# On the Nature of Consciousness and Reality

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A *fractal theory of consciousness* is considered where consciousness occurs at or below the Planck scale on the holographic foundation or boundary of space-time in a sub-quantum substrate. Consciousness communicates with perfect fidelity up to the level of living minds, that are orders of magnitude larger, using fractals that exist only when minds are at a *critical point*. Consciousness, and perhaps even memory, operate external to the human mind, analogous to the resilience and redundancy benefits seen in modern information technology *cloud computing*. An *existential checksum* or constructor mechanics theory of reality is also proposed. Experiments from quantum mechanics are used to demonstrate the operation to show how a consistent reality, of any given *now,* is created.

Beyond metaphysical or theological questions like the *why* of life or the *why* of a universe, the list of major open questions in science is, arguably, short. Near the top of almost every list, one will find questions related to the *nature of consciousness* and the *nature of reality*. While speculative and in the style of an outline essay, a theory is presented for a *fractal theory of consciousness* and an *existential checksum* or constructor mechanics theory of reality. The hope of this essay is that the analogies used in these theories will help drive research toward the formal solutions to these key questions.

> *"However mysterious the mind-body problem may be for us, we should always remember that it is a solved problem for nature."*
> *-- Carlo Rovelli, Helgoland: Making Sense of the Quantum Revolution [1]*

## Consciousness

A *fractal theory of consciousness* is considered where consciousness occurs at or below the Planck scale on the holographic foundation or boundary of space-time i.e., a sub-quantum substrate. Consciousness communicates, with perfect fidelity, up to the level of living minds, that are orders of magnitude larger, using fractals that exist only when minds are at a *critical point*. Consciousness, and perhaps also memory storage, operate external to the human mind, analogous to the resilience and redundancy benefits seen in modern information technology *cloud computing*.

## Renormalization as a Link between Consciousness and Fundamental Physics

Recent research has hinted at relationships between the tool used by physicists known as *renormalization* that is a mathematical technique which raises analysis "up a level" to ignore infinities that prevent finding a quantitative solution [2]. Scientists have noticed that similarities exist between human perception and renormalization that support the theory of brains operating at a *critical point* - where every neuron has influence on the network as a whole [3]. Research in renormalization, as well as *deep learning* and biological learning, all point to a common theme of compression of information i.e., the optimization of data processing [2]. Experiments by many scientists have created a description of the brain as balanced precariously at a critical point between periods of calm and avalanches of activity [4].

Science writer Natalie Wolchover described the work of Pankaj Mehta and David Schwab on artificial intelligence deep learning:

> "renormalization, which allows physicists to accurately describe systems without knowing the exact state of all their component parts, also enables the artificial neural networks to categorize data as, say, "a cat" regardless of its color, size or posture in a given video. Renormalization is a systematic way of going from a microscopic to a macroscopic picture of a physical system, latching onto the

> elements that affect its large-scale behavior and averaging over the rest… a suite of sophisticated approximation schemes is required to slide up the distance scales, dilating the relevant details and blurring out irrelevant ones along the way" [2, 5].

Notice how renormalization, as an approximation and methodology, is similar to Isaac Newton's use of the *limit* in Calculus as well as techniques created by Benoit Mandelbrot with his *fractal* math. Benoit Mandelbrot's famous paper *How long is the coast of Britain?* shows how fractal mathematical techniques are similar to the renormalization concept of "rising up a level" (e.g., an observer viewing a fractal) thus averaging out the coarse items to find higher order relationships for optimization of speed (reduction of calculation time) or to get a holistic "view," and ultimately a solution, for what seemed to be a problem hidden in infinities - as seen in the example for the approximate answer to the length of the coast line of Britain [6].

