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Links Between Consciousness and the Physics of Time

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Abstract

This paper gives a personal response to the question: "What does new knowledge about the physics of time and quantum mechanics really tell us about the nature and capabilities of consciousness?" The introduction provides a starting point, unifying traditional concepts from philosophy and the scientific method. The next section reviews the varieties of quantum physics, and new experiments likely to change our understanding of time, the multiverse and quantum mechanics, and lead to new technologies. The final section discusses neural networks from computer programs to consciousness and the soul. It argues that the concept of noosphere , with some capabilities forward and backward in time, is physically plausible, mathematically meaningful and necessary to make sense of the full range of our experience.

1. Introduction: A Question and A Starting Point

What does new knowledge about the physics of time and quantum mechanics really tell us about the nature and capabilities of consciousness?

There is certainly no consensus on the answer to this question, even among leaders in the relevant disciplines; therefore, any completely honest effort to fully address this question at the present time will depend somewhat on the personal experience of the author. each of the papers in this issue will be presenting possible positions. In my own case, I am drawing mainly on the cutting edge of three different disciplines, which usually do not understand each other very well: (1) the physics of time in quantum mechanics, for which there are important new experiments in process now which seem likely to change and crystallize a lot of the diffuse concepts now in play [1,2,3]; (2) the neural network field, which provides a path to functional, mathematical understanding of intelligent systems and consciousness ranging from some simple computer programs to levels of intelligence and consciousness beyond what human brains possess [4,5,6]; (3) hard-core mysticism, which, through discipline of the mind, attempts to get a clearer understanding of the levels of consciousness and the capabilities and values which it

[1] [1]The views herein represent no one's official views, but the paper was written on US government time

entails [7]. I am grateful to Dr. Menas Kafatos for asking me to provide a balanced personal response to this question, drawing on all three disciplines, without the truncations and partial truths which are unavoidable within the usual constrained "stovepipes" and provincial cultures of this world.

The question above was phrased carefully, to be focused and broad, but not so broad as to bring in other important topics, such as the role of pacemakers or clocks in governing learning in the brain [5].

Different schools of thought in these three disciplines and different schools of philosophy tend to make very different assumptions about how we can answer questions like the one I am addressing here. No sets of ultimate assumptions or axioms in words can be proven or disproven by logical arguments in words and mathematics alone. Nevertheless, some sets of axioms do lead to internal contradictions or to outcomes such as total destruction or the mental hospital. Based on a combination of direct personal experience and efforts to understand that experience in a coherent way, I have ended up with a starting point illustrated in Figure 1:

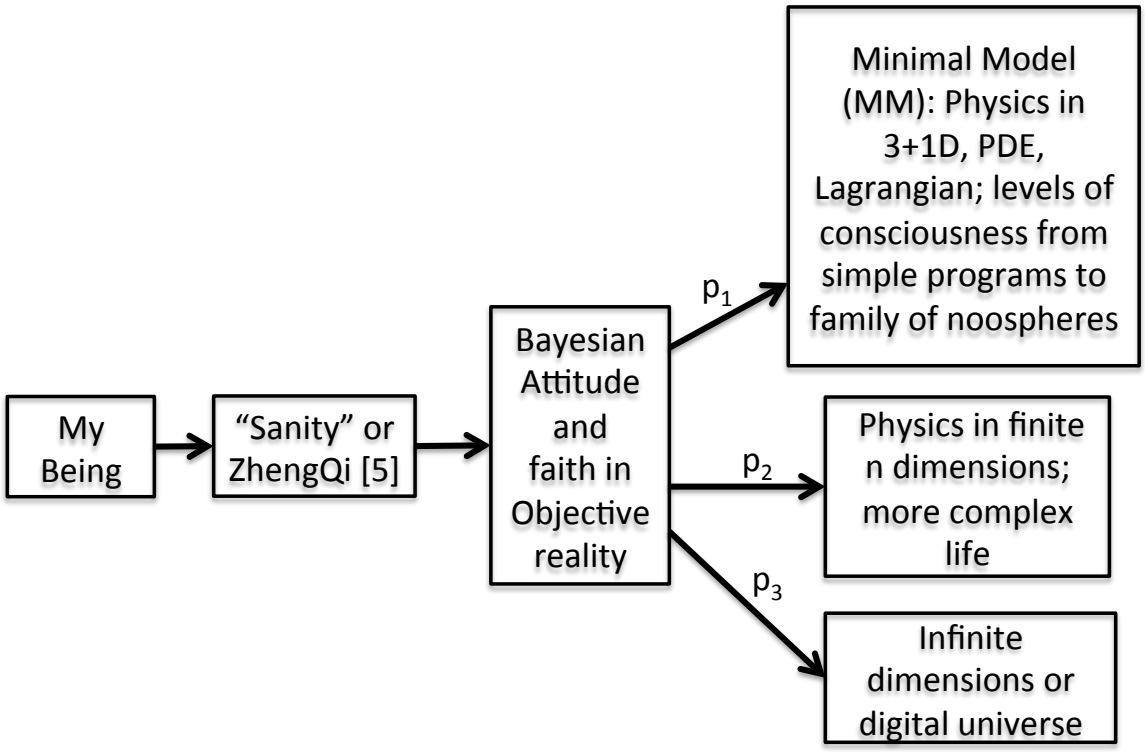

Figure 1. My Starting Point, Foundation

Of course, the things I have learned on the right side of this figure have looped back, and changed how I discuss the issues on the left; this is a natural part of how learning and intelligence work.

1.1 My Being

Going from left to right in Figure 1, I start out with the deepest foundation in direct personal experience and a sense of complete personal freedom of choice. That is the same foundation which any cat in the forest starts from, and which existential philosophers like Nietzsche and Heidegger advocated and became reaware of with great effort. Of course, the cat understands that some choices can lead to unpleasant consequences, and tries hard to learn how such things work in its environment. In college, when I first read Nietzsche, I worried that such a sense of total freedom might lead people into very ugly behavior and ugly consequences – but then realized that we start out by not wanting to create ugly consequences, by definition, even if cats sometimes seem more successful than some existentialist philosophers in that regard. We naturally drive towards trying to create consequences which some describe as "pleasure,' others as "the light [7]," and still others as "utility [4]" – best understood if we can see how all three words can refer to the same thing, and if we link what we see in the mirror of science with what we feel directly.

