Multisolipsism

Universe Superposition
Relational Quantum Mechanics
and
The Reality of the No-Collapse Universe

Andrew Soltau

Abstract: A perspective on Everett's relative state formulation is proposed, leading to a simple relational quantum mechanics.

There are inevitably a large number of different versions of the world in which a specific observer could exist, and in the universe of the total unitary wave function they are all existing and superposed. If these different versions of the observer's world are taken together and superposed, the effective physical environment in the functional frame of reference of this observer would be highly indeterminate, since every possible variation of the world is included: only where observed by the observer is this world determinate, as in Rovelli's Relational Quantum Mechanics.

Although the identity of the observer as a physical body does not fit this concept, it applies inevitably to the functional identity of an observer as depicted by Everett: the state of the memory defining the record of observations. In this relativised quantum mechanics the collapse dynamics applies only to the functional frame of reference of the observer and raises no incompatibility with the linear dynamics. The multiple identities of the observer produced on observation are in idiosyncratically defined effective physical environments, each defining different, specific, determinate measurement records.

1 Introduction

On the view presented here, a relational quantum mechanics is a direct consequence of the Everettian formulation (1957). While Everett proposes an automatically functioning machine as a model of an observer, a physical entity, he defines the state of the memory of this automaton as the functional identity. It is from the perspective of this identity, and only from this perspective, that there is the appearance of collapse in the no-collapse universe. Inevitably, in a no-collapse universe, this identity is multiplely realised: there are many identical copies of this identity. Taking Everett's Relative State Formulation at face value, the universe is the coincident simultaneity of all possible versions of the determinacy of the physical environment. In this situation, all the identical 'copies' are the same thing in the same place at the same time; thus there is in fact only a single observer: one which is present simultaneously in all of those versions of the world. The effective physical environment of this observer is the simultaneity of all of these versions of the world, an effective superposition of all of them.

In such an environment, only the correlations with the environment arising from direct interactions with the environment are determinate, since all other aspects of the environment are the superposed sum of all possible arrangements of matter and energy in the world. This naturally produces a relativisation of the conventional view, since the definition of the physical environment is different for each observer of this type. As with Rovelli's Relational Quantum Mechanics (1996), this gives rise to personal parallel realities for observers. Although a relational view is a far cry from our accustomed view of the world, it resolves a number of interpretational difficulties with quantum mechanics, while at the same time being ontologically parsimonious. Given Everett's functional definition of the observer (1957, p. 457) embedded in a quantum theory without collapse, it appears that such a relational quantum mechanics is inevitable.

While quantum mechanics has passed every test of the accuracy of the formalism, the implications for physical reality appear to contradict fundamental common sense notions. This suggests a classic systems analysis problem where a paradox points to the mis-typing of some significant element of the system. Rovelli is specific about the element in question:

> Thus, I propose the idea that quantum mechanics indicates that the notion of a universal description of the state of the world, shared by all observers, is a concept which is physically untenable, on experimental ground. (1996, p. 7)

In other words, the concept is a wrong general assumption, 'excess baggage' like many previous global assumptions, as Hartle (2005) clearly illustrates. If this assumption is dropped, and a relational view of quantum mechanics is adopted, much of the difficulty of interpretation of quantum theory is swept away. The

description of the world effective for each observer is relative to the functional frame of reference of that individual observer, essentially a conceptual extension of the principle underlying special relativity. Such interpretations are naturally compatible with relativity because of the locality of observers.

A relational quantum mechanics is based on correlations, the determinacy of the effective reality of each observer being defined by his correlations record, a structure of information. In this kind of interpretation, transtemporal reality can be understood as an information process, operating at a different logical level to the physical. This perspective explains the mechanism of Everett's appearance of collapse (1973, p. 9) as a process closely related to, but nonetheless distinct from, the physical linear dynamics. This can only work with an observer defined by a structure of information, but this is exactly what Everett proposes (1957, p. 457). Taking Everett literally, the functional identity of the observer is a structure of information, and the appearance of collapse is an information process. This naturally resolves both the measurement problem and the longstanding puzzle of the nature of time.