Thus, perhaps the similarities between the techniques used to solve fractals and renormalization hint at a deeper connection in nature. Could it be that the nature of the smallest units of space-time, let us say a theoretical Planck-length space-time "pixel," as opposed to a fundamental particle like an electron, is actually not a square or circle, in terms of its shape or dimension, but is, rather, a fractal shape? Could a space-time pixel that is fractal in nature possibly provide a sink-like surface area where gravity dilutes and is, thus, why gravity is so comparatively weak compared to the other three fundamental forces in the Standard Model, as it diffuses into the "cracks" of the fractal pixels of space-time?

## Consciousness via Fractals

Fractals are *scale invariant.* [7]. When a system's properties remain unchanged when viewed at different scales, we say it is *scale invariant*. This is the key attribute of fractals where the same patterns repeat themselves at smaller and smaller sizes. This feature of scale invariance or *self-similarity* is comparable to zooming in, with a magnifying glass, on an image to uncover finer, previously not visible, new structure or details. However, when done on fractals, no new detail appears and the image does not change. Instead, we see the same pattern repeating over and over [8, 9].

Extensive study of phase transitions have shown how scale invariant phenomena such as fractals and power laws emerged at the *critical point* between phases [10-18]. Woodrow L. Shew et al., noted in their research that "findings suggest that in the cortex, balanced excitation and inhibition establishes criticality, which maximizes the range of inputs that can be processed, and spontaneous activity and input processing are unified in the context of critical phenomena" [19]. John M. Beggs, in his book *The Cortex and the Critical Point,* notes:

> "One of the main consequences of being near a critical point is scale-free property. These are hypothesized to lead to optimal information transmission and also thought to optimize dynamic range, sensitivity to inputs, information storage, and computational power. Just being near the critical point will produce optimality over the scale of the brain" [20].

Brains are optimized at the critical point and consciousness fades as the brain drifts away from it, for example when a person is under anesthesia. Adam J. Eisen and his team:

> "found that propofol-induced unconsciousness is associated with destabilized neural dynamics. ... Propofol disrupts the balance between cortical excitation and inhibition. This balance is known to be critical for maintaining the stability of cortical dynamics. Combined with our findings, this paints a picture in which propofol tampers with this balance, causing widespread cortical instabilities and thereby disrupting the brain's capacity for information processing. Overall, our analysis suggests a mechanism for anesthesia that involves destabilizing brain activity to the point where the brain loses the ability to maintain conscious awareness" [21].

## Is Consciousness basically Cloud Computing?

Some of the principles that drove the creation of modern information technology *cloud computing* include its resiliency and redundancy. These traits are also common to life, or gene pools, focused on long-term survival. Thus, we might extend the cloud computing analogy to brain criticality.

At the critical point, brain signaling is *scale invariant* (a fractal pattern going down to the smallest scale). Thus, might it be the case that life has found a "location" or mechanism for optimal information processing?

Might it be the case that human consciousness does not actually lie inside our physical brain but, rather, lies in the space-time boundary as described in the Holographic Principle? According to the Holographic Principle, information encoding everything taking place in our three-dimensional world is encoded on the boundary of that region as a kind of hologram [22-30]. Perhaps the reason for brain criticality is that, by reaching a state of scale invariance, actual thought and intelligence, occurring at the microscopic boundary is, thus, able to be communicated up (and sensory inputs down) a "fractal ladder" to the scale of neurons in our macro world.

The brain, at its critical point, where self-similar fractals occur and each smaller fractal scale or level is exactly in-sync (has the perfectly identical pattern) with the top level fractal (by definition), thus becomes a "vertical" human data network communication channel. Life as experienced in the living minds of organisms, in order to *read* and *write* data with perfect fidelity on a sub-quantum space-time substrate, utilizes fractals in minds at a critical point. Only a fractal pattern can maintain perfect fidelity up and down such a scaling distance. It is this idea that explains why consciousness occurs at a critical point - which is the only state where fractal self-similar and scale invariant structure can occur.