1.2 Sanity or ZhengQi ("Integrity")

If we are all like cats, in a way, can we avoid being crazy cats? Our work in neural networks and consciousness [5,8] suggests that humans possess a unique ability to lose touch with reality, and go to war with themselves in a way which hurts all their selves, compared with all other mammals on earth. Conversely, if humans learn a system of axioms and skills which I would refer to as "sanity" or "zhengqi" they can achieve a level of consciousness and effectiveness far beyond what most people imagine [5].

The key issue is how we deal with words, mathematics and other symbols of reasoning. If we have a kind of magical faith in words (as in the earlier Wittgenstein and much of the theory of Chomsky) or if we treat them as nothing but meaningless additional variables in our world (as in the later Wittgenstein and theories of B.F. Skinner), either way we rest on an unrealistic foundation, which impairs our ability to do the best we can with these tools of thought. Humans are not born with full sanity, full ability to integrate words and other symbols into our natural intelligent thinking, for two reasons: (1) we are at an early stage of the biological evolution of making use of words and mathematics, far too early for logic to be in our genes; (2) sanity requires learning and honing many skills and details, which tends to require challenging learning through experience in any case (yea unto learning calculus).

Freud's concepts of "sanity" and Confucius' concepts of "integrity" were associated, historically, with all kinds of florid details which I do not mean to advocate here. Here I refer to the core common concepts, reviewed in [5], such as the concept of asking "what would I do if I were wise?", which requires some understanding of the self. It entails a sensitivity to primary feelings like "light" and "utility," and an ability to distinguish them from emotions which are more secondary, like means to an end. It entails a seamless two-way translation and consistency between symbols and direct nonverbal life, so that one is always prepared to "speak from the heart" in a reflective manner when it would not predictably cause pain or confusion in the minds of those one is speaking to. And it entails learning not be the kind of person who is easily confused or aberrated when others

speak from the heart. It entails being able to project the full power of one's will and emotions into challenges or questions which the whole self, verbal and nonverbal, has agreed on. It entails an openness to experience and feelings and a sense of responsibility far beyond that of the artificial robots which some employers try to turn their employees into, at great loss to their larger enterprise[5,9]. It entails the mental energy to be able to do creative, independent thinking, driven by deep questions and motivations, not constrained by social taboos, as needed to generate value added in one's thinking. And it entails the ability to be honest to oneself about realities like our uncertainties. It entails a full understanding of the concept of rational decision-making developed by Von Neumann [10], explained and elaborated on by Raiffa [11] and others, which is just as fundamental as the concepts of logical reasoning developed by Socrates. Ultimately, full sanity and self-awareness requires full understanding of how our own minds work, yea unto the details and the mathematics.

1.3 Bayesian Attitude and Objective Reality

Going one step further to the right on Figure 1, I have learned through sanity and experience to take a Bayesian attitude towards life, and to have faith in the existence of objective reality.

At this level of depth in my foundation, I am not (yet) proposing a specific model for how we should use Bayesian principles in learning about life and our world. That comes later, when we flesh out the science and try to see more precisely what fits our brains and what works in engineering [6,12].

For now, I am simply asserting the view that no one I know of on earth is justified in making a commitment of 100% to any of the options on the far right of Figure 1, or to any of the alternatives to them. There are some people who claim to be scientists, who will look at a menu of five theories of physics, and will energetically work to arrive at "an opinion" – a choice of one of the five which they will then commit their entire life to defending, yea unto making war on anyone who would even dare to test their darling. In truth, I have seen an NSF panel where a leading scientist said: 'We cannot fund X because it is a high risk proposal. It is high risk because it carries a risk that they will disprove my theory." We do need to form personal impressions, in order to make decisions about our work, but the sane and rational approach [10,11] is to try to understand our uncertainty, to formulate subjective probability estimates which we are ready to update, and to make a special effort to seek evidence which helps us improve our probability estimates. We do not need precision to two decimal places, or consensus in society, in these kinds of probability estimates.

Of course, excessive insane claims of certainty and empty words in the realm of spirit and mysticism can be even more damaging than those in the realm of science. The growing threats of religious and cultural wars all over the earth should make this point painfully obvious to anyone sane enough to care about the continued existence of humans on earth. If any readers feel personally insulted by these words, they might want to ask themselves why they feel that they are the ones making insane claims of certainty grounded only in empty words. A new way of thinking is needed, not only for the sake of truth and human potential, but also for the sake of simple survival.

The psychology of these problems is worth examining further. People with low tolerance of cognitive dissonance [13] often overcommit themselves to one particular theory, ideology or religion dogma. People with high tolerance of cognitive dissonance sometimes commit themselves to several mutually contradictory things at once, and imagine they have found an answer when they have only built an incoherent inconsistent collage which weakens their ability to do anything. Even worse, some ideologies combine both kinds of weakness. The discipline of sanity is important for all of us, across the whole spectrum of personality types.

With regards to objective reality, it is important to remember that objective reality is not just a matter of what we see from moment to moment with our eyeballs. Faith in objective reality is essentially the belief that there exists some fundamental mathematical representation of the total state of the cosmos we are living in (including all space and time), that the cosmos follows some kind of universal mathematical law, and that our brains, minds and experience can be explained as emergent phenomena within that cosmos driven by that law. Core Western mystics have often said: "Nothing we are studying is supernatural; it is all about understanding the higher laws of nature."

The traditional Copenhagen version of quantum mechanics asserted that objective reality is no longer a tenable concept in physics, but strong empirical evidence across many fields of technology has strongly disproven that particular variation of quantum mechanics [14]. In today's practical and empirical quantum mechanics, as developed to predict a large range of experiments in electronics, photonics and condensed matter physics, it works better to assume that wave functions over infinite dimensional space represent possible specific states of the cosmos, of the "multiverse," and that we need to calculate probability distributions (density matrices) over such possible wave functions in order to correctly predict experiments [14,15]. The multiverse is one concept of what objective reality might be like.

I do not claim to have proven even to myself that objective reality exists. However, it is still part of the foundation I use, because experience tells me: (1) nothing in physics or life contradicts the idea as yet; (2) it is a very rich and fruitful concept in making sense of experience; (3) it is natural for us to try to understand what lies behind our experience as well as possible, and it is very premature at best for us to give up on the very possibility of an understandable cosmos.

