

Multisolipsism

Universe Superposition

Relational Quantum Mechanics

and

The Reality of the No-Collapse Universe

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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 universe in which a specific observer could exist, and in the universe of the unitary wave function they are all existing and coincident. If these different versions of the universe are superposed, the effective universe in the functional frame of reference of this observer would be highly indeterminate, since every possible variation of the universe 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 a collapse dynamics applies only to the functional frame of reference of the observer and raises no incompatibility with the linear dynamics.

1 Introduction

On the view presented here a relational quantum mechanics is a direct consequence of the Everettian formulation. Depending on how the observer is defined, identical copies of the observer may well occur in more than one of the 'many worlds' of a no-collapse context. 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.

If the observer is defined as a physical body in the ordinary way this does not apply since a physical body is entangled with its specific environment, thus even apparently identical observers are not identical at the quantum level. However, while Everett proposes an automatically functioning machine as a model of an observer, he considers the state of the memory of this automaton to be the functional identity; it is from the perspective of this identity that there is the appearance of collapse in the no-collapse universe. For the observer defined in this way, as a structure of information, this 'universe superposition' must apply; such an observer is ubiquitously present in many different versions of the world, thus the physical environment of such an observer is the effective superposition of all of them.

Universe superposition is a philosophical device not a causal explanation, it is a metaphor for the unlocalised nature of the Everettian universe, with respect to which indexical version of the world an observer is in, for an observer simultaneously present in many such versions. 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 this gives rise to personal parallel realities for observers, and although this relational view is a far cry from our accustomed view of the world it resolves a number of traditional interpretational difficulties with quantum mechanics while at the same time being ontologically parsimonious. Given Everett's functional definition of the observer 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. (1996,7)

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. Rovelli's central message is that 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 Einstein's special relativity. Unsurprisingly, such relational interpretations are entirely compatible with relativity, the different frames of reference of observers in relativity being simply the different frames of reference in quantum mechanics also.

A relational quantum mechanics is based on correlations, thus the determinacy of the effective reality of each observer is defined by the correlations record, a structure of information. In this kind of interpretation the transtemporal reality is an information process, and operates at a different logical level to the physical. This perspective explains the mechanism of Everett's appearance of collapse 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; 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 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. (5,2003)

2 The Everettian Observer

Although Everett describes a physical entity as a model of an observer, a mechanical automaton, he makes the 'function of 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. (1957,457)

Thus the functional identity of the observer is defined solely by the memory contents, a structure of information. Additionally, it is solely 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 by 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. (462)

The sequence of states of the memory describes a subjective collapse of the wave function in a static no-collapse environment, thus for an observer defined as the state of the memory Everett's formulation clearly describes an environment in which there is the subjective appearance of collapse for this observer in the no-collapse universe. This experiential definition of the observer may seem a very inadequate concept to satisfactorily define the complexity of the mind of a human observer, let alone the physical entity one naturally considers oneself to be, however, as will be shown, this definition fully defines both the functional definition of the mind and the determinacy of the physical body of the observer in an Everettian no-collapse domain.

3 Universe Superposition

Following Vaidman (2002) 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*”, 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 the 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 a real identical copy of oneself existing in each such world. Furthermore, as Deutsch explains there is no question about which of these copies one actually is, one is all of them;¹

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, 279)

Taking Everett's no-collapse formulation literally, every possible world exists, and the universe is a simultaneity of all possible worlds. This means that all of the identical copies of an observer are existent and coincident. 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 state of the physical environment, defined by a specific wave function.² 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 superposition of all of the wave functions defining these worlds.

This concept cannot apply to the observer as traditionally defined, as a physical entity, because decoherence ensures that each ostensibly³ identical copy of the body of the observer is quantum entangled with a different world, and thus at the quantum level they are not identical; this is the only basis on which they can be said to be in different physical environments in the Everettian simultaneity of all possible worlds. However, all these ostensibly identical copies are experientially identical, all of these bodies are making the same identical observation of the present moment, and have 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, in the functional frame of reference of this observer, the effective physical environment is a superposition of all of them. This is a relative or perspectival world, such as

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

2 Even if the world is considered to be determinate only with respect to the macroscopic objects it is still defined by a specific wave function, that resulting in the superposition of all wave functions defining worlds which have this macroscopic definition.