This reading of Everett provides only a subjective solution and it is often assumed that an objective physical solution is required to explain quantum theory in a satisfactory manner. However, it appears that this assumption may be all that stands between us and a logically complete interpretation of quantum theory, and as Schlosshauer states:

> ... if we realize that the often deeply felt commitment to a general objective definiteness is only based on our experience of macroscopic systems, and that this definiteness in fact fails in an observable manner for microscopic and even certain mesoscopic systems, the author sees no compelling grounds on which objective definiteness must be demanded as part of a satisfactory physical theory, provided that the theory can account for subjective, observational definiteness in agreement with our experience. (2003, p. 5)

2 The Everettian Observer

Although Everett describes a physical entity as a model of an observer, a mechanical automaton, he makes the 'the memory contents', the sole causal functional structure of the observer:

> If we consider that current sensory data, as well as machine configuration, is immediately recorded in the memory, then the actions of the machine at a given instant can be regarded as a function of the memory contents only, and all relevant experience of the machine is contained in the memory. (1957, p. 457)

Additionally, it is with reference to the 'state of the memory' of versions of the observer that Everett shows there is the appearance of collapse, and the resolution of the measurement problem, requiring only the linear dynamics, 'pure Process 2 wave mechanics':

> When interaction occurs, the result of the evolution in time is a superposition of states, each element of which assigns a different state to the memory of the observer. Judged by the state of the memory in almost all of the observer states, the probabilistic conclusion of the usual "external observation" formulation of quantum theory are valid. In other words, pure Process 2 wave mechanics, without any initial probability assertions, leads to all the probability concepts of the familiar formalism. (p. 462)

The state of the memory seems somewhat obviously a phenomenon subsidiary to the physical entity one ordinarily identifies with, but as Everett states, the physical form is a superposition of multiple versions of the observer:

> ... there will not, generally, exist a single observer state. There will, however, be a superposition of the composite system states, each element of which contains a definite observer state and a definite relative object-system state. (1973, p. 10)

Thus it is solely at the experiential level, meaning with regard to the state of the memory of sensory experiences, that there is determinacy. The functional identity of the observer is defined solely by the memory contents, and only from the perspective of the state of the memory, a structure of information, is there effective collapse. The sequence of states of the memory describes the appearance of collapse of the wave function, in a static no-collapse environment. Thus, for an observer defined as the state of the memory, and only for such an observer, Everett's formulation clearly describes the quantum mechanics of an environment in which there is the subjective appearance of collapse.

3 Universe Superposition

Following Vaidman, the term world will be used to refer to "*... the totality of (macroscopic) objects: stars, cities, people, grains of sand, etc. in a definite classically described state*" (2002; his italics), and the term universe to refer to the totality of all such possible worlds, as in Everett. Inevitably, there are in the universe a very large number of worlds which one could be in at the present moment. Every world having the same identical appearance to one's observations, and having given rise to the same identical appearance at all points in one's past, is a world one could be in at the present moment. Since all of these worlds exist in the Everettian universe, there is inevitably, also, an identical copy of oneself in each

such world. Furthermore, as Deutsch explains,[1] there is no question about which of these copies one actually is, one is all of them:

> If, aside from *variants* of me in other universes, there are also multiple identical *copies* of me, which one am I? I am, of course, all of them. Each of them has just asked that question, 'which one am I?', and any true way of answering that question must give each one of them the same answer. (1997, p. 279; his italics)

Taking Everett's no-collapse formulation literally, every possible world exists, and the universe is a simultaneity of all such possible worlds. This means that all the identical copies of an observer are existent and superposed. If the identical copies are truly identical, such a condition equates to there being only one of this entity. Such an entity would exist in, and be correlated with, all of those worlds in which there was an 'identical copy', in other words, all those worlds containing the definition of that observer. Each world is a specific version of the physical environment, defined by a specific quantum state. Since the single entity, conforming to the definition of a specific observer, is simultaneously present in a large number of worlds, the effective universe of this observer is the simultaneity of all of them, defined by the sum of all of the quantum states defining these worlds.

In every world where there is an identical copy of the observer, the body of this observer is making the same identical observation of the present moment, and has the same identical record of observations made in the past. Using Everett's functional identity of the observer, there is therefore one single observer which is in all these bodies, in all these worlds. Subjectively, simply meaning within the functional frame of reference of this observer, the effective physical environment is the simultaneity of all of them, and thus, effectively, a superposition.