1.4 Three Specific Viewpoints and the Plan for this Paper

What do the physics of time and quantum mechanics tell us about the nature and capabilities of consciousness?

The answer to this question depends on which of the three alternative viewpoints on the right side of Figure 1 happens to be true, in objective reality. But none of us on earth in this century really know which of the three is true. Many of us, with different databases of experience to draw on, would rationally want to include other alternatives besides the three on the right side of Figure 1. Therefore, this paper will discuss different possible answers to the question, as a function of which viewpoint we choose. It will also discuss what we can do more to learn more about the answer, by active research aimed at reducing our uncertainty and surviving while we do so.

The differences between the three viewpoints at the right of Figure 1 largely reflect uncertainties about the underlying laws of physics. Therefore section 2 will focus on the issues in physics in more detail. Section 3 will discuss neural network models of consciousness, levels of consciousness and the role of time in that context.

For many years, I have worked to flesh out the Minimal Model (MM) mentioned in Figure 1. This has included developing the mathematics and analyzing the implications for rational action in the world we live in, including both the local aspects and the aspects which people term psychic or spiritual. Yet I would only estimate p_1 to be about 10 percent, from my viewpoint now. It is rational for most of us to base more than half our energy and activity on MM at this time, because we simply do not know enough about the concrete aspects of the other possibilities. MM itself is already complex enough to be a great challenge for the coming century or more, and rich enough to support much greater progress, both human progress and technological progress (and hazards), to the utmost of what we are capable of at present. MM is already so complex that I usually must divide it up into pieces, living parallel lives to support different aspects of what it calls us to do and what it calls us to understand better.

MM unifies some aspects which some would view as extremely materialistic and conservative, and other aspects which even Karl Pribram would hesitate to discuss for fear of being labeled "too way out." The physics aspect is far more conservative, on balance, than the mainstream today, but MM also suggests how "paranormal" abilities can exist even within such conservative physics. The key idea is that "paranormal" ability and "spiritual" realities are simply just aspects of the huge realm of life which can emerge naturally in a large and complex universe [16,17], even in 3+1 dimensions.

As this paper goes to press, I am raising my personal estimate of the probability that MM might be the whole truth. The reason is that new mathematics [38] shows me that the emergent behavior possible in a 3+1-dimensional universe is even richer than I had appreciated a month ago. In the new stochastic path formulation of physics, the example of studying a photon propagating through a polaroid polarizer shows us how alternative possible "scenarios" or "paths" can have real effects, similar in some ways to the parallel universes of the more classical "multiverse" models [15,21].

2. The Physics of Time in a Quantum Cosmos

What do recent results in quantum physics tell us about the nature of time, potentially relevant to consciousness?

2.1 Varieties of Quantum Physics in General

Again, as in Section 1, there are different viewpoints out there. Quantum theory, like the theory of democratic institutions, is not one specific theory or model of how the universe works. Figure 2 depicts four families of quantum field theories which are important in mainstream mathematical physics today.

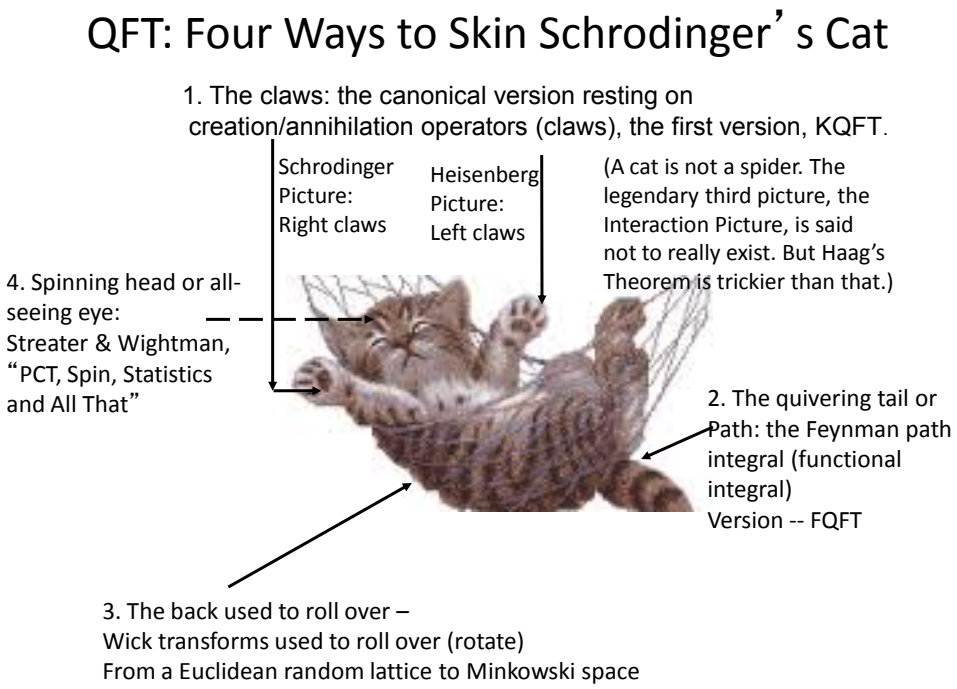

Figure 2. Four families of quantum field theories (QFT)

The two versions which are used most widely today, in making empirically testable predictions, are the canonical quantum field theory (KQFT) and the Feynman path approach (FQFT) [18]. FQFT tends to dominate high energy theory lately, but KQFT still seems to be the main foundation of massive empirical efforts in photonics, electronics, quantum computing and the like. Many have faith in the convenient belief that KQFT and FQFT always give the same predictions, such that we can use either one without worrying which one is true. Personally, I doubt this, because of some recent results [18,19]. For simplicity, in this paper I will focus on KQFT, the version which won the Nobel Prize for Feynman, Schwinger and Tomonaga, and on a neoclassical version I have developed myself.

2.2. Review of Technical Properties of KQFT and Neoclassical Field Theory

In classical physics, and in the neoclassical theory, we assume that the cosmos has only four dimensions, three of space and one of time. More precisely, we assume that the state of the cosmos across all space time is fully specified by specifying a function $\underline{\phi}(t, \underline{x})$ or $\underline{\phi}(x_\mu)$, where $\underline{\phi}$ is a mathematical vector (just an ordered array of numbers), where t is time, and where $\underline{x}$ is a point in three-dimensional space. The notation "x_μ" refers to a pair of t and $\underline{x}$, and makes it easier to build specific theories which obey Einstein's theories of relativity.