3 Meaning identical apart from the world with which it is quantum entangled.

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; since this is an effective superposition of every possible world in which this observer exists, only the observer herself, 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. Thus the Everettian observer defines a physical universe, by virtue of being the referent for the universe superposition, although the definition has only the level of resolution of sensory experience .

The subjective 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, as a mathematical structure of information, being instantiated in a large number of coincident versions of the physical environment, and thus the effective functional frame of reference of this mathematical structure of information is the effective superposition of all of them. In the Everettian no-collapse universe, as in any kind of many worlds interpretation, there exists an indexical array of versions of determinacy of the world, and this effective superposition is simply the result of an observer, defined as a structure of information, being unlocalised with respect to which indexical 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 of these worlds. Nonetheless, the physical environment of the observer, the effective superposition, is defined by the superposition of all of the wave functions defining these worlds. It is thus highly indeterminate, even at the macroscopic level. Although the definition has only the level of resolution of sensory experience, the effective environment defined is nonetheless a physical quantum domain, and thus the physical environment is determinate only to the level of resolution of the observations made. 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.

3.1 Logical Levels

While a specific physical body is part of a specific physical environment or world, a specific indexical sector of the universe 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 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 a definition of location in space and time.⁴ Since every ostensibly identical copy of the body must have identically the same record of observations, and make identically the same observations, the extrinsic location of the Everettian observer is identically the same with respect to location in space-time, in every indexical world in which it is instantiated. However, indexical location with respect to which world the body is in, is unknown and unknowable, thus the Everettian observer can have no definition of extrinsic location with regard to the indexical location in the universe, meaning which world a specific body, in which it is instantiated, is in. Since the extrinsic location defined by the record of observations is defined solely with regard to location in space-time, the same identical Everettian observer, with the same identical extrinsic space-time location, is present in all indexical worlds in which it is instantiated.

The Everettian observer, a mathematical structure of information, is present ubiquitously in all instantiations, and the functional frame of reference of this Everettian observer is the simultaneity of all of them. Thus subjectively, from the perspective of this observer, it exists simultaneously in all of these worlds in which it is instantiated; all of them are coincident in space-time, in the same overall universe defined by the unitary wave function, and the effective physical environment is the subjective superposition of all of them. Thus a naturally occurring difference in quantum definition between the subjective and objective frames of reference arises. Subjectively, the functional frame of reference of the observer is the universe superposition, defined at the quantum level by the superposition of the wave functions of all of the possible variations of a world instantiating this observer. This is the effective physical environment of this

⁴ More correctly, the observations of many observers would constitute only an indication of location, only once the observations included the findings of modern cosmology could it be said they constituted a definition of location in any absolute sense.

observer, and it is highly indeterminate. The objective frame of reference by contrast is usually taken to be a specific determinate world, the matter and energy making up a well-defined physical environment, determinate to a fine level of quantum detail due to decoherence.⁵

The experiential definition of the observer seems somewhat obviously to be a phenomenon subsidiary to the physical entity one ordinarily identifies with, but in Everett the physical form is a superposition of multiple versions of the observer, only at the experiential level is there determinacy. As he states

... 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. (1973,10)

Only subjectively, from the perspective of the observer as a structure of information, is there effective collapse.

4 The World Hologram

As with the mechanical automaton, observations are added to the memory of a human observer to form records of events, but they are also utilised as the basis of a complex functionality of a quite different order to this basic recording mechanism: they are integrated into an accessible map or model of the environment, which then becomes the basis of intelligent operation in the world. This inner representation of the environment 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 observations⁶. The observation of the present moment is the immediate and lucid

5 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.

