Preliminary study for developing instantaneous quantum computing algorithms (IQCA)

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Abstract Since the mid-1990s theoretical quadratic exponential and polynomial Quantum Computing (QC) speedup algorithms have been discussed. Recently the advent of relativistic information processing (RIP) introducing a relativistic qubit (r-qubit) with additional degrees of freedom beyond the current Hilbert space Bloch 2-sphere qubit formalism extended theory has appeared. In this work a penultimate form of QC speedup – Instantaneous Quantum Computing Algorithms (IQCA) is proposed. Discussion exists on passing beyond the quantum limits of *locality and unitarity* heretofore restricting the evolution of quantum systems to the standard Copenhagen Interpretation. In that respect as introduced in prior work an ontological-phase topological QC avails itself of extended modeling. As well-known by EPR experiments instantaneous connectivity exists inherently in the nonlocal arena. As our starting point we utilize Bohm's *super-implicate order* where inside a wave packet a super-quantum potential introduces nonlocal connectivity. Additionally EPR experiments entangle simultaneously emitted photon pairs by parametric down-conversion. Operating an IQCA requires a parametric up-conversion cycle an M-Theoretic Unified Field Mechanical (MUFM) set of topological transformations beyond the current Galilean Lorentz-Poincairé transforms of the standard model (SM). Yang-Mills Kaluza-Klein (YM-KK) correspondence is shown to provide a path beyond the *semi-quantum limit* to realize the local-nonlocal duality required to implement IQCA.

1 Precis – *Hypothesis non fingo*

If [all physicists] follow the same current fashion in expressing and thinking about … field theory … hypotheses being generated is limited possibly the chance is high that the truth lies in the fashionable direction But on the off chance that it is in another direction - a direction obvious from an unfashionable view of field theory - who will find it? Only someone who sacrifices himself from a peculiar and unusual point of view one may have to invent for himself. - R Feynman Nobel Prize lecture.

Instantaneous quantum computing algorithms (IQCA) must obviate current SM restrictions of Locality and Unitarity – The fundamental parameters of quantum theory [1]; meaning that quantum mechanics (especially the Uncertainty Principle) cannot be considered an impenetrable Planck-scale *Basement of Reality.* History has shown good theories are logical and have broad explanatory power. As well-known, severally the SM is incomplete; its main pillar Quantum Electrodynamics (QED) has been violated with $\sigma 5$ confidence the level appropriate for claiming discovery [2]; thus, a need for additional physics.

Although this work is highly speculative with a paucity of essential experimental evidence; the avenue remains inherently viable because required approbative theoretical fundaments key to formulating any pragmatic model justifiably point the way to an imminent paradigm shift to occur in the process of discovering additional dimensionality [3-5] finally mitigating M-Theory. Laying claim to Newton's *Hypothesis non Fingo* (I do not feign hypotheses) [6] best effort for correspondence to existing theory is made to proceed deducing warranted suppositions *post hoc ergo non propter hoc*.

Seemingly obvious from the point of view of empirically demonstrated EPR instantaneity IQCA appear feasible. But the dilemmas of EPR signaling no-cloning no-deleting and no-go class theorems have handicapped that position [7-9]. EPR entanglement is generally achieved by bringing simultaneously paired parametric down converted photons from nonlocality into locality. To include a parametric up conversion cycle in order to operate an IQCA has been opaque from Euclidean bits or even Minkowski-Riemann space qubit engineering. Now by obviating the fundamental quantum principles of locality and unitarity a method for obviating uncertainty and supervening decoherence is devised [5]. The new field of Relativistic Information Processing (RIP) while adding an additional degree of processing freedom remains an untenable intermediate step [5].

The no-cloning no-go theorems state the impossibility of creating identical copies of arbitrary unknown quantum states; proving the impossibility of perfect non-disturbing measurement schemes [7-9]. The state of one system can be entangled with the state of another system; using controlled NOT and Walsh–Hadamard gates to entangle two qubits. Entangling is not cloning. In this basis well-defined states cannot be attributed to a subsystem of an entangled state. A cloning process results in a separable state with identical components. The no-cloning theorem describes pure states; the no-broadcast theorem generalizes this for mixed states. Also of interest is the time-reversed dual of the no-cloning theorem called the no-deleting theorem.

All these theorems relate to quantum states in isolation and have been proven inviolate. This is true in terms of SM quantum physics. But Nature is often full of surprises. A key theoretical supposition introduced relates to the so-called M-Theoretic Bulk (more detail in an ensuing section). Firstly, let us clarify how the term Bulk is used: According to M-Theory the visible 3D universe is restricted to a 3-brane (manifold where we live) inside a higher dimensional (HD) space (the bulk) a domain of large-scale extra dimensions (LSXD) in our model where various brane transitions compactifications and correlations continuously occur as a hyperstructure called a brane bouquet [10].

This is 10D in string theory 11D in M-Theory and 12D in our ontological-phase topological field theory (OPTFT) because of an additional Einsteinian unified field control factor [25]. We have designed experiments to obviate this suggested brane topology [11,12] - There is something required by the nature of reality itself; the meshing of local temporality and nonlocal holographic instantaneity demands inherent continuously evolving causally separated copies of the 3D QED *particle-in-a-box*. This is a continuous-state product of Calabi-Yau dual 3-brane mirror symmetric topology. This is a naturally occurring freebie Feynman talked of the necessity of a synchronization backbone requirement for implementing universal quantum computing (UQC) [5,13-15].

According to Huerta a *brane scan* classifies Green–Schwarz strings and membranes in terms of invariant cocycles on super-Minkowski spacetimes forming a *brane bouquet* generalizing this by consecutively forming invariant higher central extensions induced by these cocycles which yields the complete fundamental bulk brane content of string/M-theory including the D-branes and the M5-brane as well as the various duality relations between these culminating in the 10-and 11D super-Minkowski spacetimes of string/M-theory and leading directly to the aforesaid brane bouquet [10].

We must modify Huerta's brane bouquet to include the Randall-Sundrum concept of a warped-throat singular D3-brane with largescale additional dimensions (LSXD) [16,17] into a model of uncertainty as a traversable programmable manifold of finite radius [5,18,19]. Current thinking for all practical purposes insists that gravity *must be* quantized. This arises from the current belief that the quantum mechanical stochastic foam is the impenetrable basement of reality. String theory an evolution of Kaluza-Klein theory has been developed as the theory of quantum gravity [20,21]; but there is no *a priori* reason that gravity must be quantized.

Maybe we should not try to quantize gravity. Is it possible that gravity is not quantized and all the *rest of the world is? Now the postulate defining quantum mechanical behavior is that there is an amplitude for different processes. It cannot be that a particle which is described by an amplitude such as an electron has an interaction which is not described by an amplitude but by a probability seems that it should be impossible to destroy the quantum nature of fields. In spite of these arguments we should like to keep an open mind. It is still possible that quantum theory does not absolutely guarantee that gravity has to be quantized* [22]. - RP Feynman.

Current thinking states that the KK-XD and beyond to 10D string theory are invisible because they are curled up at the 10^{-33} cm Planck-scale. This is not the only interpretation. Randall-Sundrum have proposed an alternative to compactification and LSXD [16,17]. We extend the Randall-Sundrum model and modify the M-theoretic constraint of one unique compactification producing the 4D SM. There was an initial problem with Kaluza's 5D model; Klein added *cyclicality* to the line element which solved the problem.

This extremely important key concatenation of parameters may be difficult to grasp initially:

- Compactification cycles continuously through all dimensionality – 12D to virtual 0D.
- The Planck-scale is a virtual asymptote never reached putatively when cyclic compactification reaches the Larmor radius of the hydrogen atom the cycle begins again.
- This system is built microscopically on a least-unit [23] with correspondence to the Wheeler-Feynman-Cramer Transactional Interpretation where the present instant is a standing-wave of the future past.
- To that scenario is added Calabi-Yau dual mirror-symmetric 3-tori.
- Simplistically this tower interpretation enables an annihilation-creation dimensional (brane) subtractive interferometry of the continuous compactification cycle keeping XD-LSXD invisible.
- Uncertainty is a cyclically rotating manifold of finite radius Perhaps 6D at the semi-quantum limit Randall-Sundrum throat; beyond which lies he M-Theoretic LSXD 12D bulk.

Fourteen experimental models have been devised to falsify this putative M-Theoretic-UFM model [11,12] which if successful allows experimental access XD-LSXD [24] and developing new forms of algorithms [25-27].

1.1 Beyond r-qubits

Also, we do not at this time attempt to write sample M-Theoretic UFM algorithms or convert existing QC algorithms to instantaneous form only outline the semi-quantum Bohmian Implicate Order duality framework required to compose such IQCAs when technologically required. Such an attempt at this point is likely to fall short as a brane-based IQCA we assume must be written in an M-Theoretic context.

Our proposed M-Theoretic-Unified basis for UQC is 12D. But the r-qubit is likely to only require a 6D quaternion-octonion algebra to describe. The manifest reason at the moment is that a new set of UFM transformations beyond the current Galilean-Lorentz-Poincaré is required to understand/operate and formalize the qubit basis. Let us remind the reader that this form of topological quantum computing [5] will not only eventually lead to IQCA but intrinsic to that process is as allowed by the additional degrees of freedom provided by a 6D qubit is that the programmable spacetime structure enables an instantaneous $P \equiv 1$ surmount of the uncertainty principle which supervenes decoherence [5].

