Comment on Quantum Computers

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Quantum computing program will waste resources unless a better understanding of quantum mechanics is applied.
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CONTENTS

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I. DOE AND QUANTUM COMPUTING

The boldness of this proposal is that it was done without understanding the basis for quantum behavior. This proposal is done in such exquisite detail to lead one into thinking there is not a problem with our understanding of quantum mechanics. The disguised assumption that has been a myth in most all DoE work from high energy physics to atomic physics since it was originally founded as the AEC is that quantum mechanics and quantum field theory are correct and well understood subjects. For Einstein the greatest problem facing physics his entire career was the lack of understanding of what the Quanta of energy really was and how it came into existence. That problem is not what the DoE wants to confront. It is also the principal problem holding back the engineering of the quantum computer. The failure of this myth can be seen in the very few problems quantum mechanics can actually solve and where it has stopped progress in older DoE/AEC programs. Neutron spectroscopy of the 1950s was to yield an understanding of the nucleus, high energy accelerator experiments of the 1960s-present were to yield the source of the strong force, and controlled plasma and laser fusion from 1970s-present were two viable examples of the application of this collective gathering of knowledge that has so far yielded naught.

The DoE as an honest broker, is a myth, it has shown great incompetence in doing basic science, by exerting control over the science press with its own and its national lab employees insuring its policies will not be challenged by editing the major physics journals in the US. Even if these goals for quantum computing are worthwhile, the DoE's record on producing a physical understanding has been a major failure in the basic science. The root of the failure is that discovery cannot be dictated, programmed, or managed top down by building a couple institutions, which will have their own economic goals for existence. When the DoE is challenged technically their real interest become apparent. One of the most illuminating examples is the treatment cold fusion received in order to protect its monopoly on failed nuclear theories by stage managing poor attempts of replication at Cal Tech and MIT along with slander "pathological science" which was used to manipulate the United States Patent Office. Currently cold fusion replication now number in the thousands but the original discovery in 1989 (Fleischmann and Pons, 1989) was only one of a number different process which include fission from fracture (Carpinteri *et al.*, 2015) and dust enhanced fission and fusion in microwave cavities (Egely, 2016), with recent work (Mizuno and Rothwell, 2019) removing some of the material road blocks to engineering application (Wallace *et al.*, 2012) (Wallace and Wallace, 2019). High energy physics has stalled because of the poor semi-classical models that are employed to model the physical collisions. The lack of understanding scattering in general is a significant barrier to quantum computing because it is needed to describe decoherence. At the root of these failures was the use of a series of broken quantum theories that started to evolve in the early 1930s. This generates a lack of trust in both the DoE capacity to evaluate scientific work, but also the academics and universities that take the DoE's money. It appears that a sheep like culture has developed since the 1960s in physics associated with the DoE and possibly the other funding organizations such as the NSF.

The DoE in the past used the "go small" theme of Feynman to study nano science. Using this connection to Feynman, the DoE appears to be flogging a petrified Trojan horse to justify the move into quantum computing to preserve its budgets. The danger of following any of Feynman's ideas on quantum mechanics very far was laid down to me in 1966-67 by Jack Steinberger and Polykarp Kusch who did not take seriously the quantum electrodynamics (QED) of Schwinger, Feynman, Tomonaga, and Dyson. In fact Prof. Kusch came up with an experiment to challenge the method to show QED was indeed incorrectly constructed (Wallace and Wallace, 2015). This work around resorted to non-unique expansion techniques. which inject mathematical and not physical data about the structure of particles and fields. The specific errors in assembling QED: 1) failed to conserve energy both by not including relativity and using singular potentials, 2) used non-unique sums to represent pseudo-physical processes that were improperly described. The unfortunate contribution of QED was it became a model for high energy theories, which further stalled progress and wasted resources.

The DoE is late to the game of quantum computing as nature has been using quantum computers in its most basic functions to generate primitive forms of information. To understand how nature produces information requires understanding how quantum mechanics actually functions or else the efforts on quantum computing will be wasted as one will very rapidly get lost in the volumes of data produced. Quantum information at its heart is a study of the basic quantum mechanism where generating information from disorder is the first step in defining particles and fields. These fundamental processes show their true importance because they have the ability to scale as emergent structures and deal with collections of particles and fields either as currents or coherent collection of spins so the same quantum tools can be used on larger scales (Wallace and Wallace, 2014a) (Wallace and Wallace, 2017).

