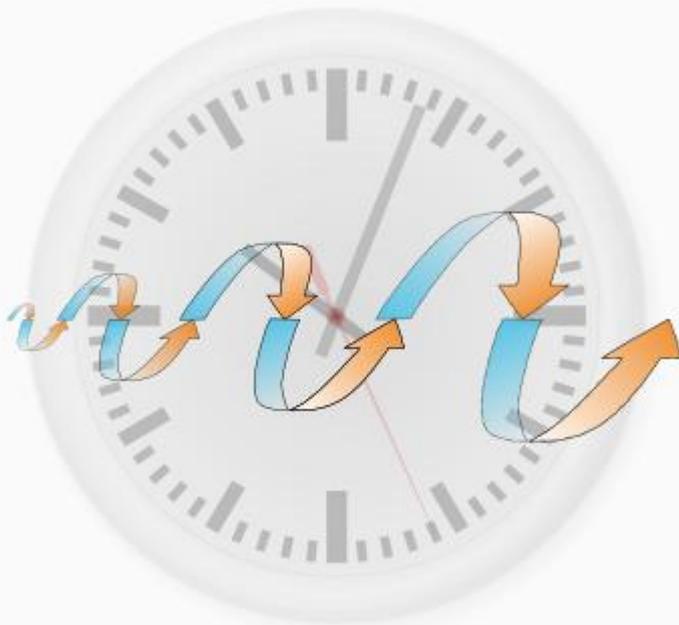


# It So Happens



A new view of  
reality based on  
the deepest  
findings of science

David Stringer

# It So Happens

A new description of reality that fits the deepest findings of science

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## Introduction

Ontology is a branch of philosophy that attempts to explain what the universe is made of. Any one such explanation is known as "an ontology." This book offers a new ontology, one based on science.

Science studies nature by methodical measurement and observation of its details. It is incredibly good at this, so good that one might think that there is nothing more that anyone could add. Yet when we ask big questions like: what is the universe made of and how does it all work, we find that there is something to be added.

What's missing is a top-down description of the universe, an ontology, that actually fits neatly with all the bottom-up empirically derived details that science provides. This is not a failing of science. It is simply not their role to seek ontologies and it is not a role they want to take on. It is the role of philosophers.

Of course, scientists have some views about the general workings of the universe but they have a multitude of such views that cannot be fitted together without raising paradoxes. When scientists explain big science to the public, on TV say, they talk of these paradoxes and refer to the "weird" behaviour of nature.

I have studied science all my adult life, professionally and as a hobby. I have worked through the difficult mathematics of quantum theory and relativity to be sure that I grasped the fine details that science has so successfully discovered. I came to the conclusion that the paradoxes and weirdness that scientists speak of are not due to any flaws in the theories of science. They are due to the absence of a top-level ontology that fits all the details of all the branches of science, from fundamental physics to cosmology and even psychology.

What follows is an ontology that I have developed over about fifteen years and will continue to develop. I am confident that it fits well with science. It also goes beyond science, as any ontology must, to cover aspects of the universe that we know exist yet have proved beyond science so far. I refer particularly to subjective experience, thought and consciousness.

This book presents a new ontology that fits science in a way that avoids the usual paradoxes and weirdness that arise when classical, relativistic and quantum science are brought together. No ontology can do this without a radical rethinking of what reality is.

# Enigmas

Any new ontology should offer solutions to the following big questions:

## *What's the matter?*

We cannot measure matter! In any quantum measurement, there is a quantum measurable (the thing being measured) and a measuring apparatus that is also fundamentally quantum. Measurement is a change in the state of an apparatus that occurs in response to a property of the measurable. In general, measurables can be objects or events. Which of these two are being measured in a quantum experiment?

If measurable and apparatus are made of matter particles, we can imagine the situation as being like the collision of billiard balls, one ball representing the measurable particle and the other representing a particle in the apparatus. We see the one ball approaching the other, a virtually instantaneous collision, then the two balls departing. The situation is quite different in a quantum measurement. Before the "collision" there is no incoming information from an approaching particle or wave. Likewise, after the collision, nothing is observed or measured departing. The apparent collision is all that there is. There has never been half a wave packet or a partially collapsed wave measured or observed; no moment when a part-wave, part-particle entity was detected. What is measured is an event in which we assume that two particles interacted even though we never measure any particle between its supposed interaction events. One measurement we can make between interaction events is measurement of a "particle's" force fields. But a field is an abstract concept, a potential, not matter in any sense. Measuring a field involves the measuring of force particles which, like the matter particles, yield no information except at their interaction events. So we still end up measuring events, not objects. If anything, measuring fields takes us even further away from measuring an actual particle of matter.

No quantum particle has ever been detected literally in-flight. We say that the very act of measuring it converts it, instantaneously, from travelling-wave to particle-with-momentum. What does it mean to say "with momentum?" Momentum is a classical concept. When we say that we measure quantum momentum, we mean that we measure something in a quantum experiment that corresponds in some way to classical momentum. This correspondence is valid in the case of large quantum numbers (very many particles) but not for individual quantum particles.