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

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 the world hologram as the cumulative integrated record of the sequence of observations⁷.

This division of a part of the mind is not arbitrary, this is the operational level of subjective experience, 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.

4.1 The Experiential Interface

It could be considered that drawing a line between the world hologram and the rest of the mind is not a credible distinction, but we all have 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 just the same way as the output of the neural system representing images of sensory data. Naturally, some observations are taken in subliminally, thus aspects of the world are recorded although not consciously noticed in the sensorium, thus observation will be taken here simply to mean any sensory formulation of external or internal processes recorded in the neural network.

As the integrated record of the observations of the observer, the world hologram fits Everett's concept of the functional identity of the observer precisely. Since in Everett it is solely the contents of the memory that defines the functionality of the machine, 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 sensory information and machine configuration. It is 'the state of the memory', the record of all observations, here the state of the world hologram, according to which the probabilistic formulations are upheld in a no-collapse situation.

⁷ 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 would not be observed unless the observer experienced their effect, and thus would not necessarily be part of the world hologram.

4.2 Self Identity

This definition of the observer naturally subsumes the ordinary experiential identity, the self image which defines everything one knows oneself to be. The physical self image, the mental picture one holds of one's physical self, is built up from observations of oneself, and as such it is part of the world hologram.⁸ This self image is the integrated sum of all of the observations one has made of oneself. One observes the body not only externally in mirrors but internally through proprioception and enteroception, and all these observations are added to the self image figure in the world hologram, the self identity. These observations, however, are all one actually knows of one's body. Just as the world hologram is the known world, the self image is the known physical self, a mental construct formed from observations. One identifies with the body as a whole, but one knows only that much of the body one has observed.

In the same way, the self image holds a representation of one's mental nature and characteristics, and this is all part of the self identity figure in the world hologram also. As with the body, while one is aware of being a thinking, feeling entity, a mind in a body, one does not know the whole of one's mind. Neural network patterns are altered with each neural impulse, and associations and ingrained responses are built up as a result. The vast majority of this information is unknown by the individual; what one knows are all the mental properties one experiences, such as thoughts, feelings, memories and expectations, all of which are observations and are added to the self identity in the world hologram.

4.3 The Body of Information

In the subjective functional frame of reference of the world hologram, the centered world of the observer, the physical world is highly indeterminate, and this applies even to the body of the observer. The world hologram exists not only in all of the ostensibly identical copies of the body of the observer, it exists in the bodies of observers where the structure of the body is slightly different, but that difference does not impact the definition of the world hologram. The layout of the specific pathways of minor blood vessels interior to the body of a given observer, for instance, could be in any number of different configurations. In the universe of the unitary wave function every different variation of this observer exists, thus variations with the same world hologram but different configurations of these blood vessels exist. The same is true for every physical variation of the body

⁸ Naturally enough, it is the central figure in this concept of the world, but this central figure is far more immediately obvious to some individuals than to others. Some people have a full and precise view of their appearance and 'see themselves in the picture' of their experience of reality a all times, while others just see the reality in front of them. All individuals, however, have a detailed body image in the subconscious, this physical sense of self is fundamental to self identity.

possible with the same world hologram, variations embodying physical distinctions of aspects of the body which have not been experienced, and thus have not impacted the world hologram. By the same reasoning as before, there is one world hologram which is in all of these bodies, and in the Everettian universe they are all coincident; subjectively, from the perspective of this world hologram, reality is a universe superposition in which all these bodies are effectively superposed. Thus not only is the majority of the physical world indeterminate but the majority of the fine detail of the structure of the body is indeterminate also.

Calling the world hologram the observer may seem like a step away from physical realism, but this world hologram does not exist in vacuo; while objectively it is a pattern of information instantiated in a very large number of bodies, subjectively it exists in and is part of a real and specific physical body, the superposed sum of all of the bodies in which this world hologram exists. In other words, that much of the body which is known and represented in the self image is determinate, and it is only this which is determinate. Thus the world hologram contains the definition of the determinacy of the physical body, and the self image defines the fully accurate and correct identity of the body of the observer.