The brain at its critical point, where all scales are identical fractals (i.e., synchronized), becomes synonymous with the definition of a "vertical" human data network telecommunications channel. According to the formal definition of a telecom channel, when a continuous stream of fixed-length frames are sent, a synchronized receiver can in principle identify frame boundaries forever, and receivers can usually maintain synchronization despite transmission errors [31, 32].

If all particles and forces that create our reality can, in theory, be encoded in a boundary, then why not consciousness as well? Colloquially, this might imply that every consciousness is part of a single consciousness (the singular boundary of our universe) and perhaps even add some merit to metaphysics as one's conscious *self* may already, and inherently, exist external to our physical world.

## Consciousness as a Tool for Life

We may consider life less as an "inventor," and more of an entity that commandeers, almost always, out of necessity. We can envision life, with an ecosystem on planet earth that becomes increasingly large, diverse, complex, and intelligent, using whatever "tools" it can find for any competitive advantage e.g., neurons, memory, categorization and labelling, planning, learning, language, etc. Then we can imagine life seeking improvements on each of these including long-term memory, modeling, written language, and possibly even fractal messaging and holographic memory as fast, resilient, and perhaps abundant critical information processing and storage resources.

We can speculate that it is the fractal structure that allows life to utilize yet another advanced data processing mechanism and to access a microscopic space-time substrate. We can imagine life using fractal structures for not only optimal memory storage but, perhaps, also to access an ultimate memory or ultimate "library of libraries," akin to Carl Jung's *collective unconscious* [33-36]. There is an obvious analogy here between the self-similar and infinite regression of a fractal, and the recursive nature of consciousness where a mind can ask or ponder i.e., why it asks why it asks why.

But is there any evidence that the Universe is fractal at a fundamental microscopic scale? Modern theoretical research does support this claim [37-44]. Oliver Lauscher et al., note that:

> "spacetime is a fractal in general, with a fractal dimension of 2 on sub-Planckian length scales. … The scale-free relation suggests that at distances below the Planck length… is a special kind of fractal with a self-similar structure. …This phenomenon is familiar from fractal geometry"[37].

Mary Alexandria Kelly et al., who proposed the idea of human brains using holographic reduced representations (HRRs) or associative memory, note that:

> "The mathematics of holography has long been suggested as the principle underlying the neural basis of memory… holographic associative memories have also been used to model how humans

understand analogies and the meaning of words, how humans encode strings of characters, and to model how humans perform simple memory and problem-solving tasks" [43].

Another example of research that supports the idea of a deeper reality, with the capability of memory, involves theoretical work in the field of fundamental physics regarding *quasiparticles*. Institute of Theoretical Physics professor Leon Balents states that "unlike other particles we know of, these quasiparticles (Abelian anyons) can, in effect, remember how they have been manipulated… your electrons, photons, and quarks - may themselves emerge from something deeper" [44].

If consciousness is fractal and exists with memories on a holographic boundary, then many questions still remain. Has a microscopic consciousness, or even a collective subconscious, always existed? What is the exact process or protocol by which memories are stored and fractal messages sent? What is the minimum and maximum size (in bits) of a fractal message? Can we observe, prove, or even change fractal messages or memories in a brain or in the holographic boundary? If we understand the mechanisms deeper, can a machine be built that has consciousness? Does this model imply that a specific consciousness could exist after the death of its associated physical body or brain? Is there a maximum limit to the amount of memory in the holographic boundary of a universe? Could an increase in the amount of memory stored in a holographic boundary be in any way part of the observed Dark Energy driven expansion of the size of our Universe?

*"… Weaving the world. In his hands it flowed out of nothing and in his hands it vanished into nothing once again. Endlessly. Endlessly. … Not chaos itself lay outside of that matrix. And somewhere in that tapestry that was the world in its making and in its unmaking was a thread that was he and he woke weeping."*
-- *Cormac McCarthy* -- *The Crossing* [45].