Before quantum physics, we assumed that it was possible to measure motion. Motion appeared to be the smoothly changing spatial location of objects with a continuous existence. Interestingly, our experience of seeing smoothly moving objects is a kind of illusion constructed by our brains. Our eyes see in a sequence of snap-shots which, unprocessed, would represent motion as objects jerking from one fixed location to the next, without a smooth transition. Our brains have given us a strong psychological bias toward the idea of smooth motion, one that is appropriate at our everyday scale but not at the subatomic scale of quantum events. The properties of a supposed interaction between a quantum particle (matter or force) and a particle of the measuring apparatus are static. The properties only change from one such measurement event to the next. They are not observed to be smoothly changing or continuously existing. The fact that we do not measure motion at the quantum scale, along with the knowledge that we have a strong bias towards believing in the concept of smooth motion, should make us question whether it really exists at all. If there is no smooth motion, there can be no matter particles undergoing motion.

If there are no matter particles, there must be something else that makes the causal links between related events but it does not have to be anything that moves. It could be, for instance, a feature of an underlying or implicate process that produces the sequence of events. Such a process might well include the concept of motion and we might be able to model the process using wave-like and field-like concepts but we can only deduce these from the measurable properties of events. The key difference between smooth motion and a sequence of events is that properties are not in a definite state until the moment of an event whereas they are always in a definite state in smooth motion. The enigmas raised by quantum physics disappear if properties are seen to be indefinite, only potential, covering an expanding range of possible states in the moments between one event and any causally consequent event.

In short, quantum measurements are more consistent with the detection of instantaneous events than particles. There is no empirical evidence for matter at the quantum level. Matter at the classical scale may be an illusion that emerges from an unimaginably vast number of events per moment and the consistent conformance of the unfolding event pattern to classical physics in the limit of large event numbers.

## *When is now?*

Einstein's Relativity shows that clocks run at different rates when being accelerated or when under the influence of different amounts of gravity. But in these circumstances, ALL natural processes run at different rates, just as the clocks do. We can therefore say that clocks always measure the rate of natural processes that travel with the clock.

Relativity also indicates that time travel is possible. Yet we have never received anything from the future, not even information. Also, if time travel were possible, there is the paradox of an offspring going back in time to kill an ancestor. Then the murderer would not be born... would not go back in time... would be born... ad infinitum.

The time travel enigma would not arise if there were no future and no past, only the present. This could only be the case if the present moment was the same for the whole universe. This would seem to contradict Einstein's Relativity, or would it?

Where equivalent clocks run at different rates due to relativistic effects, the clocks cannot all be measuring when now is. If two clocks are initially synchronized, then made to experience significantly different gravity, they will report different times when brought back together. Clearly, if they give two **different readings** at the same location and at the **same moment**, their readings cannot refer to moments.

It seems that the time that Relativity refers to, clock time, is not the same as the flow or sequence of moments. Einstein overcomes this by showing that, for observers, there is no absolute simultaneity. But observers conform to clock time. It is therefore possible that there is no absolute simultaneity in clock time, yet there is in moment time.

In short, there are two different concepts of time. The one that we experience and measure, that conforms to Einstein's Relativity and makes up a facet of spacetime is clock time. The one that we cannot sense and measure, which has no past or future yet provides a distinct direction of "time" is the flow or sequence of moments. Each moment is shared by the whole universe. The universe is always in the present moment.

Returning to the statement that clocks always measure the rate of natural processes that travel with the clock. It seems that this rate is a local rate of change per moment. This amount varies. We don't know what the rate of change per moment is because we have no way to measure moments. Einstein's General Relativity shows how the rate varies with gravity (and acceleration). Note that I am only talking about actual clock rates here, as determined by bringing two previously synchronized clocks together, not apparent clock rates as determined by distant non-co-moving observers.

The simultaneity of "moment" time does not contradict Einstein. Relativity does not have observers literally seeing another observer's future. It only shrinks or stretches the apparent clock time between observed events. Crucially, the correct temporal order of events is always conserved for all observers. Nor does moment-time introduce an absolute. We cannot measure moments or their flow.

To sum up, the enigmas of time and time travel are removed if there are seen to be two concepts of time. The more fundamental is the flow or sequence of moments where the whole universe shares each moment. Clock time is about how things change per moment.

### ***Why no Quantum Gravity?***

It has not been possible to reconcile gravity with Quantum Theory. If gravity is treated as a force field mediated by particles (gravitons) infinities arise when the field is quantized. Given that Einstein's General Relativity and Quantum Theory are the two most successful theories in physics, it seems unlikely that there is anything fundamentally wrong with either theory.

Einstein's General theory of Relativity is a classical theory. That is, it deals with the dynamics of objects in space and time under the influence of gravity but without any reference to Quantum Theory. To match Relativity with Quantum Theory, gravity is treated as an ordinary force and therefore has a force field mediated by quantum particles (gravitons). The obvious question is whether there is a way to have gravity as an influence on objects without it being a conventional force. Obviously the very fact that gravity has proved impossible to quantize already suggests this might be so but there is another clue. Gravity, unlike other forces, can be seen as a curving of spacetime. Energy in all its forms, including mass, causes spacetime to be curved into a sort of landscape with more curvature where there is more energy. Energy-change is in turn influenced by the curvature of spacetime at each location.