The same principle applies to the mind. The world hologram exists not only in all of the bodies of observers which have the same identical mind, it exists also in the bodies of observers in which the mind is slightly different, but the world hologram is identically the same; they have the same record of observations, both of the physical world, and of the output of all the mental processes of the body-mind; and as before, the effective physical environment is the superposition of all of the worlds containing this world hologram. Thus from the experiential perspective, the perspective of the observer as defined by the world hologram, only that much of the mind as has been observed is determinate, and all else is indeterminate. Only those mental properties which have been observed are determinate, and these are part of the world hologram, which thus contains the definition of the determinacy of the mind. The self identity is therefore a full and accurate definition of the whole of the body-mind of the observer, including the determinacy of the psychological identity, and all else is indeterminate.

A world determinate only where observed is a well-aided idea, though none the less counter-intuitive for that. That one's very body-mind should be determinate only where observed is a natural extension of this concept, but certainly a significant degree stranger. However, it helps to note that the body-mind, like the world, is not 'not there' where not observed: the reality is all possibilities, except where observed, it is a fullness not an emptiness. Thus despite the fact that this definition of identity is vague about the details of the body and the specifics of much of the mind, the individual is a person who does have all these properties, even if they are not precisely defined and determinate in the world hologram. Just as the physical environment effectively collapses where observed, so too does the body-mind of the observer, acquiring specificity where experienced.

5 Relational Quantum Mechanics

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. A very similar definition of a functional frame of reference is produced by considering correlations at the physical level. As the physical body interacts with the environment, correlations are established, and the body acts as a repository for this information. The resulting structure of information is a cumulative record of the correlations. As with the world hologram, the cumulative correlations record as a *ding an sich* is a structure of information which exists ubiquitously in all of the worlds in which it is instantiated, and all are coincident. Thus the functional frame of reference in which it exists is the effective superposition of all of the worlds instantiating it.⁹ This equates to Rovelli's Relational Quantum Mechanics.

In Relational Quantum Mechanics the environment system is defined solely by the physical correlations established with the environment. As Rovelli emphasises, "Correlation is "information"..." (1996,9), and it is solely the cumulative sum of this information that defines the determinacy of the effective environment system. As he states "a complete description of the world is exhausted by the relevant information that systems have about each other." (16). Thus the physical environment is determinate where defined by the record of correlations, and otherwise indeterminate. If one considers the memory of the observer to be a record of observations in the widest possible sense, meaning correlations formed with the environment by any physical object, as on Rovelli's view ¹⁰, then the physical correlations record is the state of the memory of that object, and fits Everett's concept of the observer precisely also. This is the state of the memory defining the observations at the physical level, while the world hologram is the state of the memory defining the observations at the experiential level.

9 As before, this is simply a metaphor for the natural state of the Everettian no-collapse universe. The physical functional frame of reference of this structure of information is the simultaneity of all of the versions of the physical universe in which it is instantiated, defined by the superposition of all of their wave functions.

10 "By using the word "observer" I do not make any reference to conscious, animate, or computing, or in any other manner special, system. ... the observer can be a table lamp." (1996,3)

5.1 The Physical World Hologram

The world of which the determinacy is defined by the physical correlations record is the familiar domain of the world hologram, though defined at the quantum level instead of just the level of sensory experience. This world must naturally be determinate about everything defined in the world hologram, since the world hologram is the record of a subset of the correlations made with the environment: everything observed at the sensory level must have been interacted with, but not everything that is interacted with is observed at the sensory level. The physical correlations record includes the definition of quantum interactions with the environment, and is thus of a very much higher level of resolution. Nonetheless, no greater extent of the world is defined topographically: observation at the physical level extends no further than observation at the sensory level. Naturally, each quantum interaction results in entanglement with the environment, and thus the body of the observer engaging in that interaction is determinately part of a specific version of the physical world. However, the correlations record is a structure of information present in every version of the physical world in which the identical interaction took place, and the functional frame of reference of this structure of information is therefore the effective superposition of all of them. Given a functional frame of reference defined by a structure of information a universe superposition situation is automatically established. The functional frame of reference of the observer defined by a specific correlations record is indeterminate except where defined by this structure of information, since all possible variations of those aspects of the world not defined by these correlations are effectively superposed.