2. Need for a realistic basis and new classes of quantum algorithms

Currently qubits are algebraically designated utilizing Block 2-spheres in Hilbert space. This scenario is a convenience for mathematical manipulation; since Hilbert space is not physically real [28] neither does a 2-sphere provide a sufficiently realistic qubit basis conforming to the needs of true UQC. Therefore, our existing basis for qubits and by correspondence descriptions of QIP [algorithms] is not realistic. This of course is moot by current thinking and is proposed here because a key supposition is that UQC will not occur without systematic violation of the Uncertainty Principle which requires an M-Theoretic qubit basis [5].

Decoherence is considered bulk-scalable UQC final problem. It is said that topological quantum computing is the most advanced QC model generally because it is theorized to solve this problem; but the protected qubits are not yet experimentally accessible [29]. Topological quantum computing operates cryogenically as 2D quantum Hall quasiparticle-Anyon based localized Majorana zero modes that are in topologically protected braided states that do not decohere. Operationally a subspace a collective non-local property of the non-Abelian anyons is employed to encode quantum information in the topologically protected manner This protection arises from the presence of an energy gap and from non-locality.

In our IQCA model it is the nature of Calabi-Yau mirror-symmetric brane topology (the 12D quantum state copy) that allows uncertainty to be surmounted and decoherence supervened not by topological protection but because the quantum states position in the topological brane-bulk is causally free of SM quantum restrictions of locality and unitarity! To repeat since the HD brane copy is causally free of the 3-space QED quantum state decoherence is inherently nonexistent during the computation cycle [5]. This is essentially a completely realistic form of topological protection.

Quantum algorithm research and development remains in its infancy because although a fair number of quantum gates and qubit technology research platforms exist it is safe to say that until an actual UQC implementation capable of bulk operation occurs a complete conception of what sufficient quantum algorithms are seems unlikely; especially if much of the novel new parameters proposed are required [5]. Meaning for example that the first true bulk quantum computing system should in actuality be scalable. But a dearth of quantum algorithms to implement sufficient quadratic speedup for practical utility beyond classical computing may remain. We propose a new class of unified field mechanical (UFM) based holographic quantum algorithms with asymptotic speedup beyond the purely classical holographic reduction algorithmic process currently under development even to the point of a new class of instantaneous algorithms. There is recent talk of an end to locality and unitarity as a new basis for QC along with the new field relativistic information processing (RIP); these scenarios may cause dramatic changes in QC research.

2.1 An evolution in the concept of algorithm

The concept of Algorithm in simplest terms a classical algorithm is a finite sequence of instructions step-by-step process or set of rules followed in calculations or other computed logical operations which always terminates. A quantum algorithm is purported to run on a *realistic model* of quantum information processing usually applied to algorithms that are inherently quantum using some essential feature of quantum computation such as quantum superposition or entanglement. The development of algorithms for simulating quantum mechanical systems was Feynman's original motivation for proposing a quantum computer [13-15]. Quantum algorithms require modules that are uniformly scalable and reversible (unitary) that can be efficiently implemented; the most commonly used model has been the quantum circuit model [30-32].

Furthermore, in general, an algorithm is the procedure or set of instructions used to perform an information processing task. According to the strong Turing-Church thesis: Any algorithmic process can be simulated efficiently using a probabilistic Turing machine Here the word efficiently classifies algorithms into two main complexity classes - P and NP where P is a polynomial type algorithm and NP the non-deterministic polynomial type algorithm. An algorithm is of the P-class if it has an 'efficient solution' meaning it runs in a polynomial time the size of the problem to be solved An NP-class algorithm does not have an efficient solution or requires super-polynomial (usually exponential) time. For example, prime factorization of an integer is an NP-type algorithm because no efficient solution is known for solving the problem. Deutsch first showed by simple example the existence of an efficient QC solution for a classically classified NP problem [33].

In 1994 Shor demonstrated that prime factorization has an efficient solution in QC But only a few NP-class problems can be solved efficiently with a QC [34]. But only a few NP-class problems can be solved efficiently with a QC [34]. Numerous NP-class problems exist for which no efficient algorithm is known even in QC. Although it is clear that P is a subset of NP but whether P6 = NP or P = NP is still an unsolved puzzle to the QC research community [32].

In general input to a quantum algorithm consists of n classical bits and the output also consists of n classical bits. If the input is an n-bit string x then the QC takes input as n qubits in state $|x\rangle$. Then a series of quantum operations are performed at the end of which the state of the n qubits is transformed to some superposition $\sum_y \alpha_y |y\rangle$. Afterwards a measurement is made which has as output the n-bit string y with probability $|\alpha_y|^2$ [32].

2.2 A look at the Church-Turing hypothesis

The Church-Turing thesis states that any function that can be computed by a physical system can be computed by a Turing Machine Many mathematical functions cannot be computed on a Turing Machine such as the halting function $h:\mathbb{N} \rightarrow \{0,1\}$ that decides whether the i^{th} Turing Machine halts or the function that decides whether a multivariate polynomial has integer solutions. Therefore the physical Church-Turing thesis is a strong statement of belief about the limits of both physics and computation Some functions can be computed faster on a quantum computer than on a classical one but as noticed by Deutsch [33-35] this does not challenge the physical Church-Turing thesis itself: a QC could even be simulated by pen and paper through matrix multiplications. Therefore what they compute can be computed classically .

Several researchers have pointed out that Quantum theory does not forbid in principle that some evolutions would break the physical Church-Turing thesis [36-38].

Technically the only limitation upon quantum evolution is that it be by unitary operators. Then as Nielsen argues it suffices to consider the unitary operator $U = \sum |i, h(i) \oplus b\rangle\langle i, b|$ with i over integers and b over $\{0,1\}$ to have a counterexample [37]. The paradox between Deutsch's and Nielsen's arguments is only an apparent one as both are valid; the former applies specifically to Quantum Turing Machines and the latter to full-blown quantum theory This is not satisfactory; if Quantum Turing Machines are to capture Quantum theory's computational power it falls short and needs amending. Unless in contrast quantum theory itself needs to be amended and its computational power brought down to the level of the Quantum Turing Machine [39,40].

Most likely quantum theory will be amended. It was known very early on that quantum algorithms cannot compute functions that are not computable by classical computers however they might be able to efficiently compute functions that are not efficiently computable on a classical computer [5]. This scenario may evolve also.

2.3 Algorithms based on the quantum Fourier transform

The first QC algorithms were called the 'black-box or 'oracle' framework where part of the input is a black-box implementing a function $f(x)$ The only way to extract information about f was to evaluate it on the x inputs. These early algorithms used a special case of the quantum Fourier transform the Hadamard gate. This allowed a problem to be solved with fewer black-box evaluations of f than a classical algorithm would need [40]. Deutsch [35] formulated the problem of deciding whether a function $f:\{0,1\} \rightarrow \{0,1\}$ was constant If one has access to a black-box implementing f reversibly by mapping $x, 0 \mapsto x, f(x)$; one further assumes that the black box does implement a unitary transformation U_f mapping $|x\rangle|0\rangle \mapsto |x\rangle|f(x)\rangle$. Deutsch's problem is to output "constant" if $f(0) = f(1)$ and to output "balanced" if $f(0) \neq f(1)$ given a black-box for evaluating f. Thus, to determine $f(0) \oplus f(1)$ ($\oplus$ denotes addition modulo (2) Outcome '0' means f is constant and outcome '1' means f is not constant [40].

Classical algorithms would have to evaluate f twice to solve the problem. A quantum algorithm need only apply U_f once to produce.

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$$\frac{1}{\sqrt{2}}|0\rangle|f(0)\rangle+\frac{1}{\sqrt{2}}|1\rangle|f(1)\rangle. \tag{1}$$

With an end to the no-cloning Signal theorems by M-Theoretic UFM parameter-based UQC another basis change will likely occur for QC development.

Under these conditions, if $f(0)=f(1)$ applying the Hadamard gate to the first register yields $|0\rangle$ with probability 1 and if $f(0)\neq f(1)$ then applying the Hadamard gate to the first register and ignoring the second register leaves the first register in the state $|1\rangle$ with probability 1/2; thus a result of $|1\rangle$ can only occur if $f(0)\neq f(1)$ [40]. Of special interest given

$$\frac{1}{\sqrt{2}}|0\rangle|\psi_0\rangle+\frac{1}{\sqrt{2}}|1\rangle|\psi_1\rangle \tag{2}$$

a 'Hadamard test' can be performed if a Hadamard gate is applied to the first qubit. A measurement will give '0' with probability $\frac{1}{2}+\mathrm{Re}\left(\langle\psi_0|\psi_1\rangle\right)$ [40].

2.4 Exponential speedup by quantum information processing

The salient utility of UQC is the offering of algorithms that will provide a fully exponential speed-up over classical algorithms making them the most sought-after research avenue for unleashing the power of QCs. Let's follow the work of Aaronson for finding a general theorem for developing exponential speedups from quantum algorithms; in recent efforts he makes two advances toward such a theorem in the black-box model where most quantum algorithms operate [41].

- First, Aaronson shows for any problem invariant under permuting inputs and outputs that has sufficiently many outputs (like collision and element distinctness problems) the quantum query complexity is at least the 7$^{\text{th}}$-root of classical randomized query complexity. Earlier he found a 9$^{\text{th}}$-root [42] resolving a conjecture of Watrous [43].
- Second inspired by work of O'Donnell [44] and Dinur [45] he conjectured that every bounded low-degree polynomial has a 'highly influential' variable (A multivariate polynomial p is *bounded* if $0 \leq p(x) \leq 1$ for all x in the Boolean cube). Assuming this conjecture he then showed that every T-query quantum algorithm can be simulated on most inputs by a $TO(1)$-query classical algorithm. Essentially one cannot hope to prove P$\neq$ BQP relative to a random oracle.