One strong reason why it is thought that gravity must be quantized is that significant change in energy at any location radiates out as gravity waves. It is supposed that these waves might be the wave-equivalent of gravitons, just as light waves are the wave equivalent of photons. However, while gravity waves have been detected, gravitons have not. Could it be that gravity and its waves are truly classical (non-quantum) phenomena? If so, gravity has its causes at the classical scale yet its influences have effects at the quantum scale. If this sounds unlikely, note that spacetime, even without gravity, is not a part of Quantum Theory. It has no quantum particles that somehow produce it yet it plays a part at the quantum scale.

The solution to this enigma would seem to be that spacetime and gravity are concepts that affect the evolution of potential quantum states directly, not by way of quantum events. Yet they are causes that arise at the scale of quantum event patterns. Thus they can be thought of as a kind of feedback from event patterns, if thought of as the "outputs" of events, to potential quantum states, if thought of as the "inputs" of events.

### ***Why this universe?***

Our universe has its laws of physics and its physical constants which together make the universe just the way it is. Remarkably, the universe exhibits a great deal of order. Physics contains layer upon layer of structure, each layer depending on the fine details of lower layers. Looking into deep space, effectively looking back in time, indicates that the universe has had the same physics since a few hundred thousand years after "Big Bang" and possibly earlier. However, if the universe started from a singularity (virtually nothing) physics cannot have been the same from the very start.

Stepping away from cosmology and physics for a moment, other branches of science show that order and complexity take time to develop. Take the formation of the solar system and the evolution of life as examples. What exists now did not just pop into being but passed gradually from chaotic disorder to complex order. We might reasonably expect that the order we see in fundamental physics also came about gradually.

A Big Bang that accidentally produced a universe as sophisticated as ours by chance would be so unlikely that it would be incredible. Indeed, scientists hate such coincidences. One answer that looked promising was called "Big Crunch." It was proposed that the universe ended by an inverse of the Big Bang. This further raised the idea that there might be a sequence of cosmological epochs. The universe would repeatedly pass through crunch-bang transitions. We would find ourselves in an epoch between two such transitions. The universe then has opportunity to develop order and complexity over many epochs. Our suite of physics would be the latest phase in a long sequence of gradually modified physics.

There are arguments against crunch-bang but they make assumptions that might turn out to be wrong. In particular, they assume that we already know and understand why the universe is expanding at the rate it is. Yet we still do not know what dark energy and dark matter are. There may also be other factors that drive cosmological expansion and contraction which we have not yet discovered.

Even if Big Bang really was a start from nothing, not an incremental transition, physics could have developed after singularity and before the furthest back that we can detect.

Either way, it is more credible that physics developed gradually. Whether this happened over cosmological epochs or in an inaccessible early phase of this one epoch can be left to future cosmology. For now, the miraculous appearance of a ready-formed sophisticated universe is not acceptable. It will be assumed that, however and whenever it happened, the order that we find in the universe came about in a sequence of development phases.

### ***What is thought?***

Neurophysiology provides a great deal of information about the workings of the brain. It is relatively easy to model, using artificial neural networks, many of the functions that our brains perform such as pattern recognition.

Psychology provides a great deal of information about the workings of the mind (as opposed to the brain). It is well understood that our senses, as experienced, are not like the outputs of cameras and microphones. Our thoughts and experiences are an unfolding scenario, a sort of stream of qualitative impressions that represent what is going on around us. This scenario seems to be a top-down construction, more a synthesis than an analysis. Perceptions are not so much the driver of the construction as feedback to ensure that the scenario is a good representation of the owner's immediate environment and situation. This is far removed from the naive assumption that we see an accurate movie image of what's out there.

How do we explain the connection between the mechanical workings of the physical brain and the qualitative nature of the mind's experienced senses and thoughts? There is no colour red or sound of whistle in physics; no stinging or burning sensation; no scent of perfume and no taste of sweetness. These things have physical correlates that physics can measure such as air pressure waves. But a whistle sound is something different. Some people even "see" sound as colours. It seems that the brain produces, and not always correctly, qualitative experiences to match what is physically sensed. Experience is a constructed representation of the physical world. In short, a material physical brain somehow manufactures what seems to be a non-material qualitative mind.

It has been suggested that thought is an illusion. But even an illusion of thought and subjective experience is so qualitatively different from the material and function of brains that this is no answer at all. In any case, the illusion argument assumes that objective reality is out there. Yet we only know anything about "out there" from our experiences and thoughts. This suggests the opposite of the illusion argument, that thinking is primary, more real than matter. It is better to assume that the physical universe is "made of" something from which both brains and mind can emerge.

Physics does not explain what mind is. Our thoughts, our awareness that we are a thinker of thoughts, are not physical. We might say that they are informational or that they are qualitative. It is actually difficult to find the right words to explain the experience of thinking. We certainly cannot do it using any of the concepts in fundamental physics.

