An Overall Approach to the Observer

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Abstract: In this essay I apply the same approach to the observer and to the observed. A diagram from David Bohm and Basil Hiley's *The Undivided Universe* can model both (a) thinking emerging from feeling, and (b) the Born rule as the outcome of a mathematical game for maintaining existence. Language for the relevant possibilities and information is presented in Section 1. Section 2 focuses on identities, of the observer and of the quantum particle. Section 3 applies the game of maintaining existence to both. Section 4 describes the game-board: a model of time based on nonstandard analysis where proper time is a spatially invisible *container*.

"What we have done here opens up the possibility of an overall approach that encompasses all aspects of ***objective*** *nature and of our* ***subjective*** *experience (e.g. as an observer and a thinker)."* David Bohm and Basil Hiley, *The Undivided Universe: An Ontological Interpretation of Quantum Theory.* Emphasis added.

1. Possibilities and information in an overall approach

"How many times have I said to you that when you have eliminated the impossible, whatever remains, however improbable, must be the truth?" Arthur Conan Doyle.

Sherlock Holmes is the fictional embodiment of a theory of the astute observer. One after another he reclassifies possibilities into impossibilities. When none remain, he returns to the scene for more information. He walks around, stands here, stands there, and tacitly re-learns the situation. Somewhere there is support for propositions not previously stated and arguments not previously heard. Armed with more information and with a renewed feeling for the situation, he returns to his apartment. Where, in a musical reverie, more possibilities enter his imagination. Applying the newly available information, Holmes once again dismantles possibility after possibility into impossibility—until only one remains, which he cannot dismantle.

"The task is not to make sense of the quantum axioms by heaping more structure, more definitions, more science-fiction imagery on top of them, but to throw them away wholesale and start afresh. We should be relentless in asking ourselves: From what deep physical principles might we derive this exquisite mathematical structure? Those principles should be crisp; they should be compelling. They should stir the soul...[For example] ***H*** *is a complex vector space, not a real vector space, not a quaternionic module. Give an information reason if possible!"* Christopher Fuchs, *Quantum Mechanics as Quantum Information (and only a little more).*

Physical law determines what is physically possible and impossible. Complex numbers can be used to model both.[1] In that sense, complex numbers model the laws of physics. Although there are many other items to which Christopher Fuchs addresses the same imperative—*Give an information reason if possible!*—it seems noncontroversial to begin with the physical possibilities and impossibilities of the laws of physics: If something is physically impossible, assign a zero to it. If it is possible, assign a number that is not zero. Thereafter, *possibilities* and *impossibilities* combine like the complex numbers.

If I want the *possibility* of winning in a raffle where one must be present to win, then (for simplicity, just starting with two) neither my having a ticket, nor my being present at the drawing, can be *impossible*—neither can be zero. If either is *impossible* and thus assigned a zero, then this makes it *impossible* for me to win, and likewise the *possibility* of my winning becomes zero. It's like the multiplicative product of numbers, where if either factor is zero, the product is zero. And—the product commutes. It doesn't matter which I say first.

Now say in midstream that the rules change and a ticket holder need not be present to win. In that case, the possibilities work like division to remove a factor previously multiplied. Factor out, divide away, the number corresponding to the possibility of being present, and the one factor which remains is the possibility of having a ticket.

This alone makes the type of number for translating sentences from the language of possibilities into the language of numbers a *division algebra*—real, complex, quaternion, or octonion. But the requirement of multiplicative

[1] http://fqxi.org/community/forum/topic/2420 Abbreviated here as "*simple math*"

commutativity eliminates the quaternions and the octonions, leaving only the real numbers and the complex numbers in contention.

But logically speaking, something either is a possibility or it is not a possibility. Except by its connoted probability, a possibility is not comparable in size or amount to another possibility. Since the real numbers are ordered like this (real numbers are ordered by the greater than/less than relation) they do not support a fully accurate translation of propositions written in the language of possibility.