The effective superposition proposed here is not of the same nature as a physical superposition in the ordinary sense. This type of superposition is invoked purely as a result of the functional identity, a mathematical structure of information, being multiplely realised. Thus the effective functional frame of reference of this structure of information is the simultaneity, the superimposition of all of them. As explained by Deutsch (1997, pp. 258-287), the no-collapse universe is equivalent to a multiverse of specific versions of determinacy of the world. This effective superposition is simply the result of an observer, defined as a structure of information, being unlocalised with respect to which version of the world that observer is in. Thus the effective environment is the simultaneity of all of those worlds. There is no question of otherwise separate worlds becoming physically superposed, it is simply that an observer of this nature, being present in the definition of a large number of worlds simultaneously, has as its physical environment the simultaneity of all these worlds.

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1 Referring to universes in a multiverse in the same way as the term world is used here.

This environment is a relative or perspectival world, such as considered by Saunders (1995) to be the basic one. Vaidman refers to such a world as a centered world, going on to say that:

> This concept is useful when a world is centered on a perceptual state of a sentient being. In this world, all objects which the sentient being perceives have definite states, but objects that are not under her observation might be in a superposition of different (classical) states. (2002)

The universe superposition (more correctly a superposition of worlds) is a special case of such a centered world, in that *only* that which the observer perceives has a definite state, and objects that are not under observation are in a superposition of *all* possible different (classical) states concomitant with the existence of this observer. Since this is an effective superposition of every possible world in which this observer exists, only the observer herself, defined by the record of observations, and that much of the world with which she is correlated by those observations, is determinate; and all else is indeterminate. Since this observer, defined solely by the observations made, is herself the correlations record, she defines the determinacy of a complete physical world, by virtue of being the determinant for the universe superposition: that by which the determinacy of the universe superposition is defined. Nonetheless, the physical environment of the observer, the effective superposition, is a physical quantum domain. Every possible physical environment which has the appearance to this observer, defined by the observations made, is included in the effective superposition. Thus every aspect of the environment is determinate only to the level of resolution of those observations. Thus the determinacy of the environment is defined solely by the record of observations, the state of the memory, Everett's definition of the functional identity of the observer.

3.1 The Holographic Principle

In this minimal system, both the observer and the determinacy of their reality are defined solely by their record of observations, which is of course the record of correlations with the environment. Not only is this all the definition this effective physical environment has, it is only the surface of the world facing the observer that becomes part of the definition. There is thus an interface with the rest of the universe, the observed surface of the environment system, behind which everything is indeterminate, except where defined by the interface. This is strikingly similar to the holographic principle of t'Hooft's Dimensional Reduction in Quantum Gravity (1993),[2] according to which there can be no more definition to the region beyond the interface with the universe than defined by the interface itself. This is a

2 A consequence of the second law of dynamics (Smolin, 2000, p. 174).

puzzling result in an ordinary universe, but in a reality defined by the state of the memory this interface is exactly what is defined by the correlations record. This is simply a description of the Everettian universe in the reality of an individual observer defined by the state of the memory. The holographic principle defines exactly the same type of physical environment as is defined by Everett's experiential definition of the observer.

3.2 Logical Levels

While a specific physical body is part of a specific physical environment, or world, with which it is quantum entangled, a specific record of observations, being a mathematical structure of information, clearly exists in a very large number of such physical environments. This duality, the existence of two different kinds of relationship to the environment, exists simply by virtue of the different nature of mathematical and physical structures. Specifically, physical objects have location, mathematical structures of information such as numbers and ideas do not. A mathematical structure of information has no intrinsic location, the concept does not apply. The numerical value seven, for instance, is obviously not in any particular place. Only the instantiations of information in the physical have location and other physical properties. Nonetheless, the observer as the record of observations has extrinsic location, defined by those observations. The record of observations provides some kind of definition of location in space and time.

Since every experientially identical copy of the body must make identically the same observations, and have identically the same record of observations, the extrinsic location of this experientially defined observer is identically the same with respect to the appearance of the world, in every world in which it is instantiated. However, location with respect to *which world* the body is in, is unknown and unknowable. Thus the experientially defined observer can have no definition of extrinsic location with regard to which world a specific body, in which it is instantiated, is in. Since the extrinsic location, the apparent environment, defined by the record of observations, is defined solely by observations, the same identical experientially defined observer, with the same identical extrinsic definition of the appearance of the world, is present in all worlds in which it is instantiated.

