

Logical Types in Quantum Mechanics

Andrew Soltau

Abstract: Barbour shows that time does not exist in the physical world, and similar conclusions are reached by others such as Deutsch, Davies and Woodward. Every possible configuration of a physical environment simply exists in the universe. The system is objectively static. Observation, however, is an inherently transtemporal phenomenon, involving actual or effective change of the configuration, collapse. Since, in a static environment, all possible configurations exist, transtemporal reality is of the logical type of a movie. The frame of a movie film is of one logical type, an element of a set of frames, the movie, itself of a second logical type. In a static no-collapse universe, the configurations are of the first logical type, transtemporal reality of the second. To run, the movie requires iteration, a third logical type. Phenomenal consciousness is subjectively experienced as of this third logical type with regard to physical configurations.

Everett's formulation clearly describes the transtemporal reality of an observer, which follows the physical in the linear dynamics, but departs from it on observation, giving rise to the appearance of collapse, and the alternation of dynamics defined in the standard von Neumann-Dirac formulation. Since there is no physical collapse, his formulation is disputed. Given an iterator of the third logical type, the appearance of collapse is simply evidence of iteration. Chalmers demonstrates that phenomenal consciousness is of this logical type, an emergent property of the unitary system as a whole. Given an iterative function of this nature, one contextual to the physical configurations, paradoxes of time are resolved. Subjectively, meaning from the perspective of the iterative process, time passes in an objectively static universe, and the appearance of collapse is effected.

1 The Static Universe

As Petkov (2005) shows, relativity alone means that the universe is a four-dimensional block universe, a static configuration. As Deutsch states:

Spacetime is sometimes referred to as the 'block universe', because within it the whole of physical reality – past present and future – is laid out once and for all, frozen in a single four-dimensional block. (1997, 268).

However, as Ellis demonstrates, a static four-dimensional block is an inadequate view, and he develops this basic ontology into an Evolving Block Universe model:

... the unchanging block universe view of spacetime is best replaced by an evolving block universe which extends as time evolves, with the potential of the future continually becoming the certainty of the past; spacetime itself evolves, as do the entities within it. (2006, p. 1)

This concept demands an extra dimensionality to the physical environment, in the same manner as the quantum concept of time. Even this extra dimensionality, however, defines a static array.

Deutsch (1997, pp. 258-287) explains the quantum concept of time, which he attributes to Page & Woiters (1983). The no-collapse universe is equivalent to a multiverse of moments, each one a physical snapshot of the whole world. Each one is the definition of a specific version of the physical universe at a specific moment. All simply exist. Barbour shows that the universe is a static configuration of such moments, Deutsch's snapshots: instants as he calls them. Both make clear that all possible moments, instants, snapshots, exist in static array, or simultaneity. Everything about the new physics seems to point to physical reality being a static array of static physical configurations, permanent, pre-existing aspects of the configuration space of the universe of the unitary wave function. Time does not pass. As Barbour states “The instant is not in time, time is in the instant.” (1994, p. 2885). Overall he eliminates time altogether:

The Wheeler-DeWitt equation (WDE) of canonical quantum gravity is interpreted as being like a time-independent Schrödinger equation for one fixed energy, the solution of which simply gives, once and for all, relative probabilities for each possible static relative configuration of the complete universe. Each such configuration is identified with a possible instant of experienced time. These instants are not embedded in any kind of external or internal time and, if experienced, exist in their own right. (1994, abs)

Thus, as Barbour states:

... there is a well-defined sense in which time does not exist in general relativity at all. (1997, p. 2459)

As Woodward states:

It is argued that Mach's principle leads to the conclusion that time, as we normally treat it in our common experience and physical theory, is not a part of fundamental reality; the past and future have a real, objective existence, as is already suggested by both special and general relativity theory. (1996, abs)

2 Illusion

Naturally, a static universe is directly at odds with our experience of time. Subjectively, meaning simply in the experiential reality of the conscious observer, it seems totally obvious that time is passing. This, however, can be attributed to illusion. As Davies states:

After all, we do not really observe the passage of time. What we actually observe is that later states of the world differ from earlier states that we still remember. The fact that we remember the past, rather than the future, is an observation not of the passage of time but the asymmetry of time. (2002)

As Barbour states:

... we have all had the experience of walking into a house untouched by historical development for decades or centuries and declaring it to be a perfect time capsule. This, I believe, happens to us in each instant of time we experience. The only difference is that we experience our own time capsule, not someone else's. And we are mistaken in the way we interpret the experience. (1999, p. 31)

In other words, each moment is complete, pre-existing and defined: a specific version of the universe at that specific moment, with a specific version of the observer observing it at that moment. At each moment, I have the experience of the present moment, and I have the memory of the past, and the expectations of the future. This is all part of one moment, one specific 'time capsule'. In the next moment the same thing is true: there is the experience of that moment, and the memory of the past, and the expectations of the future. All such moments simply exist, timelessly. As Deutsch succinctly puts the case:

We do not experience time flowing, or passing. What we experience are differences between our present perceptions and our present memories of past perceptions. We interpret those differences, correctly, as evidence that the universe changes with time. We also interpret them, incorrectly, as evidence that our consciousness, or the present, or something, moves through time. (1997, p. 263)

Objectively, I have no evidence of passing from moment to moment; everything can be accounted for very simply by the contents of each moment. Moreover, it is physically impossible for me to pass from moment to moment. As Deutsch emphasises:

Nothing can move from one moment to another. To exist at all at a particular moment means to exist there for ever. (1997, p. 263; his italics)

There is a different physical body in each moment, having a different experience, and they all exist, permanently, each in a specific time capsule, or snapshot. It appears as if I must have experienced all those things I remember in the past, but that was a different me. Not only a different, younger me, but a me that still exists, 'there' in that other moment. It appears as if I will inevitably experience the next moment, but that is another me also, an older me that already exists in the already-existing future. Each version of me, at each moment, is permanently part of a specific moment, timelessly. There *is* a sequence of moments like that, but I am the me of one moment. and there is a different one of those, a different version of me, at each moment. As Deutsch states: "We exist in multiple versions, in universes called

'moments'" (1997, p. 287). There is a passage of time, in the sense of a corridor of time, made up of all of the moments, and they all exist, just as all the frames of the movie film exist, 'in the can', but nothing passes from moment to moment. Thus there is no enactment of a transtemporal reality: there is no reality of sequential moments experienced by a specific observer, only a potential sequence of moments, each one containing specific version of an observer at that moment.