Perhaps the central lesson gleaned from fifteen years of quantum algorithms research is this: Quantum computers can offer superpolynomial speedups over classical computers but only for certain "structured" problems. The key question of course is what we mean by "structured". In the context of most existing quantum algorithms "structured" basically means that we are trying to determine some global property of an extremely long sequence of numbers assuming that the sequence satisfies some global regularity [41].

Aaronson offers period finding as a canonical example the core of Shor's factoring algorithms and computing discrete logarithms [46] where black-box access to exponentially-long sequences of integers $X=(x_1 \ldots x_N)$ is given; that is to compute x_i for a given i. We find the *period* of X that is the smallest $k>0$ such that $x_i=x_{i-k}$ for all $i>k$ with the promise that X is indeed periodic with period $k \ll N$ (and that the x_i values are approximately distinct within each period). The requirement of periodicity is crucial: it lets us use the Quantum Fourier Transform to extract the information we want from a superposition of the form

$$\frac{1}{\sqrt{N}}\sum_{i=1}^{N}|i\rangle|x_i\rangle. \qquad (3)$$

For other known quantum algorithms X needs to be a cyclic shift of quadratic residues [47] or constant on the cosets of a hidden subgroup.

By contrast, the canonical example of an 'unstructured' problem is the Grover search problem Black-box access is given to an N-bit string $(x_1,...,x_N)\in\{0,1\}^N$, and we are asked whether there exists an i such that $x_i = 1$. Grover formulated a quantum algorithm to solve this problem using $O(\sqrt{N})$ queries [48] as compared to the $\Omega(N)$ needed classically However Bennett et al showed this quadratic speedup is optimal [49] For other "unstructured" problems see [50-54].

This 'need for structure' limits prospects for super-polynomial quantum speedups to areas of mathematics likely to produce similar periodic sequences or sequences of quadratic residues. This is the fundamental reason why the greatest successes of quantum algorithm research have been cryptographic specifically in number-theoretic cryptography. This helps to explain why there are no fast quantum algorithm to solve NP-complete problems or to break arbitrary one-way functions [41,55].

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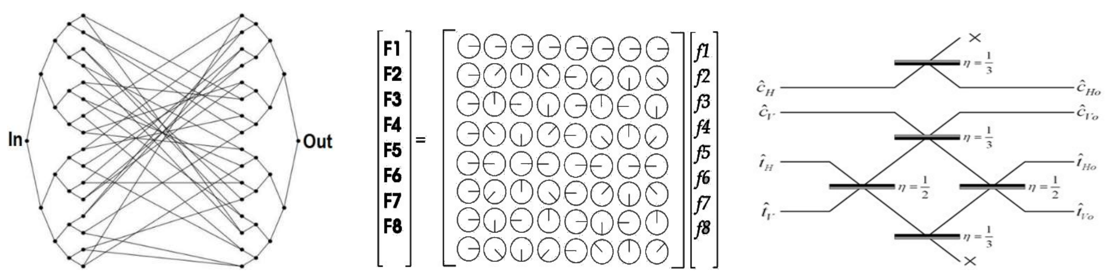


Figure 1. a) Quantum walk algorithm graph. Fig. adapted from [55]. b) Shor-like Fourier transform algorithms. c) Boson sampling algorithm. Identical single photons sent through network of interferometers then measured at output modes Fig. adapted from [56].

Quantum walk algorithms can achieve provable exponential speedups over any classical algorithm (in query complexity) but according to Childs et al. only for extremely fine-tuned' graphs [55].

In the 20 years since the appearance of Shor's factoring algorithm only a few additional quantum algorithms like Grover's search and quantum walks have appeared. Aaronson claims that while there are a number of exponential and polynomial speedup algorithms "*there just aren't that many compelling candidates left for exponential quantum speedups*" [56].

Factoring algorithms can break almost all public-key cryptosystems used today but theoretical public-key systems exist that are unaffected causing one to ask '*Can Shor's algorithm be generalized to nonabelian groups?'* [56].

Grover-like algorithms provide Quadratic speedup for any problem involving searching an unordered list provided the list elements can be queried in superposition. This implies subquadratic speedups for many other basic problems [49]. For black-box searching the square root speedup of Grover's algorithm is the best possible approach [29-31].

It was shown if a fast-classical exact simulation of boson sampling is possible then the polynomial hierarchy collapses to a 3rd-level. Experimental demonstrations with 3-4 photons were achieved [57-59].

2.5 Classical holographic reduction algorithms

Yes holographic algorithms (HA) already exist a concept originated by Valiant in 2004 [60] HA utilize a process called 'holographic reduction' mapping solution fragments 'many-to-many' so that the summation of solution fragments remains unchanged. Valiant coined the term HA because "*their effect can be viewed as that of producing interference patterns among the solution fragments*" [60]. The power of HA comes from the mutual cancellation of many contributions to a sum analogous to the interference patterns in a hologram [61]. So far HA have discovered solutions to previously unsolved polynomial problems. Although HA have some similarities to quantum computation they are currently completely classical in nature [62].

Holographic algorithms occur in the context of what is called Holant problems which generalize counting Constraint Satisfaction Problems (#CSP). A #CSP example is the hypergraph G = (VE) also called a constraint graph. Each hyperedge is a variable and each vertex v is assigned a constraint f_v. A vertex is connected to a hyperedge if the constraint on the vertex involves the variable on the hyperedge The counting problem is to compute

$$\sum_{\sigma:E\to\{0,1\}} \prod_{v\in V} f_v\left(\sigma\middle|E_{(v)}\right), \tag{4}$$

which is a sum over all variable assignments the product of every constraint where the inputs to the constrain f_v are the variables on the incident hyperedges of *v*.

A Holant problem is similar to a #CSP except the input must be a graph not a hypergraph. For a #CSP instance one replaces each hyperedge *e* of size *s* with a vertex *v* of degree *s* with edges incident to the vertices contained in *e.* The constraint on *v* is the equality function of *s* identifying all the variables on the edges incident to *v.* For Holant problems Eq (4) is called the Holant after a related exponential sum introduced by Valiant [63]. To further clarify Holant is a framework of counting characterized by local constraints. It is closely related to other well-studied frameworks such as #CSP and Graph Homomorphism. An e dichotomy for such frameworks can immediately settle the complexity of all combinatorial problems expressible in that framework. Both #CSP and Graph Homomorphism can be viewed as sub-families of Holant with the additional assumption that the equality constraints are always available [63].

Considering holographic reduction for a bipartite graph G = (UVE} the constraint assigned to each vertex $u \in U$ is f_u likewise for vertex $v \in V$ is f_v. This counting problem is $\text{Holant}(G, f_u, f_v)$. Thus for a complex 2 x 2 invertible matrix T, there is a holographic reduction between $\text{Holant}(G, f_u, f_v)$ and $\text{Holant}(G, f_u, T^{\otimes(\deg u)}, (T^{-1})^{\otimes(\deg v)} f_v)$.

Thus, $\text{Holant}(G, f_u, f_v)$ and $\text{Holant}(G, f_u, T^{\otimes(\deg u)}, (T^{-1})^{\otimes(\deg v)} f_v)$ have precisely the same Holant value for all constraint graphs essentially defining the same counting problem which can also be proved using holographic reduction. Valiant's original application of holographic algorithms used holographic reduction which has since been used in polynomial time algorithms and proofs of #P-hardness [64].

3. Ontological-phase UFM holographic algorithms

To try to stop all attempts to pass beyond the present viewpoint of quantum physics could be very dangerous for the progress of science and would furthermore be contrary to the lessons we may learn from the history of science. This teaches us in effect that the actual state of our knowledge is always provisional and that there must be beyond what is actually known immense new regions to discover – de Broglie [65].

A fundamental theory is needed which would tell us from first principles when quantum speedups are possible. There is a related longstanding open problem: Is there any Boolean function with a quantum quantum/classical gap better than quadratic? A Boolian function *f* is simply.

$$f : \{0,1\}^n \to \{0,1\} \tag{5}$$

with n input bits and a single output bit [32] We will answer yes below.

There are new results from Ben-David: If $F:S_N \to \{0,1\}$ is any Boolean function of permutations then D(F) = O(Q(F)^{12}). If F is any function with a symmetric *promise* and at most M possible results of each query then R(F) = O(Q(F)$^{12(M-1)}$) [66]. We need a 'structured' promise if we want an exponential quantum speedup. Exponential quantum speedups depend on structure For example abelian group structure glued-trees structure or relational structure…

The term Semiclassical in common usage means: intermediate between a classical Newtonian description and one based on quantum mechanics or relativity. Semiclassical physics refers to a theory in which one part of a system is described quantum-mechanically whereas the other is treated classically. For example, external fields will be constant or when changing will be classically described. In general it incorporates a development in powers of Planck's constant resulting in the classical physics of power 0 and the first nontrivial approximation to the power of (−1). In this case there is a clear link between the quantum mechanical system and the associated semi-classical and classical approximations.

Now for UFM, we create a new term semi-quantum where one part will be quantum and the other part UFM. This is a small regime of finite radius called the Manifold of Uncertainty (MOU). This is the 1st step in the realization that the central pillars of quantum field theory spacetime locality and unitarity are to be superseded. In assuming the universe is a huge information processor in terms of unitarity and locality (phenomenal) each distinct point is like a central processing unit (CPU) but in the move to nonlocality and holographic (ontological) ballistic processing there is no CPU; there is a simultaneity of information at each tessellated node. Clearly, I am trying to say this scenario is not classical or quantum but a unified field mechanical ontology. It is hard to fathom what kind of algorithm from a new class of holographic ontological algorithms able to operate without decohering the wavefunction this leads to.