In KQFT, we assume that space has an infinite number of dimensions. In the realistic version of KQFT [15,21], which led to the development of quantum computing [22], the state of the cosmos at any time t is defined by only one complex number ψ,

but ψ must be specified as a function of an infinite dimensional space called "Fock space." In KQFT, the word "multiverse" is basically just a euphemism for Fock space.

Realistic KQFT is made up of two or three pieces: (1) the modern "Schrodinger equation":

$$\frac{\partial}{\partial t}\psi(\underline{X}) = iH\psi(\underline{X}) \qquad (1)$$

where $\underline{X}$ is a point in Fock space, where $\psi(\underline{X})$ is called "the wave function," and where H is a linear operator called the Hamiltonian; and (2) a "measurement formalism" used to predict what happens at a macroscopic level when we perform a measurement, and to read out predicted probabilities for the results of an experiment. Because we usually do not know the actual state of the cosmos $\psi(\underline{X})$, we actually perform calculations on probability distributions for what the wave function might be; more precisely, we use a density matrix ρ, which we may think of as $\rho(\underline{X}, \underline{Y})$, to represent probability distributions of possible values of the wave function across Fock space [14,19].

In the neoclassical approach, we use the well-known Lagrange-Euler equations or Hamiltonian dynamic equations for classical fields [18] instead of equation 1, to define the dynamics of the cosmos.

2.3. How Backwards Time Physics Changes Things, and Experiments

2.3.1. Einstein Round One: Bell's Theorem Experiments

Then comes the interesting part.

It is important to note, ***both*** for KQFT and for the neoclassical approach, that theories of physics which have been used to make predictions in the past are ***agglomerations*** of two very different sets of assumptions, which do not fit together very well. In both cases, it has been assumed that the dynamics of the cosmos are governed by equations (like equation 1) which are symmetric with respect to time. (More precisely, the symmetry is perfect for the case of electrons and light, but there is a tricky very tiny partial asymmetry for certain kinds of nuclear experiments.) In both cases, the dynamics give us no reason to expect that causality should always run in one direction in time. The "movie of space and time" should look the same and follow the same laws even if the movie is played backwards.

Why, then, should it ever appear that causality only runs forwards in time? There is only one sensible answer: because of boundary conditions, such as "initial" and "final" boundary conditions in time [14]. Yet if time is like a river, in our neighborhood, flowing in one direction because there is a supply of water high up in the hills in another part of the cosmos, should it not be possible to build dams and local whirlpools? Could there be other regions less like a river and more like an ocean?

Years ago, Einstein proposed a decisive experiment, the Einstein-Podolsky-Rosen experiment, to let us decide between "classical physics" and "quantum mechanics." Einstein previously said that "common sense is the collection of prejudices acquired by age eighteen." But in this case he relied heavily on common sense in proposing the experiment. In predicting this experiment, he assumed a ***combination*** of Lagrange-Euler dynamics, and of classical assumptions about causality in time-forwards statistics. Later,

when Einstein's idea was turned into a real experiment, illustrated in Figure 3, his prediction was thoroughly disproven [2,3].

Figure 3. Schematic of the first "Bell's Theorem" experiments [2,3]

"Quantum mechanics" correctly predicted the outcome of this experiment. More precisely, KQFT made a prediction which has been verified to a high degree of precision in recent experiments:

$$R_2/R_0 = (1/2)\cos^2(\theta_a - \theta_b), \qquad (2)$$

where θ_a and θ_b are the angles which the polarizers are set to and R_2/R_0 is the rate at which photons are detected on both sides, relative to the rate at which pairs of entangled photons are produced by the source. The calculations by "quantum mechanics" assumed a combination of Schrodinger's equation and the usual KQFT measurement model, which is commonly called "the collapse of the wave function."

After the victory of KQFT in these experiments, J. S. Bell [23] declared that it is impossible to construct a "local realistic" theory of physics consistent with these results. Either one must give up the idea of objective reality altogether, or one must assume some kind of action at a distance, very different from what Lagrange-Euler equations predict.

Bell missed a crucial detail. For many years [14], I have pointed out that the actual theorem used in this experiment allowed for a third possibility – the possibility that classical ideas about time and causality are wrong. In other words, the Bell experiment itself may be creating something like a local whirlpool in time. This year, to prove the point, I have constructed three very simple local realistic models [2,3] which do in fact yield correct predictions for this experiment. The third of these models, MRF3, appears to make sense as an approximation of more fundamental Lagrange-Euler field models [2,3].

2.3.2. Einstein's Revenge Coming Soon?

Can local causal models also perform well in predicting more complicated experiments? In [2] and [3], I point out that KQFT and the neoclassical approach clearly disagree for the three-photon experiment illustrated in Figure 4:

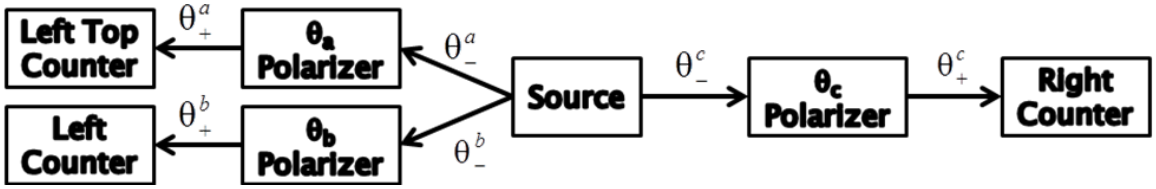

Figure 4: Three-photon experiment, for a "GHZ" source k(|0>|1>|1>+|1>|0>|0>)

More precisely, KQFT clearly predicts that $R_3/R_0(\theta_a, \theta_b, \theta_c, p)$ will depend on the permutation p, on the order of times of when photons reach different polarizer/counter pairs. All of the local realistic models predict that it does not. This experiment is now

being set up at one of the three laboratories in the world which has previously succeeded in generating these kinds of GHZ three-photon entangled states [1]. The function R_3/R_0 is certainly interesting in any case, and I only know of two ways available now to predict it – standard KQFT, and the local realistic models.