*"Checksum: a sum derived from the bits of a segment of computer data that is calculated before and after transmission or storage to assure that the data is free from errors or tampering."*
-- *Merriam-Webster Dictionary* [46].

## Reality

If we are to assume that the proposed *fractal theory of consciousness* is valid, then it must be able to explain, or at least not contradict, *quantum mechanics* including its key aspects of entanglement and decoherence e.g., conclusions from observations in Young's double slit interferometer, Stern-Gerlach, the delay-choice quantum eraser, the Quantum Cheshire Cat, etc. experiments. Once we accept the possibility that consciousness can exist partially, if not entirely, external to a biological brain (the *dual* interpretation of the classic *mind-body problem*) then considerations of consciousness as "causing" quantum decoherence moves from a view of any individual conscious organism determining reality, to a fundamental substrate of existence as determining reality, arguably a much more palatable perspective, logically speaking.

An analogy to *cloud computing* was used for the proposed model of consciousness, so let us use another analogy from modern information technology to describe reality.

## Checksums

In modern data communication networks, there is a mathematical check at each endpoint to ensure that the data sent is valid, without errors, and that timing is correct for individual packets, frames, bits, pulses, etc. This operation or process is known as a *checksum.* Various layers of network protocols have checksum checks to ensure data validity. The *Cisco Networks online learning library* notes:

- OSI layer 2: Data Link Layer, error detection and flow control for data transferred between directly connected nodes on a local network, ethernet uses *CRC* (Cyclic Redundancy Check) checksums, to detect errors that occur during transmission over the physical medium between two nodes.

- OSI layer 3: Network Layer, error detection for the packet's header, the IPv4 header contains a checksum, to detect corruption in the IPv4 header as it travels through the network.
- OSI layer 4: Transport Layer, error detection and recovery for end-to-end communication, TCP and UDP include checksums in their headers, to ensure data is received correctly by detecting corruption [47].

Note there is the risk of excessive computer system or computer network analogies directly implying the *simulation hypothesis* [48] regarding the true *nature of reality*, but that is not the specific claim here - although this essay does add support for that theory. Recall how the fractal "pipe" link from a conscious mind to a sub-quantum substrate is perfect in fidelity and near instant - aspects that support its use as an optimal method of "communication." At a sub-quantum substrate, reality may even be timeless, so, in theory, we may be able to ignore the time delay for the "processing time" of any checksum operation of reality. Note that, while data networks use checksums to validate the accuracy of data sent or received, in this theory it is the checksum itself that IS the function of the fractal connection. Note that a visual, audio, sensory, etc. input, and internal thoughts would both be "processed" in our sub-quantum substrate of reality.

## Reality from Relationships

The claim of this essay is that at the foundation of reality - similar to relational ideas from Gottfried Wilhelm Leibniz [49], Lee Smolin's *views* [50], the *relational interpretation of quantum mechanics* advocated by Carlo Rovelli [51], or even the Stephen Wolfram's *hypergraphs* [52]- we have a *logical table* or a list of associations in pairs i.e. *relations*. Reality becomes built of relations only.

In the famous Stern-Gerlach experiment, *magnetic spin* is measured in the three phases of the experiment. Logically, after the third phase of the experiment, 100% of the particles should have the same spin value as all other values appear to have been filtered out via the first two phases of the experiment. Instead, we observe that the results are, again, 50% up and 50% down for spin, as if the test has been "reset." This result can be explained in this theory. Since each "now" moment involves a checksum operation, we can imagine a check of a *particle versus spin* relation. An existential checksum is not a system (nor is reality apparently) that involves *memory* as imagined in many interpretations of the Stern-Gerlach experiment results.

When we consider quantum mechanics, we make a human error by considering the results of experiments from humans (with memory), thus the probabilistic nature of the observational results of quantum mechanics. However, if we take a different perspective, with the focus on every "now" moment as unique, then we see a much simpler model vis a vis *Occam's Razor* logic.