II. AN ENGINEER'S HISTORY OF QUANTUM MECHANICS

In the late 1920s matrix mechanics, Schrödinger equation and the Dirac equation were all essentially written down. They were not fundamentally derived from any understanding of the quantum processes or in the case of the Dirac equation forced to be a linear approximation. The problem they all suffered from was they did not include the correct relativistic basis. There is no such thing as a correct non-relativistic quantum description, at best it is an approximation that bars any understanding of structure of particles and fields.

Dirac realized this as a problem in 1932 when he tried to back away from his equation by introducing a second order equation for dealing with longitudinal fields (Dirac, 1932). This was attacked in 1934 by Pauli and Weisskoph who use the non-conservative Klein-Gordon equation for its ability to create and count particles a feature they desired (Pauli and Weisskopf, 1934). This then became the beginning of the calculus which was to grow into the Standard Model (Weinberg, 1995). After the war, quantum electrodynamics was developed to explain two experiments one by Lamb and one by Kusch which found small deviations from non-relativistic quantum predictions. To do this they invented the single virtual photon, so they did not have to deal with potentials, which they did not understand. This was a problem that went back to the 18th century that had to be resolved. The Standard Model followed a similarly damaged path using a linear relationship with a Lagrangian instead of the quadratic conservation of energy required for relativity. In doing this they missed two things the orthogonal and statistically independent space where particle and field properties are generated, which we named the self-reference frame. This new space freed physics from the dogma of having to artificially invent the fermion and boson along with an exchange boson for every force. The new space allows potentials to be generated from particle structure both electrostatic, weak, and strong (Wallace and Wallace, 2014a) (Wallace and Wallace, 2017). The second thing that was missed, was that these two independent spaces solved the measurement problem that plagued philosophers trying to understand quantum mechanics, in that they reference each other.

A. God Particle

The culmination of the Standard Model, the Higgs particle, was to supply inertia to one and all particles was an unjustified claim. The question of inertia that dates to Galileo and Newton was too temping a target for the managers and high energy theorists. The problem with the Higgs supplying mass was that nothing was left to supply the Higgs with mass. This chicken-egg problem exposes the missing circular pathway that Gödel employed to demonstrate the ubiquity of open systems not constrained by a finite set of axioms. This was the logical error showing the weakness of the Standard Model. The mathematicians and particularly John von Neumann who needed to generate a passport (Neumann, 1953) (Dyson, 2012) out of a troubled Europe in 1932 produced a tome that defined a very narrow mathematical space that Fourier would have been familiar with to describe quantum behavior that was too simple and insufficient. He put a straight jacket on the subject, for it was also the space from which the universe's description had to arise. A very tall order for a politically expedient set of axioms he knew to be faulty from his own previous work on the limitations on any axiom based description.

III. THE OPPOSITION

In physics, much like the end of the reign of the dinosaurs, there were some furry little mammals scurrying about the physics strong holds: at Princeton there was Albert Einstein with the EPR paper of 1935 on the incompleteness of quantum mechanics (Einstein *et al.*, 1935), at CERN was John S. Bell (Bell, 1964) in the 1960s, Clauser at Berkeley (Clauser *et al.*, 1969), and Aspect in France (Aspect *et al.*, 1982). These experimental test showed Bell's idea of hidden variables did not exist and gave support to quantum behavior being very different than classical physics. Bell realized the problem lay with improperly including relativity into quantum mechanics (Davies and Brown, 1986). This deduction by Bell was our theoretical starting point to examine the behavior of a spin zero boson that was relativistic and to try to discover its representation.

Having been informed of the weakness in the foundation quantum mechanics in late 1960s from a number of teachers, the first experimental evidence I personally encountered was in 1971 in trying to understand the ability of pure irons to reflect a magnetic field where Maxwell's equation fail, which on some occasions more energy is reflected back than was originally supplied. This turned out to be a very old problem that went by a number of names (Wallace, 2009a) (Wallace, 2009b) (Wallace and Wallace, 2014b). It forced us to consider how a spin zero boson operating as a longitudinal spin wave that is an oscillating magnetic exciton is described. We could measure its mass, which was exceeding small, from its dispersion curve and scale to be one billionth of that of an electron. We now had a relativistic spin zero boson to study on our lab bench that was very rich in its interactions and properties that could be measured. Our first discovery was the Hilbert space proposed by John von Neumann was insufficient for the description. There was a second space in which the properties of this boson were generated that had both space and time, however, were statistically independent from the laboratory frame. This created a separation of functions between the two spaces and a self-referencing mechanism that eliminated the measurement problem from quantum mechanics. The particular spin zero boson was a simple energy removal agent as are the other two forms found in solid state physics as the phonon and the Higgs particle of high energy physics.