Personally, I consider it very unlikely that KQFT will win this round. When we compare the neoclassical approach, *without* the "common sense" assumption about time-forwards statistics, versus KQFT *with* the assumption of collapse of the wave function, I doubt that KQFT will win. If it did, it would violate restrictions against communication faster than the speed of light, which seem to be built into the dynamic part of KQFT so far as we know. I do hope that MRF3 will predict the experiment correctly, making it the only game now left in town.

If that happens, can we resurrect KQFT? In either case, with KQFT or with Einsteinian physics, once we throw away the barnacles which led to bad predictions, we are left with dynamical theories which are absolutely symmetric with respect to time. In that case, I would have much more hope for the neoclassical alternative, because it is much simpler, and because I have no evidence to justify the extra complexity of Fock space. Nevertheless, more empirical work needs to be done here, starting perhaps with analyzing tunable spin gates in spintronics or quantum optics, which are very similar to macroscopic polarizers and may allow new technologies in computing, communication and even energy harvesting, if we get the modeling right. There is a lot of work to be done at this level, before we move on to the more complex, energetic and explosive extensions to the nuclear domain. It seems very likely that there are new phenomena to be discovered here, even before we move on to mysteries like dark energy and dark matter.

2.4 Where might the new physics lead us?

If we jump ahead a few months, and assume that backwards time physics [14] is confirmed in the new experiment, what kinds of technologies could it allow? What can we do if we can reverse the arrow time locally?

Ultimately, in the greater cosmos, time-symmetric physics would probably allow the evolution of life forms whose life cycle would be symmetric with respect to time, such that "birth" and "death" are usually mirror images of each other, and actions are chosen equally for their effects on the past and their effects on the future [24]. More definitely, a number of specific technologies begin to become possible here, too complex to do justice to here.

Nevertheless, in the 3+1-D model (or in the usual KQFT dynamics), it is not possible to change what the past was, when we know what it was. Action can change probabilities for the past and for the future, but only within the envelope of what is possible relative to what we already know. If we tried to make the past different from we knew it was, the model predicts that the Lagrange-Euler equations would be very "clever" in arranging things so as to prevent the kinds of paradoxes described in traditional science fiction. In some sense, the MM model assumes that the universe itself is more intelligent than we are as humans, because we can only approximately optimize or maximize the things we care about, while the universe can find an exact solution to the Lagrange-Euler equations even when the boundary conditions we impose require an

extremely tortuous path. Intuitively, this leads to a modern picture similar in spirit depicted in two more recent novels, Chronoliths [25] and Blackout/All-Clear [26].

All of this discussion is part of MM, which is similar in spirit to what Willis has called "the Oxford standard model of time travel" [26]. But the two other alternatives in Figure 1 might well allow real changes to what was previously true in the past and in the future, depending on how the details work out. The box in the middle right of Figure 1 may appear to include today's superstring models, but that is only because I could not fit more words into the box conveniently.

I have several times asked myself: If extra dimensions exist which would allow us to change the past, how could we know? All of the options I can think of involve the development of temporal technology based on MM, followed by tests aimed to uncover its limits, exactly as hinted at in [26]. My personal experience is of course very limited and equivocal here, but it is the reason why I only estimate p_1 as 10% at present.

Everything in this section is part of the first step in the development of the physics aspects of MM. A more complete specification of MM requires the exploration of possible Lagrangian functions capable of explaining other aspects of physics, beyond just electronics and light. In [27] and [28], I discussed a few possibilities, but have found a more plausible possibility since then; however, the details of that extension go well beyond the scope of this paper.

2.5. Some recent extensions

A thorough exploration of the full triphoton experiment as I have proposed it will also be essential to the field of analog quantum computing [39], which has considerable practical potential, above and beyond the (questionable) goal of actually building intelligent machines more conscious than the individual human brain. I hope that those applications will motivate a thorough exploration of this area.

Also, it should be noted that Karl Popper proposed some other experimental ideas [40], which have already been validated by experiment [41], which provide another important testbed for competing versions of quantum mechanics.

3. Neural Networks: From Computers to Consciousness and the Soul

The title of this section seems to call for a book, not a section, but it is possible here to summarize prior work extending over more than one book.

In the First International Conference on Consciousness, and in the neural network meetings which fed into it, there was a lot of debate on the question: "What *is* consciousness? In my chapter of the conference book [8], I first reminded people that "consciousness" has many legitimate definitions, and that it is silly to waste time debating which is the "right" one. (Also see [29].) My chapter and my work focuses on the issues of consciousness qua mind, which is essentially a synonym for "intelligent systems," once we accept the concept of objective reality and the value of looking at ourselves through the mirror of scientific thinking.

There are two types of scientific thinking essential to this enterprise. There is the usual third-person approach to science, described eloquently by Thomas Kuhn [30]. Third person science relies heavily on experiments which can be replicated by "anyone,"

and on information shared by all. In effect, third person science assesses the probabilities of theories and beliefs, conditional upon the database of what is shared by everyone. There is also first person science, which is equally serious and rational, but which tries to understand as much as we can, conditional upon the larger database of what is shared universally *plus* what we can learn from first person experience or information limited to a smaller community. Many journals and research programs properly focus on third-person science, because it allows cooperation and dialogue between people with different bases of experience (and different levels of sanity). It is important that some venues allow a more complete dialogue, including first-person science, as I am attempting here.

In the discussion of consciousness qua mind, many theorists would look at a computer program or device and ask: "Yes, it does interesting things but is it conscious or is it not?" I have argued [8] that this question itself is out of touch with reality. Consciousness as we see it in nature, in our shared experience, is not a binary attribute, or a simple matter of degree, but a matter of *levels*. We see levels of consciousness or intelligence both in nature, and in those computer designs which fit a strict definition of "intelligence." This is illustrated in Figure 5, based on [5]:

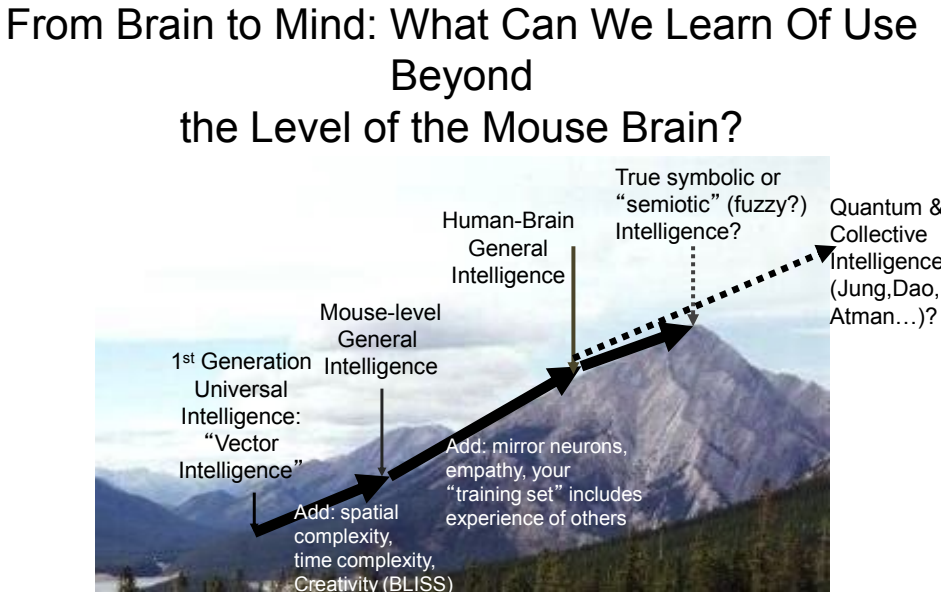

Figure 5. Levels of Intelligence

3.1 From Vector Intelligence to the Mouse Level of Intelligence

For hard core mathematical, third party science, I have argued that the grand challenge for the coming century is to fully understand and replicate that level of higher intelligence which exists in the brain of the smallest mouse [4,6,12,31], not considering whatever level of social or spiritual intelligence mice possess. I remember those researchers in artificial intelligence who promised to build an artificial Einstein within 20 years (starting in the 1960's); it seemed as if it should be easy to them, in part because they had not

really engaged with the underlying mathematical issues. Thanks to enormous progress in understanding the mathematics, we now have a better idea of what is required, and a workable roadmap all the way to the mouse level, but at the present rate of progress it seems optimistic to imagine we might be able to master each of the four key steps in 25 years each, and make it to mouse level as soon as a century from now. And so, one of my "parallel lives" is that of a hard-core scientist, trying to push people ahead to the mouse level.

It is curious how many researchers and funders suffer from aberrations which my sometime collaborator, the neuroscientist Walter Freeman, calls "category confusions." For example, they start by saying they want to understand brain intelligence, even at the level of the mouse, "on a realistic, physical basis." But they sometimes follow up by trying to model thoughts as simple physical phase changes or synchronization, as if the function of the brain could be captured by modeling it as a block of ice which periodically melts and refreezes. If we cannot even understand smart phones that way, how could we imagine that brains or souls would be so simple? Clearly we need to understand the functional, cybernetic information level, to make sense of learning in the brain. Yes, there must be a physical substratum, as with computers, but to understand how the system works, it is important to understand a mathematical level above that, the type of design which the hardware implements.

3.2 From the Mouse to the Top of the Mountain – Sanity, Integrity

Beyond the level of the mouse -- as a member of human society, I do not feel obligated to squeak like a mouse, even though I have learned a lot about myself from understand the mouse as well as I do. Since the time when I first really understood and internalized the concept of "integrity," at age 15, I have led a second life, trying to assist the effort of humans and society to progress from the mouse level to the top of the mountain depicted here. This is also possible within the realm of third party science, if one includes less precise activities like social science as part of third-party science, but the rules are different. In [5], I elaborate on what we know about the fundamental differences between human brains and mouse brains, and how they feed into the concept of sanity and human potential.

In my view, there is very little chance that the physics of time and quantum mechanics have anything at all to do with the systems-level capabilities of the mammal brain, yea even unto the peak of the mountain in Figure 5. This was discussed in great detail within NSF, when we constructed the last effort to directly address the challenge of functional understanding of mouse-level intelligence [31]. Because science needs to be open-minded, we agreed to open the door to research which takes a serious empirical approach to trying to prove that neurons can learn things which are beyond what could be learned within the realm of truly classical physics; however, even Pribram's concept of dendritic field computing can be understood within a classical approach [32].

We challenged researchers to try to prove that individual neurons in culture could learn things well beyond lagged, weighted sums and such, or local networks of the same. No

one rose to the challenge. However, in all fairness, the methods for training neurons in culture are at a surprisingly primitive level in general, and it may be worth trying again after improving those methods.

Many theoretical papers have appeared arguing that brain hardware could somehow employ special quantum demolition operators and the like, to avoid the decoherence effects which immediately seem to suggest that quantum computing in the brain is a silly idea. Yet why is it that the best technological efforts, using more controllable technology and deeper understanding of the physics, have not been able to do the same as yet, to a significant degree? While Hameroff has at times argued that the Hameroff-Penrose ORCH model may be crucial to consciousness even at the level of a sea urchin, Penrose has emphasized that it is really just a placeholder to flag a need for us to remain open-minded to complexities we do not yet understand with the human mind.

3.3 A Third Life – Beyond the Mundane

From age 15 to age 19, I believed in the mundane viewpoint which totally excludes the possibility of real paranormal, psychic or spiritual phenomena. Having read the Bayesian critique of parapsychology by D.O. Hebb [33], one of the grandfathers of the neural network field, and having taken graduate courses in logic from Alonzo Church at Princeton, I fully understood and supported the powerful arguments which persuade many scientists to reject the field. As Sagan said, "extraordinary claims require extraordinary justification." Of course, it did not help that the religions of the world make very strong, very confident assertions, which contradict each other in ways which erase the evidential value of the assertions. The sheer physical impossibility of such things convinced me it would be a waste of time to try to explain why there appeared to be evidence for psi, even in the face of personal experiences which might have made most people more open-minded [34].

However, in March of 1967, direct personal experience became so compelling to me that I felt I had no choice but to attribute a 50% probability to the possibility that paranormal events are real [17]. Curiously, that experience involved memory of the words of a speech by Mao TseTung, which I quoted to friends the day before it was given [17]. I do not put this forward as an argument for other people to change their views, but it was a major factor in my own explorations, first in scouring the literature of parapsychology, then in starting to do first person experiments myself, and finally in casting a wide net to learn what I could from other sources around the world and in learning more about what is actually physically possible. Precisely because I understood how problematic these experiences are, I understood the importance of trying to understand them better.

