How the Simulation Hypothesis answers, "Why the Quantum?"

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A short essay suggesting that the nature of computer programs, involving structure and sequence, may be a direct analogy to quantum mechanical canonical pairs e.g., the Heisenberg Uncertainty Principle with position and momentum, thus supporting the Simulation Hypothesis that our reality is a programmed simulation. Additional examples are provided from modern physics that support the Simulation Hypothesis and an idea is proposed where conscious minds are synonymous with a computer gate residing at the boundary of future and past existing to constantly create relations.

> *"In our universe, we measure time with clocks, and computers have a "clock speed," but the clocks that govern the digital universe are very different from the clocks that govern ours. In the digital universe, clocks exist to synchronize the translation between bits that are stored in memory (as structures in space) and bits that are communicated by code (as sequences in time). They are clocks more in the sense of regulating escapement than in the sense of measuring time."*
> *-- George B. Dyson -- Turing's Cathedral: The Origins Of The Digital Universe* [1]

> *"In conclusion it may very well be said that information is the irreducible kernel from which everything else flows. Then the question why nature appears quantized is simply a consequence of the fact that information itself is quantized by necessity. It might even be fair to observe that the concept that information is fundamental is very old knowledge of humanity, witness for example the beginning of gospel according to John: "In the beginning was the Word"."*
> *-- Anton Zeilinger --Professor of Physics* [2]

The mathematical foundations of quantum mechanics have been understood since the early 20th century. But John Wheeler's famous query "why the quantum?"[3] remains an open question. Perhaps a philosophical perspective might help answer this question and provide a direction forward for research into the foundations of physics.

The Simulation Hypothesis [4], that suggests our Universe or reality could be a computer program or a holographic simulation made from code, has become an idea that has gained mainstream attention. But while often brushed off as a product of our Information Age, perhaps the idea has some additional value. There is an additional aspect of the Simulation Hypothesis that may help explain why quantum mechanics exist in our reality. As George Dyson notes in his book *Turing's Cathedral: The Origins of the Digital Universe*:

> A digital universe - whether 5 kilobytes or the entire Internet - consists of two species of bits: differences in space, and differences in time. Digital computers translate between these two forms of information - structure and sequence - according to definite rules. Bits that are embodied as structure (varying in space, invariant across time) we perceive as memory, and bits that are embodied in sequence (varying in time, invariant across space) we perceive as code. Gates are the intersections where bits span both worlds at the moments of transition from one instant to the next.[1]

So, a computer instantiates a program via *structure* and *sequence*. Note the necessity of this complementary pair versus the quantum mechanical Heisenberg Uncertainty Principle with its position and momentum pair or other canonical conjugate pairs like angular position (angle) and angular momentum, energy and time, frequency and time, etc. [5, 6] In essence, might the "why" of the uncertainty between fundamental paired properties actually represent an existential constraint of a reality inside of running computer program? Are every canonical pair just another representation of a deeper uncertainty between a reality built on computational structure and sequence?

Our reality is never static. It contains entropy and its "arrow of time" and even quantum mechanical virtual particles. But are all of these and the existence of canonical pairs all hints of a reality that is a computer program or simulation? Just as the speed of light limits velocity in our Universe from Einstein's Special Theory of Relativity, perhaps the Heisenberg Uncertainty Principle provides the limit of *precision* possible in our Universe, beyond which only the program (programmer) or simulation itself operates. No observer, by definition inside our Universe, can exceed the simulation's precision in regard to sequence or structure.