So to answer Christopher Fuchs' question, **H** is a complex vector space—not real, quaternion or octonion—because complex numbers can be used to model the way in which physical possibilities of reality are taken apart and combined. As Frank Wilczek wrote, "The physical content of quantum electrodynamics (QED) is summarized in the algorithm that associates a probability amplitude with each of its Feynman graphs depicting a possible process in spacetime."[2] A probability amplitude is a complex number. Years before, Richard Feynman had translated the language of possibilities into the language of complex numbers in this way: "A probability amplitude is associated with an entire motion of a particle as a function of time, rather than simply with a position of the particle at a particular point in time."[3] Thus in quantum mechanics Feynman changed the field of possibilities from a variable like configuration or momentum to the diagram of a space-time process. Fuchs' imperative for an explanation in terms of information is satisfied by ***informationalism***: *"*The main idea of informationalism is to take the inverse relationship between information and possibility as a guiding tenet. *The Inverse Relationship Principle*: Whenever there is an increase in available information there is a corresponding decrease in possibilities, and vice versa.*"* Jon Barwise, *Information and Impossibilities*.

2. The question of identity

Erwin Schrodinger compared the simplicity of atomism to the "intricacy" of the continuum in his texts *Nature and the Greeks and Science and Humanism*. Schrodinger studied the Greeks because he wanted to learn how they discovered atomism—long before the language of modern quantum theory. In the foreword to this book, Roger Penrose writes of Schrodinger's explanation of his equation, "It had a powerful influence on my subsequent thinking." Here, the emphasis is Schrodinger's:

"If you envisage the development of physics in the last half century, you get the impression that the discontinuous aspect of nature has been forced upon us very much against our will. We seemed to feel quite happy with the continuum...But quantum theory dates 24 centuries further back, to Leucippus and Democritus. They invented the first discontinuity—isolated atoms embedded in empty space.... and these particles have turned out to be quanta of energy, because—as Einstein discovered in 1905—mass and energy are the same thing. So the idea of discontinuity is very old. How did it arise? I wish to establish that it originated precisely from the intricacy of the continuum, so to speak as a weapon in defense against it." Schrodinger, *ibid.* p 158.

Schrodinger wrote, as well, about the ancient Greek word "auto"—as in the sentence "know thyself." With this sentence enters the idea of the observer.

"You may ask—you are bound to ask me now: What, then, is in your opinion the value of natural science? I answer: Its scope, aim, and value is the same as that of any other branch of human knowledge. Nay, none of them alone, only the union of all of them, has any scope or value at all, and that is simply enough described: it is to obey the command of the Delphic deity, gnothi psauton, get to know yourself." Schrodinger, *ibid*. p 108.

Zeno's story of the race between Achilles and the tortoise, where the tortoise is given a head start, involves both the continuum and the self. There is a repeating conclusion about the continuum: from wherever he is, Achilles must first reach a point half-way between himself and the tortoise before he can overtake the tortoise. The same conclusion holds at every midpoint he reaches. It's the "intricacy" of the continuum.

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[2] ***The Origin of Mass***. Frank Wilczek. MIT Physics annual. 2003.

[3] R. P. Feynman, Rev. of Mod. Phys., **20**, 367. ***Space-Time Approach to Non-Relativistic Quantum Mechanics***.

But Achilles also understands know thyself. Although he might even believe the above propositions the night before the race, Achilles will never concede the race. He will run the race because he knows who he is—a human being who can easily walk faster than a tortoise.[4]

However, in these texts Schrodinger did not write about Zeno's paradoxes. He seems to have missed something Parmenides said: that in guiding choice, knowledge should be primary and belief secondary, which is the message of Zeno's story. Why did he miss this? I would say because of the information available.

In his review of ancient Greek thought, Schrodinger starts with the following fragment of Parmenides, whom Zeno, recall, was trying to help: *For the same is the thinking and the being.* It's also possible to translate this fragment into the equation for a non-wellfounded set.[5] But first, one must translate *auto* into *self*. The translations available to Schrodinger translated *auto* into *the same thing*. And there are, of course, other variations:

"*The same thing is for thinking and being*," which sounds like a riddle. "*The self is for thinking and being*," which sounds like an answer to the riddle. "*For the self is to think and to be*." This translation retains the infinitives that Schrodinger translated into *the thinking* and *the being.* And finally in this list:

self = (thinking, self), which is the equation of a non-wellfounded set.[6]

Curiously, translating Parmenides' ancient Greek into this equation can be compared to Schrodinger's equation in the following way: Both equations say something about continuous existence. Schrodinger wrote:

"This is intimately connected with what I called earlier the lack of individuality of a particle, or even of an atom. If I observe a particle here and now, very near the former place, not only cannot I be sure whether it is 'the same', but this statement has no absolute meaning. This seems to be absurd. For we are so used to thinking that at every moment between the two observations the first particle must have been somewhere, it must have followed a path, whether we know it or not. And similarly the second particle must have come from somewhere, it must have been somewhere at the moment of our first observation. So in principle it must be decided, or decidable, whether it is the same particle. In other words we assume—following a habit of thought that applies to palpable objects—that we could have kept our particle under continuous observation, thereby ascertaining its identity." [However on p 131] "We must not admit the possibility of continuous observation. Observations are to be regarded as discrete, disconnected events." [For example on p 151] "We cannot tell where the particle was before it hit the plate. We cannot tell through which opening it has come. This is one of the typical gaps in the description of observable events, and very characteristic of the lack of individuality in the particle. We must think in terms of spherical waves emitted by the source, parts of each wave front passing through both openings, and producing our interference pattern on the plate—but this pattern manifests itself to observation in the form of single particles." Schrodinger. *ibid*.

In Schrodinger's equation the continuous trajectory of a particle is an illusion—observation conveys information only about one physical extension of some particle after another in a stream of physical extensions. The identity of the particle itself would have to be described by a different equation.[7] Perhaps the simplest would be: *particle = (physical extension, particle),* where physical extensions are countable, not the order of the continuum (see below).

Likewise, in "an overall approach that encompasses all aspects of **objective** nature and of our **subjective** experience (e.g. as an observer and a thinker)," the equation *self = (thinking, self)* might be the simplest model of the consciousness of an observer.[8] The equation shows a continuously existing self with a constant identity:

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[4] In terms of situation theory (*simple math*), Achilles knows the situation of being the human being that he is. This is more basic than any proposition based (as a proposition must be) upon a (possible or actual) situation—which proposition, a person may then believe or disbelieve.

[5] *simple math*

[6] cf. *Behavioral game theory: Thinking, learning, and teaching*. Camerer, Colin F.; Teck-Hua Ho; and Juin-Kuan Chong. Presented at the Nobel Symposium. http://people.hss.caltech.edu/~camerer/camerer.html

[7] For a different reason Einstein had said quantum mechanics is incomplete.

[8] "*A comprehensive understanding of consciousness will likely require theories of many types...There is unlikely to be any single theoretical perspective that suffices for explaining all the features of consciousness that we wish to understand. Thus a synthetic and pluralistic approach may provide the best road to future progress.*" Van Gulick, Robert, "Consciousness", The Stanford Encyclopedia of Philosophy (Spring 2014 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2014/entries/consciousness

For every *self* on the RHS of the equation *self* = *(thinking, self)* substitute *(thinking, self)*:

self = *(thinking, (thinking, self))*

self = *(thinking, (thinking, (thinking, self)))*, and so on.

thinking changes but *self* is constant.

Computer scientists call this a stream.[9] The *self* continuously exists, while *thinking* is the type (not the substance) of the element emitted by this continuously existing stream. An individual thought is a sub-type of *thinking*—for example a premiss, a conclusion, or some other kind of proposition. In Parmenides' poem *thinking* is the domain of beliefs. Whatever one person believes another can believe the opposite, because every logical proposition has an opposite.

No matter which type of proposition is emitted by the stream, the self continuously exists. In the same way, the stream of water is always itself no matter if the leaves falling from the trees, and being carried downstream by it, are in each case different. In Parmenides' poem the self is the chariot, in which the child-at-heart is carried from the domain of belief into the domain of knowledge.

self = *(thinking, self)* is also a semantic context for know thyself. The equation supplies two focal points within the parentheses. If one has the tools to know the self, one can focus on that and ignore thinking. Then with thinking ignored it might stop for a while with the result: *(self = (…(self)…))* ⊨ *"a self contained self"*.

In Parmenides' poem that is the way of knowing, which he contrasts with the way of believing. In this context the equation is a basic model of the self of an observer, in the sense that the equation models the self, as having a continuous existence. Self is the same self on both sides of the equation.

The equation also models the lifetime that's available to a human being, where *thinking* is a kind of ticking of a clock: *being_self = (thinking, (thinking, (thinking…being_self)*. Since being an observer is necessarily being a human being, the equation seems like a good way to "start afresh" toward a mathematical model of the observer.