If we consider Young's double slit interferometer experiment, where photons sent to a detector screen will create a wave pattern, unless "which path" information (which slit the photon traveled through) was known, at which point the pattern on the screen becomes two solid vertical lines. This implies a photon or particle went through either slit 1 or slit 2, but not both simultaneously, like a wave. Here, again, we can consider the idea of a checksum operation. Using yet another I.T. analogy, we can imagine a network router examining the rules in its *routing table* going from the top to the bottom of its table list. Analogously, a reality *existential checksum* would see *photon vs two slits,* and then the detector. But this is not the same checksum line in our "table" for a *particle vs one slit,* and then the detector. Akin to the router "choosing" the *best* route in the table, reality "finds" the association in an existential checksum table and that is what is observed i.e., occurs, to ensure that reality in a conscious mind and the physical reality of the specific *now,* are consistent. We can play out this thought experiment with a reality substrate "checking" the checksum "table," "determining" the photon location or detector pattern, and "updating" the observer via the fractal channel.

## The more important Cat in Quantum Mechanics

In quantum mechanics there is a major, yet not very well known, experiment called the *Quantum Cheshire Cat* experiment [53]. What experimental physicists do is carefully utilize techniques like *weak measurements* to tweak nature into separating an *object* from its *attribute* e.g., an electron is measured over a series of test run to take the a right or left path of an interferometer beam splitter, with two split legs, and its spin or magnetism is measured on the other path - like the disembodied smile of the Cheshire Cat in Lewis Carroll's *Alice's Adventures in Wonderland* [54].

From a philosophical perspective, this is a stunning result! Our understanding of what is *fundamental* is now likely forever changed. From what we can tell, beyond the likely indivisible nature of an electron (or some string theory or quantum field theory equivalent interpretation), what do we make of an isolated, indivisible, and obviously fundamental, *attribute*? Extending our information technology analogy theme, we can intimate that, at "the bottom" of reality, at a sub-quantum level, nature can be considered to "hold" a logical table of *two item* associations. We can envision in a sort of Platonic hyperspace a vast "list of ingredients." Reality is not an electron that has a charge. It is a list of objects and attributes. Again we see a similarity to reality as a binary construction of relationships, as considered since the time of Leibniz and seen in modern theories like the relational and transactional interpretations of quantum mechanics. We realize (literally) an *existential checksum* or constructor mechanics theory of reality.

If we consider conscious minds processing outside of physical minds in this sub-quantum substrate, then our model of reality, where each human experienced "now" is equivalent to a message dialog with a universal consciousness foundation, then the non-intuitive behavior seen in many quantum mechanics experiments, becomes much less mysterious.

## Experiments Explained

Experiments like the Stern-Gerlach interferometer experiment, where nature appears to maintain a memory and "reset" after the third cycle of a selection and sorting experiment, in this model reduces to a much simpler analogy. The third cycle of the experiment no longer requires any memory or resetting of values, but instead is just another unique "now" instance and thus the same association seen on the first step of the experiment is repeated. Nature does not use memory to track the results of human experiments. It is simply repeating an already existing *checksum process* of an already existing relationship or association (**Figure 1**).

