

# The Quantum-Mechanical Frame of Reference

## Part 2: Logical Type in Time Evolution

Andrew Soltau

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 ontology. A further level of logical type resolves the paradoxes of special relativity, and reveals the full definition of transtemporal reality.

Assuming the static block universe of eternalism, the passage of time is a total paradox. Equally, the Andromeda paradox means that presentism, only what exists now is real, 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 because this produces a system that implements 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.

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 enactment 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 actuality of a sequence of versions, as the moving frame of reference passes from one to another. Everett's formulation is the physics of this process. In effect, as he states, the standard formulation of quantum mechanics is enacted.

This also provides a complete and operational definition of the transtemporal individual: the sequence of states of the memory, sapience, experienced by the consciousness that supervenes on the moving frame of reference, sentience. The interaction of the two produces the perceiving subject missing from the physics. The world of such an individual is ipso facto the class-of-worlds-as-a-world 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)

... the distinction between the past, present and future is only a stubbornly persistent illusion (Einstein, quoted in Dyson, 1979, p. 193)

This is eternalism. 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 has been considered: the past and the future do not exist, only the present moment. This, however, falls prey to the Andromeda paradox. Essentially, it does not, cannot, work because it is directly contradicted by relativity. That 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. Presentism would mean that the observer who changes direction would be radically changing the physical state of affairs in the Andromeda galaxy, which physics obviously does not allow.

In the block universe there is no such problem. The observer is simply changing what is true for that observer, 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. 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 three-dimensional world, as universally experienced. In this case both views are true: presentism is simply the inside view of the objective reality of eternalism.

## 2 The Third Logical Type

The problem is that a moving frame of reference 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. Each moment and each event along the world-line of an observer is 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 passage of time 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 in fact static: it is not going anywhere. The moving frame of reference produces the appearance of the passage of time in the static relativistic universe.

McTaggart (1908) famously held that time could not be real because two obviously correct descriptions of time, the A series and the B series, were mutually contradictory. The solution, however, is simply that both are indeed real, they are simply different types of frame of reference in the same system. The A series is the succession of moments encountered as the moving frame of reference passes through space-time, along the four-dimensional world line. The static B series of moments is the sequence of events along which it moves, in the relativistic block universe of the standard objective view, the 'view from nowhere'.

As with the resolution of the paradoxes of quantum theory described in Part 1, the problems are resolved by the vital discriminations of logical type. The A series defines a moving frame of reference. The passage of time requires it. Given this moving frame of reference, it is clear both descriptions of time are correct although they seem mutually contradictory. The reality of presentism is a specific moment, a first-logical-type phenomenon. The reality of eternalism is the existence of the whole sequence of moments, a second-logical-type phenomenon: the B series. The iteration of moments along the world-line is a third-logical-type phenomenon, giving rise to the A series.

As described in the next section, this simply explains the great paradox of the present moment, the Now as Einstein (Carnap, 1963, p. 37) dubbed it. As described in Sections 5 and 6 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.

The reality encountered 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, subjectively, 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.

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 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, train-window-type phenomenon.

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).

Here it is essential to note that the word consciousness is routinely used quite 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 to produce the sensorium, the contents of awareness: the sensory information experienced and added to the record of observations in memory. All this is well understood in modern science. 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 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 of the correct logical type to be an attribute of the moving the frame of reference, passing 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).

Thus the dynamics of physics is effectively enacted: there is the appearance of the passage of time, and the operation of the linear dynamics of quantum mechanics.

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 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: to experience the reality of the wave function is to experience the enactment of the function it defines: the time evolution of physical reality. This is 'what it is like'. In consequence, this third-logical-type phenomenon constantly iterates the moments along the worldline of the observer.

## 5 The Quantum Jump

Given this moving frame of reference, the meaning of the paradoxical quantum jump becomes obvious. 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 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*, for the individual on the inside view. As described in Part I, the individual on the inside view is the world hologram. As Everett shows, this is the protagonist of the collapse dynamics. 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.

---

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).

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. As Everett clearly states, there is only the *appearance* of collapse:

... 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 he explicitly states:

It is found that experiences of the observer ... 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. It is simply the individual, and thus the inside view. As Everett emphasises, the physical system does not change. It is the individual that changes, becoming correlated with a different version of the environment.

... *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)

The addition of the observation to the world hologram alters the definition of the individual, and this alters the definition of the world superposition. In Everett's terms, the addition of the new correlation alters the relative state.

