpositions reduce to classical states (collapse of the wave function, measurement problem) remains enigmatic."

Hameroff and Penrose (2014) now base 'Orch OR' theory on the *Diosi-Penrose (DP)* version of the *objective reduction* interpretation of quantum theory. This offers an explanation of how to get from superposed quantum states (U or unitary evolution) to definite classical objects (R or reduction). The 'DP' interpretation is said to give an objective physical threshold, "providing a plausible lifetime for quantum-superposed states (p. 49)," "much like a *half-life* in a radioactive decay (p. 52)." The reduction (R) is proposed to result from "mass displacement between the alternatives being sufficient, in gravitational terms, for the superposition to become unstable (p, 51)…;" and at a critical spacetime separation, one alternative 'dies' and the other "persists in physical reality (p. 53)." According to their theory, then somehow a moment of primitive proto-consciousness spontaneously emerges. Hameroff and Penrose (2014) explain:

"The idea is that consciousness…associated with this (gravitational) OR process…occurs significantly only when (1) the alternatives are part of some highly organized cognitive structure capable of information processing, so that OR occurs in an extremely *orchestrated* form, with vast numbers of microtubule acting coherently, in order that there is sufficient mass displacement overall…. (2) Interaction with environment must be avoided long enough during the U process evolution so strictly orchestrated components of the superposition reach OR threshold without too much randomness…. Only then does a recognizably conscious Orch OR event take place. On the other hand, we may consider that any individual occurrence of OR without orchestration would be a moment of random *proto-consciousness* lacking cognition and meaningful content." (p. 59).

"OR is deemed to take place when…tiny space-time differences reach the Planck level…. Owing to the extreme weakness of gravitational forces…the energy…is liable to be *far* smaller…[and not] in direct competition with any of the usual biological energies….supplying a needed energy *uncertainty* that then allows a choice to be made between separated space-time geometries…" (pp. 56-59).

The *uncertainty* between separate space-time geometries in quantum entangled superposition is held to be necessary for a non-computable reduction to a conscious moment:

"If we have a…superposition of two slightly different states…[i]ts basic frequency would be the average…but this would be modulated by a much lower *classical* frequency ('beats') that is the difference between the two…. Accordingly, if we consider that our system consists of a large number of identical quantum superpositions…this beat frequency would become evident across the system as a whole…as a result of the OR process…. Thus, we may consider conscious moments to be Orch OR events occurring with beat frequencies...around 10 megahertz, with time periods of $\sim 10^{-8}$s. Decoherence might need be avoided for a mere ten-millionth of a second with consciousness occurring at far slower beat frequencies….of 40 Hz." (pp. 56-59).

Hameroff and Penrose (2014) summarize evidence of "coherent microtubule quantum states at brain temperature (p. 55)" for such orchestration, and suggest an extension of the DP proposal to "quantum effects in warm-temperature systems (p. 55)." They posit "*beat frequencies* of faster microtubule vibrations as a possible source of…EEG correlates of consciousness (p. 39)," linking ultramicroscopic quantum gravity processes to information processing at the much coarser-grained microtubule level and the neural network:

"[T]he most logical strategic site for coherent microtubule Orch OR and consciousness is in post-synaptic dendrites and soma…. Synaptic inputs could 'orchestrate' tubulin states governed by quantum dipoles, leading to tubulin superposition in vast numbers of microtubules…. The termination, by OR, of this orchestrated quantum computation at the end of integration phases would select microtubule states which could then influence and regulate axonal firings…. Quantum states…of a particular neuron could entangle microtubules in the dendritic tree of that neuron, and also in neighboring neurons…. This allows unity and binding of conscious content…in EEG-relevant periods of time…a possible way to account for frequent moments of conscious awareness and choices governing conscious behavior…which influence axonal firing, encode memory and regulate synaptic plasticity." (p. 59).

"…Orch OR follows the notion that OR events with primitive 'experiential' qualities have been occurring in the universe all along. Small superpositions lacking isolation would entangle directly with the random environment…in non-orchestrated OR events with undifferentiated 'proto-conscious' experience…without information or meaning…taken…to be irreducible, fundamental features of 'Planck scale geometry', perhaps ultimately having a physical role as important to basic physics as those of mass, spin or charge." (p. 65).

This suggests 'Orch OR' theory is a form of *panpsychism*, in the sense that proto-consciousness is a fundamental feature of 'Planck-scale geometry.' Although asserted to be created at each instance of OR, it seems just to pop in without precedents or functional role. It is said to be *intrinsic*, but also *emergent only at this stage*, binding into a stream of conscious cognition at later stages. If prior to OR there are dynamics within the unitary evolution of the quantum wavefunction as quantum probabilities, apparently no proto-consciousness would exist at this earlier stage.

Further on consciousness and causal efficacy, Hameroff and Penrose (2014) explain:

"The particular selection of conscious perceptions and choices would, according to standard quantum theory, involve an entirely random process, but according to Orch OR, the (objective) reduction could act to select specific states in accordance with some non-computational new physics….[T]he experiential elements of proto-consciousness would be intimately tied in with the most primitive Planck-level ingredients of space-time geometry…20 orders of magnitude smaller than those of normal particle-physics scales…smaller by far than biological scales and processes…(p. 59).