5.2 The Body As Observer

Applying the concept of universe superposition to the physical correlations record produces a physical environment defined solely by the correlations record, as in Rovelli's theory, but the definition of the observer is peculiar. While the correlations record defines that much of the body of the observer as has interacted with the environment, it leaves undefined aspects of the observer observed internally. The observer would thus be defined in the same way as Rovelli's table lamp, being determinate where it had interacted with the environment and otherwise indeterminate. Naturally this leaves something to be desired as a full description of the conscious observer. What is defined and determinate is just a shell, a physical structure with no definition of the inner workings of a specific mind. Objectively it is a zombie, a mindless hulk. Subjectively, however, this body is home to every possible experiential identity, every possible world hologram that could be instantiated in this body with this definition of interactions with the environment. Each of these different versions of the world hologram is identically the same with respect to the physical environment, and that much of the physical body as has interacted with the outside world, being simply the

sensory version of the physical correlations record with regard to the environment. But each of these different world holograms, while defining the same 'externally identical' body and physical environment, has a different record of the self identity with regard to the mind, defining different versions of the observer with respect to the psychology, inner experiences, values, criteria and beliefs. Objectively, the mind of this body is the superposition of all of these different definitions, and thus the mind is indeterminate except where defined by physical interactions with the environment; hence a mindless hulk.

6 The Dynamics

The concept of universe superposition thus applies at two different logical levels of definition of the observer-environment combination, the experiential and the physical. Both are defined by a structure of information and both conform to Everett's view. In both cases, to make an observation is to make the transition from one moment to the next. This is an information process and potentially it can take place in a static physical domain, all that is required is for the functional frame of reference to change from one moment to the next; the nature of this process is addressed in a further paper, *Transtemporal Phenomenal Consciousness* (2009). This provides the explanatory principle for a genuinely transtemporal reality, and explains why the experiential level of reality is the only one operationally viable in this transtemporal context. The experiential level is therefore the main focus of the following, but it applies equally to both logical levels.

The time evolution of the cumulative correlations record is logically elementary, being the sequential addition of new correlations to the structure of information. 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." (1957,459).

At any specific moment the universe superposition defines the linear dynamics of the physical environment, and thus the range or spectrum of possible next moments, the time evolution of the physical environment. As an extrapolation of this linear dynamics, all of the possible new states of the individual exist in mixture or superposition 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 level of information process this is all part of the definition of a single specific subjective moment, in which the observer is the referent for a specific universe superposition.

At the operational level of information, each specific, different addition of a new correlation to the referent results in a different discrete and singular referent. Each referent defines the determinacy of a different effective physical environment, the universe superposition of this version of the individual at the next moment, and the cycle begins again; each such universe superposition defines the spectrum of possible next moments 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 subjectively singular and discrete referents, 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 referent for the determinacy 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 subjective appearance of collapse as Everett holds. Objectively, all possible versions and moments 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.” (1973,9).

6.1 Operational Levels

The level of operation of the subjective reality is here 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. This is the logical level of the collapse dynamics, the change to the linear dynamics. Thus while the collapse dynamics inherent to the reality of the correlations record 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 objective physical reality, and the collapse dynamics is the dynamics of the subjective reality; they are not alternative dynamics operating in the same context, they are simply the time evolution of the same system at different operational 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.

$$|\text{“ready”}\rangle O (\alpha|x\text{-spin up}\rangle S + \beta |x\text{-spin down}\rangle S)$$

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, as are the two physical variants of the observer, no collapse has occurred. This is the time evolution of the overall linear dynamics.