Collapse occurs, on the inside view, as the world hologram is updated, the moving frame of reference passing from one snapshot to the next: the quantum jump. As described in Part 3 this is an information process, and it is meta to the physical that defines the snapshots.

As with the sequence of moments in 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.

## 6 The Standard Formulation

There are two different kinds of time, the time of space-time and the quantum concept of time, and they operate alternately. This is the cycle of operation of the linear and collapse dynamics. They are effectively enacted, alternately, in the moving

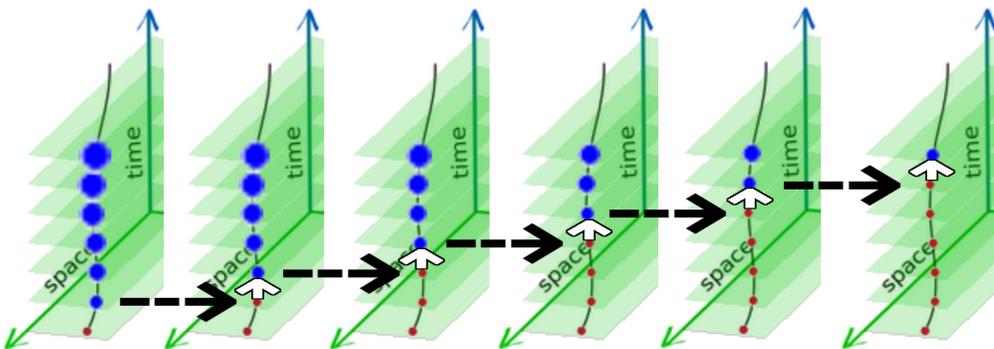
frame of reference, at different levels of logical type, defined by the standard von Neumann - Dirac formulation:

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  $|\langle\psi, \varphi_j\rangle|$ .

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 quasi-classical worlds in which this individual exists. This is here referred to as the quantum-mechanical frame of reference.

Each of the vertical 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; emphasis added).



A sequence of snapshots in the quantum concept of time.

This is the extra dimensionality Ellis (2006, 2008) is calling for as a requirement in the scientific worldview. Effectively, with progression from snapshot to snapshot, the four-dimensional space-time of relativity itself evolves: the potential of the future becomes the certainty of the past as illustrated. In principle this is already present in the current understanding of the new physics because this framework is the quantum concept of time. As Deutsch (ibid) and Barbour (ibid) state, however, quantum time is

a static array. Just as with the experience of the passage of time, this can only be a movement of the frame of reference, necessarily a third-logical-type phenomenon.

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)

In other words, the frame of reference of experience follows the predictions of the standard von Neumann-Dirac formulation.

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, one where the scene defines a specific outcome of a new observation determinately made: the world defined by a slightly different quantum state.

There is no measurement problem because the 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. It has not been possible to produce a realist construal of quantum mechanics because of the assumption that Process 1 must be subsidiary to Process 2. This is a perfectly sound assumption on the outside view, but the situation is vice versa on the inside view.

## 7 Times Three

Effectively, the enactment of the standard formulation 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. Ellis's concept of the expanding block universe is of this nature:

... 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 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)

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.<sup>2</sup>

Thus 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 unitary system, the known universe of relativity and quantum theory.

## 8 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 inherent simplicity of the system. It exists because of the identification of the sentience with the product of sapience.

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, thus 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.<sup>3</sup>

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 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

---

2 The difference between past and future is crystal clear, thus satisfying the final point of contention regarding the block universe raised by Lucas (ibid).

3 This is not panpsychism, meaning a generalised thinking faculty, but simply raw awareness.

experiencing of the perceptual reality of the individual, the world hologram. Since this is in the world defined by the quantum-mechanical frame of reference, a quantum definition and thus a function, this is the experience of the enactment of the function.

The identification of phenomenal consciousness, universe consciousness, with the world hologram, the product of access 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.

## 9 The Origin

It is generally taken as obvious that *all* of consciousness is a property of the neural system. Without question the perceptual reality, the product of access consciousness, is of this nature. Equally, the location of the experiencing consciousness seems perfectly obvious: 'here', at the centre of the experiential domain. This, however, is simply the coordinate of the *origin* of the *perspective* with respect to which the world hologram is formulated. It tells us about the access consciousness: the world hologram it produces it is structurally identical to a virtual reality. It tells us nothing about the phenomenal consciousness, except that this is the experience *of* the world hologram.