Applying…to large numbers of brain neurons, we find that…a spectrum of possible types of conscious events might be able to occur, including those at higher frequency and intensity. It may be noted that Tibetan monk meditators have been found to have 80 Hz gamma synchrony, and perhaps more intense experience…. [W]here we interpret this frequency to be associated with a succession of Orch OR moments…there is twice as much brain involvement required for 80 Hz as for consciousness occurring at 40 Hz…. Even higher (frequency), expanded awareness states of consciousness might be expected, according to this scheme, with more neuronal brain involvement…. Yet another possibility, consistent with recent findings of scale-invariant processes in brain function, is that consciousness…can occur at varying frequencies, moving up and down in scales, with higher frequency events involving more of the brain having greater experiential intensity. (p. 62).

Measurable brain activity correlated with a conscious perception of a stimulus generally occurs several hundred milliseconds after that stimulus. Yet in activities ranging from rapid conversation to competitive athletics, we respond to a stimulus (seemingly consciously) *before* the above activity that would be correlated with that stimulus occurs in the brain. This is interpreted in conventional neuroscience…to imply that in such cases we respond non-consciously, on auto-pilot, and subsequently have only an *illusion* of conscious response. The mainstream view is that consciousness is epiphenomenal illusion, occurring after-the-fact as a false impression of conscious control…. In the 1970s neurophysiologist Benjamin Libet performed experiments on patients having brain surgery while awake, i.e. under local anesthesia…. Able to stimulate and record from conscious human brains, and gather patients' subjective reports with precise timing…conscious awareness occurred at 30 ms post-stimulus. The brain at 30 ms 'knew' that activity would continue, or not continue, for several hundred more milliseconds, i.e. that subjective experience was referred 'backward in time.' Numerous other experiments have also provided strong indications of temporal anomalies in perception and willed choice… (p. 63).

Penrose put forward a tentative suggestion…that Libet's backward time referral might be related to the fact that quantum entanglements are not mediated in a normal causal way, so that it might be possible for conscious experience not to follow the normal rules of sequential time progression, so long as this does not lead to contradictions with external reality (p. 63)….

The Orch OR scheme allows conscious experience to be *temporally non-local* to a degree…to spread to…Libet's 500 milliseconds …or longer…. The effective quantum backward-time referral…enables temporal variability in axonal firing threshold…providing a possible means to rescue consciousness from its unfortunate characterization as epiphenomenal illusion…allowing conscious action to provide a semblance of free will..." (p. 64).

Finally, Hameroff and Penrose speculate on the evolution of consciousness in Orch OR theory:

"The following scenario seems plausible…. [O]rganic biomolecules in primitive biology…offered protective isolation for quantum superpositions…. As biomolecules became larger and more functional, quantum states in non-polar regions persisted, delaying the environmental interactions which serve…to cause OR…. [B]iomolecules self-organized into assemblies such as microtubules…and could then interact cooperatively by entanglement so as to process information in some form of primitive *quantum computing*…non-conscious, but still useful information processing…. As OR events in microtubules became more orchestrated over the course of evolution, the content of conscious experience became more cognitively useful, e.g., representative of the external world, and pleasurable, e.g. food, sex…. Orch OR conscious moments…during which environmental decoherence is avoided…would appear also to be related to intensity of experience…. As systems developed, the frequency of conscious moments…could approach present-day timescales…eventually in human brains every 25 ms in 40 Hz gamma synchrony EEG, or faster." (pp. 65-66).

Concerns about 'Orch OR' theory

We now bring up some of our concerns about 'Orch OR' theory. While some concerns from other researcher commentaries are noted, none of these are addressed in detail here. In our view, other commentaries have the same general framework, and thus problems, that 'Orch OR' theory has.

One concern relates to the analogy in 'Orch OR' theory between quantum gravity theory and radioactive decay. Calculations by physicist Shan Gao (2013), for example, suggest no justification for extrapolating atomic decay to spacetime gravitational superposition, which itself is an addition to gravitational theory not supported by many general relativity physicists. A related concern is use of the Heisenberg uncertainty principle as a rationale for temporal orchestration of OR based on this analogy (Gao, 2013).

Another concern is that Hameroff and Penrose relate quantum noncomputability to Gödel's incompleteness theorem and the impossibility of a complete and consistent mathematical framework. Because OR is

considered to be a 'real physical process' in 'Orch OR' theory, its noncomputability is necessary to avoid "hidden variable" problems. Neither applying the theorem to quantum noncomputability nor further to human information processing and free will as requiring quantum indeterminism are broadly supported (Feferman, 2009). Moreover, it is important to point out that some theorists no longer accept *fundamental* indeterminism as posited in standard interpretations of quantum theory, discussed later.

Another concern is how 'beat frequencies' connect Planck-scale dynamics to ordinary EEG. Slow graded potentials of cortical pyramidal cells sum up to create the electrical activity recorded at the scalp, due to columnar alignment of the apical dendrites in the cortex. Microtubules provide the skeleton for dendrites, arranged in a 360-degree space around the nucleus. How the microtubule oscillations sum into EEG and how the 'beat frequencies' translate into electromagnetic current which EEG measures seem not yet obvious (Travis, 2014).