Creative thinking has already begun to skirt this empyrean realm: *All we experience is nothing but a holographic projection of processes taking place on some distant surface that surrounds us* - Brian Greene.

Discovery of the amplituhedron could cause an even more profound shift … That is giving up space and time as fundamental constituents of nature and figuring out how the … universe arose out of pure geometry … In a sense we would see that change arises from the structure of the object but it's not from the object changing. The object is basically timeless - Nima Arkani-Hamed.

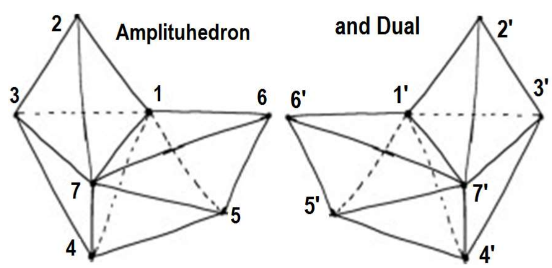


Figure 2. 7-point Amplituhedron in P^3 with Amplitude for $\left[1^-2^+3^+4^+5^+6^+7^-8^-\right]$ and its dual. The Hubble sphere, H_R may be one huge geometric Amplituhedron. With scale-invariance – microscopic to cosmic.

Figure 2 is a sketch of the basic amplituhedron element $A_{n,k,L;m}$ which lives in $G(k,k+m;L)$ the space of *k*-planes *Y* in *k* + *m* dimensions together with *L* 2-planes L1 … LL in the m-dimensional compliment of Y [69] representing an 8-gluon particle interaction using Feynman diagrams. The amplituhedron is a newly discovered mathematical object resembling a multifaceted jewel in HD Encoded in its volume are the most basic features of reality that can be calculated - the probabilities of outcomes of particle interactions. This or a similar geometric object could help remove two deeply rooted physical principles: locality and unitarity from quantum field theories' basic assumptions [67-69].

The amplitude form is positive when evaluated inside the amplituhedron. The statement is sensibly formulated thanks to the natural 'bosonization' of the superamplitude associated with the amplituhedron geometry. However, this positivity is not manifest in any of the current approaches to scattering amplitudes and in particular not in the cellulations of the amplituhedron related to on-shell diagrams and the positive Grassmannian. The surprising positivity of the form suggests the existence of a 'dual amplituhedron' formulation where this feature would be made obvious [69].

Locality is the idea that particles can interact only from adjoining positions in space and time and unitarity states that the probabilities of all possible outcomes of a quantum mechanical interaction must add up to one. The amplituhedron is not built out of spacetime and probabilities; these properties merely arise as consequences of the jewel's geometry. The usual picture of space and time with particles moving around in them is a construct "*Locality and unitarity emerge hand-in-hand from the positive geometry of the amplituhedron*" [67-69]. What's beyond the end to locality and unitarity as we know it?

In a confoundingly humorous parody, Scott Aaronson has this to say about the amplituhedron: *My colleagues and I have been investigating a mathematical structure that contains the amplituhedron yet is even richer and more remarkable. I call this structure the 'unitarihedron'...The unitarihedron encompasses within a single abstract 'jewel' all the computations that can ever be feasibly performed by means of unitary transformations the central operation in quantum mechanics (hence the name) Mathematically the unitarihedron is an infinite discrete space: more precisely it's an infinite collection of infinite sets which collection can be organized (as can every set that it contains!) in a recursive fractal structure. Remarkably each and every specific problem that quantum computers can solve - such as factoring large integers discrete logarithms and more - occurs as just a single element or 'facet' if you will of this vast infinite jewel. By studying these facets my colleagues and I have slowly pieced together a tentative picture of the elusive unitarihedron itself* [70] – Scott Aaronson.

Aaronson's parody is justified especially at this stage of development. The QC paradigm until now has been local and semiclassical. Aaronson himself said '*UQC will require a new discovery in physics*' Our *hypothesis non fingo* is that this putative discovery in physics is in fact an empirical Gödelization beyond quantum mechanics (unitarity and locality) into the 3rd regime of reality dubbed UFM [5]. We have seen that holographic computing algorithms are classical; we are not just looking for a quantum holography (already exists in NMR spectroscopy) we are proposing a special new class of UFM algorithms. In the course of preparing this paper, our opinion on this matter has evolved. We thought that the existing body of QC research would suffice; and what we had to add to the mix was ontological measurement without collapse and violation of the no-cloning theorem. We hope it is obvious that opinion has changed. If one has the stamina to read this whole volume one sees we expend a lot of effort skirting around issues without doing much of the math. This is our excuse; NASA flew around the moon a couple times before actually landing on it.

Since the framework of quantum mechanics seems to rest on unitarity most physicists will tend to look for possible ways to get around such a drastic modification. In quantum physics unitarity is a restriction on the allowed evolution of quantum systems that ensures the sum of probabilities of all possible outcomes of any event is always 1.

Giving up space and time as fundamental constituents of nature and figuring out how the cosmological evolution of the universe arose out of pure geometry is a fascinating opportunity. In a sense we would see that change arises from the structure of the object. But it's not from the object changing. The object is basically timeless. The revelation that particle interactions the most basic events in nature may be consequences of geometry significantly advances a decades-long effort to reformulate quantum field theory describing elementary particles and their interactions. Interactions previously calculated by mathematical formulas thousands of terms long are now described by computing a volume of the corresponding jewel-like 'amplituhedron' yielding an equivalent one-term expression [67-69].

In the quantum world probabilities were expressed as complex numbers with both a quantity and a phase and these so-called amplitudes were squared to produce probability. This was the mathematical procedure necessary to capture the wavelike aspects of particle behavior. Probability amplitudes were normally associated with the likelihood of a particle's arriving at a certain place at a certain time [71].

Feynman said he would associate the probability amplitude *'with an entire motion of a particle'*-*with a path* He stated the central principle of quantum mechanics: '*The probability of an event which can happen in several different ways is the absolute square of the sum of complex contributions one from each alternative way*'. These complex numbers amplitudes were written in terms of classical action; Feynman showed how to calculate the action for each path as a certain integral [44-55].

4. The superimplicate order and instantaneous UQC algorithms

Who might have guessed there might be a class of QC algorithms better than polynomial and exponential speed QIP? Let's peek at the basis for possible instantaneous algorithms. It is generally known that information passes instantaneously in systems of EPR correlated photons. We know how to parametric down-convert entangled EPR pairs; what if we can learn parametric up-conversion utilizing the tenets of M-Theoretic UFM correspondence?

Following Bohm, we assume a field $\phi(x,t)$ will take the form of a wavepacket $\alpha_c F_c(x,t)+\alpha_s F_s(x,t)$ with α_c,α_s real and positive proportionality factors; then functions $\Gamma(x,t)$ orthogonal to $F_c(xt)$ and $F_s(xt)$ will have no effect on the factor in front of Ψ_0 meaning their variation will be the same as in the ground state. Thus, chaotic variation of the field will be modified by statistical tendencies to change around an average form of the wavepacket

$$\Psi = \sum_k{}' f_k q_k \Psi_0 \tag{6}$$

In (6) the sum is over all k and no restriction made that $f_{-k} = f_k^*$ because the wave function is complex even though $f_{(x)}$ is real. Considering $q_{-k} = q_k^*$ we write

$$\Psi = \sum_k{}' \left[f_k q_k + f_{-k} q_k^* \right] \Psi_0 \tag{7}$$

where $\sum_k^{'}$ indicates summation over a suitable half of the total set of k values. With the assumption in **(7)** that the space average of the field $f_0 = 0$ we write

$$\Psi = \sum_k{}' f_k q_k \exp\left[-ikt\right] \Psi_0 . \tag{8}$$

Then write $g = \sum_k{}' f_k q_k \exp\left[-ikt\right]$ giving $R = \sqrt{\Psi^* \Psi} = \sqrt{g g^*}\,\Psi_0$ [37].

According to Bohm, inside this wave packet the super-quantum potential introduces nonlocal connections between fields at different points separated by a finite distance (unlike ground state). Now we write the quantum potential as

$$Q = -\sum_k{}' \frac{\partial^2 R}{\partial q_k^* \partial q_k} / R. \tag{9}$$

Now we evaluate the quantum potential change from the ground state

$$\Delta Q = -\frac{1}{4} \sum_k{}' \frac{f_k f_k^*}{g^* g} + \frac{1}{2} \sum_k{}' \frac{k f_k q_k \exp\left[-ikt\right]}{g} + c.c. \tag{10}$$

For a wave packet with only a small range of wave vectors the factor k on the right reduces to the fixed number k_0 while the remaining factors reduce to unity. This term varies with time but we are only interested in the wave packets for which the spread of k makes negligible contributions. But when the q_k are expressed in terms of $\phi(x)$ as in

$$q_k = 1/\sqrt{V}\int \exp\left[-ik\cdot x\right]\phi(x)dV \tag{11}$$

the quantum potential reduces to

$$\Delta Q = \frac{1}{4}\sum_k{}' \frac{f_k f_k^*}{\sqrt{\int F(x,t)\phi(x)dV}\sqrt{\int F^*(x',t)\phi(x')dV'}}. \tag{12}$$

It should be obvious the term implies nonlocal interaction between $\phi(x)$ at one point and $\phi(x')$ at other points where the integrand is substantial. Writing $Q = \Delta Q + Q_0$, with Q_0 the quantum potential of the ground state as given in

$$\Psi_0 = \exp\left[-\iint \phi(x)\phi(x')f(x'-x)dVdV'\right] \tag{13}$$

as taken from (11) with the t coordinate suppressed and where $f(x'-x) = 1/V\sum_k{}' k\exp\left[ik\cdot \le (x'-x)\right]$ we can write the field equation (14a) as (14b)

$$\frac{\partial^2\phi}{\partial t^2} = \nabla^2\phi - \frac{\delta Q}{\delta\phi}; \quad \frac{\partial^2\phi}{\partial t^2} = \nabla^2\phi - \frac{\delta\Delta Q}{\delta\phi} - \frac{\delta Q_0}{\delta\phi} \tag{14a,b}$$

Using (13) and expressing Q in terms of $\phi(x)$ by Fourier analysis Bohm obtains [37]

$$\frac{\partial^2\phi}{\partial t^2} = \frac{1}{8}\left(\sum_k{}' f_k f_k^*\right)\times\frac{f_k f_k^*}{\left(\int F(x,t)\phi(x)dV\right)^{3/2}\left(\int F^*(x',t)\phi(x')dV'\right)^{1/2}} + c.c. \tag{15}$$

Remember from the ground state the field is static because the effect of the quantum potential cancels out the Laplacian $\nabla^2\phi$ in the field equation ∇^2 is the Laplacian or divergence of the gradient of a function $\Delta f(p)$ on a point p in Euclidean space. Now with (15) in the excited state there is an additional term causing the wavepacket to move and as happens with the quantum potential the field equation is nonlocal and nonlinear [65].

