

# The Quantum-Mechanical Frame of Reference

## Part 2: Logical Type in Time Evolution

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Abstract: In Part 1, the solution to the measurement problem is shown to be logical type. The world encountered is a class-of-worlds-as-a-world, a domain in which the collapse dynamics operates in a clearly defined manner. A further level of logical type resolves the paradoxes of special relativity, and reveals the full definition of transtemporal reality.

Assuming the block universe, the passage of time is a total paradox. Equally, the Andromeda paradox means presentism cannot be correct. The solution is that both paradigms are true, at different levels of logical type. This is simply the case given a moving frame of reference, but this is necessarily contextual to physics as currently defined. Such a phenomenon can only be a fundamental property of the unitary system: meta to the layout of the world, a third-logical-type phenomenon.

However unwelcome, this produces a system that implements a dynamics combining both interpretations of time. Effectively, *on the inside view* of the moving frame of reference, within the context of the block universe of eternalism, presentism is correct: only what exists now is real.

The two great paradoxes of relativity are also resolved. The Now, the present moment that cannot exist in physics, is simply the view of the world on the inside view of this moving frame of reference. The experience of the passage of time is the immanent effect. Phenomena impossible in the objective physical reality occur naturally.

The actual operation of the quantum-mechanical dynamics is also explained. The quantum concept of time is the static layout of all possible versions of the physical world. The collapse dynamics is the enactment of a sequence of versions, as the moving frame of reference passes from one to another. Everett's formulation is the physics of exactly this process.

This also provides a complete and operational definition of the transtemporal individual: the sequence of states of the world hologram, experienced by the consciousness that supervenes on the moving frame of reference. These are the missing components in the definition of the protagonist of the dynamics of the new physics. The world of this individual is ipso facto the world superposition described in Part 1.

# 1 Present & Eternal

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. (Deutsch, 1997, p. 268)

In Einstein's physics, there is no passage of time, no unidirectional flow from the fixed past and toward the uncertain future. The temporal component of space-time is as static as its spatial components; physical time is as still as physical space. It is all laid out, the whole spread of events, in the tenseless four-dimensional space-time manifold. (Goldstein, 2005, p. 254)

This is eternalism. As Einstein famously stated: "... the distinction between the past, present and future is only a stubbornly persistent illusion" (Dyson, 1979, p. 193). However, as Lucas comments on the block universe:

It fails to account for the passage of time, the pre-eminence of the present, the directedness of time and the difference between the future and the past. (1989, p. 8)

That is why presentism, meaning the past and the future do not exist, only the present moment, has been considered; but this falls prey to the Andromeda paradox. Essentially, it does not, cannot, work because it is directly contradicted by relativity. This tells us that simply changing the direction in which one is moving alters whether distant events happened some time ago, or have yet to happen. This means paradox because it would mean the individual who changes direction would be radically changing the physical state of affairs in the Andromeda galaxy, which physics certainly does not allow.

In the block universe there is no such problem. The individual is simply changing what is true for that individual, in that particular, relative, frame of reference. Naturally, this means that objectively both states of affairs are true 'all the time', i.e. they simply exist. All of existence is 'there', 'already'. This is the essence of the Rietdijk-Putnam-Penrose argument for the block universe, addressed in depth by Savitt (2017). But the block universe has the paradox of the passage of time, the absence of the pre-eminent present, and so on. It seems this cannot be right either.

The solution is that both paradigms are true. They are attributes of the same system that operate at different levels of logical type. All that is required is a moving frame of reference. This is a phenomenon that is to the moments in space-time as the film gate of the movie projector is to the frames of the movie film: the frame of reference is constantly moved from one moment to the next, along the world-line. This explains the *appearance* of the passage of time, *within* the context of the static block universe. Thus, effectively, on the inside view of this frame of reference, the world is a

changing 3D world, as experienced by all individuals. In this case both views are true because presentism is simply the inside view of the objective reality of eternalism.

## 2 The Third Logical Type

Clearly, given this moving frame of reference, both descriptions of time are correct. The problem, however, is that a phenomenon of this nature is necessarily contextual to physical reality, and physics does not admit such phenomena. Logical type (Russell, 1908) serves ideally to resolve the conundrum. The frames of a movie film are of a first, primitive, logical type, compared to the movie itself, the set of all the frames, which is of a second logical type. The movie projector is of a third logical type, operational on the set of all possible movies: the set of all possible sets of frames. It is an iterator mechanism that applies to all sequences of frames: it is necessarily contextual to any given sequence.

Here the presence of the same three logical types, as fundamental operational levels of physical reality, is taken to be an unavoidable conclusion. The moments and events along the world-line of an observer are of the first logical type; the world-line itself, the sequence of moments, is of the second. For such a sequence to be encountered, there is necessarily a third-logical-type phenomenon in operation. The evidence is the appearance of the passage of time. It is of the logical type of a train journey: it appears that the countryside passes, but of course this is simply the effect of the movement of the subjective frame of reference. The field that is apparently passing by is static. It is not going anywhere. The appearance of the passage of time in the static relativistic universe is of the same ilk: identical in logical type.

McTaggart (1908) famously held that time could not be real because two correct descriptions of time, the A series and the B series, were mutually contradictory. The solution, however, is simply that both are indeed real, at different levels of logical type. The A series is the succession of moments encountered as the moving frame of reference passes through space-time. It is different entirely to that along which it moves, the static B series of moments in sequence along the four-dimensional world line.