McTaggart's (1908) B-series therefore exists, physically. Every possible temporal position exists, and for any two temporal positions, there is a two-term relation, which is asymmetric, irreflexive and transitive. All of the possible configurations of matter and energy in the space-time universe exist, 'already'. By the same token, however, physically, there can be no A-series: physically, the universe is logically tenseless.

3 Quantum Time

The quantum concept of time is a simple extrapolation of the quantum dynamics, to apply to the physical environment as a whole. The quantum state of the system defines the linear dynamics: the time evolution of the system with progression along the linear time dimension of space-time. The collapse dynamics is the change to the quantum state. If the quantum state defines a physical environment, then this is the change to the physical environment: time evolution in 'quantum time'. In principle, this concept is potentially incompatible with relativity. Since different inertial frames of reference have different temporal simultaneities, there can be no one universally applicable point in time at which such a change in the quantum state can be considered to occur. However, the principle is entirely compatible with relativity in the context of the Everettian formulation (1957), in which only a single frame of reference is germane.

The linear dynamics is the time evolution of a specific physical environment, defined by a specific quantum state. In the linear dynamics, the three-dimensional configuration of matter and energy in the physical environment changes, with progression along the linear time dimension of space-time, while the quantum definition of the physical environment, here the quantum mechanical frame of reference, remains constant. In the standard von Neumann-Dirac formulation (1955), collapse occurs on observation. In other words, on observation, the quantum state, and thus the effective physical environment, the quantum mechanical frame of reference, changes: the quantum jump. Thus the linear dynamics itself changes. Since this is instantaneous in 'linear time', meaning the linear time dimension of space-time, the inertial frame of reference is the same before and after the jump: position along the time dimension of space-time is unchanging in this transition from one quantum state to another: one moment in quantum time to another. Transtemporal physical space-time reality, should there be such a thing, is a sequence of such moments, equivalent in effect to Ellis's Evolving Block Universe concept (2006, 2008). Thus the essential logical structure of the universe in the quantum concept of time is identical to that of a movie: a sequence of frames, in this case quantum mechanical frames of reference, each one defined by the quantum state of the effective physical environment: each one a moment. This is the nature of observation in Everett's formulation.

4 Observation

For all the weighty evidence that there is no possibility of passing from moment to moment, this is directly at odds with the fundamental concept of observation. To make an observation is to change, from the state of not having made it to the state of having made it. Since these states exist in different moments, to make an observation is to pass from moment to moment. The making of an observation *is* the transition from moment to moment. Thus observation is an inherently transtemporal concept. Since each moment is a physical configuration, a snapshot of the whole world, to make an observation is to pass from one snapshot to another, exactly as demonstrated impossible by Deutsch. A priori analysis of the quantum dynamics, however, shows that there is a straightforward solution. A moment will be referred to as a quantum mechanical frame of reference, meaning the reality of the effective physical environment defined by the quantum state of that environment, with its inherent linear dynamics.

Subjectively, meaning simply experientially, it is clear that one is making observations and experiencing change; the movie of reality definitely seems to be running. If there is no collapse, and nothing can pass from moment to moment, then there is nothing like this in the physics of the universe, but there does not need to be. There is only the appearance of this happening in the universe, thus only the appearance requires explanation. When a movie is played from a DVD, nothing happens *in* the DVD. The appearance of a moving picture is generated by accessing the sequence of structures of information instantiating the images defining the frames of the movie. Similarly, in a static no-collapse universe, the appearance of collapse can only be the sequential accessing of a sequence of pre-existing physical states. This, however, is precisely what Everett's formulation describes. The appearance of collapse is the sequential accessing of a sequence of structures of information, each instantiating the state of the memory of the observer: Everett's definition of the functional identity of the observer.

To make an observation is to add the structure of information, representing the observation, to memory. Everett therefore defines observers in the simplest possible way, as "... automatically functioning machines, possessing sensory apparatus and coupled to recording devices" (1957, p. 457) to serve as memory. Given an observer of this nature, he then defines the functional identity of the observer as the contents of the memory, a structure of information:

If we consider that current sensory data, as well as machine configuration, is immediately recorded in the memory, then the actions of the machine at a given instant can be regarded as a function of the memory contents only, and all relevant experience of the machine is contained in the memory. (p. 457)

As an observation is made, being added to the record of sensory data in memory, the state of the observer changes. The new state is necessarily part of a new and different physical state of the observer. Whereas before the observation, the state of the observer did not contain this information, subsequently it does. Each observation made gives rise to a different state of the observer. Each sequential state is instantiated in a different version of the physical environment, a different quantum mechanical frame of reference. The result, experientially, meaning in the subjective perception of the observer, is the appearance of collapse: the appearance of a changing

physical reality. This, however, demands an explanation of what moves from moment to moment. What witnesses this change of the quantum mechanical frame of reference? This, however, is exactly where we came in. Nothing can pass from moment to moment.

A simple metaphor suggests a solution. The moments all exist, like the frames of a movie 'in the can'. Just as iteration of the frames of the movie gives rise to the motion picture, iteration of the sequence of moments would give rise to the appearance of a transtemporal physical reality. Just as with a movie played from solid state memory in a computer, nothing passes from moment to moment. In this case, all that happens is that structures of information are accessed in sequence. The only remaining question is what could possibly perform this sequential accessing.