I end this section with a final point—there are two kinds of things in the equation *self* = *(thinking, self)*: first, things that solve an equation "***X*** = *(something, something,* ***X****)*"; second, things that solve an equation "***Y*** = *(something,* ***something other than Y****)*." The solution to the former is *X* = *self*. But in the latter—from something that is not thinking, somehow arises something that is thinking. Rather than "thinking comes from thinking" this is the transition of interest. So the following section considers "*thinking = (…feeling...)*." Somewhere underneath thinking there is feeling.

3. The game's afoot

Axiomatic Decision Theory has been used to derive the Born rule.[10] But a classic television show compares the traditional axiomatic approach with the experimental approach called Behavioral Economics.[11] Studies in Behavioral Economics find that players in experimental games do not maximize utility as laid down by the purely theoretical axioms of traditional Decision Theory.

Decisions which are irrational according to these axioms have for years been studied in the laboratory—for example with laboratory animals and humans in a game called **Probability Learning** (PL). In PL, rather than based on the thinking of a rational decision maker, decisions are based on feelings which result from a type of active information[12] being made available. Those feelings are of *self-doubt.* But it is easier in PL to think of self-doubt as *regret about one's*

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[9] *simple math*

[10] David Deutsch, *Quantum Theory of Probability and Decisions*.

[11] *Mind Over Money*. http://www.pbs.org/wgbh/nova/body/mind-over-money.html

[12] Bohm and Hiley. *ibid*.

choices. PL is fundamentally a game of maintaining existence, because if ultimately a player cannot find the bait or food, then that player will cease to exist.

In PL the feelings generated by active information which guide the subject are opposing forces of *regret*. For any possible choice **X** by the subject, when the payoff occurs elsewhere, at **Y**, there is both *regret* in the player *about having chosen **X*** and also, *regret about having Not chosen **Y***. For each possible alternative, these opposing "forces" are balanced. The role of the active information about a choice without payoff is then like that of a *Bohmian quantum field*:

"The basic idea of active information is that a form having very little energy enters into and directs a much greater energy. The activity of the latter is in this way given a form similar to that of the smaller energy." Bohm and Hiley, *ibid*.

In each of its moves in PL, the subject in the experiment can choose, say, **door A** or **door B**. For each move of the subject, bait or food will always occur behind one of the doors. But the bait or food is delivered to the doors according to a random number generator set by the other player in PL, the experimenter. For example, a random number generator may supply food behind **door A** *75 percent* of the time and behind **door B** *25 percent* of the time, at random—resulting in the frequentist probability of *0.75* at **door A** and *0.25* at **door B**.

Imagine a scoreboard above each door that displays two numbers. One number is titled "***regretted choosing you***," meaning by "you" the door over which the two scores are hanging, and the other number is titled "***regretted not choosing you***." At the start of PL, for every door behind which food might occur, these two numbers are zero. As the game progresses each number gets larger.

However for every door, the opposing forces of regret are small forces and serve only as active information to guide the subject. The subject does all the work of using his legs to move to the door. This is like the ship in Bohm and Hiley's example:

*"...in the example of the ship guided by radio waves, one may say that these waves carry information about what is in the environment of the ship and that this information enters into the movements of the ship through its being taken up in the mechanism of the automatic pilot. Similarly we explain the [two slit] interference properties by saying the quantum field contains information, for example about the two slits, and that this information is taken up in the movements of the particle. In effect we have in this way introduced a concept that is new in the context of physics—a concept that we shall call **active information**. The basic idea of active information is that a form having very little energy enters into and directs a much greater energy. The activity of the latter is in this way given a form similar to that of the smaller energy."* David Bohm and Basil Hiley *ibid*. p 35. "The form similar to that of the smaller energy" in PL is the form of the subject's probability distribution over doors. The finding in the literature[13] is that the subject "learns" the probability of food occurring behind each door, and chooses each door with the same probability as that for the food occurring there.

It is important to note that there must be an information channel to carry the active information. In the situation where the subject has chosen **door A**, but the food occurs behind **door B**, active information must be transmitted by means of this information channel to the subject in order to trigger the above feelings of regret. And in the situation when the subject has chosen some **door that's different than A**, but the food did indeed occur behind **door A**, the active information about this must also be transmitted to the subject in order to trigger the above feelings of regret.

When the two numbers on the score board are equal for each door—this is the transmission of a pattern from one player to the other, and it's said that the subject "learns" the probability for food at each door.