In short, mind and brain are essentially different yet both are real. Mind depends upon brain but just how it does so is unknown. But it will be assumed here that mind and brain are both real features of the universe. Neither of them is an illusion.

## *What's the answer?*

Based on the conclusions of the enigmas outlined above, any new ontology should include the following features:

- Quantum events are empirically confirmed things that happen. Particles, waves and/or quantized fields are more likely to be features of whatever lies behind quantum events.
- There are two distinct concepts of time. The more fundamental is the flow or sequence of moments. It is only ever the present moment. Clock time, as embodied in spacetime, is about change of state of physical processes per moment.
- Spacetime and gravity are features of the universe that influence the evolution of potential quantum events directly. They are a kind of feedback from the scale of event patterns.
- The laws of physics and the constants of physics developed gradually in a sequence of phases, building layer upon layer of order.
- The essence of the universe must be something from which the objective structures of brains and the subjective streams of experience can both emerge.

The new ontology that follows in the next section takes account of these conclusions and incorporates them in a way that does not contradict the empirical findings of science.

# The New Ontology

The theories of science contain empirical and metaphysical content. The distinction is not well defined but in general, empirical content is obtained from measurements and observations but includes equations etc derived from this data. Metaphysical content is any abstract concept that has been added to give explanatory power. Empirical content comes to science from nature; metaphysical content comes to science from the human mind. The new ontology is an interpretation of science that supplements its metaphysical content, providing a broader picture that lets us see existing science, unaltered, in a new light.

There exist a number of persistent enigmas that any new ontology should address. These were discussed in the previous chapter. The key conclusions are re-stated again here.

- Quantum events are empirically confirmed things that happen. Particles, waves and/or quantized fields are more likely to be abstract features of whatever lies behind quantum events.
- There are two distinct concepts of time. The more fundamental is the flow or sequence of moments. It is only ever the present moment. Clock time, as embodied in spacetime, is about change of state of physical processes per moment.
- Spacetime and gravity are features of the universe that influence the evolution of potential quantum events directly. They are a kind of feedback from the scale of event patterns.
- The laws of physics and the constants of physics developed gradually in a sequence of phases, building layer upon layer of order.
- The essence of the universe must be something from which objective brains and subjective streams of experience can both emerge.

## The Essence

Fundamental particles such as photons and electrons might be thought of as active matter, "active" because they have behaviour; somehow they have in-built rules of how to act and the ability to do it consistently. If these particles are not individual objects but features of an underlying process, the process can be thought of as active information, information with in-built rules of how to act and the ability to do it consistently. It is proposed that the essence of the universe is Active Information defined as follows:

### Active Information:

- is the essence of process. It is fundamentally both information-like and processor-like as one combined concept. The two facets are inseparable
- is more than what we mean by the common term "information". It is not the same as and does not include or require data
- is more than what we mean by the common term "active". It is not the same as and does not include or require a processor
- can be contrasted with active-matter which is what we might call physical objects including classical and quantum entities (stars, atoms, electrons etc)
- is autonomous, self-transforming, self-storing and mutually interacting
- is universally interconnected
- is fundamental to everything else. Space, time, matter and thought all emerge from Active Information. It is not extended in any sense, is not contained by anything and does not move. It changes but only by its own intrinsically "active" nature

## The Process

The essence of the universe is Active Information. There is no real distinction between the actions being performed and the information that is affected by the actions. However, we have no language to describe a process other than as actions and information as if they were separate. One should take care not to think of the process as an algorithm running on a processor and acting on stored data.

The process is presented here as four layers of order, numbered one to four. Each layer constrains the order of layers above it (higher number) and exerts influence on layers below it. The boundary between layers is not necessarily distinct. That is, there may be information and actions that fit between two layers but they are less relevant.

The process operates in cycles. That is, the process goes through a suite of actions then repeats it, on and on. Each cycle is a moment of fundamental time.

### Layer 1

This is the Quantum layer. It has the following informational concepts:

- Quantum Potentialities:
  - are things that could actually happen now or later but have not happened yet
  - are the source from which Actualities arise
  - are the remaining Consequences of all previous Actualities
  - interconnect Consequences with each other

- An Actuality:
  - is one indivisible thing that actually happens
  - is produced from parts of one or more Consequences in Potentialities
  - is created and re-absorbed within one cycle of the process
  - has properties that can be measured and/or experienced
  - is the source of a new Consequence in Potentialities
- A Consequence:
  - arises from a single Actuality
  - is a distinct new origin within Potentialities and its subsequent evolution which is a superposition of possibilities
  - carries causal information about its originating Actuality
  - contributes to one or more new Actualities, possibly at different cycles. Following any such contribution, the Consequence is necessarily changed and reduced
  - is a "remaining" Consequence until it contributes leaving nothing

Note that there is no spacetime at this layer. What follows is what happens at Layer 1 in each cycle.

The process advances Potentialities once per cycle. That is, it moves them on to a new state. One can also think of this as an advancing and superposing of Consequences. This advancement is a change in what could happen next in the universe before anything does actually happen. The more cycles that a Consequence has existed, the more it will have changed and the more it will have expanded its superposition of possibilities.