5 Logical Types

Russell (1908) defines a set as being of different logical type to the members of that set. Each frame of a movie is of a first, primitive, logical type. A movie film, the set of frames making up the movie, is of a different, second, logical type. Similarly, with regard to quantum time, a specific quantum mechanical frame of reference is of the first, primitive, logical type. A sequence of quantum mechanical frames of reference, the enactment of quantum time, is of the second logical type. The linear dynamics is a property of a specific quantum mechanical frame of reference, defined by a specific quantum state. It is thus of the first logical type. The collapse dynamics, the change of the linear dynamics, is a property of a sequence of quantum mechanical frames of reference, and thus of the second logical type.

Objectively, nothing can move along the linear time dimension of space-time; the block universe is static, since the past and the future exist in the same way as the present. Thus, objectively, the linear dynamics is a static layout. The collapse dynamics is similarly static. Quantum time would be the enactment of the collapse dynamics, the change of the quantum state. However, as Deutsch and Barbour explain, all the snapshots, instants, block universes, exist timelessly, 'already'. Thus, objectively, the system is static at this logical level also. All possible moments exist 'already', and nothing can move from moment to moment. Everything that exists is a permanent part of a specific physical moment.

The system is objectively static, but then so is the movie film, which is brought to life by the frames being iterated: by a projector, a DVD player, a computer, or any device capable of changing the functional frame of reference from one frame of definition to another. Each frame of the movie is of the first logical type, and the movie, the set of frames, is of the second logical type. Iteration is of different logical type again, being an operation which applies to all movies. The operation of iteration is inherent in the dynamic structure of all movies. It is thus of the logical type of the set of all possible movies, a third logical type. In order for the collapse dynamics to be enacted, there must be a change to the quantum state. Since all possible states exist 'already', this implies a transition of the functional frame of reference from one quantum mechanical frame of reference to another. This requires something of the third logical type. This appears to be paradoxical. If there is to be something that is to the moments as a projector

is to a movie, it would have to be 'outside' the universe of all the possible moments, an oxymoron. However, the no-collapse universe itself is, by definition, of this third logical type. It is the context of all possible sequences of frames of reference, all possible transtemporal realities. It is of the correct logical type to be an iterator of quantum mechanical frames of reference.

6 The Third Logical Type

The ongoing transition from one quantum mechanical frame of reference to another is the iteration of a sequence of moments, the sequential access of different quantum mechanical definitions of the physical environment. But with reference to what can this point of view be changed? A process of this nature can only take place with respect to a point of view that is an emergent property of the system as a whole. Only something of the third logical type is in a position to encounter a change in the quantum mechanical frame of reference. In other words, something of this logical type is essential to the process of making an observation, and thus the enactment of a transtemporal reality, as experienced by conscious observers.

The standard formulation defines the linear and collapse dynamics, the first and second logical types. Nothing physical can ever pass from moment to moment, thus the collapse dynamics can never be exercised by something physical. The existence of the third logical type, however, automatically takes care of this difficulty in making sense of time in the new physics. To project onto the universe as a whole the property of iteration of quantum mechanical frames of reference, physical moments, may seem absurd, but appears to be required. Just as only a working computer system as a whole is in a position to change the functional frame of reference from one address in memory to another, only something contextual to the moments is in a position to change the functional frame of reference from one physical moment to another.

Objectively, as physical entities, we are in the logical position of the first logical type. We are part of a specific physical moment, aspects of a specific configuration in the physical reality defined by WDE. As such we are in the same logical position as the definition of a character in a frame of a movie, at a specific address in the memory of a computer. From such a position, the only possible conclusion is that the system is static. The workings of the system as a whole are naturally invisible from this point of view. This is the perspective of any physical entity.

The third logical type is inevitably something of a mystery. Properties of the no-collapse universe as a whole are, by definition, outside of the remit of the science of the world we find ourselves in as physical entities. On the other hand, if one's functional frame of reference were changing from moment to moment, the transtemporal reality we find ourselves experiencing is exactly what it would be like. 'Subjectively', meaning simply in experience, a series of moments is experienced. Each one is a specific snapshot, defining, along with the state of the physical environment, the state of the body and the mind. Naturally, the same question arises subjectively as objectively. If what is experienced is the changing state of world, body and mind, what is the point of view from which this change is taking place? Subjectively, in one's experience, the answer is straightforward. It is phenomenal consciousness, pure subjectivity.

This is the one and only thing that seems to make the transition from moment to moment. One encounters change, in world, body, and mind, all of which are different in different moments. Different states of world, body and mind, at different moments, are experienced in sequence, by phenomenal consciousness. Phenomenal consciousness, effectively at least, passes from moment to moment. This is the nature of the experiential reality of each conscious observer.

7 Consciousness

The idea that consciousness is directly involved in collapse is not new: London & Bauer (1939), Wigner (1961). To be in such a position it would have to be contextual to the physical moments, as the iterator is contextual to the movie film. It is increasingly accepted that consciousness is not part of the physical moments. As Mermin states:

Quantum mechanics offers an insufficient basis for a theory of everything if everything is to include consciousness. (1998, p. 7)

Similarly, Shanon states:

Since one cannot derive consciousness from matter (or, again, from either brain or computational processes) one had better regard consciousness as fundamental. (2002)

Only one kind of consciousness, however, is fundamental, not derived from matter and energy, and outside the scope of quantum mechanics.

The term consciousness is used for two very different types of phenomena, access consciousness and phenomenal consciousness, as explained by Block (1995). Chalmers (1995, 1996) makes the same distinction between awareness and experience. Access consciousness is the accessing of the information structures of the brain, in all its different and various forms, such as recall and introspection, thoughts, moods, emotions and dreams: the accessing of information and the general mental activity of information processing giving rise to the contents of awareness, the sensorium. As such it is very obviously a property of the body, and thus an attribute of the physical world. As Chalmers states, there is a straightforward functional explanation for every aspect of this kind of consciousness in terms of physiology (1996, p. 46). The overall result, the inner life of the observer, subjective reality, can best be understood as an emergent property of the body-mind. Clearly, the body-mind exists in different states at different moments, giving rise to access consciousness in different states at different moments.