The point we have been building up to in this section is that the nonlocality represents an instantaneous connection of the field at different points in space. However, as Bohm reminds us this is significant only over the extent of the wavepacket. In the usual interpretation the spread of the wavepacket applies to a region within which according to the uncertainty principle nothing whatsoever can be said regarding what is happening. Therefore, the de Broglie-Bohm-Vigier causal interpretation [84] attributes nonlocality only to situations in which the usual interpretation cannot attribute well-defined properties [65].

It is of key importance to note that a wavefunction of the form $\Psi = q_k \exp[-ikt]\Psi_0$ does not correspond to the usual picture of an oscillation. This is shown by (15) because the term $\nabla^2\phi$ is absent. This result follows because stationary wavefunctions usually correspond to static situations contradicting intuitive expectations of a dynamic state of motion [65].

But Bohm was only thinking from a 4D Standard Model perspective in terms of an amplituhedronic-type (volume) for a Wheeler-DeWitt wavefunction of the universe $H\Psi = 0$ instantaneous EPR-holographic algorithms should prove possible with sufficient UFM insight.

When considered in terms of our UFM brane topological additions to the structure of matter and Bohm's superimplicate order, full utility of nonlocal information as hinted by EPR correlations hints at the possibility of instantaneous algorithms.

Unified Theory postulates that spacetime topology is 'continuously transformed' by the self-organizing properties of the long-range coherence of the unified field [85,86] In addition to manipulating conformational change in HD brane topology from the experimental results we attempt to calculate the energy Hamiltonian required to manipulate Casimir-like boundary conformation in terms of the unified field equation $F_{(N)} = \aleph / \rho$ (simple unexpanded form). This resonant coupling produced by the teleological action of the unified field driving its hierarchical self-organization has local nonlocal and global (complex LSXD) parameters. The Schrödinger equation extended by the addition of the de Broglie-Bohm quantum potential-pilot wave mechanism has been used to describe an electron moving on a manifold; but this is not a sufficient extension to describe HD unified aspects of the continuous-state symmetry breaking of spacetime topology which requires further extension to include action of the unified field in additional dimensions.

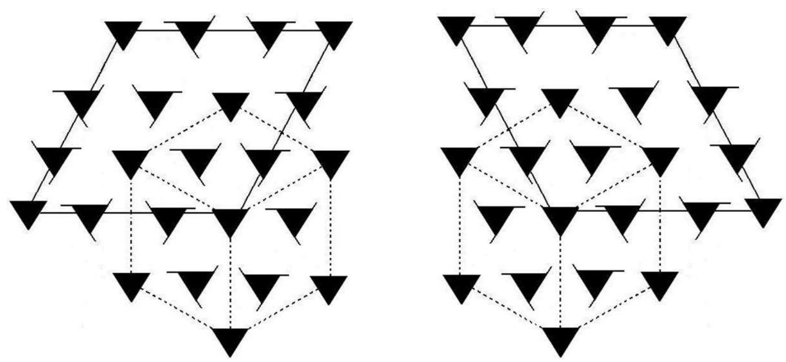


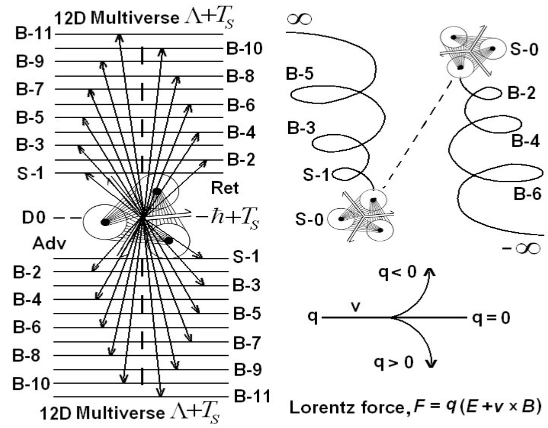
Figure 3. Emergence of Euclidean shadow vertices from local lattice gas array. If the central vertex of the cube represents a Euclidian point, the 12 satellite points represent HD control parameters. The triangles with obverse tails represent left-right nilpotent symmetry.

5. Evolution of M-Theory

Every Calabi-Yau manifold with mirror symmetry or T-duality admits a hierarchical family of supersymmetric toroidal 3-cycles as shown conceptually in Fig. 4, 4a shows possible duality couplings and 4b is meant to illustrate the compactification–boost hierarchy.

In type-II string theories closed strings are free to move through the 10D bulk of spacetime but the ends of open strings attach to D-branes. In type-IIA their dimensionality is odd – 1,3,5,7 and even in type IIB – 0,2,4,6. Through different gauge symmetry conditions various types of strings or branes are related by S-duality which relates the strong coupling limit of one type to the weak coupling limit of another type T-duality relates strings/branes compactified on a circle of radius R to strings/branes compactified on a circle of radius $1/R$.

Following work by Sundrum [87] for 5D General Relativity where the Einstein action is $\ni \partial_\mu$ or $\partial_5 Gr^0_{MN}(x) \to 0$ for large-scale XD fluctuations $ds^2 \ni Gr_{55}\left(dx^5\right)^2 = Gr_{55} R^2 d\theta^2 \Rightarrow Gr^{(0)}_{55}(x) \equiv$ dynamical XD radius. Randall and Sundrum [16,17] have found an HD method to solve the hierarchy problem by utilizing 3-branes with opposite tensions $\pm\sigma$ residing at the orbifold fixed points which together with a finely tuned cosmological constant from sources for 5D gravity for a spacetime with a single S_1/Z_2 XD orbifold [88-90].



(a) (b).

Figure 4. Conceptualized string (S) and brane (B) couplings in Advanced-Retarded spacetime arising from a least-cosmological unit D0 S-0 a) String-brane duality couplings from 0 to 12D for odd-even Fermi-Bose topologies b) Ising model spin-glass rotations which driven by an internal Lorentz-like force or external resonances for vacuum engineering.

These 3-branes with opposite tensions residing at the orbifold fixed points along with their model of a finely tuned cosmological constant serve as sources for 5D gravity.

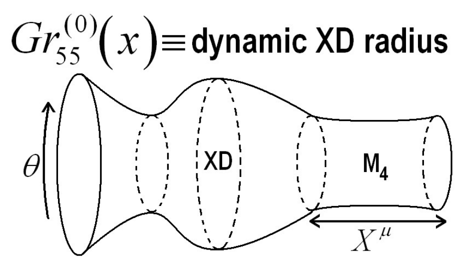


Figure 5. Sundrum's view of the dynamic oscillations of bulk large size XD readily making correspondence to the continuous-state dimensional reduction parameters inherent in the multiverse cosmology paradigm. Redrawn from [91].

6. Lorentz condition in complex 8-space and tachyonic signaling

In order to examine as the consequences of the relativity hypothesis that time is the 4th dimension of space, and that we have a particular form of transformation called the Lorentz transformation, we must define velocity in the complex space. That is, the Lorentz transformation and its consequences, the Lorentz contraction and mass dilation etc., are a consequence of time as the 4th dimension of space and are observed in three spaces [30]. These attributes of 4-space in 3-space are expressed in terms of velocity as in the form $\gamma = \left(1-\beta^2\right)^{-1/2}$ for $\beta \equiv v_{\mathrm{Re}}/c$ where c is always taken as real.

If complex 8-space can be projected into 4-space what are the consequences? We can also consider a 4D slice through the complex 8D space. Each approach has its advantages and disadvantages. In projective geometries, information about the space is lost. What is the comparison of a subset geometry formed from a projected geometry or a subspace formed as a slice through an XD geometry? What does a generalized Lorentz transformation "look like"? We will define complex derivatives and therefore we can define velocity in a complex plane [92].

Consider the generalized Lorentz transformation in the system of x_{Re} and t_{Im} for the real time remote connectedness case in the $x_{\mathrm{Re}}, t_{\mathrm{Im}}$ plane. We define our substitutions from 4-to 8-space before us

$$\begin{aligned} x &\rightarrow x' = x_{\mathrm{Re}} + i x_{im} \\ t &\rightarrow t' = t_{\mathrm{Re}} + i t_{im} \end{aligned} \tag{16}$$

and we represented the case for no imaginary component of x_{Re} or $x_{\mathrm{Im}} = 0$ where the $x_{\mathrm{Re}}, t_{\mathrm{Re}}$ plane comprises the ordinary 4-space plane.