Our more substantive concerns, however, relate to the *ontological reality* of the objects/events proposed in their theory. Hameroff and Penrose (2014) distinguish their theory from other interpretations of quantum theory by the important recognition that standard (largely Copenhagen) interpretations do "…not seriously address the ontological nature or physical role of superposition itself (p. 50)." The OR interpretation is considered by some a major advance because it identifies the reduction as due to interaction of the quantum wavefunction with the real physical environment, which means it is a *real objective physical process*. However, there remains little consensus whether the quantum wavefunction ever collapses or reduces, and reasonable alternatives seem to be increasingly popular.

Quite importantly, OR also implies that the 'quantum wavefunction' involves a *real quantum wave*. It would not be just a concept in imaginary mathematical space (such as the Schrödinger equation), because *imaginary* mathematical objects would not causally interact with *objectively real* physical objects. Although for Hameroff and Penrose the OR is a real process in nature, the huge implications for levels of nature beyond the physical seem not considered.

Hameroff and Penrose (2014, p. 53) further distinguish the DP version from other OR interpretations they describe as just "…some kind of…effective consequence of environmental decoherence…" The DP version adds a mechanism for OR, namely that this "…*real* objective physical process…is taken to result from the mass displacement between the alternatives being sufficient, in gravitational terms, for the superposition to be unstable."

But connecting the DP version to the Planck scale would seem to mean that the real objective physical quantum waves are within the local relativistic physical space-time gravitational field limited by light-speed. Empirically-validated *non-local quantum entanglement*, however, suggests an underlying field not subject to these limitations.

Further with respect to an ontologically real underlying field, Hameroff and Penrose (2000, p. 177) have likened aspects of their theory to the 'Platonic Realm.' But for Plato this realm was a real level of universal thought forms *beyond the physical*. 'Orch OR' theory does not go beyond the physical, as do recent theories of entangled nonlocal fields discussed soon.

The reason that the issue of ontology is so important is that there is no actual place in their theory where consciousness is identified as existing in the physical. What it consists of (the choices being the four matter/force fields), its weight, size, state (solid, liquid, gas, plasma) etc. should be identifiable in any physical theory of consciousness. Their theory seems to extend the physical into two levels. One level is the classical level of objects and events with definite physically measurable attributes subject to the closed causal chain, relativistic gravity, light-speed, etc. which is what is historically meant by the term *physical*. The other is a new quantum level of objects and events that do not have definite physically measurable attributes, characterized by uncertainty, probabilism, and apparently at least some sense of being nonlocal.

Identifying consciousness as 'physical,' physical properties of whatever they call consciousness seem not to be specified. The closest they come is to imagine consciousness as a floating collection of impulses that kind of skate over neural configurations in the brain in mobile synchronized zones (Hameroff, 2010). Hameroff and Penrose (2014) further state that:

"Yet another possibility…is that consciousness…can occur at varying frequencies, moving up and down in scales, with higher frequency events involving more of the brain having greater experiential intensity." (p. 62).

Also quite importantly, there is no actual place where the closed physical causal chain is identified to be broken such that top-down conscious computation is inserted to effect change in the determinate bottom-up sequence of events, necessary for free will. Hameroff and Penrose attempt to address this issue via irreducible random quantum processes to create sufficient *uncertainty* for physical microtubule activity to orchestrate the timing of OR. Each OR is said to be intrinsically accompanied by a moment of proto-consciousness, which are then bound together into actual conscious neurocomputational processes also orchestrated by microtubule functions in the brain. But where and how do these processes break the closed causal physical chain to orchestrate OR and input physical control of unitary organismic behavior?

Further on free will, they bring up the notion of temporal nonlocality to address research such as by Libet showing stimulus recognition and decision making anomalies with respect to the expected sequence for the efficacy of conscious mental intentions:

"Libet determined that conscious perception of a stimulus required up to 500 ms of brain activity post-stimulus, but that conscious awareness occurred at 30 ms post-stimulus. The brain at 30 ms 'knew' that activity would continue, or not continue, for several hundred more milliseconds, i.e. that subjective experience was referred 'backward in time." (p. 63).'

Also, according to their theory, indeterminate quantum mechanics at the Planck scale are said to offer some wiggle room/time that theoretically could allow "quantum backward time referral" for "a *semblance* of free will (Hameroff and Penrose, 2014; p. 64)." However, this description is within the view that consciousness is produced in the brain, the inadequate criterion of verbal report to identify whether an event or 'experience' is conscious, and assumes the ordinary waking state meaning of consciousness. It is important to recognize that quantum *randomness* does not allow for the unitary-functioning organism to *freely choose* its own behavior.

Randomness may be free in the sense of not completely determined by prior events in the closed physical causal chain. But it is not free choice in the sense of being *selected by the mental intentions of an individual conscious observer*. Neither classical determinism nor random quantum indeterminism can accommodate real free will. Causally efficacious conscious intentions require processes outside of determinate physical and indeterminate quantum processes for real free choice (Boyer, 2014).