We cannot access this layer so we cannot tell what, if anything, the states of Potentialities change with respect to. We might guess that the simplest universal thing is cycle count. Thus we could speculatively model the advancement of Potentialities at Layer 1 using something like a Schrodinger equation but with cycle count in place of time or spacetime.

After the advancement of Potentialities, the new state of the universe is one that offers different potential Actualities. The next step within a cycle is therefore the transformation of some parts of some Consequences into new Actualities.

An Actuality is, so to speak, made out of transformed Potentialities. Think of the creation of an Actuality as the coalescing, condensing or collapsing of parts of one or more Consequences and the transformation of that body of Active Information into a new form. It might help to think of the parts of Consequences that make a new Actuality as being informationally particle-like. Thus a new Actuality can then be thought of as equivalent to a quantum event.

The actions of Layer 1 determine what constitutes a valid potential new Actuality. Only an extremely small proportion of valid potential Actualities in any one cycle go on to become Actualities in that cycle. However, Layer 1 has no rules for determining which potential Actualities become Actualities. The "selection" made by Layer 1 is totally random although higher layers may influence or override this Layer 1 selection process.

After Actualities have been created in a cycle, Layer 1 then transforms the Actualities back into Potentialities. Each Actuality becomes a new source of Consequences within Potentialities. Where an Actuality was created from parts of Consequences that had advanced and superposed their properties over many cycles, it now becomes focussed, unsuperposed, concentrated. Thus the creation and re-absorption of Actualities is a counter to what would otherwise be the uncontrolled growth of possibilities in Potentialities.

Layer 1 constrains Layer 2 (and above) because, in each cycle, there is a limited range of potential Actualities. The limit is due to the Layer 1 rules that determine what constitutes a valid potential Actuality. However, Layer 1 allows Layer 2 to influence which valid potential Actualities it "selects" to be actually created.

If the universe only had Layer 1 (as it might have had in an early phase) there would be random quantum events with no enduring structure in the ongoing pattern of events.

## Layer 2

This is the Local layer. It has the following informational concepts:

- An Internal Actuality:
  - is an Actuality (see Layer 1) that is an integral part of an Objective Structure (defined below). That is, it contributes to the stability of the Objective Structure
  - has properties such that its Consequences will all be part of the structure
  - is the outcome only of Consequences that are of the Objective Structure
  - Cannot be measured or sensed because the Consequences of Internal Actualities contribute only to further Internal Actualities of the same Objective Structure

- An External Actuality:
  - Is an Actuality (see Layer 1) that is part of an Objective Structure but either:
    - its properties are such that its Consequences will not all be part of the same Objective Structure
    - or it was itself formed from at least one Consequence that did not originate in the same Objective Structure
  - can be thought of as transferring properties into or out of its Objective Structure
- An Objective Structure:
  - is an enduring pattern of mostly Internal Actualities and their Consequences that remains self-similar
  - may itself be a structure made up of other Objective Structures
  - has internal properties shared by its Internal Actualities and their Consequences which are hidden from anything external
  - has external potential properties that evolve in superposed states until a cycle when the structure has an External Actuality
  - includes its own internal Objective Space
- Objective space:
  - is a sub-concept of Objective Structures. That is, it is not something that exists independent of Objective Structures. Its existence is created and maintained by Objective Structures and is shared by them.
  - is an abstract space, essentially informational, not a physical volume
  - is a domain of extension with degrees of freedom for extensive properties of Objective Structures
  - is essentially local in the sense that it may appear different from the perspective of different Objective Structures and even from different parts of the same Objective Structure
  - may equate to the spacetime of Special Relativity, without gravity

The properties and actions of an Objective Structure result from the cooperation of its Actualities and Consequences working together as one thing. It is constrained by Layer 1 but also has influence in that it can "select" among valid potential Actualities in each cycle. This influence allows an Objective Structure to have properties and behaviours not found at Layer 1.

Layer 2 emerges when event patterns become stable. These patterns have their own behaviour but, because an Objective Structure is a pattern of Actualities **and** their Consequences, this behaviour feeds back into Potentialities. Thus the behaviour of Potentialities also changes and as a result affects all Consequences, not just those of Objective Structures. Most notably, when Consequences advance within each cycle they now do so with respect to spacetime. Objective Space is the structure of spacetime. It is created and maintained by Objective Structures so it is essentially a local reference frame. Spacetime has no Actualities of its own. It is a reference that Consequences change with respect to.

The properties and behaviours of an Objective Structure introduce the concept of extension. Every Objective Structure creates and maintains its own Objective Space. This is its own local space to which its internal Actualities and their Consequences relate. The apparent spacetime properties of internal Actualities of an Objective Structure are not shared with other Objective Structures.

Objective Structures also share a mutual concept of extension. Every Objective Structure contributes to the creation and maintenance of a shared Objective Space and maintains its own relationship to that space. The spacetime properties of the external Actualities-and-Consequences of an Objective Structure are shared with other Objective Structures. Thus an Objective Structure is only spatio-temporally located by its last external Actuality. In following cycles, until its next external Actuality, it is in a superposition of possible locations (and other properties) from the perspective of other Objective Structures.