Let us recall that the usual Lorentz transformation conditions is defined in 4D real space. Consider two frames of reference Σ at rest and Σ' moving at relative uniform velocity v We call v the velocity of the origin of Σ' moving relative to Σ. A light signal along the x direction is transmitted by $x = ct$ or $x - ct = 0$ and also in Σ' as $x' = ct'$ or $x'-ct' = 0$ since the velocity of light in vacuo is constant in any frame of reference in 4-space. For the usual 4D Lorentz transformation we have as shown in Eq. (16) $x = x_{\mathrm{Re}}, t = t_{\mathrm{Re}}$ and $v_{\mathrm{Re}} = x_{\mathrm{Re}} / t_{\mathrm{Re}}$

$$\begin{aligned} x' &= \frac{x - vt}{\sqrt{1 - v^2 / c^2}} = \gamma\left(x - vt\right); \quad y' = y; \\ z' &= z; \quad t' = \frac{t - \left(v / c^2\right) x}{\sqrt{1 - v^2 / c^2}} = \gamma\left(t - \left(\frac{v}{c^2} x\right)\right) \end{aligned} \tag{17}$$

for $\gamma = (1 - \beta^2)^{-1/2}$ and $\beta = v / c$. Here x and t stand for x_{Re} and t_{Re} and v is the real velocity.

We consider the $x_{\mathrm{Re}}, t_{\mathrm{Im}}$ plane and write the expression for the Lorentz conditions for this plane Since again t_{Im} like t_{Re} is orthogonal to x_{Im} and t'_{Im} is orthogonal to x'_{Im}; we can write

$$\begin{aligned} x' &= \frac{x - i v t_{\mathrm{Im}}}{\sqrt{1 - v^2 / c^2}} = \gamma_v\left(x - v t_{\mathrm{Im}}\right); \quad y' = y; \\ z' &= z; \quad t' = \frac{t - \left(v / c^2\right) x}{\sqrt{1 - v^2 / c^2}} = \gamma_v\left(t - \left(\frac{v}{c^2} x\right)\right) \end{aligned} \tag{18}$$

where γ_v represents the definition of γ in terms of the velocity v; also $\beta_{v\mathrm{Im}} \equiv v_{\mathrm{Im}} / c$ where c is always taken as real [93] where v can be real or imaginary.

In Eq (18) for simplicity, we let x', x, t' and t denote $x'_{\mathrm{Re}}, x_{\mathrm{Re}}, t'_{\mathrm{Re}}$ and t_{Re} and we denote script v as v_{Im}. For velocity v is $v_{\mathrm{Re}} = x_{\mathrm{Re}} / t_{\mathrm{Re}}$ and $v = v_{\mathrm{Im}} = i_{\mathrm{Im}} / i t_{\mathrm{Im}}$; where the i drops out so that $v = v_{\mathrm{Im}} = x_{\mathrm{Im}} / t_{\mathrm{Im}}$ is a real value function In all cases the velocity of light c is c. We use this alternative notation here for simplicity in the complex Lorentz transformation.

The symmetry properties of the topology of the complex 8-space gives us the properties that allow Lorentz conditions in 4D, 8D and ultimately 12D space. The example we consider here is a subspace of the 8-space of $x_{\text{Re}}, t_{\text{Re}}, x_{\text{Im}}$ and t_{Im}. In some cases we let $x_{\text{Im}} = 0$ and just consider temporal remote connectedness; but likewise we can follow the anticipatory calculation and formulate remote nonlocal solutions for $x_{\text{Im}} \neq 0$ and $t_{\text{Im}} = 0$ or $t_{\text{Im}} \neq 0$. The anticipatory case for $x_{\text{Im}} = 0$ is a 5D space as the space for $x_{\text{Im}} \neq 0$ *and* $t_{\text{Im}} = 0$ is a 7D space and for $t_{\text{Im}} \neq 0$ as well as the other real and imaginary spacetime dimensions we have our complex 8D space.

It is important to define the complex derivative in order to define velocity v_{Im}. In the $x_{\text{Re}}t_{\text{Im}}$ plane then we define a velocity of $v_{\text{Im}} = dx/dit_{\text{Im}}$. In the next section we detail the velocity expression for v_{Im} and define the derivative of a complex function in detail [85].

For $v_{\text{Im}} = dx / idt_{\text{Im}} = -idx / dt_{\text{Im}} = -iv_{\text{Re}}$, for v_{Re} as a real quantity we substitute into our $x_{\text{Re}}, t_{\text{Im}}$ plane Lorentz transformation conditions as

$$x' = \frac{x_{\text{Re}} - v_{\text{Re}} t_{\text{Im}}}{\sqrt{1 + v_{\text{Re}}^2 / c^2}}; \quad y' = y;$$

$$z' = z; \quad t_{\text{Im}}' = \frac{t_{\text{Re}} - v_{\text{Re}} x_{\text{Re}}}{\sqrt{1 + v_{\text{Re}}^2 / c^2}} \tag{19}$$

These conditions are valid for any velocity $v_{\text{Re}} = - v$.

Let us examine the way this form of the Lorentz transformation relates to the properties of mass dilation We will compare this case to the ordinary mass dilation formula and the tachyonic mass formula of Feinberg [94] which nicely results from the complex 8-space.

In the ordinary $x_{\text{Re},}\ t_{\text{Re}}$ plane then we have the usual Einstein mass relationship of

$$m = \frac{m_0}{\sqrt{1 - v_{\text{Re}}^2 / c^2}} \quad \text{for} \quad v_{\text{Re}} \leq c \tag{20}$$

and we can compare this to the tachyonic mass relationship in the *xt* plane

$$m = \frac{m_0^*}{\sqrt{1 - v_{\text{Re}}^2 / c^2}} = \frac{im_0}{\sqrt{1 - v_{\text{Re}}^2 / c^2}} = \frac{m_0}{\sqrt{v_{\text{Re}}^2 / c^2 - 1}} \tag{21}$$

for v_{Re} now $v_{\text{Re}} \geq c$ and where m^* or m_{Im} stands for $m^* = im$ and we define m as m_{Re}

$$m = \frac{m_0}{\sqrt{1 + v^2 / c^2}} \tag{22}$$

For m real (m_{Re}) we can examine two cases on v as $v < c$ or $v > c$ so we will let v be any value from $-\infty < v < \infty$, where the velocity v is taken as real or v_{Re}.

Consider the case of v as imaginary (or v_{Im}) and examine the consequences of this assumption. Also we examine the consequences for both v and m imaginary and compare to the above cases. If we choose v imaginary or $v^* = iv$ (which we can term v_{Im}) the $v^{*2} / c^2 = -v^2 / c^2$ and $\sqrt{1 + v^{*2} / c^2}$ becomes $\sqrt{1 - v^{*2} / c^2}$ or

$$m = \frac{m_0}{\sqrt{1 - v_{\text{Re}}^2 / c^2}} \tag{23}$$

We get the form of this normal Lorentz transformation if v is imaginary $(v^* = v_{\text{Im}})$.

If both v and m are imaginary as $v^* = iv$ and $m^* = im$ then we have

$$m = \frac{m_0^*}{\sqrt{1+v^{*2}/c^2}} = \frac{im_0}{\sqrt{1-v^2/c^2}} = \frac{m_0}{\sqrt{v^2/c^2-1}} \tag{24}$$

or the tachyonic condition.

If' we go "off" into x_{Re} t_{Re} t_{im} planes then we have to define a velocity "cutting across" these planes and it is much more complicated to define the complex derivative for the velocities. For subliminal relative systems Σ and Σ' we can use vector addition such as $W = v_{\text{Re}} + iv_{\text{Im}}$ for $v_{\text{Re}} < x,\ v_{\text{Im}} < c$ and $W < c$. In general, there will be four complex velocities. The relationship of these four velocities is given by the Cauchy-Riemann relations in the next section.

These two are equivalent. The actual magnitude of v may be expressed as $v = [vv^*]^{\frac{1}{2}}\hat{v}$ (where $\hat{v}$ is the unit vector velocity) which is formed using either of the Cauchy-Riemann equations. It is important that a detailed analysis not predict any extraneous consequences of the theory. Any new phenomenon that is hypothesized should be formulated in such a manner as to be easily experimentally testable.

Feinberg suggests several experiments to test for the existence of tachyons [94]. He describes the following experiment – consider in the laboratory atom A at time t_0 is in an excited state at rest at x_1 and atom B is in its ground state at x_2. At time t_1 atom A descends to the ground state and emits a tachyon in the direction of B Let E_1 be this event at $t_1\, x_1$. Subsequently at $t_2 > t_1$ atom B absorbs the tachyon and ascends to an excited state; this is event E_2 at $t_2 x_2$. Then at $t_3 > t_2$ atom B is excited and A is in its ground state. For an observer traveling at an appropriate velocity $v < c$ relative to the laboratory frame events E_1 and E_2 appear to occur in the opposite order in time. Feinberg describes the experiment by stating that at t_2' atom B spontaneously ascends from the ground state to an excited state emitting a tachyon traveling toward A Then at t_1', atom A absorbs the tachyon and drops to the ground state.