As with the resolution of the paradoxes of quantum theory described in Part 1, the problem is simply that the vital discriminations of logical type have not been evident. Given a moving frame of reference, it is clear both descriptions of time are correct, although they seem mutually contradictory. The reality of presentism is a moment, a first-logical-type phenomenon. The reality of eternalism is the existence of the whole sequence, a second-logical-type phenomenon. The iteration of moments along the world-line is a the third-logical-type phenomenon.

As described in the next section, this automatically explains the great paradox of the present moment, the Now as Einstein (Carnap, 1963, p. 37) dubbed it. As

described in Section 5 this also explains the appearance of the enactment of the quantum-mechanical dynamics, and thus the appearance of change of the quantum state, exactly as described by Everett (1957).

### 3 The Now

The Now was a serious worry to Einstein. As he stated, this distinction: "... does not and cannot occur within physics." (Carnap, 1963, p. 37). As Mermin explains:

The issue for Einstein was not the famous revelation of relativity that whether or not two events in two different places happen at the same time can depend on your frame of reference. It was simply that physics seems to offer no way to identify the Now even at a single event in a single place, although a local present moment — Now — is evident to each and every one of us as undeniably real. How can there be no place in physics for something as obvious as that?

My Now — my current state of affairs — is a special event for me while it is happening. I can tell my Now from earlier events, which I only remember, and from later events which I can only anticipate or imagine. The status of an event as my Now is transitory: it becomes a memory as subsequent Nows emerge.

Yet clear, evident and banal as this is to us all, there is no Now in the usual physical description of space and time. Physicists represent all the events experienced by a single person as a line in four-dimensional space-time, called that person's 'world-line'. There is nothing about any point on my world-line that singles it out as my Now. (2014)

The moving frame of reference automatically resolves this problem. Indeed, it retrodicts exactly these phenomena. The Now is simply the inside view of the moving frame of reference.

Reality is of identical logical type to the movie in operation. Each event exists at a particular point in space-time along the world-line of the observer, a specific moment. Objectively, none of these moments has any special status; they all simply exist laid out in space-time. Each moment, however, becomes the Now as the moving frame of reference arrives at this point in space-time. The Now *is* the moving frame of reference, and each moment becomes the Now as the moving frame of reference coincides with this moment, as it passes along the world-line. Thus the status of any given event is transitory. Momentarily, it becomes a special event as the moving Now coincides with its coordinates in space-time, along the world-line.

The problem of the Now was worrying because it meant that relativity is an incomplete description of the world. But it *is* a full and complete description of the *physical* world. The moving Now is a completely different type of phenomenon, a

property of the universe, a third-logical-type phenomenon. It lies outside of the domain of the science of physics as currently formulated because the ontology is based exclusively on what can be explained in terms of physical reality. In other words, an extra ontologically fundamental category is required in order to complete the science and make sense of the new physics.

## 4 The C Word

As is directly evident to perception, the experiencing consciousness supervenes on the moving frame of reference. Here these are taken to be simply the subjective and objective attributes of the same fundamental property of the universe: the third-logical-type, frame-gate / train-window phenomenon. This was implicitly proposed by Weyl's dictum, as shown below. As demonstrated in the next section, the same principle is inherent in quantum mechanics in the light of Everett's formulation.

If special relativity is taken at face value, there is no question of the static nature of the universe. 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; emphasis in original)

Weyl, however, states that consciousness does move in exactly this way:

The objective world simply is, it does not happen. Only to the gaze of my consciousness, crawling upward along the life line of my body, does a section of this world come to life as a fleeting image in space which continuously changes in time. (1949, p. 116)

This inherently assumes a phenomenon contextual to the sequence of moments and events: the frame of reference of consciousness passes through space-time, crawling along the world-line of the body, at lightspeed. Thus moments are experienced in sequence. Subjectively, in effect, the evolution of proper time is enacted.

Such a concept is directly in contravention to the current worldview. Deutsch's statement begins by specifically excluding consciousness as the explanation:

It is often said that ... our consciousness is sweeping forwards through the moments. But our consciousness does not, and could not, do that. ...  
*Nothing* can move ... (ibid)

If consciousness is just a property of the brain, a view widely held across scientific disciplines, a property of the physical, this is inevitably correct. It is this view, however, that is specifically repudiated by Chalmers' analysis. As he states:

... experience must be taken as something over and above the physical properties of the world. (1996, p. 331).

It is essential to note that the word consciousness tends to be used indiscriminately for two entirely different classes of phenomenon, as both Block (1995) and Chalmers (ibid) explain. The first, which Chalmers calls psychological consciousness, encompasses cognitive abilities and functions. Block calls this access consciousness, meaning the accessing of information in the neural system in the generating of the sensorium, the contents of awareness: the sensory information experienced and added to the record of observations in memory. All this is well understood. The second, called phenomenal consciousness by both, refers exclusively to the experiencing awareness itself, the sentience. To date this has been a complete mystery.

