Implications of fractal and renormalization concepts extended for unification and decoherence theories.

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Recent articles summarizing recent research noting the proclivity of renormalization techniques to solve self-organized criticality and deep learning could intimate that the challenges with the unification of Quantum Mechanics and Relativity, and with finding a formal solution for quantum decoherence, could be chimeras if the human observed nature of reality itself are actually renormalizations of an infinite fractal space-time that is intractable with current techniques.

Two recent articles by Jennifer Ouellette and Natalie Wolchover [1] [2] that reference renormalization and fractals in both Per Bak's famous paper on self-organized criticality [3] and by Pankaj Metha and David Schwab paper on A.I. deep learning [4] could be pointing to an even larger application of renormalization techniques in fundamental physics. The mathematical technique called renormalization, in essence, raises analysis "up a level" to ignore infinities that prevent a quantitative solution.

First note this key passage from Oulette's article on the work of Per Bak and others uniting the concepts of self-organized criticality in the brain and renormalization:

> *"Through deep learning, there is also the hope of a better theoretical understanding of human cognition. Vijay Balasubramanian, a physicist and neuroscientist at the University of Pennsylvania, said he and other experts who span his two fields have long noticed the conceptual similarity between renormalization and human perception. "The development in Pankaj and David's paper might give us the tools to make that analogy precise," Balasubramanian said. For example, the finding appears to support the emerging hypothesis that parts of the brain operate at a "critical point," where every neuron influences the network as a whole. In physics, renormalization is performed mathematically at the critical point of a physical system, explained Sejnowski, a professor at the Salk Institute for Biological Studies in La Jolla, Calif. "So the only way it could be relevant to the brain is if it is at the critical point." There may be an even deeper message in the new work. Tishby sees it as a hint that renormalization, deep learning and biological learning fall under the umbrella of a single idea in information theory. All the techniques aim to reduce redundancy in data. Step by step, they compress information to its essence, a final representation in which no bit is correlated with any other. Cats convey their presence in many ways, for example, but deep neural networks pool the different correlations and compress them into the form of a single neuron." [1]*

Also consider this statement below from Oulette's article in the context of the collapse of the Schrödinger wave function upon a quantum system's observation or interaction with the environment:

> *"The brain is an incredibly complex machine. Each of its tens of billions of neurons is connected to thousands of others, and their interactions give rise to the emergent process we call "thinking." According to Bak, the electrical activity of brain cells shift back and forth between calm periods and avalanches — just like the grains of sand in his sand pile — so that the brain is always balanced precariously right at that the critical point." [1]*

Then consider this sentence below in Oulette's article compared to the nature of dual-slit interferometer experiments, the hallmark of the essence of Quantum Mechanics, where the interference pattern is generated on the screen by the delivered photon, unless "which-path" knowledge is known that is perhaps a situation analogous to a self-organized criticality "critical point," where any randomness or ambiguity of the photon path (as a wave) is eliminated.

> *""A brain that is not critical is a brain that does exactly the same thing every minute, or, in the other extreme, is so chaotic that it does a completely random thing, no matter what the circumstances," Chialvo said."[1]*

Also note these key passages on deep learning referencing fractals and renormalization from Wolchover's article on Mehta and Schwab's work:

> *"The new work... demonstrates that a statistical technique called "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. Fortunately for physicists, most microscopic details don't matter; describing a table doesn't require knowing the interactions between all its subatomic quarks. But 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. Mehta and Schwab's breakthrough came ... when they decided to focus on a procedure called variational or "block-spin" renormalization...method involves grouping components of a system into larger and larger blocks, each an average of the components within it. The approach works well for describing fractal-like objects, which look similar at all scales, at different levels of resolution; Kadanoff's canonical example was the two-dimensional Ising model — a lattice of "spins," or tiny magnets that point up or down. He showed that one could easily zoom out on the lattice by transforming from a description in terms of spins to one in terms of blocks of spins." [2]*

Philosophical Implications

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 fractal math [5]. 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.

Thus perhaps the similarities between the techniques used to solve fractals and renormalization intimate a deeper connection in nature? Could it be that the nature of the smallest units of space-time (let's say a theoretical Planck-length space-time "pixel", as opposed to a fundamental particle like an electron) is actually not a "square" or "cube," in terms of its shape or dimension, but is rather a fractal shape. Would a space-time pixel that is fractal in nature possibly provide a sink-like surface area where gravity dilutes and is thus so comparatively "weak" to the other three fundamental forces in the Standard Model as it diffuses into the "cracks" of the fractal nature of space-time? Could this model possibly also answer the major questions of why we cannot solve the major challenges of the nature of Quantum Decoherence and the dreamed of grand unification of Quantum Mechanics and General Relativity as, in this model, they simply cannot be united, vis a vis how the infinite fractal coastline cannot be measured directly with its infinite fractal nature? Is a similar renormalization process thus needed to explain the "creation" of our daily "reality" by a conscious mind that, in essence, "elevates" our calculation attempts out of the Quantum world into our daily reality scale and we thus "push" the infinities of the Schrödinger equation (i.e. the required continuous number line for the wave function) under the proverbial rug? Could this be the long sought paradigm shift needed that has left the best minds in the world unable to solve or find the mathematical unification equation or solution as maybe no equation or precise mathematical answer exists (again vis a vis the measurement of the fractal coastline length) but, while involving apparent or even actual infinities, the reality of the world does exist just like a fractal exists?

If we re-examine Roger Penrose's famous "three worlds" model of reality, as noted in his book The Road to Reality [6], of a metaphysical Platonic World of fundamental mathematical laws or equations, perfect circles, pi, and infinity that make the foundation rules required of a miraculously consistent Physical World

filled with an abundance of identical particles and quantized forces with this physical reality of atoms and energy the material required to make a human body needed to make a human brain needed as a vessel for a human mind or consciousness that exists in a Mental World that might be the only thing or place or mechanism possible to create or discover or hold the first Platonic World of ideas and mathematical laws and infinite concepts? Might this new model of a fractal space-time perhaps solve or reduce Penrose's three world model to a Universe or reality of only fractal (infinite) objects and conscious minds that can (or must) renormalize them to literally "think outside the infinite box" and experience or create a reality. By existing in a "higher" level of a "vertical" renormalized fractal reality what might then logically lie "above" us along this same existential axis?

[1] Ouellette, J. Sand Pile Model of the Mind Grows in Popularity, *Scientific American,* April (2014) and reprinted: *https://www.quantamagazine.org/toward-a-theory-of-self-organized-criticality-in-the-brain-20140403.*
[2] Wolchover, N. AI Recognizes Cats the same way Physicists Calculate the Cosmos. Retrieved from *https://www.wired.com/2014/12/deep-learning-renormalization/* December. (2014) and reprinted: *https://www.quantamagazine.org/deep-learning-relies-on-renormalization-physicists-find-20141204.*
[3] P. Bak, C. Tang and K. Wiesenfeld, Self-organized criticality: an explanation of 1/f noise, *Phys. Rev. Lett.* 59, 381 (1987).
[4] P. Mehta and D. Schwab, An exact mapping between the Variational Renormalization Group and Deep Learning. Retrieved from *https://arxiv.org/pdf/1410.3831.pdf* October (2014).
[5] B. Mandelbrot, How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension. *Science.* 156 (3775): 636–638 (1967).
[6] R. Penrose. *The Road to Reality: A Complete Guide to the Laws of the Universe.* Knopf. (2005).