Phenomenal consciousness, on the other hand, the pure subjectivity, experiencing, is a complete mystery. As a result, it too is simply held to be an emergent property of the living body-mind system. Chalmers, however, in his exhaustive analysis of consciousness (1996), shows that phenomenal consciousness cannot be explained in any way by physiology, and has no functional or reductive explanation. As he states:

The failure of consciousness to supervene on the physical tells us that no reductive explanation of consciousness can succeed. (1996, p. 106)

Not only is phenomenal consciousness the one and only feature of the conscious observer that currently has no physical or psychological explanation, it *cannot* be explained by the physical. This is meta to the physical. Chalmers concludes that phenomenal consciousness is necessarily contextual to physical reality:

I suggest that a theory of consciousness should take experience as fundamental ... we will take experience itself as a fundamental feature of the world, alongside mass, charge, and space-time. (1995, p. 216)

In other words, it is an emergent property of the universe as a whole. As such it is of the third logical type. This means that the subjective passage of time need not be an illusion. Every conscious observer has direct evidence of a sequence of moments in physical reality, accessed by phenomenal consciousness. If phenomenal consciousness is contextual to the physical moments, this is no illusion. It is simply the enactment of collapse, and the subjective experience of change, quantum time in transtemporal reality.

8 Subjective Transtemporal Reality

Phenomenal consciousness is pure subjectivity, and as such it embodies the quintessentially subjective property of identification. As Bitbol states, referring to pure subjectivity as Mind:

Indeed, as soon as (abstract) Mind identifies itself with a point of view, it can but identify itself to a particular one. ... Mind, having no point of view of its own, can but adopt particular points of view and identify itself completely with each of them. Mind is by itself point-of-view-less, just as it is placeless and timeless. (1991, p. 8)

Thus for Mind, a phenomenon of the third logical type, to identify with a point of view is to have only that point of view. Subjective identification is an inherently singular process: a basic logical requirement for identification is that the identifier be unique.

8.1 Change

The no-collapse universe of the unitary linear dynamics is a static array of static moments. Everett's formulation addresses only this static structure, and the appearance of collapse that exists within it as a potential information process. He does not address any mechanism for the transtemporal enactment of such a process. According to Bitbol his primary concern was:

... to avoid considering any physical transition from the possible to the actual. And, since 'actuality' is usually considered as the most obvious characteristic of an experimental result, Everett had but one solution in order to eliminate the necessity of considering a transition: it was to spread out 'actuality' onto every term of the superposition. (1991, p. 7)

Given that every aspect of the no-collapse universe exists 'already', every aspect of reality, past and future, is 'actuality'. Nothing changes; but to make an observation is to change. So the question is, *how* does something, even of the third logical type, *make* an observation? On the view presented here this is essentially a virtual phenomenon, like the motion picture of a movie.

The movie projector is simply an iterator of the frames of reference. It does not, itself, change in any way; it changes something other than itself in iteration. It simply changes the frame of reference defining the image. Thus something in the relational position to reality of the third logical type does not need to change in any way, only to change the frame of reference defining the physical moment: the quantum mechanical frame of reference. Just as well for the metaphor, since something in the position of the third logical type is necessarily an emergent property of the totality of all physical possibilities, which by definition can hardly change.

Though its definition cannot change, the identification can change, and does so, automatically, with the addition of an observation to the current identity. Everett defines the functional identity as the state of the memory. He also shows that there is the appearance of collapse “Judged by the state of the memory ...” (1957, p. 462), meaning with respect to this identity. Thus, to identify with this functional identity, the structure of information with respect to which there is the appearance of collapse, is to identify with this observer, in this physical environment, at this specific moment, complete with the appearance of collapse. This, however, does not sound transtemporal, this sounds more like Deutsch's “... differences between our present perceptions and our present memories of past perceptions” (1997, p. 263): a specific structure of information, experienced at a specific point in time. However, although Everett's appearance of collapse is indeed the description of a specific point in time, it is the specific point in time at which collapse actually happens. This is a specific point in linear time, which is also the point of transition from one quantum mechanical frame of reference to another: the transition from one moment in quantum time to another. This transition takes no linear time: it is instantaneous with regard to the linear time dimension of space-time.

8.2 Collapse

At the point in time where the next observation is added to the record of observations, there is subjective collapse. The record of observations is necessarily the record of correlations with the environment. As this changes, the quantum mechanical frame of reference changes. Since the new functional identity therefore exists in a new and different quantum mechanical frame of reference, a different effective physical environment defined by a different quantum state, this is one step forward in quantum time: to make an observation is to pass from one moment to another. This appearance of collapse can only actually take place from the perspective of a point of view contextual to the moments: something to which the no-collapse universe is effectively an array of possible physical moments, Deutsch's multiverse of snapshots. The third logical type is by definition in this position. As each observation is added to the functional identity, the identity changes, and, subjectively, there is collapse. Quantum time is enacted. As Tegmark (1997) explains, this only happens subjectively, on the inside view of the quantum mechanical frame of reference. Objectively, on the outside view, there is only the linear dynamics.

8.3 Linear

In between collapses, as the standard formulation states, the system “... evolves continuously according to the linear, deterministic dynamics” (Barrett, 1998). Objectively, this is a static domain, a block universe. Objectively, the whole layout of possibilities of events in the four-dimensional space-time matrix is a static given. Subjectively, however, identified with the functional identity of the observer, at a specific point in space-time, this environment is dynamically changing. Within the context of a specific linear dynamics, matter and energy are in a state of continuous evolution. The state of the matter and energy as a three-dimensional configuration in space evolves, as the position along the time dimension of space-time changes. This is the time evolution of the physical environment due to the linear dynamics, the change of the three-dimensional configuration of matter and energy, in the progression along the linear time dimension of space-time, as defined by a specific quantum state. Objectively, and with respect to quantum time, this domain is a static four-dimensional block universe. Subjectively, identified with a structure of matter and energy, changing in the time evolution of the linear dynamics, the passage of time along the linear dimension of space-time is experienced.