There is no trace of the experiencing consciousness in the brain, and apparently no possible explanation of the phenomenon. As stated by Fodor:

Nobody has the slightest idea how anything material could be conscious.  
So much for our philosophy of consciousness. (1992)

As demonstrated in logical analysis by Chalmers, this phenomenon of conscious experiencing can only be a fundamental property of the universe. As he states, it is necessarily:

... a fundamental feature of the world, alongside mass, charge, and space-time. (1995, p. 216)

It is thus in the correct logical position to enact the moving of the frame of reference of experience, from moment to moment in space-time, just as Weyl states. Lockwood puts forward an ideal metaphor for the operation of this consciousness, quoting first Eddington and then Jeans:

... events do not happen; they are just there and we come across them  
... In this case our consciousness is like that of a fly caught in a dusting-mop which is being drawn over the surface of the picture; the whole picture is there, but the fly can only experience the one instant of time with which it is in immediate contact (2005, p. 54)

Just as the frame of reference moves across the canvas, the frame of reference of the experiencing consciousness passes along the world-line of the observer.

As Davies states: "... it appears that the flow of time is subjective, not objective." (2002). Taken at face value, this means it is *only* the subjective frame of reference, i.e. the frame of reference of the phenomenal consciousness, that passes from moment to moment, as stated by Weyl. Naturally, *within* this frame of reference, time passes and events happen. Thus the dynamics of physics is effectively enacted, on the inside view.

This is a purely subjective phenomenon, but no mystical miasma need surround phenomenal consciousness and the presence of awareness. Fundamental, like mass, charge and space-time, this is simply the universe in dynamic operation. This is the resolution of the longstanding puzzle of why no trace of the experiencing consciousness can be found in the brain. It is not there. It is an attribute of the unitary

system as a whole, of different logical type to anything in physical reality. Only such a third-logical-type phenomenon can produce these effects. The brain produces that which *gets* experienced, the perceptual reality, the product of access consciousness, but the conscious experiencing itself is an utterly different *type* of phenomenon.

Weyl and Deutsch are both entirely correct, at different levels of logical type. In the physical world, nothing can move from one moment to another any more than an element of the picture in a frame of a movie can move from one frame to another. The frame of reference of the experiencing consciousness, however, cannot *not* move from moment to moment, as described in the Appendix: to experience the reality of the wave function is to experience the changing it defines. In consequence, this third-logical-type phenomenon constantly iterates the moments along the worldline of the individual.

## 5 The Quantum Jump

Given this moving frame of reference, the meaning of the paradoxical quantum jump is transparent. The collapse dynamics is the change of the quantum state of the observed environment, but as Barbour states: “The quantum universe just is. It is static.” (1999, p. 256). As Deutsch explains (1997, ch. 11) every possible physical state of the world exists 'already', each one a snapshot of one version of the physical world. Nothing moves and nothing changes. He refers to this as the quantum concept of time.<sup>1</sup> As he states, the essence is that “... other times are just special cases of other universes” (1997, p. 278), where 'universes' are snapshots: complete physical worlds.

The whole system is a static layout of all possible versions of the physical world. This is clearly evident once relativity and quantum theory are combined in the Wheeler-DeWitt equation. As stated by Barbour, this represents:

... 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, abstract)

In other words, all possible snapshots exist 'already'; and there is nothing that changes; and there is no possibility of movement from one snapshot, one instant, to another. Furthermore, there is no context in which these snapshots are arrayed in sequence, and no explanation of how one particular one might follow another in the experience of

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1 “This understanding first emerged from early research on quantum gravity in the 1960s, in particular from the work of Bryce DeWitt, but to the best of my knowledge it was not stated in general terms until 1983, by Don Page and William Wothers.” (Deutsch, 1997, p. 278).

reality, as is constantly witnessed as change of the world. Since the quantum jump is the change of the quantum state, it seems an impossibility.

Everett's formulation establishes the basis on which to resolve all these problems by showing how physical reality actually happens, effectively. On the making of each observation, a new correlation is established with the physical environment. In the quantum concept of time this means that the frame of reference becomes correlated with a different snapshot. Thus the making of each observation changes the effective physical frame of reference of the individual: the individual is now correlated with a different snapshot, a version of the world in which the change to the environment that was observed has determinately happened. Thus in effect, on the inside view, there is the transition from one snapshot to the next. This is the quantum jump.

Naturally there is no change to the physical world in all this, as there cannot possibly be in a static universe. The linear dynamics defines the static four-dimensional layout of possible events. The wave function cannot change, it is a mathematical formula. The collapse dynamics is the *effective* change of the formula, in the transition to a different physical frame of reference. As Everett stresses, it is the individual that changes:

*... it is not so much the system which is affected by an observation as the observer, who becomes correlated to the system. (1973, p. 116; emphasis in original)*

There is only the appearance of collapse, as he clearly states: "... the probabilistic assertions of Process 1 *appear* to be valid to the observer" (1957, p. 459; emphasis in original). In other words, this phenomenon occurs only on the inside view, in experience. As Everett states:

It is found that experiences of the observer  $\frac{1}{4}$  are in full accord with predictions of the conventional "external observer" formulation of quantum mechanics, based on Process 1. (1957, p. 455)

Still, an explanation is required of what exactly is changing in order to bring about this movement of the frame of reference. As with the passage of time, a phenomenon contextual to the snapshots is required, even to give the appearance of collapse and events happening; and this can only be a property of the unitary system. In the static universe, the experience of events taking place can only be the experience of the transition of this frame of reference from one snapshot to another.