So by the transmission of active information, one process—the behavior of the subject in the PL—acquires the same pattern as that of another process—the behavior of the experimenter. Thereby the Born rule for the particle and the PL equation in mathematical game theory have the same general form:

$$\textbf{\textit{Probability\_X(A) = Probability\_Y(A)}}.$$

But in the Born rule, ***Probability_Y(A)*** is the product of two *complex* numbers, for example:

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[13] *simple math*

$$P_i = \Psi_i \, \Psi_i^* \qquad i = A, B.$$

What does this mean?

4. The game-board

A Summary of *Simple Math for Questions To Physicists*

$$properTime_p = (clockTime, properTime_p) \qquad p = \text{“of the continuously existing particle”}$$

$$clockTime = (nonstandardPast, standardPresent, nonstandardFuture)$$

standardPresent in each instance is an increasing, countable number. *nonStandardPast* and *nonstandardFuture* comprise infinitesimals from nonstandard analysis, halos in the monad that surround its standard part.

$$nonstandardFuture \vDash \Psi_i \, \Psi_i^*$$

$$nonstandardPast \vDash P_i$$

nonstandardFuture and *nonstandardPast* are in terms of channel theory situations that support infons: (**a**) supported by the *nonstandardFuture,* expressed in the language of possibilities; (**b**) supported by the *nonstandardPast,* expressed in the language of frequentist probabilities. The elements of information reveal a partial image[14] of PL:

nonstandardFuture $\vDash \Psi_i \, \Psi_i^*$ For every i, (**A**) In the mathematical game involving the Schrodinger particle, this means there's the possibility Ψ_i that a location in space, index i, will exist and offer mathematical "bait" **and** the possibility Ψ_i^* that all locations other than i will exist but not so offer. (**B**) In the mathematical game of QED and QCD, this means there's the possibility Ψ_i that an interaction of type (not substance) i will exist and offer mathematical "bait" **and** the possibility Ψ_i^* that all types (not substances) other than i will exist but not so offer. (**C**) In the mathematical game involving the Bohmian particle, this means there's the possibility Ψ_i that trajectory, index i, will exist and offer mathematical "bait" **and** the possibility Ψ_i^* that all trajectories other than i will exist but not so offer. (**D**) In the PL itself this means there's the possibility Ψ_i that a door, index i, will exist and offer food when opened **and** the possibility Ψ_i^* that all doors other than i will exist, but not offer food when opened.

nonstandardPast $\vDash P_i$. For every i, (**a**) In the mathematical game involving the Schrodinger particle this means there's the probability P_i that an event occurred where a physical extension of the particle chose spatial index i. (**b**) In the mathematical game of QED and QCD, this means there's the probability P_i that an event occurred where the interaction chose its substance to be of type i. (**c**) In the mathematical game involving the Bohmian particle, this means there's the probability P_i that an event occurred where the particle chose trajectory i. (**d**) In the PL itself, this means there's the probability P_i that an event occurred where the subject chose door i.

That (a) there exists a bijection between the *nonstandardFuture* and the *nonstandardPast* (because they exist within the same monad) and (b) the Born rule $P_i = \Psi_i \, \Psi_i^*$ holds between the respectively supported possibilities and probabilities[15], means that information in the *nonstandardFuture* <<**A**>> (<<**B**>>, <<**C**>>, <<**D**>>) translates perfectly into information in the *nonstandardPast* <<**a**>> (<<**b**>>, <<**c**>>, <<**d**>>). However, the information <<**a**>> in the *nonstandardPast* does not perfectly translate into the information <<**A**>> in the *nonstandardFuture*. This is because information <<**a**>> conveys information only about index i, while information <<**A**>> conveys

[14] The image emerges through the lens of a nonstandard model of time and channel theory (Barwise) focused on the Born rule. What may be inferred from this partial image is its possible cause: a mathematical structure infomorphic to PL, a game of maintaining existence. To accommodate the full structure, ***standardPresent*** would have to support an otherwise invisible equation: that in the mathematical game, [100 x $\sum P_i \, \Psi_i \, \Psi_i^*$] percent of choices manage to "consume" the "bait." Then the unconsumed "bait," it might be argued, is dark energy.