Adding together the concept of a partially shared extensional spacetime among Objective Structures and the internally shared wholeness of each individual Objective Structure, what emerges is a nascent universe of objects, in the sense that there are complex event patterns that exhibit object-like behaviour. However, due to the predominance of Internal Actualities, these objects still exhibit a great deal of quantum behaviour and Layer 1 randomness.

Layer 2 constrains Layer 3 (and above) in that it has rules of Objective Space and how a whole Objective Structure behaves in that space. Layer 3 is also constrained to influence only the external Actualities of Objective Structures. From the perspective of Layer 3, many external Actualities-and-Consequences of Layer 2 are interactions between Objective Structures. Note that the constraints of Layer 1 also apply to Layer 3.

If the universe only had Layers 1 and 2 (as it might have had in an early phase) there would either be a virtual gas of quantum and mostly sub-atomic objects or, at lower temperatures, a universe of stable atoms. The phase change that happens to the universe when atoms become stable leads to the emergence of Layer 3.

### Layer 3

This is the classical layer. It has the following informational concepts:

- A Classical Structure:
  - is a structure that is made up of Objective Structures that are bonded together sufficiently for their combined External Actualities to themselves be an enduring pattern that remains self-similar
  - may itself be a structure made up of other Classical Structures
  - differs from Objective Structures in that it has so many External Actualities (see Layer 2) that its internal extensional space is irrelevant. That is, its External Actualities are so frequent that it is rarely or never independent of its environment in the way that an Objective Structure can be
  - contributes to a shared Classical Space
- Classical space:
  - is a sub-concept of Classical Structures. That is, it is not something that exists independent of Classical Structures. Its existence is created and maintained by Classical Structures and is shared by them.
  - is an abstract space, essentially informational, not a physical volume
  - is a domain of extension with degrees of freedom for extensive properties of Classical Structures
  - is essentially local in the sense that it may appear different from the perspective of different Classical Structures and even from different parts of the same Classical Structure
  - may equate to the addition of gravity to the geometry of flat spacetime

The properties and actions of a Classical Structure result from the cooperation of its Objective Structures working together. It is constrained by Layer 2 but also has influence in that it can "select" among valid potential external Actualities of its Objective Structures in each cycle. This influence allows a Classical Structure to have properties and behaviours not found at Layer 2.

The properties and behaviours of a Classical Structure augment the concept of extension in layer 2. Every Classical Structure contributes to a shared Classical Space. This is a space to which its constituent Objective Structures relate (externally) but **is also** visible to other Classical Structures.

The concept of a fully shared extensional spacetime among Classical Structures, one that includes gravity (and possibly other undiscovered extensional concepts) leads to a large-scale universe of classical objects which are actually complex event patterns that exhibit classical-object-like behaviour. However, due to their underlying Objective Structures, classical objects are not totally divorced from quantum behaviour and randomness.

Layer 3 constrains Layer 4 in that it has rules of Classical Space and how a whole Classical Structure behaves in that space. Note that the constraints of Layers 1 and 2 also apply to Layer 4.

If the universe only had Layers 1, 2 and 3 (as it surely had in an early phase) there would be the objective world of planets, stars and galaxies but no subjective world of thinkers of thoughts.

## Layer 4

This is the subjective layer. It has the following informational concept:

- A Subjective Structure:
  - is an enduring pattern of Actualities and their Consequences that retains a strong interdependence and strong interconnections
  - is a particular type of pattern. That is, most patterns, including those of Objective and Classical structures, would not be Subjective structures
  - requires and can only be created by a particularly sophisticated arrangement of Classical Structures: a brain.
  - is probably independent of and hidden from other Subjective Structures
  - includes its own internal Subjective Space. A subjective space is a stream of subjective experience, thought or awareness AND a directionality in which that stream is heading.

The properties and actions of a Subjective Structure result from the cooperation of some of the Classical Structures of a brain working together as one thing. Which Classical Structures are taking part in this cooperation may change on very short time scales but are part of the same brain.

A Subjective Structure is constrained by Layer 3 but also has influence in that it can "select" among valid potential external Actualities of the Objective Structures that constitute the Classical Structures of the brain. This influence allows a Subjective Structure to have properties and behaviours not found at Layer 3.

The properties and behaviours of a Subjective Structure introduce the concept of Subjective Space. Every Subjective Structure creates and maintains its own Subjective Space. This is not an extensional space but an experiential space that is qualitative in nature. It is the stuff of thought, experience, qualia, awareness etc.

Subjective Space is not shared with other Subjective Structures but is local and private to its own Subjective Structure. The brain patterns that result in Subjective Structures are learnt and memorised during a brain-owner's development so that the mature brain correctly matches perceptions etc to appropriate subjective experiences and thoughts.

Layer 3 constrains Layer 4 in that a brain can only be made of Classical Structures, ones that obey all the same laws of physics as other Classical Structures. Note that the constraints of Layers 1 and 2 also apply to Layer 4.