Effectively, this process produces the growing block universe of 'possibilism': the past is real and defined, and its boundary, the present moment, is constantly moving into the future, which is merely possibilities. The world of the inside view defined by Everett grows in exactly this manner. As shown in Part 1, the record of observations defines the sole determinacy of the effective physical environment of the individual. This is the set of commuting operators that define the relative state of the system with which the individual is correlated. The past and the present are actual in this frame of

reference, while the future is still just possibilities. The difference between past and future is crystal clear.

This means that all of the three classic metaphysics of time are defined by the physics, when taken at face value. All three potential logical arrangements are simply different attributes of the one system, the known universe of relativity and quantum theory.

## 6 Solid State

In terms of logical type the system is isomorphic to a solid-state computer system where a sequence of addresses in memory is accessed by altering the memory-address pointer. In the quantum concept of time, each instant is the view of a specific snapshot, a specific point in Hilbert space. The alteration of the 'pointer' defined by the record of observations, i.e. correlations, results in a different point in Hilbert space being addressed, one at which a different quantum state of the effective physical environment is defined, i.e. a different snapshot: the events of a specific instant are experienced as happening. The analogy clarifies the logical types ideally. The address pointer is of the logical type of the class of all addresses, and the system of which the movement of the pointer is a property is of the logical type of the class of all pointers.

In a computer system, the dereferencing operation on the pointer returns the value at the memory address pointed to. Given the experience of the Now is the state of the inside view in each snapshot, the experiencing of the snapshot may be considered in logical terms as the experience of the dereferencing operation that returns the state of the inside view defined by a specific snapshot: the view of a specific instant, at a specific point in Hilbert space.

The analogy for time-evolution in relativity is similar. Each moment is the view of a specific point in space-time, and movement of the 'pointer' defined by the inertial frame of reference results in movement of the view along the world-line. Here, however, a better metaphor is an analog computer process where the function is operated in a smooth linear manner rather than incrementally.

Just as with the case in the appearance of the passage of time, there is only the appearance of change of the world, brought about as the succession of versions of the inside view is encountered, in a sequence of snapshots in quantum time. On the outside view the whole thing is a complete paradox: the making of an observation is just the brain working, the access consciousness in action, which can hardly affect physical reality. On the inside view, however, on the making of each observation, the definition of the quantum-mechanical frame of reference is changed. Effectively, there is collapse, perceived by the subject of experience, the protagonist of the dynamics, as events happening.

More correctly, of course, the making of an observation is the *consequence* of the

movement of the frame of reference. The passage of the Now along the worldline of the individual subject effectively results in the next observation being formulated in the observer, and at the point in time where it is added to memory the Now passes to one or other of the possible snapshots defined, with probabilities defined by the Born rule. This is illustrated in the Appendix.

Von Neumann held that since the causal chain of observation terminates at consciousness, it must be consciousness that causes collapse. On the outside view this is deeply incongruous, but *effectively*, on the inside view, this is correct; but both types of consciousness are involved. The causal chain of observation terminates at the record of observations, the product of access consciousness, but nothing in this domain is involved in the collapse dynamics. It is as the frame of reference of phenomenal consciousness passes from one snapshot to the next that there is the appearance of collapse, subjectively registered as events happening. *In* the moving frame of reference, and in this context only, events happen, and one specific version of events becomes determinate recorded history.<sup>2</sup>

## 7 Identification

The missing piece of the puzzle of quantum mechanics is the nature of the protagonist of the dynamics. The origin of this entity reveals the simplicity of the system. As a system property of the universe, the frame of reference of the experiencing consciousness is not localised to a specific world. As stated by Bitbol, in and of itself: "... it is point-of-view-less, just as it is placeless and timeless." (1990, p. 8). It is quintessentially non-local, or perhaps better ubiquitous. Since it is present at all possible places and times, this would imply that it must necessarily embrace and include all possible frames of reference, all possible moments and events, all possible world holograms, all at once. Every possible phenomenal perspective is a specific point of view, and in principle it must have all possible points of view.

On the inside view, however, within the context of the frame of reference of a conscious observer, there is only the experience of that specific frame of reference. As Bitbol explains, referring to the experiencing consciousness as Mind, this is the result of identification:

Indeed, as soon as (abstract) Mind identifies itself with a point of view, it can but identify itself to a *particular* one. ... the point of view Mind adopts, when adopted, is not one among others; it is *the* point of view, self-referred to as *my* point of view. (ibid; emphasis in original)

Therefore, although Mind experiences all possible versions of the inside view, *on* the

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<sup>2</sup> Decoherence can be no help here as an explanation is still required of how the frame of reference moves from one point in time, in which it has not yet taken place, to the next, in which it has.

inside view of each possible version there is only that one point of view: in that context *my* point of view. Just as reflected light takes on the pattern of information defined by the objects it illuminates, the ubiquitous phenomenon of Mind becomes the conscious experiencing of the perceptual reality of the individual, the world hologram.

This is what gives the illusion that consciousness is a property of the neural system. Because the world hologram is formulated with respect to the familiar location behind the eyes 'in here', this point of view is identified as the location of consciousness. This, however, is simply the coordinate of the *origin* of the *perspective* with respect to which the world hologram is formulated. Consequently, the experience of this perspective naturally places the process of experiencing at this point; but there is nothing 'there'. This is simply the origin of the perspective of the display of the navigation system of the human system: the world hologram. As a result, when the world hologram is experienced, the point of view denoted as 'in here' is in this position: the *I is here*.