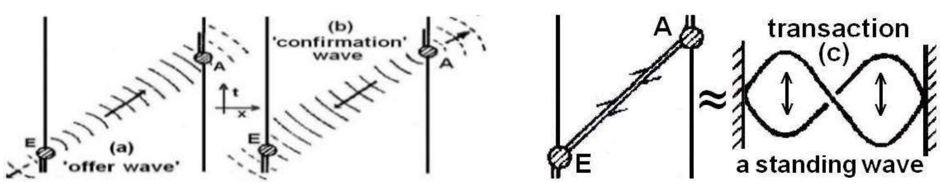


Figure 6. Cramer's Transactional Interpretation. a) Offer-wave. b) confirmation-wave combined into the resultant transaction. c) taking the form of an HD future-past advanced-retarded standing or stationary wave. Figs Adapted from Cramer [95].

It is clear from this that what is absorption for one observer is spontaneous emission for another. But if quantum mechanics is to remain intact so that we are able to detect such particles then there must be an observable difference between them: The first depends on a controllable density of tachyons, the second does not. In order to elucidate this, point we should repeat the above experiment many times. The possibility of reversing the temporal order of causality sometimes termed 'sending a signal backwards in time' must be addressed [96]. Is this cause-effect statistical in nature? In the case of Bell's Theorem these correlations are extremely strong whether explained by $v > c$ or $v = c$ signaling.

Bilaniuk formulated the interpretation of the association of negative energy states with tachyonic signaling [85,94,97]. From the different frames of reference thus to one observer absorption is observed and to another emission is observed. These states do not violate special relativity. Acausal experiments in particle physics have been suggested by a number of researchers [98,99]. Another approach is through the detection of Cherenkov radiation which is emitted by charged particles moving through a substance traveling at a velocity $v > c$. For a tachyon traveling in free space with velocity $v > c$ Cherenkov radiation may occur in a vacuum causing a tachyon to lose energy becoming a tardon [11,12,94].

In prior work [85,94] in discussions on the arrow of time, we have developed an extended model of a polarized Dirac vacuum in complex form that makes correspondence to Calabi-Yau mirror symmetry conditions, which extends Cramer's Transactional Interpretation [85,95] of quantum theory to cosmology. Simplistically, Cramer models a transaction as a standing wave of the future-past (offer wave-confirmation wave).

However, in the broader context of the new paradigm of Holographic Anthropic Multiverse cosmology it appears theoretically straight forward to 'program the vacuum'. The coherent control of a Cramer transaction can be resonantly programmed with alternating nodes of constructive and destructive interference of the standing-wave present. It should be noted that in UFM cosmology the de Broglie-Bohm quantum potential becomes an eternity-wave, $\aleph$ or super-pilot-wave force of coherence associated with the U_F ordering the reality of the observer or the locus of the spacetime arrow of time.

To perform a simple experiment to test for the existence of Tachyon/Tardyon interactions, an atom is placed in a QED cavity or photonic crystal. Utilizing the resonant hierarchy, by interference, a reduced eternity wave, $\aleph$ is focused constructively or destructively as the experimental mode may be, and according to the parameters illustrated by Feinberg above, temporal measurements of emission are taken.

7. Instantaneous propagation velocity in complex 8-space

Utilizing the Cauchy-Riemann relations we formulate the hyperdimensional velocities of propagation in the complex plane in various slices through a hyperdimensional complex 8-space. In this model finite limit velocities $v > c$ can be considered. In some Lorentz frames of reference instantaneous signaling can be considered. It is the velocity connection between remote nonlocal events and temporal separated events or anticipatory and real time event relations.

It is important to define the complex derivative so that we can define the velocity vy_{Im}. In the *xit* plane then, we define a velocity of $v = dx/d(i\tau)$. We now examine in some detail the velocity of this expression. In defining the derivative of a complex function, we have two cases in terms of a choice.

With the differential increment considered, Consider the orthogonal coordinates *x* and it_{Im}; then we have the generalized function $f(x,t_{\text{Im}}) = f(z)$ for $z = x + it_{\text{Im}}$ and f(*z*) = $u(x,t_{\text{Im}}) + iv(x,t_{\text{Im}})$ where $u(x,t_{\text{Im}})$ and $v(x_{\text{Im}},t_{\text{Im}})$ are real functions of the rectangular coordinates *x* and t_{Im} of a point in space $P(x,t_{\text{Im}})$. Choose a case such as the origin $z_0 = x_0 + it_{0\text{Im}}$ and consider two cases one for real increments $h = \Delta x$ and imaginary increments $h = i\Delta t_{\text{Im}}$. For the real increments $h = \Delta t_{\text{Im}}$, we form the derivative $f'(z_0) \equiv df(z)/dz_{z_0}$ which is evaluated at z_0

$$f' = \lim \Delta x \to 0 \left\{ \frac{u(x_0 + \Delta x, t_{0\text{Im}}) - u(x_0, t_{0\text{Im}})}{\Delta x} + i\frac{v(x_0 + \Delta x, t_{0\text{Im}}) - v(x_0, t_{0\text{Im}})}{\Delta x} \right\} \tag{25a}$$

or

$$f'(z_0) = u_x(x_0, t_{0\text{Im}}) + iv_x(x_0, t_{0\text{Im}}) \text{ for } u_x \equiv \frac{\partial u}{\partial x} \text{ and } v_x \equiv \frac{\partial v}{\partial x}. \tag{25b}$$

Again, $x = x_{\text{Re}}$, $x_0 = x_{0\text{Re}}$ and $v_x = v_{x\text{Re}}$.

Now for the purely imaginary increment $h = i\Delta t_{\text{Im}}$ we have

$$f'(z_0) = \lim \Delta t_{\text{Im}} \to 0 \left\{ \frac{1}{i}\frac{u(x_0, t_{0\text{Im}} + \Delta t_{\text{Im}}) - u(x_0, t_{0\text{Im}})}{\Delta t_{\text{Im}}} + \frac{v(x_0, t_{0\text{Im}} + \Delta t_{\text{Im}}) - v(x_0, t_{0\text{Im}})}{\Delta t_{\text{Im}}} \right\} \tag{26a}$$

and

$$f'(z_0) = -iu_{t\,\mathrm{Im}}(x_0, t_{0\mathrm{Im}}) + v_{t\,\mathrm{Im}}(x_0, t_{0\mathrm{Im}}) \tag{26b}$$

for $u_{\mathrm{Im}} = u_{t\,\mathrm{Im}}$ and $v_{\mathrm{Im}} = v_{t\,\mathrm{Im}}$ then

$$u_{t\,\mathrm{Im}} \equiv \frac{\partial u}{\partial t_{\mathrm{Im}}} \text{ and } v_{t\,\mathrm{Im}} \equiv \frac{\partial v}{\partial t_{\mathrm{Im}}}. \tag{26c}$$

Using the Cauchy-Riemann equations

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial t_{\mathrm{Im}}} \text{ and } \frac{\partial u}{\partial t_{\mathrm{Im}}} = -\frac{\partial v}{\partial x} \tag{27}$$

assuming all principle derivations are definable on the manifold and letting $h = \Delta x + i\Delta t_{\mathrm{Im}}$, we use

$$f'(z_0) = \lim h \to 0 \;\; \frac{f(z_0+h) - f(z_0)}{h} = \frac{df(z)}{dz}\Big|_{z_0} \tag{28a}$$

and

$$u_x(x_0, t_{0\mathrm{Im}}) + iv_x(x_0, t_{0\mathrm{Im}}) - \frac{\partial u(x_0, t_{0\mathrm{Im}})}{\partial x} + i\frac{\partial v}{\partial x}(x_0, t_{0\mathrm{Im}}) \tag{28b}$$

with v_x for x and t_{Re} that is $u_{\mathrm{Re}} = u_{x\mathrm{Re}}$, with the derivative form of the charge of the real space increment with complex time we can define a complex velocity as

$$f'(z_0) = \frac{dx}{d(it_{\mathrm{Im}})} = \frac{1}{i}\frac{dx}{dt_{\mathrm{Im}}} \tag{29a}$$

we can have $x(t_{\mathrm{Im}})$ where x_{Re} is a function of t_{Im} and $f(z)$ and using $h = i\Delta t_{\mathrm{Im}}$ then

$$f'(z_0) = x'(t_{\mathrm{Im}}) = \frac{dx}{dh} = \frac{dx}{idt_{\mathrm{Im}}} \tag{29b}$$

Then we can define a velocity where the differential increment is in terms of $h = i\Delta t_{\mathrm{Im}}$. Using the first case as $u(x_0, t_{0\mathrm{Im}})$ and obtaining $dt_{0\mathrm{Im}} / \Delta x$ (with i's) we take the inverse. If u_x which is v_x in the $h \to i\Delta t_{\mathrm{Im}}$ case have both u_x and v_x one can be zero.

Like the complex 8D space, 5D Kaluza-Klein geometries are subsets of the supersymmetry models. The complex 8-space deals in extended dimensions, but like the TOE models, Kaluza-Klein models also treat $n > 4$D as compactified on the scale of the Planck length 10^{-33} cm [85,94].

In 4D space event point P_1 and P_2 are spatially separated on the real space axis as $x_{0\mathrm{Re}}$ at point P_1 and $x_{1\mathrm{Re}}$ at point P_2 with separation $\Delta x_{\mathrm{Re}} = x_{1\mathrm{Re}} - x_{0\mathrm{Re}}$. From the event point P_3 on the t_{Im} axis we move in complex space from event P_1 to event P_3. From the origin $t_{0\mathrm{Im}}$ we move to an imaginary temporal separation of t_{Im} to $t_{2\mathrm{Im}}$ of $\Delta t_{\mathrm{Im}} = t_{2\mathrm{Im}} - t_{0\mathrm{Im}}$. The distance in real space and imaginary time can be set so that measurement along the t_{Im} axis yields an imaginary temporal separation Δt_{Im} subtracts out from the spacetime metric the temporal separation Δx_{Re}. In this case occurrence of events P1 and P2 can occur simultaneous that is the apparent velocity of propagation is instantaneous.