The experientially defined observer, a mathematical structure of information, is present ubiquitously in all instantiations, and the functional frame of reference of this observer is the simultaneity of all of them. Thus subjectively, meaning within this functional frame of reference, the observer exists simultaneously in all of these worlds in which it is instantiated. The different logical level of structures of information thus provides a way to understand an effective environment of the observer quite different to the standard concept of the physical world. Objectively, the functional frame of reference of an observer is the world in which the body of

the observer is usually understood to exist, a specific determinate world, the matter and energy making up a well-defined physical environment, determinate to the level of quantum detail due to decoherence.[3] Subjectively, however, meaning within the functional frame of reference of the experientially defined observer, the effective physical environment is the universe superposition of all such worlds: a highly indeterminate domain, determinate only where observed.

4 The World Hologram

Observations are added to the memory of a human observer to form records of events, as with the mechanical automaton, but they are also utilised as the basis of a complex functionality of a quite different order to this basic recording mechanism: an accessible map or model of the environment is formed from the integrated synthesis of these observations, which then becomes the basis of intelligent operation in the world. This inner representation of the environment is highly familiar to each of us; it is the known world of the observer. Whenever one recalls the appearance of a significant place one has visited, or where one might have put the house keys down, it is this structure of information one is accessing.

As we can all attest, when we access this model of the known world it is experienced as a spatially distributed environment, exactly alike in representational form to the way we understand the physical world to be arranged: in terms of solid three dimensional objects and the distances and spaces between them. Since this inner representation of the world is experienced as spatially distributed and three dimensional, while in fact being encoded in the neural network of the brain, it is effectively a hologram of the world known through observations.[4] The observation of the present moment is the immediate and lucid view of the real world which is added to this 'world hologram' at each moment. The observation is here defined as the structure of sensory information registered in the neural network, and apparent in the sensorium, and the world hologram as the cumulative integrated record of the sequence of observations.[5]

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3 In the light of the significance of this duality, mathematical structures of information could be said to exist at a different 'logical level' to the physical, an ideal or Platonic realm, not distinct from the physical realm but being simply a different logical relationship to determinacy in that realm.

4 Naturally the observations and the consequent world hologram are structured not solely in terms of visual information but in all five senses.

5 This definition of the world hologram is purely functional and unrelated to any specific areas of the brain or class of memory. While the world hologram obviously comes under the banner of memory, there are properties of the mind associated with memory, such as learned stimulus-response associations, which are not observed unless the observer experiences their effect, and thus not inherently part of the world hologram.

4.1 The Experiential Interface

This division of a part of the mind is far from coincidental. This is the operational level of subjective experience, meaning the experience itself and the record of experiences, as distinct from all the processes which go to make up subjective experience, and corresponds to a specific cut in the von Neumann chain. From this experiential perspective, the sensory information from the body's sensors is the input to the neural system, while the sensory image experienced is the output. The world hologram is the integration over time of this output, corresponding to the contents of the memory of the recording automaton in Everett's view. Each of us has direct experiential evidence for this divide: all observations are made in the sensorium, the field of inner experience, and the output of internal computations in the neural system is experienced in this sensorium in the same way as the output of the neural system representing images of sensory data.[6] Naturally, some observations are taken in subliminally, thus aspects of the world are represented in the sensorium, although not consciously noticed. Therefore, observation will be taken here simply to mean any sensory formulation of external or internal processes in the sensorium, defined as the experiential output of the neural system.

The world hologram is the integrated record of the observations of the observer, Everett's definition of the functional identity of the observer. Since in Everett it is solely the contents of the memory that defines the functionality of the observer, and all relevant experience is contained in the memory, it is therefore this mathematical structure of information which is deemed to constitute the functional identity of the observer, the cumulative record of "... current sensory data, as well as machine configuration" (1957, p. 457)[7]. It is this record of observations, here the state of the world hologram, according to which the probabilistic formulations are upheld in a no-collapse situation.

4.2 Correlations

The world hologram is the integrated synthesis of all observations made by this observer. Naturally, each observation forms a correlation with the environment: the environment must be, and can only be, such as to give rise to that observation. The world hologram, being the integrated record of these observations, is thus the correlations record. The world hologram is the cumulative structure of information defining the correlations with the physical environment, and all else is indeterminate in this observer's functional frame of reference. Thus, this structure of information is the determinant of the universe superposition, meaning that the determinacy of the effective physical environment in the universe superposition is

6 One can argue that internal observations are not necessarily made solely in terms of the five senses, but one must then supply a sixth sense of some kind!