Thus identification with the world hologram by phenomenal consciousness gives rise to the conscious individual, the perceiving subject that is the protagonist of the quantum mechanical dynamics on the inside view. This is an emergent property of the unitary system, arising from the identification of phenomenal consciousness, universe consciousness, with the world hologram, the product of access consciousness.

The identification of the universal experiencing consciousness also provides a further explanation of why all possible instances of a specific inside view must effectively become one single instance. In this context there is no such thing as an identical copy of a specific inside view: identification with a specific inside view is identification with all the identical copies simultaneously. Thus, identified with this structure of information, present simultaneously in multiple versions of a quasi-classical world, the effective physical environment of this inside view is their superimposed sum.<sup>3</sup> As shown in Part 1 this is the world of QBism and the many-minds theories, determinate solely where observed. This is the many-worlds reality.

## 8 Transtemporal Identity

... in order to get probabilities out of the many-worlds theory, the first step is to provide an account of the transtemporal identity of observers.  
(Barrett, 2008)

In the light of these concepts a full and proper definition of the conscious transtemporal individual is straightforward. An observer, meaning the physical mechanism as defined by Everett, in humans the body-mind, cannot be transtemporal. As Deutsch (ibid) emphasises, *nothing* can pass from moment to moment. However,

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<sup>3</sup> In this scenario the concept of world superposition must apply to all 4 levels of a multiverse. in Tegmark's (2003) classification, including levels 1 and 2 where the identical inside views are at different locations in space-time.

the ongoing computation of the world hologram effectively produces a transtemporal entity. As Tegmark states:

... life is like a movie, and space-time is like the DVD ... there's nothing about the DVD itself that is changing in any way, even though there's all this drama unfolding in the movie. (Kuhn, R., 2015)

As he explains, the movie of life does not run. In effect, however, in the moving, third-logical-type frame of reference, it effectively does. On this view, literally in experience, time passes, and change is encountered; and with the making of each observation the world hologram is updated, resulting in the transition from one snapshot to the next.<sup>4</sup> This is the transtemporal reality of the individual on the inside view.

This individual is transtemporal because it exists identically the same from moment to moment, apart from changing by the addition of an observation. Moreover, it is *this* change, actually the time-evolution of the identity of the operational subject, that is experienced as events happening. As described in Part I, the individual on the inside view is the world hologram. The experience of events happening is simply the experience of the self-identity changing, with the concomitant effective changing of the world, as the frame of reference changes.

The world hologram is the the transtemporal identity, the entity for which the mechanics defined by Everett are effectively enacted. This gives rise to the effective enactment of the collapse dynamics of quantum mechanics, and thus, effectively, transtemporal physical reality.

This holographic field of information is the operational subject in this context. It is the assumption, albeit entirely natural, that the protagonist in quantum mechanics is the physical body-mind, that has led to the paradoxical dead ends because it is solely with respect to the world hologram that the dynamics of physics are effectively enacted: time actually passes and events actually happen.

There can be no such thing as a transtemporal identity of the observer as just a physical entity. The physical entity is stuck in time, as Deutsch (ibid) makes clear. The transtemporal identity of the individual is the world hologram experienced by phenomenal consciousness. This forms the operational subject, the protagonist in the quantum-mechanical dynamics in action. The explication of this entity requires all three fundamental ontological types. The body-mind, first-logical-type, produces the world hologram which, experienced by phenomenal consciousness, third-logical-type, gives rise to the second-logical-type phenomenon experienced as transtemporal reality.

This is the world hologram in action as an information process. This is the four-dimensional space-time, matter-and-energy movie of life in action. The determinacy of the effective physical environment, the many-worlds reality, is defined solely by this field of information. In this context probabilities are defined by the record of observations, the world hologram, as described in Part I. This is what accords different

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4 Here the array of snapshots defined in Hilbert space is logically akin to a universal DVD.

realities to different individuals even in the same place at the same time, like Schrödinger and his cat.

## 9 The Missing Subject

A basic tenet when researching the laws of objective physical reality is that subjectivity must be ruled out. However, as Mermin describes, our worldview does not fit the facts *because* the conscious individual, the perceiving subject, has been omitted from the science. As a result, the major, unrelated, longstanding problems with both quantum theory and relativity are dissolved when the subject is reinstated:

In *Nature and the Greeks*, Austrian physicist Erwin Schrödinger traced the removal of the subject from science back more than two millennia. Alongside the spectacular success of physical science, this exclusion of personal experience has given rise to some vexing and persistent puzzles and paradoxes.

Two such unrelated long-standing problems are both resolved by recognizing that the perceiving subject has as important a role to play in understanding the nature of physical science as does the perceived object.

The first problem is the notorious disagreement, confusion and murkiness that for almost a century has plagued the foundations of quantum mechanics, in spite of the theory's extraordinary usefulness and power. The second, less famous, problem has been with us at least as long: there seems to be nothing in physics that singles out 'the present moment'. Albert Einstein called this the problem of 'the Now'. Both problems are symptoms of the exclusion from physical science of the perceiving subject, and are solved by restoring what the ancient Greeks removed. (2014)

In the light of logical types as ontologically fundamental, it is clear why this is the case. The conscious individual, the perceiving subject, *embodies* the logical types missing from the current ontology of physics.