A. Pythogoras Contribution to Physics → Two Spaces

The building of quantum computers is an engineering activity and details of how quantum mechanics works are necessary in the construction of any device this complex that must function at low energy. The principle laws of physics are conservation laws and the most basic is energy conservation laws that have often been misused in the past. For matter with mass, free of any external potentials, meaning for a single particle there are three terms. Total energy E is related to the kinetic energy cp and the self-energy mc^2, where p is linear momentum, c is the speed of light, and m is the rest mass. The relativistic conservation of energy found in equation 1 has been tested over wide ranges of energy.

$$
\begin{gathered}
E^2 = (pc)^2 + (mc^2)^2 \\
c^2 = a^2 + b^2
\end{gathered}
\tag{1}
$$

That Pythagorean sum requires two orthogonal and independent spaces each with space and time coordinates, but completely independent of each other. A neat trick the multiverse crowd failed to notice that allows both a description of dynamics as well as particle structure and properties. The kinetic energy is defined in the lab frame of 4-space where dynamics takes place. The self-energy is defined in a statistically independent space, which also has its own space and time dimensions, but with some serious restrictions (Wallace and Wallace, 2014a) (Wallace and Wallace, 2017).

The independence of the two spaces, which are coupled together via the particle properties that are generated in the self-reference frame and exposed as properties in the lab frame solves the long standing quantum measurement problem that use to require an external observer. The activity in the two spaces now fulfills that function. What is lost in this creation is the mathematical continuum of infinite precision and what is gained is basic information about matter's description of inertial mass, charge, and spin, the principal elements of primitive information. The same model can be extended to massless fields of the photon and electron neutrino generating quantization of fields naturally and even to baryons with their more complex structures (Wallace and Wallace, 2017).

When equation 1 is generalized to include a potential, then the laboratory frame relativistic quantum equation for dynamics looks much like the Schrödinger equation with two new terms that allow dealing with both particles and fields. Now in the lab frame the solutions to the freely moving particle contains the Lorentz contraction and time dilation of relativity. The mechanism for particle pair production is embedded in this new equation, which self generates the statistical independence between the self-reference frame and the lab frame as this process randomizes particle location leading to limited measurement resolution to a standard. It is within the self-reference frame description where entanglement takes place under the control of a single clock in that frame.

$$\frac{\hbar^2}{2m}\{\nabla^2\Phi - \frac{1}{c^2}\frac{\partial^2\Phi}{\partial t^2}\} + i\hbar\frac{\partial\Phi}{\partial t} = (V + \frac{V^2}{2mc^2})\Phi \quad (2)$$

1. Bosons and Fermions

The differential equations in space and time in the self-reference frame are very different from the laboratory frame since dynamics is not what is described, rather the particle or field structure. The spatial equations are second order and generate two solutions: boson and fermion. The failure of the Dirac equation was making it first order. Even with a damaged equation it is possible to squeeze out some results and in the case of the Dirac equation it was the electron's magnetic moment. The structure of the boson and fermion description as a function of relative energy of the observing laboratory frame produces not only the inertial mass but also the charge, weak or electrostatic, for elementary particles. Things are a little more complex for baryons that have fractional quark components.

This new statistically independent space for an elementary particle like the electron does not allow access from the lab frame, we only can measure the properties it generates. However, quantum mechanics is not a closed axiomatic system as proposed by von Neumann, but an open system that scales. That means large coherent quantum objects can be created out of primitive objects and behave as independent units in their own self-reference frames. These new frames can be probed easily (Wallace and Wallace, 2014b) (Minev *et al.*, 2019). It is in probing these domains that their existence was realized. It is these larger quantum objects found in superconducting circuits and magnetic materials that can be used to fashion components for quantum computing.