$$\alpha|\text{“spin up”}\rangle O |x\text{-spin up}\rangle S + \beta |\text{“spin down”}\rangle O |x\text{-spin down}\rangle S$$

This is the objective perspective; if the observer is Wigner's friend then this is her definition as far as Wigner is concerned before he enters the room.¹¹ Subjectively, however, each of these superposed situations instantiates a different identity of the observer, and subjectively they are 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 observer plus the observation x-spin up, and other the initial identity of the observer 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 superposed, but subjectively, meaning in the functional frame of reference of the each 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

$$|\text{“spin up”}\rangle O |x\text{-spin up}\rangle S$$

or to

$$|\text{“spin down”}\rangle O |x\text{-spin down}\rangle S$$

which, subjectively, 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, 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 referent for a new universe superposition which defines a new linear dynamics as a result, different in each case.

11 While decoherence eliminates the superposition in the linear dynamics almost instantly under the majority of situations, in Wigner's functional frame of reference the linear dynamics defines a superposition of these states, since there is an identical copy of his world hologram in worlds corresponding to both states, and remains so unless and until he makes an observation of the result of the experiment.

6.2 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 physical 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, an indexical shift in the overall linear dynamics of the Everettian universe. Objectively, observation does not make any difference to the physical situation whatsoever. Subjectively, in the functional frame of reference of the observer, it results in determinacy of the effective physical environment because it changes the referent. In the new definition of the functional frame of reference a new correlation is defined, and thus determinacy exists where before there was indeterminacy, and a new linear dynamics is defined as a result. 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 referent. This is the perspective of the observer from a different indexical position in the overall reality of the universe of the unitary wave function. Naturally the observer does not actually change position, indeed, neither the observer defined as the body or 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 subjective 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 referent, 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.

6.3 Transtemporal Phenomenal Consciousness

The remaining problem is that there seems to be no mechanism whereby this information process might be enacted, other than the physical interactions of the quanta of the universe, but this leads straight to the heart of the measurement problem; what is the basis on which the physical interactions are defined, and to which the collapse dynamics applies? On the view presented here the collapse dynamics operates at a different logical level, but since this information process is of course instantiated in the physical it seems difficult to argue that this is fundamentally anything other than a physical process.

An analysis of the logical type of the process produces a simple solution. For something to be in a position to change the functional frame of reference in a static no-collapse universe, it would have to be to the array of possible functional frames of reference as the whole of a working computer system is to the array of memory. The metaphor is straightforward, only a working computer system as a whole can change a pointer to an address in memory from one address to another. Similarly, it is proposed, only the entire physical system as a unitary whole can change the operational frame of reference from one functional frame of reference to another. This is not to suggest that the universe system we find ourselves in is a giant computer, only that the operational logical type of the collapse dynamics must be a property of the unitary system as a whole, since only the system as a whole is in the correct logical relationship to the indexical array of functional frames of reference to be able to bring about a change of the point of reference from one to another. To make an observation is an inherently transtemporal process, it is to change the definition of the structure of information defining the observer, and thus to pass from one functional frame of reference in the indexical array to another. This can only be enacted by something 'outside' of the array, and since there is no 'outside' of the universe the process can only be an emergent property of the unitary system as a whole. This is a very brief summary of the concept of Transtemporal Phenomenal Consciousness, which also concludes that the phenomenal consciousness of an observer is the epiphenomenon of this process, hence the title. This solution is in essence meta-physical, but invokes only an emergent property of the system as a whole, the Everettian universe as multiverse, a system for which we already have evidence; as Deutsch states “The evidence that other universes exist is at least as strong as the evidence for pterodactyls or quarks” (1996,227). That such a system could have emergent properties is trivial, and it is inevitable that an emergent property of this kind must be responsible if there is to be any change in a no-collapse and hence static environment.