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. 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 '*T*' is '*here*'. Metaphorically, the '*T*' is '*here*' only in the same way as the light from the sun, reflected off a painting, is the light coming from the painting. The sun is not in the painting, and the phenomenal consciousness is not in the brain.

The process of identification 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 can be no such thing as an identical copy of a specific inside view: inevitably, in the frame of reference of a ubiquitous phenomenon, identification with a specific inside view is identification with all the identical copies simultaneously. 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>4</sup> As shown in Part 1, this operates as defined in QBism and the many-minds theories, determinate solely where observed. This is the many-worlds reality.

---

<sup>4</sup> In this context 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.

## 10 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)

The component missing from the physics is the world hologram. 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. Given a moving frame of reference, however, the ongoing computation of the world hologram effectively produces a transtemporal entity.

The individual, the world hologram, 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 protagonist, the operational subject, that is experienced as events happening. In other words, the experience of life in reality is the experience of the time evolution of the identity. The sequence of states of the world hologram is the transtemporal identity of the individual.

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, 2015)

As he explains, the movie of life does not run. Effectively, however, in the moving, third-logical-type frame of reference, it does. On this view, literally in experience, time passes, and change is encountered: with the making of each observation the world hologram is updated, resulting in the transition from one snapshot to the next.<sup>5</sup> This is the transtemporal reality of the individual on the inside view.

In the light of these concepts a full and proper definition of the conscious transtemporal individual is straightforward. In operational terms the world hologram works in a manner logically identical to inter-frame compression in movies. The frame is updated using the definition of the changes to the frame. In the process of observation it is the state of the memory that is updated. Thus the experience of events happening is simply the experience of the identity of the protagonist changing. This changes the frame of reference because this alters the definition of the class-of-worlds-as-a-world that contain it. The identity of the protagonist is the same from snapshot to snapshot except for the addition of each new observation, and this is experienced as the change of the world as the frame of reference is updated.

The transtemporal identity of the individual is the world hologram experienced by phenomenal consciousness. This forms the operational subject, the protagonist in the

---

<sup>5</sup> Here the array of snapshots defined in Hilbert space is logically akin to the frames of a universal DVD.

quantum-mechanical dynamics in action, 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.

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 the transtemporal experiential entity passing through time. 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.

This is an information process, and the holographic field of information is the operational subject in this context. It is solely with respect to the world hologram that the dynamics of physics are effectively enacted: time actually passes and events actually happen. The transtemporal identity exists only at the level of information.

## 11 The Omitted Subject

A basic tenet of physics 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, instantiates and embodies the logical types missing from the current ontology of physics.

The paradoxes of quantum theory are resolved because the protagonist lives in a world superposition, a second-logical-type phenomenon, as described in Part 1. The paradoxes of relativity are resolved because the experiencing consciousness is the subjective attribute of the third-logical-type moving frame of reference. All together this comprises the perceiving subject, the conscious individual.

Moreover, there is a precisely world-hologram-shaped hole in the physics. As Wilczek writes:

The relevant literature [on the meaning of quantum theory] is famously contentious and obscure. I believe it will remain so until someone constructs, within the formalism of quantum mechanics, an "observer," that is, a model entity whose states correspond to a recognizable caricature of conscious awareness, and demonstrates that the perceived interaction of this entity with the physical world, following the equations of quantum theory, accords with our experience. That is a formidable project, *extending well beyond what is conventionally considered physics*.

Like most working physicists, I assume, perhaps naively, that this project can be accomplished, and that the equations will survive its completion unscathed. In any case, only after its completion might one legitimately claim that quantum theory is defined by the equations of quantum theory. (2006, p. 142; emphasis added)

The world hologram is literally the definition of these terms. Firstly, as has been shown in Part 1, this entity is the definition of conscious awareness: it *is* the conscious awareness itself, meaning the perceptual reality. Secondly, there is no question that the interactions of this entity with the environment follow the equations of quantum theory because that is the whole point of Everett's formulation. That is exactly and specifically what he demonstrates:

... 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 scheme here is the standard von Neumann-Dirac formulation, and as Everett makes very clear it is "Judged by the state of the memory" (1957, p. 462) that the dynamics of quantum mechanics effectively operate. In other words, the full operation of the standard formulation applies specifically and solely to the state of the memory, the world hologram. The interaction with the physical world naturally accords with the experience of each individual because it is the experience of the world hologram, the virtual reality representation of the physical world.