In this context, something of the nature of the third logical type is equally essential. Nothing can move along the time dimension in the linear dynamics except something contextual to the domain, just as it takes someone outside of a picture to run their finger or eye across the image. The contents of the image are all 'there', only the frame of reference of perception is changed. Similarly, all the contents of the four-dimensional block universe are 'there'. Only the three-dimensional frame of reference of perception is changed, as the time evolution of the linear dynamics is experienced. In the universe described by special relativity, as Penrose states:

... particles do not even move, being represented by “static” curves drawn in space–time’. Thus what we perceive as moving 3D objects are really successive cross-sections of immobile 4D objects past which our field of observation is sweeping. (1994, p. 389)

The configuration of matter and energy in space changes as the field of observation passes along the time dimension of space-time. Given a static pre-existing block universe, this requires that the 'field of observation', the frame of reference of perception, is contextual to the 4D reality.

8.4 The Specious Present

The functional identity of the observer is defined by the record of observations, which changes only with the new addition of an observation. Since this process is dependent on neural processes, there are periods of time in which a specific configuration is constant. Such a period of time, the duration of a specific state of the record of observations, in the linear time dimension of space-time, is here considered to be the specious present: the period of time in which the experiential reality is constant.¹ During this period, in-between observations, the state

¹ As a first approximation one could take the frequency of visual images required on a display screen so as to eliminate flicker as the change is detected, around 75 Hertz. Provided the refresh rate of the screen is above this value, the observer cannot detect discrete images, suggesting that the 'refresh rate' of the neural visual system operates at approximately this frequency.

of the body-mind of the observer evolves in accordance with the linear dynamics. Time passes, while the observer remains briefly in the same experiential state, in the same moment, passing along the time dimension of space-time in that moment. During this period, the next observation is being formulated in the neural system. On completion of this formulation, there is collapse.

8.5 The Standard Formulation – The Inside View

Thus, subjectively, there is an overall progression along the linear time dimension of space-time, punctuated by jumps to a different quantum mechanical frame of reference. Time passes as the system evolves in the time evolution of the linear dynamics. The time evolution of the linear dynamics progresses until an observation is made. This changes the record of observations, which changes the quantum mechanical frame of reference, and thus the linear dynamics. The time evolution of the new version of the linear dynamics progresses until an observation is made, and the cycle continues. Subjectively, linear and collapse dynamics alternate, as defined by the standard von Neumann-Dirac formulation. Thus, as Everett states:

... we were able to show that all phenomena will *seem* to follow the predictions of this scheme to any observer. (1973, p. 110; his italics)

8.6 Branching – The Outside View

During the specious present, the system evolves according to the linear dynamics. Thus all possible observations that the neural system could be in the process of formulating, are simultaneously present in this system in superposition or mixture. Objectively, at the point in time where the next observation is added to the record of observations, all possible additions take place in the linear dynamics. The iterator, of the third logical type, generates every possible addition, and as a result gives rise to all possible variations of a quantum jump to a different next moment, each one a different quantum mechanical frame of reference. The subjective experience of each such jump, however, is of a singular and specific jump to a specific next moment. Identification is a singular process. Thus, as Everett states:

... with each succeeding observation (or interaction), the observer state "branches" into a number of different states. (1957, p. 459)

9 The Triune Observer

In the sequential access of different definitions of the experiential state of the body of an observer, a process of the third logical type, the appearance of collapse is created. This is the subjective experience of a transtemporal reality. However, there is no physical object or structure of information which actually changes. Different states of the body-mind exist in different moments. Not only is there no thing which changes, something of the third logical type cannot change either.

As pure subjectivity, phenomenal consciousness identifies with one moment after another. However, that which identifies with one moment after another does not change, any more than the light in the projector changes. Just as the movie is, at each moment, the projection of a different frame, on the same screen illuminated by the same light, subjective reality is, at each moment, a different quantum mechanical frame of reference, in the experience of the same phenomenal consciousness. It is only *in* the experience of the mental life of the observer *by* the third logical type that observations are made, and there is a subjective transtemporal reality. Thus it is only in the juxtaposition of the phenomenal consciousness with the access consciousness, the subjective with the objective, experiencing with awareness, that this occurs.

In each conscious observer, what is experienced is the sensorium, the 'output' of the neuro-endocrinal system. The overall process that produces the sensorium is access consciousness: the sum of all the mental processes of information that give rise to the contents of awareness. It is in the forms of access consciousness that all the observations of the physical environment are formulated, as too are all observations of internal processes, the reporting of 'machine configuration' in Everett's formulation. This is the interface between experiencer and experienced. This is the true divide in Cartesian dualism. This is also the interface at which the effective physical environment is defined, as shown in *The World Hologram* (Soltau, 2010). It is only at the experiential level of definition, at the end of the von Neumann chain, that there is the definition of a specific, discrete, determinate, physical reality. It is also only at this level of definition that there is a genuine transtemporal reality, because it is only at this level that the experiencer accesses moment after moment. This is, nonetheless, the experience of the physical world: the experience of access consciousness in the sensorium is the output of the final measuring instrument, the body-mind.

As each observation is made, the correlations record changes, and the effective physical environment, the quantum mechanical frame of reference, changes, as does the concomitant linear dynamics. Thus, from the point of view of the observer, subjectively, on the inside view of the changing quantum mechanical frame of reference of the observer, there is a sequence of such moments. Quantum time is effected. It is effectively a four-dimensional, space-time, matter and energy movie, being a sequence of frames: quantum mechanical frames of reference. The duration of each moment is the specious present. This is the enactment of the standard formulation, from the point of view of the observer, defined as Everett's functional identity.