In a first effort to find physical explanations, I naturally considered the old idea that some part of the body might have evolved to interface with some little known force fields or quantum effects, in much the same way that the eye evolved to detect light. After all, if we were a species of blind people, the whole idea of an eye might seem rather fantastic, little connected to what we would "see" in everyday life. (H.G. Wells wrote a story, the Country of the Blind, on this theme.) Evolution might well have found special molecular

systems, unlike what is common in our technology today, for this organ, just as it found a unique arrangement in the eye itself. However, this type of model simply did not seem powerful enough to explain either the best-verified data available at the time from parapsychology [35], or my own experience. The data seemed to call for a very powerful kind of signal processing here, to direct information from one point of the earth to another. I tried to remain open-minded to this conservative option for many years, but it simply did not work well enough. The phenomena seemed to be impossible to explain, without the assumption of some kind of complex matrix between the two points in communication, or even more extreme and improbable modifications of the laws of physics.

In the end, I converged on the basic "MM" concept alluded to in Figure 1. I converged on the view that the complex matrix is simply a living matrix, and that we humans are a symbiotic life-form, partly based on the biology that everyone knows about, and partly based on something similar to the "noosphere" described by people like Vernadsky [42] Teilhard de Chardin [43, 44]. The noosphere, more properly, is the nervous system or mind of the entity which we are in symbiosis with; though it has a physical basis, and physical inputs and outputs, our interface is primarily a matter of information flow within the noosphere, at the cybernetic level rather than the physical level. For us, it is reasonable to speak of "the" noosphere, but logic suggests that any organism must be one member of a larger species, presumably across a larger field of the cosmos.

This idea takes some getting used to, but so does quantum mechanics, backwards-time physics, or even relativity. It can accommodate most of the core experiences described by cultures all over the earth. For example, the central concept of "qi" or "tao" in Chinese mysticism clearly fits very well with the notion of cybernetic-level "psychic energy" described by Freud, for which we now know the mathematics [5], which is quite distinct form the concept of energy in physics. It is consistent with many of the views expressed in the Upanishads, in which it is said that our most powerful experiences seem to be those of being inside a greater Mind or Self, and that many of the lesser experiences can be explained as shadows of the greater Mind. The old fuzzy word "soul" can be seen as a way of talking about this other side of our selves. The Western concept of "alchemical marriage" can be seen as the goal of a kind of rational Pareto optimal path in the symbiosis. In this view, sanity at a mundane level naturally leads us to an openness to experience, which leads to this next level, where we still maintain effective individual thought but also couple more effectively into a kind of global inner dialogue, with patterns of connectivity not unlike that in a neural network.

All of this certainly goes beyond the realm of consensus, third party science. However, as a model it can be useful in guiding experiments in parapsychology (hinted at in [5]), and it offers some greater hope for survival in considering where humanity may be going as a species in confronting many obvious mundane threats to its very existence. Mobilizing a higher level of consciousness may be essential to meeting some of the new threats to our existence, from sources such as nuclear conflict, climate change, sheer entropy and misuse of technology, aggravated by difficult cultural, social and political problems [36].

I am intrigued by evidence that the majority of productive PhDs in the US have also had experiences which drive them beyond the usual mundane viewpoint – even though fear and social convention limits their ability to follow up or discuss the matter.[37].

Still, Figure 5 suggests two aspects of this viewpoint which are within the scope of third-party science. Within the realm of third party science, it is clear that there are two qualitatively new capabilities which can be added even to the top of the mountain, to yield a level of intelligence beyond what the human brain can achieve on its own. One is a full use of what can be achieved in true quantum neural networks, embodying the technology hinted at section 2. Another is a more complete implementation of the principle of symmetry [4], which leads to a kind of multimodular design far beyond the simple-minded multiagent systems now being developed. True multimodular intelligence implements something like direct transfer of skills and functions between agents, but within a context of gated, smooth rational learning.

In my view, our noosphere – for all its evident lack of maturity at present – possesses both of these important capabilities. Also, it is possible to build computer systems which do the same. But individual human brains do not. Therefore, for humans to keep up with the levels of consciousness and effectiveness which computers could be built to have, they wold need to develop more fully the capabilities which they possess as part of the noosphere.

Cultures throughout the world have included efforts to develop these capabilities. Now, through the development of deeper understanding, and use of the scientific method, which help us understand what is real and what is not in this realm, there is hope that we could do much better in the future as in the past, and accelerate the progress of our minds both at the mundane and the noetic level. Schools which fully exercise the brain, the body and the soul of all students, of all classes and genders, may be crucial to this hope.

REFERENCES

[1] National Science Foundation, New lower-cost technology to produce many entangled photons and test their properties, http://www.nsf.gov/awardsearch/showAward?AWD_ID=1444491

[2] P. Werbos, Local Realistic Model of Bell Theorem Experiment and Alternative Model of Quantum Measurement. http://arxiv.org/abs/1403.0469, 2014

[3] P. Werbos, Example of Lumped Parameter Modeling of a Quantum Optics Circuit, SPIE Proc. Quantum Information and Computation XII, SPIE 9123-10, May 2014, http://arxiv.org/abs/1309.6168

[4] P. Werbos, P. Intelligence in the brain: A theory of how it works and how to build it, Neural Networks, Vol. 22, Issue 3, April 2009, Pages 200-212

[5] P. Werbos, Neural networks and the experience and cultivation of mind. *Neural Networks* 32 (2012): 86-95.