[15] Given these premisses—that every particle or process has its own $properTime_p$; that each $properTime_p$ comprises a stream of *clockTimes* which are monads from nonstandard analysis: that each *clockTime* comprises (a) a *nonstandardFuture* supporting propositions about a conjunction of local and nonlocal possibilities for a spatial field $\Psi_i \, \Psi_i^*$ and (b) a *nonstandardPast* supporting propositions about the frequentist probabilities for events P_i; further, that an "infomorphism" is a bi-conditional meaning a translation between languages, and that for each *clockTime,* there is an infomorphism between these two languages—then the concluding proposition is $P_i = \Psi_i \, \Psi_i^*$. (More details in *simple math*.)

information about all the indices. This is an irreversible flow of information associated with how the active information in the PL operates. The subject learns a probability distribution from the experimenter and not the other way around.

For $\boldsymbol{P_i = \Psi_i\ \Psi_i^*}$ to hold throughout *clockTime* requires that the Heisenberg picture hold throughout *clockTime*. Which means that within *clockTime*, $\boldsymbol{\Psi_i}$ must be a constant complex number—in order to maintain existence of the information channel between the *nonstandardFuture* and *nonstandardPast* throughout the course of the game that's played during *clockTime*. There being a stream of *clockTimes* for the particle means that one *clockTime* is destroyed and another is created. And in the (theoretically) infinitesimal region between *clockTimes*, potentially changing instances of $\boldsymbol{\Psi}$ occur as in the Schrodinger picture.[16] Each $\boldsymbol{\Psi}$ may change in value there because the game does not exist there. $\boldsymbol{\Psi}$ and space ($\mathbf{r}_{\text{all}} = \mathbf{r}_1, \mathbf{r}_2, \mathbf{r}_3 \ldots$) in the Schrodinger equation unfold from **theHolomovement**, *theHolomovement* = $((r_{\text{all}}, \Psi(r)),\ (r_{\text{all}}, \Psi(r)),\ \textit{theHolomovement}))$, a stream the order of the continuum which is the context for proper time: *theHolomovement* $\vDash$ $\textit{properTime}_p$ or

$$[\textit{theHolomovement} = ((r_{\text{all}}, \Psi(r)),\ ((r_{\text{all}}, \Psi(r)),\ \textit{theHolomovement}))] \vDash [\textit{properTime}_p = (\textit{clockTime},\ (\textit{clockTime},\ \textit{properTime}_p))]$$

$$[\textit{theHolomovement} = ((r_{\text{all}}, \Psi(r)),\ ((r_{\text{all}}, \Psi(r)),\ (((r_{\text{all}}, \Psi(r)),\ \textit{theHolomovement})))] \vDash [\textit{properTime}_p = (\textit{clockTime},\ (\textit{clockTime},\ (\textit{clockTime},\ \textit{properTime}_p)))]$$

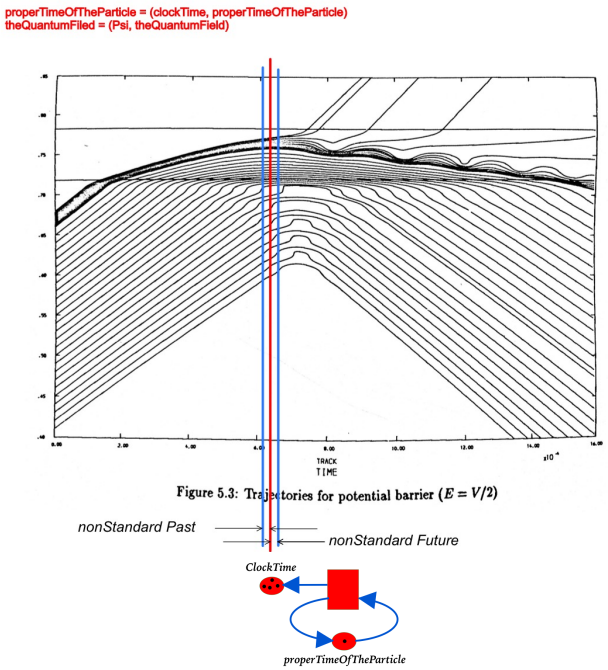
etc. And similarly,

$$[\textit{properTime}_p = (\textit{clockTime},\ \textit{properTime}_p)] \vDash [\textit{particle} = (\textit{physical extension},\ \textit{particle})], \text{ etc.}$$

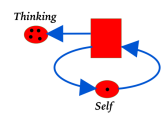
Diagrams

The Born Rule as a game of maintaining existence

The potential barrier E=V/2 is an example. Other formulas would also illustrate the idea.



Did the driver look like this diagram of a Petri net?