Other observations in our Universe support the Simulation Hypothesis including the Bekenstein Bound [7] regarding information encoded on the two-dimensional surface of black holes:

> The formula implies that all of the microscopic information that's inaccessible from outside a black hole is encoded on its surface. It's as if the volume enclosed by that impermeable boundary contains no additional information, as if the boundary itself is the more important, more fundamental object. [8]

Additional remarks from Princeton physicist John Wheeler also support the Simulation Hypothesis including his famous remarks regarding "It from Bit":

> It from bit. Otherwise put, every it - every particle, every field of force, even the space-time continuum itself - derives its function, its meaning, its very existence entirely - even if in some contexts indirectly - from the apparatus-elicited answers to yes-or-no questions, binary choices, bits. It from bit symbolizes the idea that every item of the physical world has at bottom - at a very deep bottom, in most instances - an immaterial source and explanation; that which we call reality arises in the last analysis from the posing of yes–no questions and the registering of equipment-evoked responses; in short, that all things physical are information-theoretic in origin and that this is a participatory universe. [9]

Wheeler wrote that "[t]he dimension-free character of the bit at last frees us from the dimension-tyrannized land of … everyday physics of particles, fields, of space-time." [10]

Other observations in support of our Universe being a simulation or computer program occur in modern mathematics. Note how the irrational numbers π and e can actually be represented via a simple non-infinite formula. Formulas enable the calculation of any power of the mysterious e for any real number, integer, or fraction from negative infinity to infinity, to any desired precision. [11] David Bailey et al. in the journal *Mathematics of Computation* note:

> Another spigot algorithm, the BBP digit extraction algorithm, was discovered in 1995 by Simon Plouffe. This formula, unlike others before it, can produce any individual hexadecimal digit of π without calculating all the preceding digits. [12, 13]

Italian physicist Carlo Rovelli in his book *The Order of Time,* notes how "order matters" in quantum mechanics and how this "noncommutativity determines an order and, consequently, a germ of temporality in the determination of two physical variables."[14] Rovelli states that "at a fundamental level, the world is a collection of events not ordered in time."[14] Contrast this remark versus the concept of a *method* in Java computer code.

Rovelli invokes Saint Augustine and states that "time is…entirely in the present, in our minds, as memory and as anticipation" i.e., the present does not exist. [14] Thus, again we see a pairing with future and past, sequence and structure. We can imagine quantum mechanics as creating the arena or "boundary walls" of our reality, the structure, while our conscious minds, via yes-no decisions, establish the sequences.

Conscious minds may in fact, at a fundamental level, only be establishing relationships. Rovelli is a proponent of Relational Quantum Mechanics where "[t]he physical content of the theory has not to do with objects themselves, but the relations between them. … Quantum mechanics is a theory about the physical description of physical systems relative to other systems, and this is a complete description of the world."[15]

Our conscious minds may be considered a "relation gate" as every microsecond our minds *relate:* object to object, observation to memory, memory to memory – implying all of reality is composed of *relations.*

Special Relativity has shown that neither *space* nor *time* are fundamental; events can have different durations etc. What is fundamental are *relations*. Every thought or analogy in our mind can be considered an act of relation. Perhaps the primordial and maybe singular entity in all existence is, thus, a conscious mind acting as a "relation gate." John Wheeler was obsessed with solving the puzzle of the observer (participator) in quantum mechanics. He wrote:

> "To describe what has happened, one has to cross out that old word 'observer' and put in its place the new word 'participator.' In some strange sense the universe is a participatory universe" … "no elementary phenomenon is a phenomenon until it is an observed phenomenon. … What we choose to measure matters." [10]

With no actual present and only a past and a future, might consciousness simply be "what it feels like" to be a computational "relation gate" at this intersection? Might every moment be just a pivot between an establishment of one relationship and then of another. A conscious mind "inside the program" of our Universe can never come to a complete stop, or exit the program to "see all the code" and comprehend both the structure and the sequence of reality at the same time as, by definition, it is inside and part of this universe. Never in our reality is there zero change. At any given microsecond minds simply relate things. But a mind inside a program can never know the entire program (sequences and structure) or else they would, by definition, be outside the program.

In essence, in our reality there is always at least some sort of duality of fundamental variables to prevent our simulation from literally stopping a la a computer "runtime error." With perhaps the exception of the surface of a black hole, we exist in a reality that has quantum rules (must have the quantum) to ensure a Universe of constant change and a reality that is mathematically consistent, and also to prevent *precision* beyond the fundamental structure and sequence aspects of a Universe that most likely is a coded simulation.

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