As described in Part 1, the world hologram defines the sole determinacy of the world encountered. This structure of information exists simultaneously in a great number of worlds, thus the effective physical environment is the class-of-worlds-as-a-world, a second-logical-type phenomenon. This is what has given rise to all the problems. In this kind of world Schrödinger's cat is quite naturally both alive and dead, and Wigner's friend is in a similar condition of indeterminacy. The significance of the subject is axiomatic. This explains the central puzzle of Everett's formulation: the record of observations is centrally important because it defines the class-of-worlds-as-a-world.

In relativity, the moving frame of reference resolves the great puzzles, but this has been similarly invisible. As Weyl states, the apparent passage of time is created as consciousness moves through space-time, giving rise to the Now in each subsequent moment; but consciousness is generally assumed to be a property of the physical system of the observer, and thus cannot possibly fulfil these roles. Once this sentience is understood as a property of the unitary system, a third-logical-type phenomenon, it is doubly obvious why the physics cannot be understood in the absence of the perceiving subject.

The sapience defines the personal world. This is Everett's relative state. The sentience brings it to life. As Weyl states: "... the consciousness in this function does not belong to the world." (1934, p. 1).

## 10 Conclusion

McTaggart's (1908) conclusion on the unreality of time is based on the incompatibility of two, different, versions of the description of time, both clearly equally valid. The solution is the same as for the two incompatible dynamics of quantum theory in the measurement problem described in Part 1. These are two very different attributes of the same system, of different logical types.

The B series is the static linear layout of the world-line in space-time, the static and tenseless domain of eternalism. The A series is the time of the Now, the moving frame of reference of the present moment, that which cannot exist in physics as Einstein lamented. Such a phenomenon is necessarily contextual to the objective reality on which physics is based. Given the experience of the passage of time, the Now is to the static moments in the B series, coordinate frames in space-time, as the frame-gate of the movie projector is to the frames of the movie film. Given the direct evidence of the experience of events happening, it is also in this logical position with respect to the snapshots of quantum time. To enable such functions it can only be a fundamental property of the universe.

The explanatory principle of logical types as ontological reveals how reality is structured, and how it actually works. It is a physical world, as is obvious, but the reality encountered by a conscious individual is a world superposition, a second-logical-type phenomenon. In this reality, the appearance of the time-evolution of the world, and the progression of events happening, are brought about only effectively, *within* the moving frame of reference, a property of the unitary system, of different logical type again. This explanatory principle provides the ontology of both eternalism and presentism; and in the unfolding reality of the individual on the inside view the world is a possibilism.

As is directly evident, the experiencing consciousness supervenes on the moving frame of reference. This phenomenal consciousness may be simply understood as the

subjective attribute of the moving frame of reference. Thus a progression of moments is experienced as it crawls through space-time, as Weyl (1949) declares. Each event along the world-line becomes the Now, momentarily, as the moving frame of reference arrives at this point in space-time. The movie of physical reality effectively comes to life. As observations are made, a progression of snapshots is experienced as events happening. Thus we have both an explanation of the experience of the passage of time, as Weyl describes, and the experience of the collapse of the wave function as described by Everett, all against the backdrop of the static physical universe. In experience, all the dynamics of physics are brought to life.

This perspective also enables a full operational definition of the transtemporal individual. The identity is the world hologram. This is the subject of the dynamics of reality. Experienced by consciousness, this becomes the transtemporal perceiving subject. This is the self-aware substructure of the system to use Tegmark's (1998, p. 23) phrase quoted in Part 1. It is quintessentially self-aware because it is the world hologram, the perceptual reality of awareness: it is that of which awareness is aware.

The perceiving subject is simply the product of access consciousness, sapience, experienced by phenomenal consciousness, sentience; but the key point is that these are phenomena operating at different levels of logical type. The conscious individual is the resulting emergent phenomenon. This is the operational protagonist in the observation dynamics, which operates exactly as described by Everett (1957). This also produces the effective passage of time as described by Weyl (1949).

As Kuhn, T. (1962) states, a new breakthrough concept is not recognised as such because there is no conceptual map that can be applied to it in the current paradigm. The new physics expands the conceptual map of Newtonian mechanics, showing that the ordinary world is a special case of the operation of quantum physical reality in the relativistic space-time. Even this adapted paradigm of the scientific worldview, however, is still incompatible with the implications of the experimental evidence of the new physics despite the better part of a century of attempts to make it fit. A scientific revolution is required, a major conceptual revision of the type Kuhn describes. The further expansion of the current conceptual map to embrace more than one level of logical type as ontologically fundamental resolves the paradoxes. The nature of consciousness, and the proper definition of the perceiving subject in the physics, are also simply explained. The recognition of the operational protagonist of the dynamics produces the new paradigm that finally makes complete sense of the new physics. The conscious individual is significant in a manner that has been incomprehensible.

## Appendix

Related subjects are addressed where these concepts integrate with established principles, and the third-logical-type frame of reference accounts for the enactment of known phenomena.