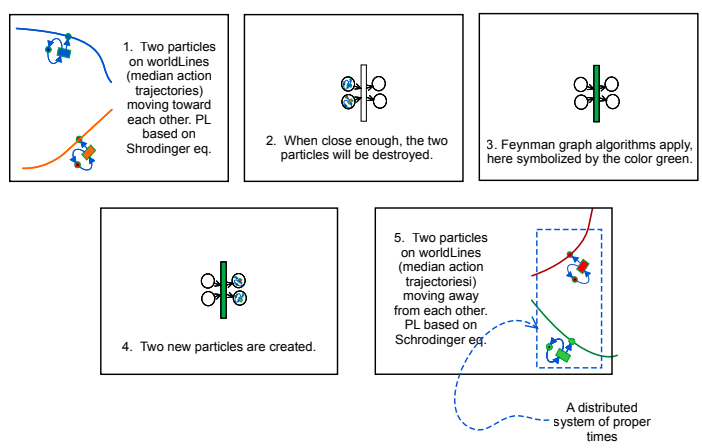
"Does it feel like anything at all to be a self-driving car, or is it a zombie in the sense of having behavior without experience?" Max Tegmark

It does "feel like anything at all" ***iff*** *self = (self)*. Given *self = (self)*, then thoughts can exist: *self = (thinking, self)*. It can also work the other way: *thinking* can stop and then *self = (self)*.

There is an empirical question, perhaps for a study in laboratory animal neuroimaging, about the stream of consciousness. Do interoceptors (e.g. heart related sensors) or proprioceptors (e.g. breathing related sensors) constitute the feedback loop—in this Petri net, the arrows and the place for *self*?

Systems of proper times

(more detail is needed)



To see a few more curiosities:

Show the player's choice by re-drawing a part of the Petri net. Re-draw the Petri net to show the choices of both players during a *clockTime* and connect to a Petri net for the quantum field.

Draw the Nash equilibrium.

Compare to an open string between branes.

[16] cf. Bohm and Hiley, ibid. p. 29. #2

"So what we now suggest is to give up the idea that the particle has a continuous existence and to suppose instead that it is more like our ink droplet model, which is continually unfolding and re-enfolding." Bohm and Hiley, *ibid*. p. 367.

Systems of Proper Times. This diagram involves some ideas for possible next steps. Compared to the existence of the particle/process—which is modeled via PL as a game of survival, or a game of existence, played on the game board of *properTime*—the existence of a *properTime* itself would depend, for one, on something that holds the *nonstandardFuture* apart from the *nonstandardPast*. If these two were to collapse into each other, then *clockTime* would no longer be a system comprising *nonstandardFuture*, *standardPresent*, and *nonstandardPast*. Instead, it would simply be a point. In that situation the particle/process could not exist—because there would be no possibilities for it and no information about it, due to the associated disappearance of the informorphism between *nonstandardFuture* and *nonstandardPast* based on the Born rule, and the associated disappearance of a "game board" for mathematical structure infomorphic to PL. For *properTime* to exist, the *nonstandardFuture* must be separated from the *nonstandardPast*. From this perspective, the *standardPresent* may be more than just a point of zero dimensions and zero extent.

To express entanglement—and also decoherence—in this model there is the **distributed system**. (cf. Barwise and Seligman, *Information Flow: The Logic of Distributed Systems*.) The idea is that the interaction of particles/processes assembles a distributed system of *properTimes*—a system which then supports infomorphisms from one particle/process to another. Decoherence would disassemble such a system. It's perhaps a logical outline for the details of calculation.

The Born rule as a game of maintaining existence. This diagram overlays simulation data from *The Undivided Universe: An Ontological Interpretation of Quantum Theory* (David Bohm and Basil Hiley, p. 77). It shows one element *clockTime* from the stream of *clockTimes*, each modeling the "droplet" as a physical extension on a trajectory—with a continuously existing particle being the stream that emits these physical extensions. In PL each *clockTime* supports a pair of moves—for its move in the *nonstandardFuture* of *clockTime,* "the experimenter will put food behind a door," and for its move in the *nonstandardPast* of *clockTime,* "the subject selected a door." When the subject misses the "food" there is lost energy and a transmission of active information which guides the subject's subsequent behavior.