7 On this view, machine configuration is recorded only where observed at the sensory level, and is thus included in the record of observations.

defined by, and only by, the record of observations. Effectively, the world one knows is 'the real world'.

5 The Dynamics

The time evolution of the cumulative correlations record is logically elementary, being the sequential addition of new correlations to the structure of information as new observations are made. As a mathematical structure of information, the correlations record is intrinsically singular and discrete, so if there is a change in the definition of the world instantiating this structure of information, such that more than one possible outcome exists for its time evolution, it fissions. Thus there is a branching tree of correlations records. As Everett states “... with each succeeding observation (or interaction), the observer state "branches" into a number of different states.” (1957, p. 459).

At any specific moment, the universe superposition defines the linear dynamics, the linear time evolution of the physical environment, and thus the range or spectrum of possible next moments. At the level of information process, this is all part of the definition of a single specific experiential moment, in which the functional identity of the observer, the record of observations, is the determinant for this specific universe superposition. As an extrapolation of this linear dynamics, all of the possible new states of the individual exist in superposition or mixture at the physical level, and thus all of the possible new correlations that could be added to the definition of the observer are defined in the linear dynamics of this physical system, the effective physical environment.

At the logical level of information, each specific, different addition of a new correlation to the determinant results in a different discrete and singular determinant. Each determinant defines a different effective physical environment, the universe superposition for this version of the individual at the next moment, and the cycle begins again. Each such universe superposition defines the linear time evolution of the universe superposition for this version of the individual at this moment, and so on. This iterative loop is the exercise of the collapse dynamics, a transtemporal sequence within the unchanging overall linear dynamics of the no-collapse universe, giving rise to a branching tree of experientially singular and discrete determinants, each defining the determinacy of a different physical environment, the effective physical environment for that version of the observer.

This collapse dynamics is an information process, the progressive change of the definition of the observer, the determinant of the physical environment, resulting in the change of the effective physical environment of this observer. Thus, objectively, there is no collapse; there is only the appearance of collapse as Everett holds, and only subjectively, in the functional frame of reference of this observer. Objectively, all possible versions of the world are subsumed in the overall unitary

linear dynamics. Subjectively, the reality is a sequence of determinate observations. Thus, as Everett states, "... the formal theory is objectively continuous and causal, while subjectively discontinuous and probabilistic." (1973, p. 9).

5.1 Operational Levels

The level of operation of the experiential reality defined by the record of observations is an information process at a different logical level to the wave equation and the linear dynamics, and following different rules of logical operation, at least in regard to location and superposition. It is at this logical level that there is collapse, the change to the effective linear dynamics. Thus, while the collapse dynamics is incompatible with the linear dynamics, it operates at a different logical level to the physical, the logical level of the linear dynamics. On this view, the linear dynamics is the dynamics of the physical reality, and the collapse dynamics is the dynamics of the experiential reality: respectively objective and subjective reality. They are not alternative dynamics operating in the same context; they are simply the time evolution of the same system at different logical levels. To illustrate this, Barrett's classic example (1998) is examined from both perspectives.

When an observer O goes to measure the x-spin of a physical system S that begins in a superposition of x-spin eigenstates, the initial condition of the physical system to be measured is indeterminate.

$$|\text{“ready”}\rangle_O \, (\alpha \, |\text{x-spin up}\rangle_S + \beta \, |\text{x-spin down}\rangle_S)$$

The cumulative correlations record defines the functional identity of the observer, to which will be added either the observation of x-spin up or x-spin down. Objectively, as regards the entire Everettian universe immediately after the observation, the two possible results are simultaneously existent and superimposed, as are the two physical variants of the observer. No collapse has occurred. This is the time evolution of the overall linear dynamics.

$$\alpha \, |\text{“spin up”}\rangle_O \; |\text{x-spin up}\rangle_S + \beta \, |\text{“spin down”}\rangle_O \; |\text{x-spin down}\rangle_S$$

This is the objective perspective; if the observer is Wigner's friend then this is his definition as far as Wigner is concerned before he enters the room.[8] Subjectively, however, meaning from the perspective of Wigner's friend in the room, each of these superimposed situations instantiates a different identity of the observer, and each one is singular and monovalent. The correlations record of the first situation has fissioned to become two different correlations records, giving rise to the definitions of two different variations of the observer, one the initial identity of the