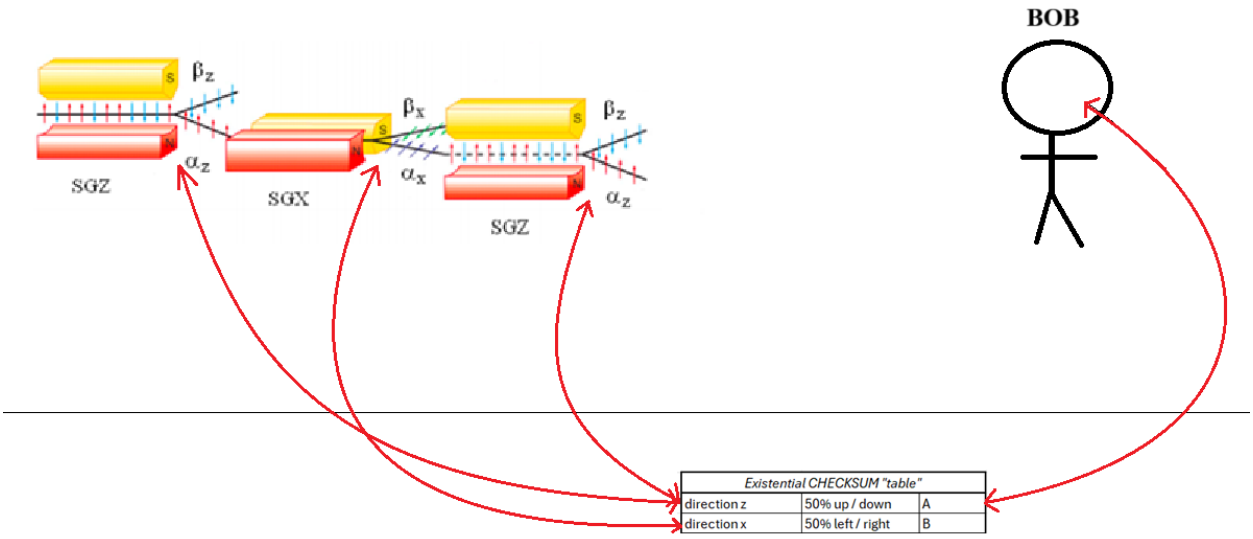


**Figure 1.**
*The Stern-Gerlach experiment (above) interpreted via an "existential checksum" or constructor mechanics theory of reality. The human observational results (Bob) appear to reset, after the third phase of the experiment, as the conscious "now" involves a new checksum operation on fundamental entities, but this does not involve reality using a memory of the first phase.*

The classic Young's double slit interferometer experiment, considered to be the heart of the mystery of quantum mechanics, in a similar manner loses its luster. Nature is not tracking if an observer has or does not have "which path" information. Rather, a conscious "now" *checksum process* is different for each scenario, as the associations in the existential web of relationships for each scenario (knowing which path information and NOT knowing which path information) are different relationships and, thus, different realities or observed realities or results (**Figure 2**).