For the example of Bell's Theorem, the two photons leave a source nearly simultaneously at time $t_{0\mathrm{Re}}$ and their spin states are correlated at two real spatially separated locations $x_{1\mathrm{Re}}$ and $x_{2\mathrm{Re}}$ separated by $\Delta x_{\mathrm{Re}} = x_{2\mathrm{Re}} - x_{1\mathrm{Re}}$. This separation is a space-like separation which is forbidden by special relativity; however in complex space the points $x_{1\mathrm{Re}}$ and $x_{2\mathrm{Re}}$ appear to be contiguous for the proper path 'travelled' to the point.

8. *Post scholum deductionem* - Why a new transformation group is needed?

The UFM Transformation is different from the Galilean and Lorentz-Poincairé group transformations in that in its simplest form it is stationary in *ds_0 with no temporal components* (still ontological displacement). This is because its transformation process, which is cyclic, moves *upwards* through the HD/LSXD brane topology bulk. As a further challenge, it also has an *ontological* component with no energy transferred; only topological information. This is the duality: Usual localized phenomenological quantal field mediation up to the semi-quantum limit, and ontological holographic nonlocally. The UFM transform is a topological-phase interaction with an energyless UFM force of coherence mediated by *topological charge* in conjunction with a nilpotent zero-totality (defined in [5,85]).

However, all new theory must make correspondence to existing theory; when referring to a Standard Model particle in motion &c, the T_N would include all pertinent aspects of Galilean and Lorentz-Poincairé transforms. This is no different than the additions made to CM with the discovery of QM.

9. Summation

A critic of Aaronson's Unitarihedron parody blog of the Amplituhedron, called Aaronson's Unitarihedron a diaperhedron! There is always risk when *a bear goes over the mountain* '*to see what he can see',* as the old nursery song goes. I still remember vividly Tom Toffoli chastising Vlasov, a young Russian postdoc at the time, at Physcomp96, regarding his paper putting forth a relativistic qubit; now 20 years later finally there is talk of r-qubits and a new field of relativistic information processing (RIP) is well under way. In any case, we have 'put up' viable protocols [11,12] much simpler and more revealing than those putatively to be processed by the CERN LHC.

Now here's the rub; let's consider a general case of n = 500 electron qubits in a linear superposition of all 2^{500} possible classical states, much larger than the number of particles estimated in the classical universe (10^{80}):

$$\sum_{x\in\{0,1\}^n} \alpha_x \left| x \right\rangle. \tag{30}$$

This exponentially huge superposition is 'the private world' of the electrons involved and measurement only allows us to find the n bits (500) of information $\left|\alpha_x\right|^2$. If our UFM model proves successful in surmounting uncertainty, then measurement does not change the system, leaving all 2^{500} possible superposed states intact. This also leads to violation of the no-cloning theorem. Profoundly, 'ontological-phase eversion cycles for IQCA', provide the explorable framework for producing instantaneity.

The framework for the imminent age of discovery we term unified field mechanics (UFM); a 3rd regime of reality in the progression Classical Mechanics $\rightarrow$ Quantum Mechanics $\rightarrow$ UFM. Just as infinities (ultraviolet catastrophe) in the Raleigh-Jeans Law describing blackbody radiation led to Planck's 1900 formulation of the process of energy absorption and emission, becoming known as the quantum hypothesis - any energy radiating atomic system can theoretically be divided into a number of discrete 'energy elements' ε, with each element proportional to the frequency v individually radiating energy by: $\varepsilon = hv$.

There is an obvious parallel today in the renormalization of the troublesome infinities in quantum field theory. It is quite curious that in this case, a reversal occurs, and quantization is undone again by entry into the 3rd regime. Since quantum mechanics can no longer be considered the 'basement of reality', an initial discovery popping out of the UFM prize bucket, is that QM uncertainty is a 'complex manifold of finite radius'. The new set of UFM transformations beyond the Galilean-Lorentz-Poincaré naturally cancel the infinities from fundamental principles, not in an *ad hoc* manner.

Physicists still 'believing' in a quantum universe, where the Planck-scale is the 'basement of reality', adamantly proclaim the impossibility of violating the quantum uncertainty principle. Here is the manner in which science fiction writer Isaac Asimov put it: "*You can't lick the uncertainty principle man, any more than you can live on the sun, there are physical limits to what can be done*" [100]. The assumed Physical Limits apply of course, to the tools available to us currently to the semi-quantum limit. Suggested experimental protocols [11.12], *when* proven successful, begin the awaited UFM paradigm.

In HD space, each particle is comprised additionally of a mirror symmetric brane topology of conformal scale-invariant components, Huerta's brane bouquet [10]. A Dirac-like KK spherical rotation occurs cyclically, separating each mirror symmetric half, and reconnecting it again in continuous dimensional reduction compactification cycle [85]. If a *measurement* is taken when the symmetry is reconnecting, the cross-section is revealed; like the 3-sphere able to 'see' the insides of circles in Abbot's book Flatland. This ontological-phase moment, is the pragmatic gateway to LSXD.

The conceptual framework for this discovery occurred while pondering solutions to the inherent problem of anyonic 'topologically protected' states in TQC. I realized I would need to develop, what I decided to term, an 'Ontological-Phase Topological Field Theory (OPTFT) that entailed a dynamic duality of quantum mechanics and unified field mechanics. *When the great innovation appears, it will almost certainly be in a muddled incomplete and confusing form. To the discoverer himself it will be only half understood; to everybody else it will be a mystery. For any speculation which does not at first glance look crazy there is no hope* - Freeman Dyson [101].

OPTFT, essential for UFM bulk UQC, will end up taking us far into the future; with it one leaves polynomial and quadratic algorithmic speedup in the dust, as it will soon enough be possible to develop 'instantaneous algorithms' by utilizing the full EPR aspects of nonlocal holography. The reduction of all information about any fermion state to the instantaneous direction of its spin vector; the specification of locality as occurring within the fermion bracket and nonlocality as outside it; full derivation of spin helicity and zitterbewegung. The description of all known boson states (for the first time) in terms of fermion combinations and the derivation of the SU(2) structure of the weak interaction. The first explicit representation of baryon wavefunctions with the consequent explanation of baryon mass and the SU(3) structure of the strong interaction; the first explanation of vacuum as the dual structure to a fermion which maintains a nilpotent zero totality.

Now we get to important reasoning for extending the de Broglie-Bohm-Vigier approach. The Copenhagen interpretation claims that any path-determining measurement will destroy the interference pattern; however, the key idea is that the causal interpretation predicts that interference will persist if future techniques allow a sufficiently subtle non-demolition measurement to be performed. There is an extensive body of literature referring to the evolution of the Elitzur-Vaidman Interaction Free-Measurement scenario [5,85]; which is abandoned as unnecessary in our experimental approach for surmounting uncertainty [5,85] demonstrating the incompleteness of the Copenhagen description of reality, beckoning new physics. Vigier proposed that nonlocal interactions are not absolutely *instantaneous*, but causal and superluminal; they are mediated by the de Broglie-Bohm pilot-wave quantum potential, and carried by superluminal phase waves in a covariant Dirac-type ether consisting of superfluid states of particle-antiparticle pairs [5,85]. We have noticed a duality between Newton's and Einstein's gravity (instantaneous versus luminal) [3] in addition to a complex 'manifold of uncertainty' bridging the gap between quantum mechanics and UFM; it turns out experimentally, that this duality is a real condition, a principle of nature.

Vigier writes: *In my opinion the most important development to be expected in the near future concerning the foundations of quantum physics is a revival in modern covariant form of the ether concept of the founding fathers of the theory of light ... it now appears that the vacuum is a real physical medium which presents some surprising properties*.

Considerable effort was expended to review the causal-stochastic approach to hint at its foundation for UFM. Whether one is inclined to accept anything to do with the parameters of the de Broglie-Bohm-Vigier interpretation at all; one must even if myopically, agree that the interpretation has sufficient richness to point in the direction we want to take it. Bias was so strong against heliocentricity that it literally took thousands of years before its pieces could finally be placed into the fabric of reality. While progress seems to be inevitable, it can be thwarted for lengthy periods. The de Broglie-Bohm-Vigier scenario has been waylaid for nearly 100 years; but finally, the day of reckoning persistently looms…

A big question is, does an ontological measurement change the basis for quantum algorithms? Would such a scenario (other than putatively removing the need for error correction cycles) provide another category of speedup? We have considered that UFM based UQC is primarily a boon to measurement, and possibly in that case, classes of quantum algorithms might remain the same. Let's not call it 'parallel QC" but rather, could we discover a class of 'holographic UQC' with asymptotically infinite speedup? As we devise, it is not called infinite; but with nonlocal EPR-like dual-Amplituhedron connectivity, it is termed a class of 'instantaneous' ontological algorithms! The Larmor cyclotron radius of the circular motion of a charged particle in the presence of a uniform magnetic field. This scenario, in conjunction with an incursive harmonic oscillator, applied to the finite hyperspherical radius of uncertainty at the semi-quantum limit, is the gateway to the regime of Einstein's long sought unified field theory.

This preliminary study, only evaluated putative frameworks/regimes suggesting IQCA viability once empirical access opens to LSXD utilizing incursive harmonic resonance surmounting the finite semi-quantum radius of uncertainty. A preliminary step has appeared [102]. We pointed out attempts to write a IQCA is futile until the UFM transform is understood, because passing beyond the nonphysical Block 2-sphere qubit to likely 6D hyperspherical r-qubits remains opaque without the new transform.

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