8 Even if the superposition becomes a mixture, due to decoherence, in Wigner's functional frame of reference, the world is effectively a superposition of these mixed states, since there is an identical copy of his world hologram in worlds corresponding to both states. This remains so until he observes the result of the experiment.

observer plus the observation x-spin up, and other the initial identity plus the observation x-spin down. These two different correlations records exist in two different functional frames of reference. Objectively the two slightly different versions of the physical environment are superimposed, but subjectively, meaning in the functional frame of reference of each of the individual entities defined by each of the two different correlations records, there is a single determinate version of the physical environment, in which a specific singular observation has just taken place. This provides exactly the outcome predicted by the standard von Neumann-Dirac collapse formulation, which is that the quantum-mechanical state of the system will collapse either to

$$|\text{“spin up”}\rangle_O \; |\text{x-spin up}\rangle_S$$

or to

$$|\text{“spin down”}\rangle_O \; |\text{x-spin down}\rangle_S$$

which, subjectively, in the functional frame of reference of Wigner's friend, is exactly what it does. Subjectively, one or the other happens, as the observer defined by the correlations record fissions, and in the functional frame of reference of each of the resulting versions of the observer there is a specific determinate result. Two different versions of Wigner's friend each experience a specific, different, determinate result to the measurement. At the operational level of information structures there are two different results of the observation, thus two parallel situations exist. In each of the two parallel situations the observer has made a determinate observation, and the resulting cumulative correlations record is the determinant for a new universe superposition which defines a new linear dynamics as a result, different in each case.

5.2 The Relational Transtemporal Perspective

Like the universe proposed on early interpretations of quantum theory, the physical environment defined solely by correlations is indeterminate except where observed. In a physical environment with multiple observers of equal status, this is a severe problem, since it requires an explanation of how mere observation affects the global, and presumably physical, definition of the world, but in a relativised quantum mechanics, observation changes only the functional frame of reference of only a single observer. Moreover, while the concept of observation changing the physical world has naturally been viewed with considerable scepticism, on this view there is no objective physical effect at all. It is only the functional frame of reference of the observer which changes, a shift in the individual view of the overall linear dynamics of the Everettian universe. As Everett states:

> *... 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; his italics)

Objectively, observation does not make any difference to the physical situation whatsoever. Subjectively, meaning in the functional frame of reference of the observer, it results in determinacy of the effective physical environment, because it changes the determinant. In the new definition of the functional frame of reference, a new correlation is defined, and thus determinacy exists where before there was indeterminacy. This is not a physical change but a change in perspective, a change in the position of the viewpoint taken, and thus a consequent change in the effective environment. This is now the environment of the observer having made that observation and added that correlation to the definition of the determinant. This is the perspective of the observer in a different version of the world, a different position in the overall reality of the universe of the unitary wave function. Naturally, the observer does not actually change position. Neither the observer defined as the body nor as the world hologram change in any way. This is the slightly different perspective of a slightly different version of the observer. Nothing changes position except the functional frame of reference. This provides the appearance of collapse at the physical level, in a no-collapse universe, since the functional frame of reference of the correlations record is, at each point in the time evolution, the universe superposition defined by the determinant, the effective physical environment. This is the collapse dynamics as an information process, operating at a different logical level to the linear dynamics of the physical. This is the process of observation; it is an information process.

The measurement problem is dissolved by taking transtemporal experiential reality to be an information process, the exercise of the collapse dynamics, taking place at a different logical level to the physical. The layout of the physical universe is defined by the unchanging overall linear dynamics, and the shifting viewpoint of the observer is defined solely by the cumulative correlations record, giving rise to the appearance of collapse with the addition of each new correlation. Thus, there is on this view no such thing as collapse at the objective physical level, only the subjective appearance of collapse in the functional frame of reference of the observer, as on Everett's interpretation: a transition from one definition of the frame of reference to another, as the observation is added to the functional identity.