This is the omitted subject. The world hologram is the "observer". With this in place, the paradoxes evaporate. The world that operates the mysterious collapse dynamics is the world superposition, the effective physical environment of this protagonist. It is this that explains all the bizarre implications. As shown in Part 1, indeterminacy except where observed is natural in this type of world, axiomatic. Quantum Bayesianism is essentially correct, as are the many-minds theories. This is inside-view physics.

The omitted subject is the world hologram experienced by consciousness, the product of sapience experienced by sentience. The world hologram defines the determinacy of the personal world. This is Everett's relative state. The sentience brings it to life. This is universe consciousness, the subjective attribute of the third-logical-type phenomenon. As Weyl states: "... the consciousness in this function does not belong to the world." (1934, p. 1). Once the sentience is understood as a property of the unitary system, a third-logical-type phenomenon, it is doubly clear why the meaning of the physics could not be understood in the absence of the perceiving subject. The world hologram defines the subjective frame of reference, the inside view, and thereby the quantum-mechanical frame of reference defining the many-worlds reality; and the phenomenal consciousness is the transtemporal awareness of the time evolution of the quantum-mechanical frame of reference.

## 12 Conclusion

McTaggart's (1908) conclusion of the unreality of time is based on the incompatibility of two different versions of the description of time, both of which are clearly valid from the direct evidence of experience. The resolution 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. Eternalism is simply the world of the static block universe of special relativity. The A series is the sequence of temporal events encountered in the moving frame of reference, as it passes along the world-line. This is the time of the Now, the ever-moving present moment. This, however, cannot exist in physics, as Einstein lamented. Relativity defines the B series.

Given the direct and immediate evidence of both series, a resolution is clearly required. The only possible answer is a third-logical-type phenomenon, contextual to the series of moments along the worldline, a moving frame of reference. The evidence seems incontrovertible. If an information process is in progress, then by necessity there is a moving and/or changing frame of reference, and, the time evolution of the inside view is an information process.

The third-logical-type moving frame of reference provides the explanatory principle inherent in the requirement of Einstein's Now: the present moment, universally experienced, constantly moving into the future. The Now of the A series 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. In other words, it is necessarily contextual to the sequence of moments. This is the nature of the operational principle of the universe. 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. Thus a progression of moments is experienced as it crawls through space-time, as Weyl (ibid) 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 the linear dynamics is effectively enacted. This explains the *appearance* of the time evolution of the world, in the static physical universe. As Weyl states, the result is "... a fleeting image in space which continuously changes in time" (ibid). In effect time passes.

This process is punctuated by collapse. As observations are made, the frame of reference of the Now progresses from snapshot to snapshot. As Everett describes there is the *appearance* of collapse of the state vector. Effectively, events happen in the static physical universe. In experience, all the dynamics of physics are brought to life. This lies outside what is conventionally considered physics because it is essentially information technology. This is the nature of inside-view physics.

This perspective also enables a full operational definition of the transtemporal individual. The identity is the world hologram. 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 awareness is the phenomenal consciousness. The perceiving subject is the product of access consciousness, sapience, experienced by phenomenal consciousness, sentience. 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 collapse dynamics. As Everett states, it is: "Judged by the state of the memory" (ibid) that the dynamics of quantum mechanics effectively operate.

The conscious individual is significant in a manner that has been incomprehensible. The solution lies outside the boundary of the questions being asked, but this is classic scientific revolution. The new paradigm does not fit into the current worldview, and this is the reason it seems wrong. As usual, however, the new paradigm subsumes the old. The objective physical world is exactly as defined in the current paradigm, but the physical reality encountered is a world superposition. As has been shown, this does not involve any change to the physics. This is a purely conceptual revolution. An ontological dualism reconciles the paradoxical phenomena of quantum theory. The

third logical type resolves the paradoxes of special relativity.

The recognition of the operational protagonist of the dynamics produces the new paradigm that makes complete sense of both pillars of the new physics. This is the world hologram experienced by the consciousness of the unitary system. Effectively time passes as the Now of the moving frame of reference passes through space-time. The making of observations is experienced as events happening in physical reality. For this protagonist, all three of the metaphysics of time are realised.

## References

Barbour, J.: 1994, "The timelessness of quantum gravity: II. The appearance of dynamics in static configurations", *Classical and Quantum Gravity*, Volume 11, Issue 12, pp. 2875-2897.

Barbour, J.: 1999, *The End of Time*, Weidenfeld & Nicolson, London.