[6] P. Werbos, From ADP to the Brain: Foundations, Roadmap, Challenges and Research Priorities, in Prof. Int'l Conf. Neural Networks, 2014. IEEE. http://arxiv.org/abs/1404.0554

[7] P. Werbos (2012), Rebuilding the Bridge Between Science and Mysticism, Rose-Croix, Vol. 9, http://www.rosecroixjournal.org/issues/2012/articles/vol9_74_86_werbos.pdf. See also http://drpauljohn.blogspot.com/2012/11/remembering-what-is-most-important-one.html

[8] P.Werbos, What do neural nets and quantum theory tell us about mind and reality? In

K. Yasue, M. Jibu & T. Della Senta, eds, No Matter, Never Mind : Proceedings of Toward a Science of Consciousness : Fundamental Approaches (Tokyo '99) . John Benjamins Pub Co, 2002. http://arxiv.org/abs/q-bio/0311006
[9] N.M. Ashkanasy and C.P.M.Wilderom, *Handbook of organizational culture and climate*. Sage, 2000.
[10] J. Von Neumann and O. Morgenstern, *The Theory of Games and Economic Behavior*, Princeton NJ: Princeton U. Press, 1953.
[11] H. Raiffa, H., *Decision Analysis*, Addison-Wesley, 1968
[12] P. Werbos, P., Mathematical foundations of prediction under complexity, Erdos Lectures/Conference 2010, http://www.werbos.com/Neural/Erdos_talk_Werbos_final.pdf
[13] Samuel L. Leven and Daniel S. Levine. Multiattribute decision making in context: A dynamic neural network methodology. *Cognitive Science* 20.2 (1996): 271-299.
[14] P. Werbos, P. Bell's Theorem, Many Worlds and Backwards-Time Physics: Not Just a Matter of Interpretation, Intl J Theoretical Physics, e-pub date 2 April 2008. http://arxiv.org/abs/0801.1234
[15] David Deutsch, The Fabric of Reality: The Science of Parallel Universes and Its Implications, Penguin, 1997
[16] Loren Eiseley, Preface, in David Lindsay, *Voyage to Arcturus*, Wilder Publications, 2009 (reprint)
[17] P. Werbos, Space, ideology and the soul: A personal journey. In Krone, R., ed., *Beyond Earth*, Apogee Books, 2006. http://www.werbos.com/Space_personal_Werbos.htm. See also http://drpauljohn.blogspot.com/2010/04/true-ghost-story.html
[18] S. Weinberg, *The Quantum Theory of Fields*. Cambridge U. Press, 1995
[19] Paul J.Werbos. Extension of the Glauber-Sudarshan mapping for classical and quantum energy spectra. International IFNA-ANS Journal *Problems of nonlinear analysis in engineering systems*,[1]1(41), v.20, 2014, 1-10 (in English); and [1]1(41), v.20, 2014, 11-21 (in Russian). arXiv:1402.5116
[20] Andrey Belkin, et al, Observation of Little-Parks Oscillations of the Kinetic Inductance at Low Temperatures Using a GHz Resonator with Two Parallel Superconducting Nanowires. APS Meeting Abstracts. Vol. 1. 2011.
[21] B.S.DeWitt & N. Graham eds, *The Many Worlds Interpretation of Quantum Mechanics*, Princeton U. Press, 1973
[22] David Deutsch, Quantum theory, the Church-Turing principle and the universal quantum computer. *Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences* 400.1818 (1985): 97-117.
[23] J.S.Bell, *The Speakable and Unspeakable in Quantum Mechanics*, Cambridge U. Press, 1987
[24] P.Werbos, Self-organization: Re-examining the basics and an alternative to the Big Bang, in K.Pribram, ed, *Origins: Brain and Self-Organization*, Erlbaum, 1994
[25] Robert Charles Wilson, *The Chronliths*, Orb Books, 2011
[26] Connie Willis, *Blackout* and *All Clear*, Spectra 2010 and 2011
[27] Andre Adamatzky and Guanrong Chen, eds , *Chaos, CNN, Memristors and Beyond: A Festschrift for Leon Chua* , World Scientific, 2013
[28] P.J.Werbos. A three step program for return to reality in physics. International IFNA -ANS Journal "Problems of nonlinear analysis in engineering systems, 1(37), v.18, 2012, 1-23. http://www.kcn.ru/tat_en/science/ans/journals/ansj_cnt/12_1_1/12_1_1.htm
[29] D.S.Levine and S.J.Leven, eds, *Motivation, Emotion, and Goal Direction in Neural Networks*, Erlbaum, 1992.
[30] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, Third Edition, University of Chicago Press, 1996.
[31] National Science Foundation, *Emerging Frontiers in Research and Innovation 2008*, http://www.nsf.gov/pubs/2007/nsf07579/nsf07579.pdf.
[32] P.Werbos, Quantum theory and neural systems: Alternative approaches and a new design. In K. Pribram ed., Rethinking Neural Networks: Quantum Fields and Biological Evidence, Erlbaum, 1993.
[33] Hebb, D. O. (1949), Organization of Behavior, Wiley 1949
[34] http://drpauljohn.blogspot.com/2010/04/true-ghost-story.html
[35] Targ, R., & Puthoff, H. E. (2005). Mind-reach: Scientists look at psychic abilities. Hampton Roads Publishing.
[36] Millennium Project, video of release of State of the Future 2014, http://usinnovation.org/video/report-release-2013-2014-state-future

[37] Greeley, A. M., & McCready, W. C. (1975). Are we a nation of mystics? New York Times Magazine, Jan. 26, 1975.Reprinted in Goleman, Daniel, and Richard J. Davidson, eds. Consciousness, the brain, states of awareness, and alternate realities. Ardent Media, 1979.
[38] Werbos, P.J. (2015) Stochastic Path Model of Polaroid Polarizer for Bell's Theorem and Triphoton Experiments, *International Journal of Bifurcation and Chaos*, March 2015. (Partial version posted at vixra.org.)
[39] P. Werbos (2014),Time-Symmetric Physics: A Radical Approach to the Decoherence Problem. In Proceedings of the workshop on Quantum Computing of the conference Pacific Rim Artioficial Intelligence (PIRCAI-=2014), J. Steck and E. Behrman, eds. The slides and audio of this keynote talk are available at www.werbos.com/quantum.htm
[40] Popper, Karl Raimund. *Quantum theory and the schism in physics*. Vol. 3. Psychology Press, 1992.
[41] Kim, Yoon-Ho, and Yanhua Shih. "Experimental realization of Popper's experiment: Violation of the uncertainty principle?." *Foundations of Physics*29.12 (1999): 1849-1861.
[42] Vladimir I. Vernadsky, The Biosphere and the Noosphere, English translation, *American Scientist* (1945): xxii-12.
http://www.larouchepub.com/eiw/public/2005/2005_1-9/2005-7/pdf/30-33_7_featnoosphere.pdf
[43] Pierre Teilhard de Chardin, The Phenomenon of Man, revised English translation, Harper and Row, 1965.
[44] Activation of Energy: Enlightening Reflections on Spiritual Energy, English translation, Harcourt, 1976.