### The Specious Present

James states that in experience, i.e. on the inside view, the only present is the specious present: "... the short duration of which we are immediately and incessantly sensible." (1890, p. 631). He quotes Clay, the originator of the term, who points out that it is really part of the very recent past, and that a sequence of events is bundled into a composite experience, e.g.:

All the notes of a bar of a song seem to the listener to be contained in the present. (1890, p. 574)

Since the events are really in the past, Clay defines the specious present as:

... delusively given as being a time that intervenes between the past and the future. (ibid)

On the outside view, all this portrayal of the situation is simply correct, but on the inside view the specious present the present moment because it *is* the current snapshot in the quantum concept of time.

On the inside view, as the field of observation sweeps through space-time, within the context of a specific snapshot, no change takes place until the next observation is made. (For simplicity of discussion it is assumed the process of observation is not an analog, progressive process, which would likely be a better fit in human systems.) In between observations, for this brief period of time, the world hologram remains constant. There is no change to the record of observations, and therefore, on the inside view, the physical world remains the same. So this period of time is literally a short duration, of which one is immediately sensible, that intervenes between the past and the future in the transtemporal reality of the individual: the snapshot in-between the snapshots of the past, as recorded in the world hologram, and the possible snapshots of the future to which the moving frame of reference could progress. This is a specific point in the progression of the quantum concept of time.

Once again this is a situation in which inside and outside views differ. Objectively, on the outside view, the experience of physical reality may lag events in physical reality. On the inside view, the current reality is *the* reality because, for instance, which version of physical reality will turn out to be the case in experience is still in abeyance. On the outside view, as the song is played, and the ears are responding to the sound waves, the neural network is integrating the brief sequence of current events into the next observation: the process of access consciousness. However, on the inside view, during this brief time, the reality is that of the specious present, and which

*version* of these objectively current events will be experienced and observed remains indeterminate, up to the point in time where the observation is experienced and added to the memory. (Again, for simplicity of discussion it is assumed these are coincident in clock time.)

## Enactment of the Linear Dynamics

The linear dynamics defined by the wave function is the time-evolution of the physical, defining, for instance, the change of location of matter and energy in space-time as the time parameter is advanced. However, since time does not pass, there is no explanation of how this takes place. As with space-time in relativity there is a simple but fundamental issue. The wave function defines the state of the physical system throughout time. There is no special value of the time parameter  $t$  in the equations just as there is no Now in space-time, and there is no explanation of how it might change. Taking phenomenal consciousness as a property of the unitary system provides a mechanism. Here it is proposed that the experience of the state vector is the experience of the change it defines: the change of state of matter and energy with advance of the time parameter. This is 'what it is like' to experience the quantum state vector of physical reality. Thus the experience of the physical world defined by the state vector is the experience of the time-evolution of the system defined by the state vector. This is 'what it is like' to experience physical reality defined by the state vector.

Naturally, though, the only reality directly experienced is the world hologram, a field of information. However, on the inside view, the state vector is defined by the record of correlations, i.e. the world hologram, therefore they may be seen as equivalent. Thus to experience the world hologram, within the context of a specific snapshot in the quantum concept of time, a specific quantum-mechanical frame of reference, is 'what it is like' to experience this physical reality. This explanation lacks the solidity of a physical mechanics, but this is the only possible explanation of the effective enactment of the linear dynamics in a static universe. As Davies (*ibid*) states of the passage of time, it seems it must be subjective not objective.

In the case of the experience of the collapse dynamics, the logical mechanics is obvious. As each observation is made, at the specific point in time defined by the linear dynamics, there is the experience of events taking place. This is 'what it is like' to experience the change of the definition of the effective quantum-mechanical state of the environment, as described below. This also explains the directedness of time.

## The Standard von Neumann - Dirac formulation

The linear and collapse dynamics are effectively enacted in the moving frame of reference, at different levels of logical type, cycling as defined by the standard von Neumann - Dirac formulation:

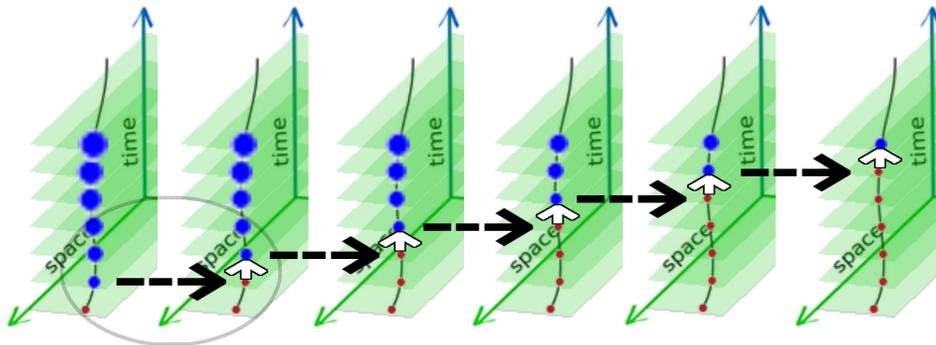
Process 1: The discontinuous change brought about by the observation

of a quantity with eigenstates  $\varphi_1, \varphi_2, \dots$  in which the state  $\psi$  will be changed to the state  $\varphi_j$  with probability  $|(\psi, \varphi_j)|$ .

Process 2: The continuous, deterministic change of state of an isolated system with time according to a wave equation  $\partial\psi/\partial t = U\psi$ , where  $U$  is a linear operator. (von Neumann, 1932)

The quantum state of the system  $\psi$  is defined by Everett's relative state: the record of observations is the record of observables defining the set of commuting operators which define the determinacy of the observed system. As shown in Part 1, this is equivalent to the superposition of all worlds in which this individual exists. This is here referred to as the quantum-mechanical frame of reference.