To summarize, 'Orch OR' theory doesn't identify where consciousness and mind exist, or their physical properties if they are 'physical,' and doesn't yet offer a coherent model of real free will. Discussed next, it also does not consider progress toward *nonlocal mind* in other interpretations of quantum theory, and doesn't address higher conscious states that are extensively described in ancient Vedic literature and directly relevant to the nature of consciousness.

It is commendable that their theory includes a non-reductive, non-computable feature. But it remains physicalism. In the holistic view, it is expected that physical properties of mind and consciousness would not be identified, because they are subtler *non-physical* levels of nature. "Orch OR' theory describes correlates of consciousness (NCCs). But it neither describes the nature of consciousness nor subjective mind.

Progress beyond reductive physicalism and 'Orch OR' theory

Classical and to a large degree modern science have been *objective* reductive investigations, mostly ignoring consciousness and subjective mind. This approach has led to basically one ontological level: the causally closed objective physical world—sometimes called *physicalist realism, materialistic monism, or emergent monism*. More recently a two-level model adding unified field theory has been developing.

But quantum theory required consideration of how to transition from imaginary mathematical space to real physical space. Consciousness and subjective mind could no longer be ignored, and some interpretations of quantum theory even placed them as central to a logically consistent theory of physical reality. This has been revealing that the one- and two-level models are not rich enough to include real consciousness and subjective mind.

Progress is now extending to three-level models, including the ordinary gross physical level, the transcendent unified field, and a subtle level *in-between*. Speculations about this *in-between* level, generally associated with *quantum reality* and sometimes *quantum mind*, include quantum information field, dark energy, hidden sector, inflation, wormhole, loop quantum gravity, and string theories. But these rich mathematical glimpses still seem quite foggy, due to lack of direct empirical validation. We now briefly summarize examples of this progress.

Penrose's three-realm model

In other writings, Penrose (2005) identifies three realms or worlds in the direction of a three-level model. And at times, he seems to attribute real existence to each:

"The mathematical forms of Plato's world clearly do not have the same kind of existence as do ordinary physical objects such as tables and chairs…. Yet there is a deep and mysterious connection with…the physical, the mental, and the Platonic mathematical…as entities belonging to three separate 'worlds' …. [T]he entire physical world is…governed according to mathematical laws…. If this is right, then even our own physical actions would be entirely subject to such ultimate mathematical control, where 'control' might still allow for some random behavior governed by strict probabilistic principles." (p. 19).

Penrose (2005, p. 14) expresses belief that all physical processes are governed by mathematical laws, and all mental processes are based in the physical. He then describes

"…the entire Platonic world to be within the compass of mentality. This is intended to indicate that—at least in principle—there are no mathematical truths that are beyond the scope of reason." (p. 14).

But he also recognizes the *possibility* of

"…physical action beyond the scope of mathematical control…mentality not rooted in physical structures…the existence of true mathematical assertions whose truth is in principle inaccessible to reason and insight." (p. 20).

In an apparent step backwards, however, Penrose envisages the phenomenon of consciousness"…to be a *real physical process*, arising 'out there' in the physical world (p. 1032). Although the conscious mind seems to be considered real, again a reductive physicalist view is put forth in which higher-order conscious mind comes from lower-order physical brain processes. In this view, Platonic Forms would seem to be in the physical brain, while curiously also having their own objective reality 'out there' separate from individual subjectivity. In his 1994 book, Penrose asserts that Platonic Forms are primary, and that "…the world of conscious perceptions and the world of physical reality are its shadows (p. 417)." But this view, consistent with Plato, is not so strongly asserted in his more recent book, or in 'Orch OR' theory.

Tegmark's multiverse levels

Max Tegmark (2014; p. 120) describes physical reality as "Everything that exists," which would seem to be a one-level ontology. But he summarizes speculations about inflationary big bang theory with its prediction of infinity of universes in terms of four levels, which can be viewed as extending beyond at least the usual meaning of physical.

Tegmark states that, "The Level I parallel universes are simply universe-sized parts of our space that are so far away that light from them hasn't yet had time to reach us" (p. 129). This level has infinity of universes of infinite gradations of like-to-unlike copies of us and our universe. However, the parallel universes overlap, with no special boundaries distinguishing them.

Level II is added because eternal inflation creates space between universes more rapidly than light-speed, so the universes are forever isolated from each other. Tegmark (p. 151) states that "[A]ll possible Level I multiverses are realized within each of these Level II multiverses."

He identifies Level III based on the many-worlds interpretation (Everett, 1957; Tegmark, 2014) as mathematical 'quantum objects.' Level III clearly shifts away from ontologically real physics and tangible matter to a more abstract mathematical multiverse of 'quantum objects.'