6 Multisolipsism

Given universe superposition, each functional identity is in a unique frame of reference, and, as in Rovelli's Relational Quantum Mechanics, the physical environment in the functional frame of reference of the observer is determinate only where observed. Since different observers inevitably make different observations, this equates to personal parallel realities at the physical level, different effective universes for each observer. This, however, is not only entirely in accord with the known physics, it is directly implied. As Rovelli states:

> ... a quantum mechanical description of a certain system (state and/or values of physical quantities) cannot be taken as an "absolute" (observer independent) description of reality, but rather as a formalization, or codification, of properties of a system relative to a given observer. (1996, p. 6)

Remarkably, not only can observers have different accounts of the same events, they can compare their accounts without contradiction:

> ... the comparison does not lead to contradiction, *because the comparison is itself a physical process that must be understood in the context of quantum mechanics* (Laudisa & Rovelli, 2002; their italics)

Thus, although two observers can have different accounts of the same events, because in one system the result of an observation is determinate and in another it is not, when one goes to find out the state of the system for the other, the discovery of this information is a new observation in the functional frame of reference of the observer acquiring the information. Wigner's discovery of the result of the experiment, and the corresponding state of his friend, is the observation that makes these states determinate in his frame of reference. Thus quantum mechanics accommodates each individual being in a personal physical parallel reality. Given Everett's definition of the observer, in the context of universe superposition, this is completely inevitable: each observer is in a different, unique version of the effective physical environment, because each individual is the sole determinant for their specific version of of the determinacy of the physical reality.

We encounter each other in physical reality, and thus it seems entirely obvious that we are all in the same physical reality. However, in each individual reality, other observers are, like any other property of the reality, highly indeterminate. Functionally, the presence of other observers in the personal reality can best be understood as the presence of icons, in the observer's reality, of other observers: each one experiencing a different universe superposition, a personal parallel reality. This explains how one is able to encounter other people, in the reality one is in, despite their being in parallel realities. The people one encounters are icons, 'avatars' of the other observers, in one's personal reality. The observers themselves are in their own realities, while the overall domain we are all in is the Everettian universe. Each avatar icon is that much of the other observer which is determinate in one's own reality, as a result of correlations formed with that observer.

The situation is subjectively solipsistic. In the functional frame of reference of the observer, the world is determinate only where defined by correlations with this observer, who thus holds a very different status to other observers perceived in their reality. Objectively, however, it is the exact opposite, in that all observers are inherently of equal status. All observers are inherently equally real, each in a personal parallel reality. This is a many worlds situation where each world is a personal, solipsistic universe superposition. It's multisolipsism!

7 Conclusion

Taking Everett literally, the universe is a simultaneity of all possible worlds: possible versions of the physical environment, each one a determinate world at the macroscopic level due to decoherence. Coupled with his definition of the functional definition of the observer as the record of observations, a structure of information, multiple realisability means that the effective physical environment of each individual observer is the simultaneity of all possible versions of determinacy of the world concomitant with the existence of this observer, a 'universe superposition'. The environment is thus determinate solely where defined by the record of observations, the record of correlations with the environment, and otherwise indeterminate, as in Rovelli's Relational Quantum Mechanics.

On this view, the transtemporal time evolution of the effective physical environment is purely subjective, meaning there is only the appearance of collapse, as Everett states. The process of observation is an information process: the addition of observations to the state of the memory, causing a change in the functional frame of reference defined by the correlations record. Naturally, the frames of reference are instantiated in the physical, but the process is not a physical process. It can best be understood as the sequential access of different functional frames of reference, in the array defined by the unitary linear dynamics: an information process.

Subjectively, meaning in the functional frame of reference of the observer, this information process is the experience of the making of observations, which results in the changing of the world hologram of the observer. From the point of view of the observer, the effective physical environment changes, because the correlations record changes, and thus the universe superposition changes. The result is transtemporal reality, a sequence of physical, four-dimensional, space-time environments; and the progressive change is the appearance of collapse in Everett's formulation, for an observer with a functional identity defined as the state of the memory.

It has always seemed possible that the physical reality collapses on observation, but there are many problems with this concept, not least of which is that a non-physical event triggers a change in the fundamental physical definition of the environment. In a personal parallel reality of this nature, as in any relational quantum mechanics, the making of the observation *is* the change to the definition of the effective physical environment, since the determinacy of the environment is defined solely by the cumulative record of observations. The observations define an interface with the rest of the universe, of precisely the type defined by the holographic principle. Beyond the limits of this definition is total indeterminacy, the totality of the Everettian no-collapse universe of the unitary wave function.

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