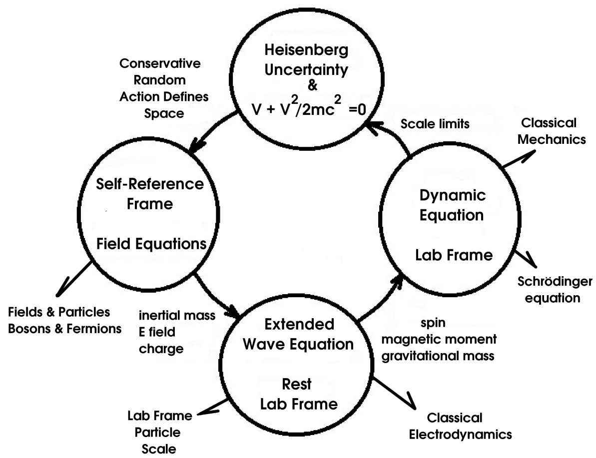
B. Entanglement and Open Scaling

The self-reference frame with its own independent clock, shared by all elements in that frame operates with a single spatial radial coordinate even though the spatial dimensions of the space maybe 1, 2, or 3 dimensional. This removes the geometrical spatial dimensions expressed as the angular coordinates in a spherical representation from consideration. This loss in access to the angular coordinates results in the diffraction behavior of a single particle where its field samples all apertures of a diffraction screen. It ensures entangled behavior over a fiber optic network or in a free space transmission. The self-reference frame is structurally compatible with relativity that is required to complete a relativistic quantum mechanics that was revealed missing in the EPR paper of 1935, and Bells's work in the 1960s. Tests of Bell's work showed there were no hidden variables in quantum mechanics, but he could not eliminate an entire hidden space required by conservation of energy that conforms to relativity. The strangeness associated with quantum mechanics is nothing more than the functioning of this private space with its own private time whose clock begins on the creation of the spaces. This is not a permanent space, but one defined with the creation of a particle or a field. This gives the entire concept of time two forms, one for the laboratory space and the self-reference frame.

IV. QUANTUM COMPUTERS ACCESSING THE NEW SPACE

What makes quantum computing a viable engineering concept is that these quantum spaces are scalable and accessible that can also be closely monitored. We have examples of this with the longitudinal spin wave and superconducting circuits that depend either on collective spin behavior or coherent conduction. Whereas, for elementary particles and fields it is characteristics of the particle or field that are generated in their self-reference frames. In quantum computing applications processes such as non-linear mixing, detection, and pair-production may be controlled and incorporated as elements of a computer (Wallace, 2009b). Here the problem is with decoherence and that takes an understanding of the scattering problem in general, which has not been well developed in physics (Wallace and Wallace, 2018).

A. Circular Structure and the Measurement Problem



The coupling of activity and spaces to generate the primitive properties of matter and fields. Taken from page 317 *"yes Virginia, quantum mechanics can be understood"*

The circular structure of the interplay between the self-reference frame and the laboratory frame, needs to be recreated in a functioning quantum computer to efficiently use resources. The mathematical basis for this activity are the limited resolution spaces where the measurements are comparisons of the real entities. This should not be much of a surprise because in 1878 Georg Cantor (Cantor, 1878) (Dauben, 1979) was able to prove that for the mathematical continuum the concept of a spatial dimension is not something that is unique and is really only an indexing scheme that functions for any dimension. Real space does not have elective dimensions and finding spaces of limited spatial resolution frees the calculus of these non-physical continuum spaces of arbitrary dimension and the resulting mathematical uncertainty.

B. Things That can be Built

Quantum computing, quantum information, and all sorts of special application devices become possible once the realization of how quantum properties are actually created. The first step is the defining of primitive and abstract information, and what it costs to create those items. Their processing is then defined by the ways their base carriers can be manipulated and combined in low loss circuits. The limitations are on the energy required to maintain these low energy entities to maintain their coherence to ensures efficient operation. Because of these constraints on energy usage and flexible network structure that depends on local timing these architectures should be expected. This entire area unlike high energy physics or astronomy with few and expensive instruments can be accessed with rather modest equipment requirements by any with a real interest. Physics is a difficult endeavor where individuals have shown a distinct advantage over organizations and that should continue to be the case for quantum computing.

The first task in any program to build a quantum computer is to understand what makes quantum mechanics work and that is totally missing from the proposed guide lines to future work.

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