6.4 The Measurement Problem

On this view the measurement problem is resolved by taking subjective reality to be an information process, the exercise of the collapse dynamics taking place at a different logical level to the physical. The two quantum mechanical dynamics are incompatible but the reason is straightforward, they are simply the different dynamics of the different operational levels of the same system. 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 on this view there is no such thing as collapse at the objective physical level, only the subjective appearance of collapse, as on Everett's interpretation. The linear dynamics is the dynamics of objective reality, applicable both to the overall physical definition of the universe and to the effective physical environment of a given observer at a specific moment. The collapse dynamics is

the subjective change of the linear dynamics of the functional frame of reference of that observer, the appearance of physical collapse.

7 Multisolipsism

The body is the obvious identity for an observer, but in a no-collapse universe it cannot be the basis of transtemporal identity. While we obviously are bodies, an even more fundamental sense of identity and existence is the subjective life of each person, the stream of consciousness, the flow of observations and the experience of the process of reality. On the view presented here the experiential level is fundamental, on equal footing with the physical. Each individual observer is a transtemporal information process in the overall system; one defining at each point in time the subjectively effective determinacy of the physical environment of that observer, including the body-mind.

Relational Quantum Mechanics equates to personal parallel realities, different effective universes for each observer; 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)

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 comparison is a new observation in the functional frame of reference of the observer making the comparison. This is true at the experiential level in the same way as it is true at the physical level in Relational Quantum Mechanics. Thus each individual is in a personal physical parallel reality, each observer being in a different personal version of the effective physical environment, because each individual is the sole referent for a specific version of of the determinacy of the physical reality. 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. (1996,6)

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 this reality, of other subjective realities, each one representing another subjective 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 people, the people themselves being in their own realities; the overall domain we are all in being 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 that the world is determinate only where defined by correlations with the 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 acknowledged as 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!

8 Conclusion

Taking Everett literally, the functional identity of the observer is a structure of information and quantum mechanics is relational. The effective physical environment of each individual observer is the 'universe superposition', the simultaneity of all of the possible versions of determinacy of the world concomitant with the existence of the observer defined by a specific record of correlations with the environment. The environment is thus determinate where defined by the correlations record and otherwise indeterminate. This certainly entails a major departure from the assumptions of generations of scientific inquiry as this equates to personal parallel realities. The system is very minimal, however, requiring only the unitary wave function as an indexical array of functional frames of reference, and an emergent property of the unitary system that changes the point of reference from one to another. Deutsch (1997) states categorically that there can be no passage of time in a quantum environment, and at the physical level this is indisputable, thus the only possible implementation of collapse and change must be a process operating at a different logical level to the physical, an information process, and this process must operate in a context 'outside' or meta to the indexical array of physical frames of reference to which they refer.

On this view the unitary wave function is literally the no-collapse physical universe and the time evolution of the effective physical environment is purely subjective. The process of observation is an information process, the subjective addition of observations to the state of the memory causing a change in the functional frame of reference defined by the correlations record. Naturally this

process is instantiated in the physical, but the process is not a physical process, it is the sequential access of different functional frames of reference in the indexical array defined by the unitary linear dynamics. Subjectively this information process is the experience of the making of observations which results in the changing of the world hologram of the observer, including the change to the self concept of the observer; this is the experience of the observer and his world becoming one moment older in time. Objectively it is the changing of the referent, the world the world hologram defines, the universe superposition; this is transtemporal reality in a physical, four-dimensional, space-time environment, 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; each observer is defined solely by the cumulative correlations record, and defines the determinacy of their reality.

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, as in the holographic principle of 't Hooft's Dimensional Reduction in Quantum Gravity (1993). According to this principle there is no more definition to reality in the volume behind the interface with the environment system than that which is defined by the interface, the observed surface of the environment system. In a world with many observers this is difficult to interpret, but in a personal parallel reality this interface is exactly what is defined by the correlations record. According to the holographic principle there is no more definition to the region beyond the interface in that it is indeterminate, but this is simply a description of the Everettian universe in the reality of an individual observer. The holographic principle defines identically the same physical environment as does Everett's experiential definition of the observer. Beyond the limits of this definition is all possibilities, the totality of the Everettian universe.

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