The linear dynamics is the dynamics of objective physical reality, of the first logical type, and the collapse dynamics is the transtemporal subjective reality, the change to the linear dynamics, of the second logical type. The exercise of the collapse dynamics can only take place from the point of view of the third logical type. The transtemporal observer can only be a phenomenon encompassing all three. For there to be an observer there must be a body-mind to instantiate the observation, of the first logical type. The making of the observation, the transition from the state of not having made it to the state of having made it, can only be effected by something of the third logical type. The making of observations gives rise to the ongoing transition from moment to moment, the enactment of quantum time, of the second logical type. Given such an observer, there is a full and complete explanation of the exercise of the collapse dynamics, and the appearance of the passage of time to conscious observers.

It is increasingly understood that time only happens subjectively. As Davies states: "... it appears that the flow of time is subjective, not objective." (2002). As he continues:

... I and others argue that it is some sort of illusion. ... This illusion cries out for explanation, and that explanation is to be sought in psychology, neurophysiology, and maybe linguistics or culture. (2002)

On the view presented here, the flow of time is indeed a purely subjective process, but it is the very opposite of illusion. The subjective passage of time is the only passage of time, the changing of the field of observation, sweeping along the time dimension of space-time, in the static relativistic block universe moment. Likewise, the subjective making of observations is the only change to the quantum state possible in a static universe. As Davies goes on to say:

A second possibility is that our perception of the flow of time is linked in some way to quantum mechanics. It was appreciated from the earliest days of the formulation of quantum mechanics that time enters into the theory in a unique manner, quite unlike space. The special role of time is one reason it is proving so difficult to merge quantum mechanics with general relativity. (2002)

On the view presented here, while linear time is very much like space, quantum time is indeed quite unlike it. The collapse dynamics is not a space-time phenomenon, but a phenomenon intrinsically meta to the space-time block universe moments in which the functional identity of the observer is sequentially defined. Objectively, the flow of time is not just illusory, there is no such thing. It is a purely subjective phenomenon, meaning a phenomenon of the third logical type. The objective view is equivalent to the view of a character in a frame of a movie. From this perspective, the universe is static: the operational nature of the system is invisible. However, the conscious experience of an observer is the experience of phenomenal consciousness encountering moment after moment: in effect, passing from moment to moment. This may sound unscientific, but conscious observers do experience change, and the passage of time. Evidently, the passage of time is purely subjective. However, this does not mean it is something happening in a brain. It means that the phenomenon we consider to be pure subjectivity, what which experientially passes from moment to moment, as phenomenal consciousness clearly does, can only be of the third logical type.

11 Verification

The objective physical reality as defined by quantum mechanics, and logically categorised in the quantum concept of time, is an array of all possible moments, all possible quantum mechanical frames of reference. Only something of the third logical type can access moment after moment in sequence. Thus this concept can be verified by experiment, one that can be subjectively performed by a conscious observer with language at any time. The experiment reveals nothing new, it is the exercise of a very well-known phenomenon. Nonetheless, it could be considered conclusive, given the context described here.

To carry out the experiment, you simply answer for yourself such questions as:

- Am I passing from moment to moment?
- Am I experiencing the passage of time?
- Am I changing?
- Do I change?

If none of these is the case, you are a solely a momentary physical entity in a block universe, a permanent component of a specific physical moment. There is no question that is inevitably the case with respect to the body-mind: the physical state of the observer and the consequent logical state of the mental life, the access consciousness. Additionally, however, if any of these is the case, your phenomenal consciousness, the subjectivity, is evidence of the third logical type. It is an emergent property of the system as a whole. Given a static physical universe, there is no alternative explanation. As Deutsch specifically explains (1997, pp. 258-287), *nothing* physical can pass from moment to moment: everything physical is part of a moment.

Physical iteration of moments is not possible. It requires the point of reference called 'now' to pass from moment to moment, but as Deutsch states emphatically: "... 'now' *does not move through time.*" (1997, p. 262; his italics). Physical explanations do not work. However, we have evidence only of the appearance of collapse and the passage from moment to moment, *subjective* transtemporal reality. Moreover, Everett's formulation explains the logical core of this process of observation. The process of observation is, itself, a collapse dynamics: the record of observations changes, and since this is a change to the correlations established with the environment, this changes the quantum mechanical frame of reference. Thus any more complex explanation is redundant, and can be dismissed with Ockham's razor. There is no need to postulate physical collapse; there is the appearance of collapse inherent in the linear dynamics.

12 Everything and Nothing

This is not to say that phenomenal consciousness is an emergent property of the physical cosmos, which seems clearly an absurd idea. It is, however, insufficiently all-inclusive. For all its vastness, the cosmos we know is only an infinitesimal aspect of the no-collapse universe. The no-collapse universe is, by definition, all possible descriptions of a physical world: in the absence of collapse, all possible variations of the physical world must exist.

Somewhat bizarrely, the net sum of the whole of a physical universe is literally and physically nothing, since the big bang produces universes which have a zero net balance of matter and energy. As Hawking states, the:

... negative gravitational energy exactly cancels the positive energy represented by the matter (1988, p. 5).

Thus each universe sums to nothing, and therefore the system as a whole, the sum of all possible universes, sums to nothing. Standish establishes the same conclusion, but working from the perspective of information. Given that the universe is the sum of all possible quantum mechanical descriptions, he concludes:

The collection of all possible descriptions has zero complexity, or information content. This is a consequence of algorithmic information theory, the fundamental theory of computer science. There is a mathematical equivalence between the Everything, as represented by this collection of all possible descriptions and Nothing, a state of no information. (2006, p. 5)

Thus, as he states: “Something is the “inside view” of Nothing.” (p. 5).