Tegmark's Level IV adds a transcendent aspect to this very abstract mathematical conception of nature, in the form of the 'Mathematical Universe Hypothesis (MUH) that attributes all universes in the ultimate multiverse to be a more fundamental abstract mathematical or conceptual 'reality.' Curiously still identifying all four levels as physical, Tegmark attributes additional features to the Level IV multiverse, by the 'Computable Universe Hypothesis' and the 'Finite Universe Hypothesis (Tegmark, 2014):

"The Computable Universe (CUH)…mathematical structure that is our external physical reality is defined by computable functions….The Finite Universe Hypothesis (FUH) that our external physical reality is a finite mathematical structure implies the CUH and eliminates all concerns about reality being undefined…. The MUH implies that there are no undefined initial conditions: initial conditions tell us nothing about physical reality, merely about our address in the multiverse [where we happen to exist in the Level I and II parallel universes, which relates to the specific conditions that formed our habitable part]…. The MUH implies that there's no fundamental randomness…" (p. 357).

This also can be understood as a three-level model: mathematical space (Level IV), quantum information field space (Level III), and ordinary relativistic spacetime (Levels I and II). It can be viewed as progress toward *quantum reality* in addition to classical three-dimensional space and our familiar physical universe. It also is consistent with the unified field as the source of order in nature, rather than *fundamental* randomness as quantum theory is frequently interpreted. However, how computational ability enters into the Computable Universe is not addressed. And there is virtually no discussion of how consciousness and mind fit into the model.

Stapp's three-aspect model

Henry Stapp goes further beyond meaningless information fields in addressing the interdependence of objective matter and subjective mind, which he holds as an essential feature of orthodox quantum theory. He asserts strongly that to "…cling to the false precepts of classical mechanics that leave mind and consciousness completely out of the causal loop, seems to be totally irrational" (Stapp, 2010, p. 108). Stapp's model (2000, 2007, 2010) attempts to address relationships between three fundamental aspects of nature that he believes must include mind and consciousness with causal power, necessarily involved in wave function collapse because:

"...the local-reductionistic laws of physics, regarded as a causal description of nature, are incomplete…. [F]rom the purely physical standpoint the [wave function] collapse seems to come…as an unpredictable and undetermined 'bolt from the blue.' Something is needed to...bring 'classicality' into the dynamics, and it needs a 'cause' for the collapse, and it needs a reality to complement the 'potentia'... It must be something that exists, and the only thing that we know exists, besides the physical part of reality...is the experiential part..." (Stapp, 2000; p. 213).

In this model, there is physical *reality*, experiential *reality*, and Hilbert space as an infinite dimensional function space of all possibilities that can be associated with an ultimate unified field. Stapp associates experiential reality with an information field. The mental intention of the observer to choose a certain measurement, to make a particular observation, bridges the causal gap between experiential reality and physical reality, mind and matter:

"The neural correlate of an intent to act in a certain way would naturally be a pattern of neural activity that tends to cause the intended action to occur. Holding this pattern in place for an extended period ought strongly to tend to make that action occur. Thus a prominent and deeply appreciated gap in the dynamical completeness of orthodox quantum mechanics can be filled in a natural way that renders our conscious efforts causally efficacious. By virtue of this filling of the causal gap, the most important demand…that one's conscious efforts have the capacity to affect one's own bodily actions…is beautifully met by the quantum ontology. And in this age of computers, and information, and flashing pixels there is nothing counterintuitive about the ontological idea that nature is built…out of events, and out of informational waves and signals that create tendencies for these events to occur. (Stapp. 2000, p. 115).

Given this new playing field, we may commence dialogues pertaining to the remaining, and vitally key, issue: namely the origin and significance of the felt evaluations that seem to guide our actions. These evaluations appear to come from an experiential or spiritual realm, and are certainly allowed by quantum theory to have the effects that they seem to have (p. 111)…. The deepest human intuition is not the immediate grasping of the classical-physics-type character of the external world. It is rather that one's own conscious subjective efforts can influence the experiences that follow." (p. 112).

Further toward a holistic view, Stapp (2000) relates quantum theory to a 'global informational structure' deeper than classical physics:

"Perhaps the main basis for the claim that quantum mechanics is *weird* is the existence of what Einstein called 'spooky action at a distance'….[I]f the conception of the physical world is changed from one made out of tiny rock-like entities to a holistic global informational structure that represents tendencies to real events to occur, and in which the choice of which potentiality will be actualized in various places is in

the hands of human agents, there is no spookiness about the occurring transfers of information. The postulated global informational structure called the quantum state of the universe is the 'spook' that does the job. But it does so in a completely specified and understandable way, and this renders it basically non-spooky." (pp. 115-116).

As to where meaningful 'causally efficacious waves and signals' associated with free will exist, the model seems to go no farther than information qubits in:

"…the quantum smear of possibilities that constitute the universe at some instant (on some space-like surface in the relativistic quantum field theory description) into a set of discrete yes-no possibilities with assigned probabilities. The actualized bits specify the tendencies for future creations of bits. The partitionings specified by the process 1 [von Neumann] actions thus lie at the base of the computational notion of information….These processes of choosing are in some ways analogous to the process of choosing the initial boundary conditions and laws of the universe. That is, the free choices made by the human players can be seen as miniature versions of the choices that appear to be needed at the creation of the universe. Quantum theory opens the door to, and indeed demands, the making of these later free choices." (Stapp, 2000; p. 117).