At the level of a particle, within each *clockTime* the physical extension of a particle jumps from one of its trajectories in the diagram most likely to another, but on occasion to the same trajectory. This is just a different way to model the Born rule. The particle has its identity and unique continuous existence in a stream; and in PL, within *clockTimes,* that stream emits differing physical extensions onto differing trajectories.

At the level of the observer, this is a model for how the consciousness of the observer jumps from one line of thought to another, for example, when learning from a trusted person. However, always jumping from one trajectory of thought to another trajectory is an incomplete model. Also required is a model of how just one line of thought is selected for consciousness. In foraging experiments from biology, a group of probability learners, for example a school of fish (cf. Gallistel), will divide itself in proportion to the probability of food at different sites. For example, if the probability for food at **site A** is 0.75 and food at **site B** is 0.25, and if there are 20 fish in the school, 15 will stay at **site A** and 5 will stay at **site B**. Initially the fish follow *probability learning* and jump from site to site, but very quickly a *Nash equilibrium* develops where, in the final division of the school (15 at **A**, 5 at **B**), no individual fish can get a better payoff by going to the other site.

In his book *Mindful Universe,* Henry Stapp "argues for the quantum brain as a 'collection of classically conceived alternative possible states of the brain' (p. 50) all existing as parallel parts of 'a potentiality for future additions to a stream of consciousness' (p. 52)."[17] And the Nash equilibrium is like Daniel Dennett's ***Multiple Drafts*** model of

[17] "*Of all Stapp's ideas, this has perhaps the widest coinage, representing the fruit of his technical reflections in a form that can be readily understood by all scholars of the mind.*" http://www.sci-con.org/2007/06/a-review-of-henry-stapps-mindful-universe-quantum-mechanics-and-the-participating-observer/

consciousness,[18] where the largest population of cognitive elements at a trajectory wins, and the observer becomes conscious of the line of thought associated with that trajectory.[19] So in this model, believing the received line of thought is a Nash equilibrium in a game of social[20] rewards, while knowing the self is an internal journey—"For the self is to think and to be."

6. Conclusions

"Until we can explain quantum theory's essence to a junior-high-school or high-school student and have them walk away with a deep, lasting memory, we will have not understood a thing about the quantum foundations." Christopher Fuchs.

- In this model, the laws of physics are communicated to fundamental particles and processes by means of active information, which is transmitted through an information channel in *properTime* from the *nonstandardFuture* to the *nonstandardPast*—which requires work when the information channel involves a mathematical structure infomorphic to probability learning, which is a game of survival and thereforeexistence. In the language of informationalism, transmission of the laws of physics into theUniverse follows *the Inverse Relationship Principle:* the Born infomorphism translates possibilities into probabilities and therefore into Shannon-theoretic information.

- Believing and knowing are different states of consciousness. As noted in the body of the text, in certain ways believing involves the experience of a social context, while knowing involves the experience of the self.

7. Additional References

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[18] https://en.m.wikipedia.org/wiki/Multiple_drafts_model

[19] The model says nothing about the logical consistency of a person's beliefs. So in the case of a tie, in this model there is no problem with contradictory beliefs.

[20] This might be a challenge for laboratory experiments-- basically how to make the same information available as that for Hellen Keller in the well-house. In the following passage, Hellen describes a feeling of self, the interaction with Anne Sullivan, and her beginning of thinking: "*She brought me my hat, and I knew I was going out into the warm sunshine. This thought, if a wordless sensation may be called a thought, made me hop and skip with pleasure. We walked down the path to the well-house, attracted by the fragrance of the honeysuckle with which it was covered. Some one was drawing water and my teacher placed my hand under the spout. As the cool stream gushed over one hand she spelled into the other the word water, first slowly, then rapidly. I stood still, my whole attention fixed upon the motions of her fingers. Suddenly I felt a misty consciousness as of something forgotten—a thrill of returning thought; and somehow the mystery of language was revealed to me. I knew then that "w-a-t-e-r" meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, set it free! There were barriers still, it is true, but barriers that could in time be swept away. I left the well-house eager to learn. Everything had a name, and each name gave birth to a new thought. As we returned to the house every object which I touched seemed to quiver with life. That was because I saw everything with the strange, new sight that had come to me.*" — from ***The Story of My Life*** by Hellen Keller. In situation theory, Helen's thinking began with "*theSituation* ⊨ <<*exists*, '*w-a-t-e-r*'>>'" — the proposition that "This situation supports the information that there is 'w-a-t-e-r.'"