If the unitary system truly encompasses all possibilities, it not only 'has zero complexity, or information content', it is perfectly symmetrical: for every structure or arrangement, the symmetrical counterpart must also exist. If an emergent property of the symmetrical totality, the Everything that is the broken symmetry of Nothing, accesses the functional identity of an observer, in moment after moment, then 'this', the real changing world, the transtemporal physical reality experienced by a conscious observer, is what it would be like: the experiencing of the successive states of access consciousness of an observer by phenomenal consciousness. Given that this is the subjective experience of every conscious observer, it would seem that the logical obverse of Deutsch's statement is literally true: “*Nothing* can move from one moment to another.” (1997, p. 263), and does.

13 Conclusion

The enactment of the collapse dynamics is here understood as an emergent property of the unitary no-collapse universe / multiverse system as a whole. To invoke a property of this nature to explain a problem in physics is to break a number of fundamental rules of the scientific paradigm. However, on a functional systems analysis of the dynamical structure of the unitary system, this appears to be the obvious conclusion. Quantum mechanics quite clearly defines not only a static array of static block universe moments in the quantum concept of time, each one structured by the linear dynamics defined by the quantum state. It also clearly defines the mathematical form of the logical transition from moment to moment, the collapse dynamics. All that is missing is a context in which these dynamics can be enacted. Perhaps, after the better part of a hundred years in which a solution cannot be found within the bounds of the existing paradigm, it is time for some 'extraordinary science' in Kuhn's terms (1962).

On the view presented here, in the collapse dynamics of quantum mechanics, we have stumbled on evidence of the nature of the unitary universe / multiverse system as an operational whole. The physical world is the content of that system, and the transtemporal is to the physical world as the operational activity of a computer is to the addresses in memory where the information defining the frames of a movie is stored in a sequential array. This is not to suggest that the universe is simply a giant computer, only that the dynamics of the unitary system is logically explicable in these computational terms, and thus exercises a process of this nature.

The linear dynamics is the time evolution of the state of the matter and energy of the universe, along the linear time dimension of space-time. However, we know from relativity that the past, and even the future, exist in this linear dimension in the same way as the North and the South in

space. Thus this system is objectively static. This is a block universe. In the quantum concept of time, objective physical reality is an array of such block universes, each one a physical moment, instant or snapshot. Ellis derives the same kind of logical structure from the perspective of cosmology. As he states, of the changing of the four-dimensional space-time universe:

This may be difficult to implement in physical theory, but it is actually the way things work; present theoretical physics understanding simply does not adequately represent it. (2008, p. 6)

As Barbour (1999), Deutsch (1997) and Woodward (1996) demonstrate, every possible space-time configuration of matter and energy exists timelessly, 'already'. Exercise of the collapse dynamics would bring the progression to life, but no coherent concept of the physical enactment of collapse can, it seems, be produced. Thus, according to physics, there is a static array of static physical block universe moments, a sequence of quantum mechanical frames of reference. This is of the logical form of a movie 'in the can'. If these frames of reference are iterated, the system is operational. Naturally, this requires something of the logical type of an iterator. A frame is of the first logical type, a member of the set of frames that makes up a sequence, of a second logical type. Iteration is of a third logical type, being an operation applicable to all sequences of frames.

Thus, we have a choice. Iteration of the physical moments would require an emergent property of the system as a whole, a third logical type. The alternative is a paradox: an objectively static physical system which is subjectively, mysteriously, transtemporal. Physics as it is currently defined can give no definitive answer. Smart speaks for many when he states:

Talk of the flow of time or the advance of consciousness is a dangerous metaphor which must not be taken literally. (1980)

However, it must surely give pause for thought that quantum theory defines precisely the dynamics of a subjective transtemporal physical reality, but nothing actually happens. Especially when this is so clearly what each conscious observer experiences. The nature of phenomenal consciousness fits the role with precision. Experientially, there is the ongoing appearance of collapse, a genuine transtemporal physical reality, with the transition from moment to moment. This is experienced by phenomenal consciousness, which has no physical explanation. However, as Chalmers concludes, it must necessarily be a fundamental feature of the universe "... alongside mass energy and space-time" (1995). In other words, an emergent property of the system as a whole. As such it is of the third logical type. Identified with the body-mind of an observer, the linear dynamics progresses, and with the making of each observation, subjectively, there is a collapse to specificity. Everett's dynamical system of subjective transtemporal physical reality is effected, and the no-collapse universe is fully operational as a transtemporal system. The time evolution of this reality follows the standard formulation: time passes in the life of the observer, interspersed with the making of observations.

Given phenomenal consciousness of the third logical type, Weyl's classic statement is straightforwardly correct:

The world simply is, it does not happen. Only to the gaze of my consciousness, crawling up the life-line of my body, does the world fleetingly come to life. (1949, p. 116)

Subjectively, phenomenal consciousness, identified with the access consciousness of an observer, passing along the linear time dimension of space-time, up the life-line of the body, experiences the passage of time in physical reality. The world comes to life. The enactment of the passage of time exists in no other way.

While the inside view of the quantum mechanical frame of reference follows the rules of the physical in the linear dynamics, it literally transcends them in the collapse dynamics, as one version of the linear dynamics is replaced by another. As Vaidman states:

... if there is nothing in physics except the wave-function of the Universe, evolving according to the Schrödinger equation, then there are questions answering which requires help by other sciences. (2008)

As Webb quips in the *New Scientist*: “Quantum physics might be quantum - but as far as we can tell it isn't physics.” (2010).

Everett states: “ ... [our theory] can be said to form a *metatheory* for the standard theory”, a ... new, more general and complete formulation, from which the conventional interpretation can be deduced. (1957, p. 454; his italics)

Although induced by the linear dynamics, the appearance of collapse he demonstrates is meta to the linear dynamics, and any concept of physical collapse. It is a change of 'position' in the array of all possible quantum mechanical frames of reference. As shown, the enactment of such a change is necessarily of the third logical type. It is to the sequence of functional frames of reference as the iterator is to the frames of the movie. The enactment of the collapse dynamics is inherently a process meta to the physics of the universe as currently defined. On the view presented here, this is what has been discovered in quantum theory, but has nonetheless remained incomprehensible. The collapse dynamics is an operational dynamics of the unitary system as a whole, as is the passage of time along the linear time dimension of space-time. The result is an objectively static, no-collapse universe in which, subjectively, time passes, and observations are made.