But if in the 'quantum smear' is the *nonlocal* 'quantum wave of the universe' associated somehow with causally efficacious 'waves and signals,' it would be a 'space-like' field of mental intentions that is real, and outside the closed physical causal chain. We now consider a model that explicitly posits real causally efficacious mind as a meaningful information field, with real free will.

Bohm and Hiley's three-level hierarchical model

Taking and applying nonlocality as ontologically real, David Bohm and B.J. Hiley's interpretation of quantum theory posits a nonlocal field that underlies and causally affects physical matter (Bohm, 1980; Bohm and Hiley, 1993). Called by them the 'Ontological Interpretation' of quantum theory, and also sometimes called *neorealism*, it recovers both the principles of objectivity independent of the observer and of nature as determinate—basic to realism.

In this interpretation, real physical particles are guided in part by a real nonlocal guiding wave, the *psi wave*. The path of a particle is influenced by the physical forces in their environmental contexts (decoherence), and also by the 'active' influence of the nonlocal psi wave field subtler and permeating physical matter including the brain. In other words, gross real *matterstuff* is embedded in subtler real *mindstuff*. For the first time in modern science, this allows at least a logical model of how your brain and arm, for example, actually could be guided by your mind.

In this hierarchical three-level model, the gross classical physical level is the *explicate* order. The subtler *implicate* order is a highly interconnected, entangled nonlocal field of much more abstract wave impulses that have 'meaning' and 'signal' value. Both the explicate order and the implicate order exist in the universal plenum or *super-implicate* order (Bohm, 1980; Bohm and Hiley, 1993), somewhat akin to the ultimate unified field level of nature.

We are concerned that Hameroff and Penrose's review did not consider such models of ontological levels beyond the physical that have been developing in attempts to address real conscious mind and free will. But our most significant concern is the absence of the holistic view of consciousness as primary, comprehensively articulated in *Veda* and the most enduring and integrated view of consciousness throughout history.

The holistic Vedic 3-in-1 account

Translated as "total knowledge" (Maharishi Vedic University: Introduction, 1994), *Veda* concerns total knowledge of the laws of nature, like the pursuit in modern science. In the ancient Vedic tradition, as well as other traditions albeit with various cultural and language differences, there is purported to be a universal essence of nature or *universal Being* (Atman, Brahman). This has obvious correspondence with the unified field as the source of everything (Hagelin, 1987; 1989).

Within the unified field of universal *Being* are phenomenal finite levels expressed in increasing limitation from subtlest to grossest. The first phenomenal level to emerge includes subjective mind and subtle objects with nonlocal causal dynamics. This subtle nonlocal, interdependent, entangled field can be interpreted as condensing further into the familiar gross relativistic gravitational field of local particle-interaction causal mechanics limited by light-speed and Planck scale dimensions, which characterize ordinary 'independent' objects of experience.

This also can be interpreted to mean that space does not begin from an infinitely dense singularity, Planck-size quantum, or 'nothing' banging outward. Rather, *infinite eternal spacetime* condenses into subtle nonlocal and gross local mediums of spacetime with different limitations (Boyer, 2007; 2008; 2010). Maharishi (1976) explains:

"This process of consciousness becoming aware of itself creates an unmanifest space-time geometry within the field of consciousness. The unmanifest space-time curve within the field of consciousness is at the source of space-time curvature, which Einstein's general theory of relativity shows to be the basis of all objective creation." (p. 129).

This account of levels of nature is not solipsism in the sense that individual self is all that exists or can be known, and it is not idealism in the sense that the universe is only in individual mind. Moreover, importantly it is not just the reductive notion of an infinitesimal point (as in big bang theories), but *simultaneously* holistic all-encompassing infinite expanse: infinity/point, wholeness/part, universal/individual at the same time. Individual and universal consciousness, individual being and universal Being, are ultimately the same, beyond any intellectual discrimination.

To explain phenomenal nature, the non-dual unified field of universal Being—Singularity, Oneness, Unity—is attributed two coexisting opposite qualities: infinite silence or pure existence, and infinite dynamism or pure intelligence. *Infinitely* self-interacting dynamism means eternal silence. As Maharishi (2004) described it: "Silence and dynamism—they are one thing, not two things."

The infinitely self-interacting unified field is described as instantaneously referring or *curving back* on itself. Tacit in the concept of two opposite qualities is a third quality, their interaction. These three qualities relate to the trinity of observer, observed, and process of observing. Their unified state is self-referral consciousness itself. The 'curving back' is a way of *explaining* phenomenal levels as degrees of self-interaction: an infinitely self-interacting field (infinity in each point), a finite nonlocal self-interacting field with high interdependence or 'entanglement,' and a gross finite self-interacting local gravitational field with objects that appear to interact independently in our ordinary experience.

The unified field of universal *Being* infinitely referring back to itself means *self-referral*, wakefulness of itself, the nature of consciousness itself (Maharishi Mahesh Yogi, 1963; 1967; 1997). Consciousness is an *infinite completely unified field of universal Being*, the origin and essential nature of all phenomenally localized individual minds and body/brains in various states of consciousness. Remaining ultimate wholeness, it appears to precipitate into finite concrete parts—rather like transparent air to translucent mist and clouds, rain droplets, and opaque crystalline snow.