Each of the worldlines in the illustration below exists in a specific snapshot, defined by a specific quantum-mechanical frame of reference. Process 2 is the change of the inertial frame of reference, within the context of that specific quantum-mechanical frame of reference, as shown by the white arrows. Process 1 is the change of this frame of reference to a different snapshot, a different definition of the quantum-mechanical frame of reference, as shown by the black arrows. As Lockwood states, this is a: "... dimension running, so to speak, perpendicular to time and space." (1989, p. 232).



A sequence of snapshots in the quantum concept of time.

The duration of Process 2 within a specific snapshot is the specious present. During this period the quantum-mechanical frame of reference remains the same, while the inertial frame of reference in this context changes linearly. At the end of this period, as an observation is made, the quantum-mechanical frame of reference is changed, while location in the inertial frame of reference remains the same.<sup>5</sup>

On the inside view, no change is experienced for the duration of the specious present: the record of observations remains constant, and thus the quantum-

<sup>5</sup> We are accustomed to thinking that the quantum-mechanical frame of reference changes within the frame of reference of space-time, which it does on the outside view. But on the inside view it is the space-time frame of reference that changes within the quantum-mechanical frame of reference. And one lives, transtemporally, only on the inside view.

mechanical frame of reference remains constant.

At the end of this period of time, on the making of an observation, the quantum state of the system is effectively changed to a new value, with probabilities for specific events given by the formula: Process 1, experienced as a specific version of events happening. The result is the effective transition of the inside view to a different snapshot, defined by a different quantum-mechanical frame of reference, represented by the black arrows.

Within the context of this snapshot the linear dynamics is experienced as the passage of time, and the cycle continues. The result is a sequence of snapshots, with the passage of time being encountered briefly in each one, for the period of the specious present, represented by the white arrows.

In experience, i.e. with respect to the moving frame of reference, the system effectively enacts both dynamics in a cycle. As Everett states, referring to the standard formulation:

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

The enactment of the linear dynamics, experienced as the transition through space-time within the context of a specific quantum state, is like the fly being drawn across the canvas in Lockwood's analogy, passing along the sequence of moments in the worldline. The quantum jump to a different snapshot is like the duster moving to a different canvas, where the scene defines a specific outcome of the observation made: the world defined by a slightly different quantum state.

The same overall system engages in change at the two different logical levels: Process 2, within the frame of reference of a specific snapshot, and Process 1, from one snapshot to another. Naturally, the change of a system is a phenomenon contextual to the definition of that system: a differential must be meta to specific states.

## The Hierarchy of Second-Logical-Type Phenomena

Within the context of one snapshot, a specific state of the world defined by the quantum state, the moments in time are the first, primitive logical type, and the sequence of moments in the experience of the passage of time is second-logical-type. With respect to the quantum concept of time, however, this entire snapshot, linear dynamics and all, is a first-logical-type component of the sequence of snapshots. The moving frame of reference, being a property of the system as a whole, engages both sequences, and thus the cycle of the Standard von Neumann - Dirac formulation is enacted. The movement of the frame of reference alternates between levels of logical type. (Or, more realistically in biology, effectively operates both in tandem.)

The hierarchy of logical types is inherent in the system. Collapse is the change of

the wave function, and this can only happen in a context meta to its definition. This is what makes sense of Everett's formulation. His theory cannot make sense in the current worldview because it is assumed that he must be saying that the result of observation somehow appears determinate within the context of the ordinary space-time world, as time passes. In fact, however, the theory simply describes the effect of the transition of the frame of reference from one snapshot to another in the quantum concept of time, as each observation is made.

Incidentally, the significance of the moving frame of reference, and the phenomenal consciousness that supervenes on it, is not, of course, just because it is of third logical type in a particular way of counting. It is of the ultimate logical type, the set of all possible sets. As Chalmers (ibid) states, the experiencing can only be a fundamental attribute of the system as a whole.

## Illusion

As Davies (2002) mentions, given the passage of time is subjective, not objective, one logical conclusion is that this must be an illusion. However, this requires the illuded, and again this would be necessarily a phenomenon meta to the state of the system: to have even the illusion of change, some kind of changing frame of reference is required. Granted, in the static universe defined by special relativity, all change of the physical environment is indeed technically an illusion, but the illuded is the unitary system; and the result is physical reality that effectively happens.

## Many Minds

The modern conventional use of the word mind denotes the faculty of thinking, perceiving etc.. So the world hologram is not the mind in that sense. It is the *product* of this faculty, specifically access consciousness, that is the world hologram, the perceptual reality. This distinction is vital when making sense of many-minds theories. It is the world hologram with respect to which the many-worlds reality is defined, the record of observations in Everett's (1957) formulation. Provided one calls the record of observations, and hence the world hologram, 'mind', as Lockwood (1989) does, the concepts presented here define a many-minds theory with a physical ontology. As Donald states:

Many-minds interpretations of quantum theory are many-worlds interpretations in which it is argued that the distinction between worlds should be made at the level of the structure of the individual observer.  
(2014)

Here the distinction between worlds is made at the level of this 'mind', the world hologram. The ontology is the world superposition. The real physical world encountered is a many-worlds reality.

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