There is nothing special about the constituent Classical Structures of a brain that creates and maintains Subjective Structures. It is the patterns of Actualities that are special. These patterns are created by brains; not all brains but only ones complex enough to produce, memorise and recall such patterns.

Given that the essence of the universe (in this ontology) is Active Information, it is much more conceivable that the universe can contain thought and subjective experience. Think of it as a sort of direct connection with Active Information or as Active Information feeding back on itself.

Consciousness might be a further layer but might also be just a more sophisticated type of subjective structure.

## **Review**

What follows is a brief summary and review of the the new ontology

### **Time and Space**

A cyclic process with one batch of Actualities per cycle provides a real sequence of moments. However, we neither measure nor sense this sequence. We and our measuring apparatus are "made of" Actualities. Take a clock for example. One tick could take a few cycles or trillions of cycles. Clock time and therefore the time of spacetime is not tied to the cycle rate. Clock time can vary just as Einstein's relativity shows, independent of cycle time. The time and space that we sense and measure are extensional constraints on Potentialities and Actualities. They are features of a process, not an actual flow, an actual volume or an actual four-dimensional spacetime block.

The sequence of cycles provides a direction of time. The present moment is the current cycle. The process is always in the moment. It is never in a past or future cycle. The past exists only in the sense that it is the remaining Consequences of past Actualities. Potentialities are the as-yet unresolved history of the universe and it is they that provide a definite direction of time. Metaphorically, Potentialities are the past and its expanding potential contributions to the unfolding present.

A batch of Actualities all happen in the same moment (cycle of the process) but this does not raise any problem of universal simultaneity. First, spacetime is essentially local, created and maintained by each Objective Structure and Classical Structure. Second, Einstein's relativity is a part of the rules that govern the evolution of states of Consequences in each cycle and determine what constitutes a valid Actuality. These rules apply directly within Potentialities. They are influences that underlie Actualities and therefore affect quantum event patterns without having quantum events of their own. They guarantee the spacewise and timewise boundaries of every event and the correct order of events for all observers.

Space is not an actual volume and nothing moves as such. Potentialities and Actualities are all interconnected as one process. They are not inside space or clock time in any sense. Space and clock time, together as spacetime, are only features of the process that constrain the unfolding patterns of Actualities.

### **Gravity**

In the new ontology, gravity is not a force field. That is, there are no graviton equivalents in Potentialities or Actualities. Instead, gravity is deeply embedded in the concept of extensionality. This is akin to the geometric view of gravity. Classical Structures maintain a shared Classical Space which includes gravity. The rules that govern this space will be exactly those of Einstein's General Relativity or its successors.

For example, consider a star whose light passes close to a large mass on its way to us. The light starts as an Actuality of a Classical Structure that is part of the star. The light continues as a component of the Consequences of that Actuality in Potentialities. It increases its superposition of "states" (potential contributions to future Actualities) over a vast number of following cycles. This evolution of states is affected by the shape of the spacetime landscape wherever and whenever (in clock time) and in the same way as photons would have been affected. The light ends as an Actuality of a Classical Structure of the observer. This latter event is an Actuality "selected" from a range of Potentialities that conform to the rules of Layers 1, 2 and 3, rules that include General Relativity. Thus General Relativity applies to the evolution of states of Consequences (what we think of as the light in flight) and to the rules that determine what constitutes a valid Actuality (what we would call the light emission and light absorption events.)

Note that spacetime and gravity are features of the process that have no Actualities themselves. They are a part of the way that Potentialities works. The process of forming an Actuality is a process of quantization. In this ontology, spacetime and gravity are

not quantized. There are no spacetime or gravity-like events. Objective Space and Classical Space are created and maintained by Objective Structures and Classical Structures. It might help to think of them as networks that link those structures within Potentialities. The evolution of states of Consequences within Potentialities are changes that occur with respect to the networks. The networks are in turn affected by those state changes. I offer this network analogy only as illustration.

## **Cosmology**

Layer 1 has no spacetime and therefore no clock time. It still has moment time which is the sequence of cycles of the process, each with its batch of Actualities. Thus there is a significant change in physics as Layer 1 develops into Layer 2. This change occurs when event patterns begin to form and is therefore probably due to the universe cooling (or some Layer 1 equivalent) to a temperature where such patterns can remain stable. Layer 2 might also be related to the period of universal expansion. If so, Expansion is associated with the emergence of spacetime. For us, this would seem like the effective beginning of time because we live by the clock-time of spacetime.

Layer 1, having no spacetime, is beyond our clock time. We cannot say that it was the first few seconds or fractions of seconds of the universe. In terms of cycle count, it could be any length, probably much longer than the cycle count between then and now. Thus the new ontology explains how the universe had time to develop Layer 1 in the first place. It did not appear miraculously in a Big Bang but developed gradually over a virtual eternity.

Layer 2 has no gravity or at least not gravity as we know it now. There is a second dramatic change in physics as Layer 2 develops into Layer 3. This is the period when atoms formed and, as a consequence, the cosmic microwave background was emitted. Looking back in time (by looking further in space) we can see this microwave background but we cannot see beyond it.