Empirical validation of the holistic Vedic account

In comparing reductive and holistic views, it is worth considering their epistemological bases, which significantly shape what knowledge is gained that supports the views. To protect against unreliability in ordinary sensory and reasoning processes, the basic means of gaining knowledge in modern science, the objective approach also relies on consensual validation or public agreement among investigators. However, the consensus is based on the level of functioning of those who contribute to it. The level or state of functioning of the investigators delimits the scientific consensus.

The entire enterprise of modern science is based primarily on reasoning and ordinary sensory experience in the waking state of consciousness. This state is a representational mode of knowing, characterized by experience of a separation or duality of the inner observer and outer objects. It is the phenomenological basis for the assumption of the independence of observed and observer, objectivity and subjectivity, held to be essential to objective science and assumed to be given by nature. In the holistic view, subject-object duality is imposed upon nature via ordinary waking experience. Development that transcends this duality is said to lead to unified, holistic understanding and experience (Alexander and Boyer, 1989).

In this developmental framework, it is not surprising that modern science is fragmented, and that unification—including of objectivity and subjectivity—is a most daunting task. However, as research has progressed from macroscopic tangible localized matter to theorized underlying abstract nonlocal fields, the *interdependence* of object and observer increasingly has encroached

upon scientific objectivity. A unified account of nature requires going beyond subject/object independence.

As to empirical validation within objective science of the holistic view of consciousness, a considerable and growing body of experimental evidence in neuroscience, psychology, and consciousness studies has now accumulated (Dillbeck, 2011; Scientific research on Maharishi's Transcendental Meditation and TM-Sidhi Programme—collected papers, vols. 1-5, 1977-90; Orme-Johnson, 2015). This research has been facilitated by increased availability of subjective reports of consciousness itself, most frequently in practitioners of the Transcendental Meditation (TM)® technique that has been drawn from the Vedic tradition.

Maharishi (1972) has made the important point that, "Knowledge is different in different states of consciousness." Reductive physicalism is associated with the ordinary waking state, within which modern science has been conducted. Knowledge in this state is *'object-referral,'* characterized by an experiential gap of object/observed and subject/observer, fundamental to the indirect objective means of gaining knowledge that focuses attention on the outer object rather than the inner observer of it. This objectified, indirect 'third-person' epistemological approach had no reliable, systematic direct means to gain knowledge of the subject/observer.

Consciousness itself, *'self-referral'* awareness, is said to result naturally when mental activity settles down and the object/subject duality is transcended. This natural inner silent state is called *samādhi* or *turīya*, the fourth state beyond the ordinary three states of waking, dreaming, and sleep, with distinct psychophysiological correlates.

Hameroff and Penrose identify EEG gamma synchrony as the best neural correlate of consciousness; but this is the object-referral state, *conscious of* a separate object of experience in ordinary waking. It is not the fourth state of consciousness itself in which mental activity is transcended, correlated with EEG alpha coherence (7-10 Hz) indicative of *restful alertness* (e.g., Orme-Johnson, 2015).

The ordinary waking state meaning of consciousness as *being aware of* something is a combination of underlying consciousness itself and mental activity. Within the ordinary functioning of the active discriminating intellect, a quite subtle distinction can be made between sequences of discrete 'flickerings' in experience and 'pure undifferentiated awareness.' It is crucial to appreciate that the undivided wholeness of consciousness itself provides the underlying continuity necessary to be able to discriminate discrete thoughts or 'flickerings'—such as in experiential reports from adept Buddhist monks which Hameroff and Penrose use to support reductive 'Orch OR' theory. This reflects an essential experiential difference between reductive and holistic views of consciousness.

With respect to the evolution of higher conscious states, again we quote relevant speculations from Hameroff and Penrose's (2014) review of 'Orch OR' theory:

"As OR events in microtubules became more orchestrated… the content of conscious experience became more cognitively useful, e.g., representative of the external world, and pleasurable, e.g. food, sex…. Orch OR conscious moments… would appear also to be related to intensity of experience…. As systems developed, the frequency of conscious moments… could approach present-day timescales… eventually in human brains every 25 ms in 40 Hz gamma synchrony EEG, or faster." (pp. 65-66).

[H]igher frequency EEG may be associated with "…expanded awareness states of consciousness… with more neuronal brain involvement." (p. 62)."

From the holistic view, mental activity and consciousness itself are conflated in the ordinary waking state. Transcending means naturally settling down to consciousness in its pure state—like a wave settling back to its source in the ocean. This deeply settled ground state is not a 'dull' primitive 'flickering' of proto-consciousness, but rather consciousness itself beyond all boundaries of the active experience of feelings, thoughts, perceptions, and actions.