Appendix 1

Transtemporal Reality as an Information Process

Here the logical form of the standard formulation operational for the functional identity of the observer as defined by Everett is presented, somewhat tongue in cheek, as a computer program in C language. This is not to suggest that the no-collapse universe is merely a quantum computation, but just to illustrate the simple logical form of the information process operational within this context. As Whitworth notes “... all known physics seems to be computable.” (2007, p. 7), but this does not account for the physical context in which reality takes place. The key point here is simply that such a computation can only be effected by the unitary system as an operational whole.

```

void transtemporal_reality () {
    /* Initialisation */
    Boolean          new_observation = true;
    Observation      observation = LIGHT;
    Functional_Identity  observer = 1;
    World           world_hologram = NO_OBSERVATIONS;
    Correlations_Record  observables[];
    Quantum_State      $\psi$ ;
    Elapsed_Time      t = 0;
    int               c = 0;

    while (observer != 0) {
        /* Process 1 – Quantum time – Change of quantum mechanical frame of reference */
        if ( new_observation ) {
            world_hologram = world_hologram + observation;
            display (world_hologram);
            observer = observer + observation;
            observables[c++] = observation;
             $\psi$  = quantum_state_defined_by (observables)
            new_observation = false;
        }
        /* Process 2 – Space-time time – Change of inertial frame of reference */
        else {
            t = t + PLANCK_TIME
            new_observation = compute_neural_state ( $\psi$ , t);
            if ( new_observation)
                observation = get_sensorium_contents();
                break;
            }
        }
    }
}

```

If variables ψ , observation, and observables[], and function get_sensorium_contents() were instantiated in suitably coherent memory of a quantum computer, such a program would produce the subjective realities of all possible functional identities of an observer, in the form of Everett's branching tree of memory configurations.

It should be noted that objectively, in a no-collapse universe, ψ is properly a pointer, or reference, to a pre-existing quantum state, and that the implementation of the statement

$$\text{new_observation} = \text{compute_neural_state} (\psi, t);$$

is simply reading a specific attribute of that quantum state, as from a lookup table. This works very nicely given that each observable is a correlation with a specific quantum state of the environment, the correlations record being the simultaneity of all such correlations: a set of commuting operators.

The definition of the state of the memory is simplified by assuming that machine configuration is only recorded where formulated as an observation in the sensorium. As explained in *The World Hologram* (Soltau, 2010), this is the natural assumption in the case of human observers.

Appendix 2

Free-Will

As a rule, one can see no mechanism for free will, since any part of the physical world is a permanent static aspect of a permanent static frame of reference. Just as every frame of reference is pre-defined, so too is every possible sequence of frames of reference. It seems quite impossible that any aspect of physical reality could intervene to change the pre-defined sequence, which would be overriding the probabilistic definition of the physical world. It seems as if any subjective reality can only possibly run on the rails that the objective physical world defines. In this case, even though a quantum reality is a branching sequence, like a multiple choice storybook, it is difficult to see how free-will could possibly apply.

Something of the third logical type, too, can only follow along the rails of physical reality. Thus it can only follow along the linear dynamics as it unfolds in the time dimension of space-time; and at the point of collapse, there is no option but to adopt every possible new identification. Within the context of the linear dynamics, however, it is theoretically free to favour one version of subjective reality over another, as all possible versions develop and realise in that linear dynamics. One could argue that this is nonsensical, since something of the third logical type must be perfectly symmetrical. On the other hand, one might consider that it is precisely in the juxtaposition of the subjective and the objective that there is a kind of experiential breaking of symmetry.

If there is to be such a thing as free will, one can conjecture that the third logical type is in the position to influence which transition is likely to be experienced, by favouring one version of the observation being formulated in the neural network, during the specious present. Subjectively, it does seem that one can sway the way one's thoughts go, and what comes to mind, to a certain extent. Certainly one seems to be able to scratch an ear or order pizza at will. If this is the case, then this seems a likely rationale for such a phenomenon. This would explain the possibility of selecting one probabilistic outcome over another, thus altering the subjective path through the pre-defined probabilistic branching sequence of observations. The equivalent in a computer is the operational level where selections are made that switch, for instance, which branch of logic a program follows, or alter which version of the sequence of frames of a movie gets accessed. Free-will can only exist if there is something of this third logical type to select one version of the branching logic over another. To change the logical form of the record of observations, and thus the subjective reality, is, effectively, to change the linear dynamics of the domain. This is the exercise of free-will.

As Woodward explains, neither free will nor the passage of time can exist in the physical:

... even when the principle of relativity is construed narrowly, as in special relativity theory (SRT) so that its GRT generalization and Mach's principle are excluded, one is led from the absence of absolute simultaneity to the view that, in Weyl's [1949] words, "Reality simply *is*, it does not *happen*." That is, the past, present, and future all objectively exist. It is all fixed. There is no "free will". ... Refuge from this stark and unappealing reality is easily found in quantum mechanics as it is almost universally interpreted: reality is probabilistic, uncertain, and only progressively actualized by "measurements" as time "goes on". Mach's principle denies us this refuge; if inertia is relative and gravitationally induced, quantum mechanics notwithstanding, it is difficult to avoid killing time. (1996, p. 2)

However, an iterator of the third logical type realises the quantum mechanical progression in which time 'goes on', despite the complete absence of the passage of time in the physical. Thus Mach's principle, and relativity, can be upheld, and yet the passage of time can exist subjectively, as can the making of observations: the iteration of a sequence of quantum mechanical frames of reference of the functional identity in Everett's formulation. Similarly, free-will seems entirely possible.

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