Barrett, J.: 2008, "Everett's Relative-State Formulation of Quantum Mechanics", available at: <http://stanford.library.sydney.edu.au/archives/fall2008/entries/qm-everett/>

Bitbol, M., 1990, "Perspectival Realism and Quantum Mechanics", In *Symposia on the Foundations of Modern Physics*, 47-61, K. V. Laurikainen and C. Montonen (Eds.), World Scientific, Singapore.

Block, N.: 1995, "On a confusion about a function of consciousness", *Behavioural and Brain Sciences*, 18: Pages 227-47.

Carnap, R., 1963. "Carnap's Intellectual Biography" in *The Philosophy of Rudolf Carnap*, P. A. Schilpp (ed.), pp. 3-84. La Salle, IL: Open Court.

Chalmers, D.: 1995, "Facing Up to the Problem of Consciousness", *Journal of Consciousness Studies* 2(3):200-19.

Chalmers, D.: 1996, *The Conscious Mind*, Oxford University Press.

Davies, P.: 2002, "That Mysterious Flow", *Scientific American*, 287(3), 40, available online at <https://www.scientificamerican.com/article/that-mysterious-flow-2006-02/>

Deutsch, D.: 1997, *The Fabric of Reality*, Allen Lane, London.

Dyson, F.: 1979, *Disturbing the Universe*, Harper & Row, New York.

Ellis, G.: 2006, "Physics in the Real Universe: Time and Spacetime", available online at <http://arxiv.org/abs/gr-qc/0605049v5>

Ellis, G.: 2008, "On the Flow of Time", available online at <http://arxiv.org/abs/0812.0240v1>

Everett, H.: 1957, "'Relative State' Formulation of Quantum Mechanics", *Reviews of Modern Physics* 29: 454-462.

- Everett, H.: 1973, "The Theory of the Universal Wave Function", in DeWitt, B. & Graham, N. eds., *The Many-Worlds Interpretation of Quantum Mechanics*, Princeton University Press, Princeton: 3-140.
- Fodor, J.: 1992, "The big idea: Can there be a science of mind?", *Times Literary Supplement*, July 3, 5-7.
- Goldstein, R.: 2005, *Incompleteness: The Proof and Paradox of Kurt Godel*, Norton, New York.
- Kuhn, R.: 2015, "The Illusion of Time: What's Real?", available at <http://www.space.com/29859-the-illusion-of-time.html>
- Lockwood, M.: 1989, *Mind, Brain and the Quantum*, Blackwell, Oxford.
- Lockwood, M.: 2005, *The Labyrinth of Time*, Oxford University Press, New York.
- Lucas, P.: 1989, *The Future*, Blackwell, Oxford, UK.
- McTaggart, J.: 1908, "The Unreality of Time", *Mind*, 17 (1908): 456-473.
- Mermin, D.: 2014, "Physics: QBism puts the scientist back into science", *Nature*, Vol. 507, No. 7493. (26 March 2014), pp. 421-423.
- Russell, B.: 1908, "Mathematical Logic as Based on the Theory of Types," *American Journal of Mathematics*, 30, 222-262, Appendix B.
- Ryle, G.: 1949, *The Concept of Mind*, University of Chicago Press.
- Savitt, S.: 2017, "Being and Becoming in Modern Physics", *The Stanford Encyclopedia of Philosophy* (Fall 2017 Edition), Edward N. Zalta (ed.), available at: <https://plato.stanford.edu/archives/fall2017/entries/spacetime-bebecome>
- Tegmark, M.: 1998, "Is "the theory of everything" merely the ultimate ensemble theory?", available at <http://arxiv.org/abs/gr-qc/9704009v2>
- Tegmark, M.: 2003, "Parallel Universes", available at <http://arxiv.org/abs/astro-ph/0302131v1>
- Vaidman, L.: 2008, "Many-Worlds Interpretation of Quantum Mechanics", *The Stanford Encyclopedia of Philosophy* (Fall 2008 Edition), Edward N. Zalta (ed.), available at: [plato.stanford.edu/archives/fall2008/entries/qm-manyworlds/](http://plato.stanford.edu/archives/fall2008/entries/qm-manyworlds/)
- von Neumann, J.: 1932, *Mathematische Grundlagen der Quantenmechanik*, Springer, Berlin, English Translation by R. Beyer, *Mathematical Foundations of Quantum Mechanics*, Princeton: Princeton University Press, 1955.
- Weyl, H.: 1949, *Philosophy of Mathematics and Natural Science*, Princeton University Press, Princeton.
- Weyl, H.: 1934, *Mind and Nature*, University of Pennsylvania Press, Philadelphia.