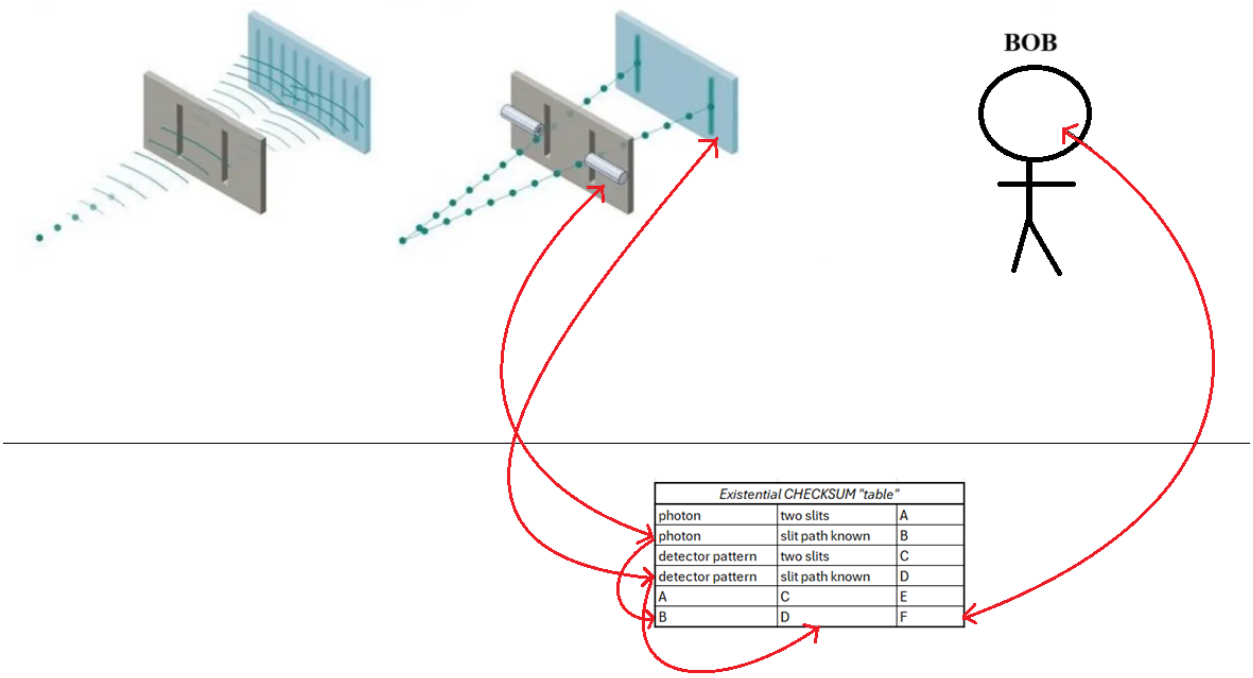


**Figure 2.**
*Young's double slit experiment (below) interpreted via an "existential checksum" or constructor mechanics theory of reality. Consciousness, in a mind (Bob), involves for every "now" a checksum operation in the sub-quantum substrate of our universe, that ensures that reality is consistent.*

In this model of reality, we now produce new and, arguably, more formal definitions including:

- *Consciousness* - is the initiation of object/attribute *checksum processing* in the sub-quantum substrate of reality.
- *Mind* – a mechanism in a living brain that moves to a fractal *critical point* in order to create a perfect fidelity communication *channel* down to a sub-quantum substrate where checksum processing against an existential *tree of relationships* occurs that ensures a consistent reality is experienced.
- *Now* – is the duration in time a living organism experiences for any *checksum processing* request.
- *Reality* – the consistent experiences created via every unique "now" in a conscious mind.

Reality as a Web of Relationships

Regardless if we imagine a matrix, spreadsheet, hypergraph, or *cellular automata*, the scale of such an existential *tree of relationships* would be beyond astronomical in size and complexity and is perhaps best described as an existential "web." It is here that the best description of this model, as if divinely inspired, can first be seen in "the arts." The British fantasy author China Miéville describes, in his book *Perdido Street Station* and in his *Bas Log* series of books, metaphysical spiders known as *Weavers* that construct and modify every single aspect of existence represented in a primordial *web*.

This essay concludes asking the reader to consider the above model of consciousness and reality and, in this context, to enjoy reading the more eloquent language from China Miéville, below, in case by chance both are describing the very same true web-like *nature of reality*:

> *Its substance was known to me. The crawling infinity of colours, the chaos of textures that went into each strand of that eternally complex tapestry…each one resonated under the step of the dancing mad god, vibrating and sending little echoes of bravery, or hunger, or architecture, or argument, or cabbage or murder or concrete across the aether. The weft of starlings' motivations connected to the thick, sticky strand of a young thief's laugh. The fibres stretched taut and glued themselves solidly to a third line, its silk made from the angles of seven flying buttresses to a cathedral roof. The plait disappeared into the enormity of possible spaces. …Every intention, interaction, motivation, every colour, every body, every action and reaction, every piece of physical reality and the thoughts that it engendered, every connection made, every nuanced moment of history and potentiality, every toothache and flagstone, every emotion and birth and banknote, every possible thing ever is woven into that limitless, sprawling web. …It is without beginning or end. It is complex to a degree that humbles the mind. It is a work of such beauty that my soul wept... ...I have danced with the spider. I have cut a caper with the dancing mad god."*
> *-- China Miéville -- Perdido Street Station (Bas Log)[55].*

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