In short, the new ontology interprets and thereby explains the two dramatic cosmological events of the "early" universe as periods of significant development of the laws of physics. Note that while it is possible that these changes to the laws of physics were already inevitable before they occurred, they need not have been inevitable throughout the virtual eternity that Layer 1 took to develop.

## **Quantum Measurement**

The new ontology re-sites the links between causally related quantum events. Traditionally, we think of matter and forces as real and the interactions between them as abstract. The new ontology reverses this picture. It has quantum events as real and has matter and forces as abstract features of a process from which the events unfold. This is much more consistent with the results of quantum experiments.

Take, for example, atoms in a two-slit experiment that exhibit interference. After an atom (a stable Objective Structure) has been emitted, it has no more external Actualities until it is absorbed on the far side of the two-slit screen. Whilst "in flight" the Internal Actualities of the atom relate to and are therefore located relative to the private Objective Space of the whole atom, not the apparatus. At these same moments, the atom's public Objective Space has the atom in a superposition of possible locations. These locations are affected and constrained by the apparatus and will therefore include the possibilities offered by both slits. Such an atom arriving at the absorber, without any intervening external Actualities, will have been influenced by both slits. Any attempt to detect an atom "in flight" must involve an external Actuality which will commit the atom to a location relative to the apparatus. By the way, I have given the example using atoms because the case that equates to photons has, for each photon, only one Actuality at the emitter and one at the absorber. That case is much simpler because there are no "in flight" Actualities as there are with atoms. The distinction between internal and external Actualities is key.

The argument has been made before that we need not be concerned about the faster-than-light collapse of the wave function because it offers no way to send signals faster than light. Still, the very notion of anything acting instantaneously across vast distances of space has always been hard to accept. The new ontology offers a different explanation. What we call wave function collapse is the coalescing/condensing of some Potentialities to form an Actuality. Potentialities are not contained within a volume of spacetime. Quite the contrary, spacetime is an abstract concept contained within Potentialities. Two or more Consequences that contribute to a new Actuality are not spacially separated. Their spacio-temporal (clock time) separation is as abstract as if it were variables in an equation. That separation is a real volume for us because we experience, measure and are made of Actualities. The distinction between Actualities and Potentialities answers the wave-collapse conundrum. Light speed is abstract in the world of Potentialities. Signals are real things in the world of Actualities.

In short, the new ontology overcomes the measurement problem.

## **Mind**

The essence of the universe in the new ontology is Active Information. Thought, experience and consciousness are informational. It is easier to accept that mental experience can emerge from active information than from active matter. In the new ontology, Subjective Structures (mind) and Objective/Classical Structures (matter) are alike in that they are enduring

self-similar patterns of Actualities and their Consequences that maintain their own abstract spaces. Mind and matter both emerge from the same essence and the same process. DesCartes' mind-body dualism is avoided and yet a thought stream nevertheless requires a brain. It's just that, in this ontology, they are not so different fundamentally.

A Subjective Structure is produced and maintained by a brain which is in turn based on Classical and Objective Structures. One can see from this that Objective has influence over Subjective. Metaphorically speaking, matter has influence over or constrains mind. The new ontology also shows a means for mind to influence matter. A thought stream has directionality. That is, it is not a sequence of isolated static thoughts but is a kind of flow where what follows is continually related to or influenced by what went before. Subjective Space includes this concept of directionality. The tiniest tweak in directionality can lead to a very large difference in the thoughts that follow. Couple this with the fact that the same is true of neural networks. Just one neuron firing or not can make a very large difference to the neural firing pattern that ensues. Putting these ideas together, Subjective Space only needs the subtlest of influence to affect the direction of a thought stream. This influence is to select from many valid potential Actualities at any moment, ones that have been constrained by Layer 2 and Layer 3 but which still leaves a range for Layer 4 to select from.

## **Process**

The Process proposed in the new ontology puts a great deal of the universe behind Actualities which are the only things that we can sense and measure. This does not mean that the underlying process is out of the reach of science. We can deduce many details about the workings of the process from consistencies within the patterns of quantum events. Of course, we already do this.

We measure quantum events and deduce properties and behaviours of active matter, whether as particles, waves, quantized fields or superstrings. These things are no less abstract or metaphysical than Potentialities and Objective Structures.

Active **matter** is an ontology, one story that fits many of the facts though certainly not all and not without raising paradoxes. The new ontology is intended to fit all the facts and to avoid paradoxes.

By the way, don't be put off by the amount of processing that has to go on in each moment. We live in "Actualities world" where time is the amount that things change per moment. There could be a virtual eternity between two moments and we would be none the wiser because there would be the same amount of change per moment for us. The process can take as long as it needs.

## ***A Prediction***

I predict that physics will discover, as it goes to ever finer time scales, that a maximum frequency of vibration will be reached. We measure oscillations in clock time so the boundary will occur at different frequencies in different frames of reference. This boundary will be due to the cycles of the Universal Process. Note that I am not saying that there is a limit to the smallness of steps in clock time. After all, light effectively carries a notional clock that is stopped. If I am right and the process has discrete cycles, no oscillation can go faster than the universal cycle rate.