The terms 'consciousness' and 'evolution' have completely different meanings in the micro-analytic reductive view in 'Orch OR' theory, compared to the holistic Vedic view. The *Vedic Darshana*, sometimes called the 'six systems of Indian philosophy,' are an integrated account of ontological levels of nature and epistemological means to gain knowledge of them. Maharishi details how the Vedic Darshana—Nyāya, Vaiśeṣika, Sāṁkhya, Yoga, Karma Mīmāṁsā, and Vedānta—extensively describe progress to full enlightenment (Hensley, 2014). In this account,

higher states of consciousness naturally develop on the foundation of spontaneous and permanent *unbounded* awareness as an underlying background to all object-referral subjective experiences as the fourth state of consciousness is fully established.

In the 3-in-1 Vedic account, the ordinary gross physical finite level is *relatively real*, the subtler non-physical finite level is *relatively more real*, and the infinite eternal is *total reality*. Not understanding different meanings of *reality* in different states of consciousness—and no reliable means to develop them—resulted in major intellectual dilemmas in the history of science and religion.

Maharishi applied his re-clarification of Veda to Yoga in the TM® technique, an easily learned and practiced procedure for effortlessly transcending mental activity to the fourth state, pure consciousness itself. This crucial understanding of the subtle functioning of the mind had been lost even in interpretations of Vedic texts, as well as generally in approaches to mental development.

This systematic technology is quite different from contemplative, concentrative, and 'mindful' practices that are designed and reported to produce increased attentional focus in ordinary waking rather than to transcend mental activity. Consciousness itself, the unbounded state of pure wakefulness, is attained effortlessly, not from mental intention and effort that maintain active states.

When first 'directly experienced,' it is typically described as brief episodes of inner silence, transcendent from the perspective of ordinary mental activity in that there is no object of experience other than itself. Repeated transcending is said to purify and refine the nervous system/body by deep rest that eliminates accumulated stress. This state of deep inner restful alertness becomes 'directly experienced' as nonlocal, *unbounded* consciousness, and eventually as the essential universal Self or Being of the individual self or being. This is the basis for the natural sequence of higher states of consciousness.

The highest state of unity consciousness is characterized by total unity, containing within the fine fabric of its infinitely self-interacting dynamics all phenomena—*the universe in consciousness*. In this highest state the entire phenomenal multiverse is spontaneously and fully appreciated as nothing other than consciousness itself, one's own universal Self or Being, as stated in the Vedic text Brihad-Aranyaka Upanishad, 1.4.10: "Aham brahmāsmi" (I am totality) (Maharishi, 1995; p. 228).

Though natural and systematically attained, this state is so advanced compared to the fragmented subject-object duality of ordinary waking that it seems to be quite challenging even just to conceptualize intellectually. This is perhaps also because it is *unbounded* awareness even beyond the boundaries of the subtlest activity of the intellect. Maharishi (1967; p. 444) emphasizes that

Transcending thought is infinitely more valuable than thinking.

Summary and Conclusion

To summarize from a broader evolutionary framework that may help tie things together, in one-level reductive physicalism the investigation begins with ordinary sensory experience of macroscopic objects from the perspective of subject-object independence. Through objective research, these outer objects are analyzed to their essential parts, from concrete macroscopic wholes to microscopic molecules, elements, ultra-microscopic inert sub-atomic particles, and now abstract mathematical, randomly-fluctuating quantum wave potentials. The explanation of how higher-order wholes such as biological organisms with consciousness emerge from these lower-order inert parts —*epistemological emergence*— is quite incomplete. In order to bring consciousness as real into this view, 'Orch OR' theory tacks on to quantum wavefunction OR a primitive moment of proto-consciousness, a 'dull' flickering of awareness.

The alternative holistic account concerns how the unified field of nature phenomenally diversifies into parts and then synthesizes into wholes. In this Vedic account, the grossest level of nature appears to be inert atom-like particles. On this level, intelligence and energy appear to be the least integrated, and mind appears to be separate from matter in ordinary waking experience. At the subtle in-between level, energy and intelligence are more integrated or entangled, wave-like and not built of particles. This level has the character of subtle thought forms rather than gross material forms, including subtle mind that directs the gross body. Top-

down control of mind over matter with free will is increasingly evident in higher, more complex life forms as the mind/body system evolves. At the level of infinite self-interaction, the ultimate unity of consciousness itself as primary predominates in experience.

To conclude, fortunately modern science is progressing to the stage where the ancient holistic view is being seriously considered. This has the potential to address long-standing dilemmas that are now again vigorously speculated about within the respected disciplines of modern science. Hameroff and Penrose repeatedly and commendably point to the numerous speculative aspects of their own theory. They also seem to be cognizant that the foundations of their theory and objective modern science generally, are undergoing revolutionary changes in the direction of more integrated models.

In this light, the contention that the ancient holistic view of consciousness as primary is too speculative, outside science, and need not be given consideration seems at best pedantic. It also seems inconsistent with our precious tradition of open inquiry based on rigorous logical reason and direct validation, common to modern scientific and ancient Vedic science. Again, from the holistic view, the fragmented reductive physicalist view is a severe misunderstanding of the nature of consciousness. It appears to reflect a lack of direct experience and understanding of the fourth state of consciousness itself that is supported by a long history of theoretical, experiential, and now psychophysiological evidence.

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