Process Physics: Self-Referential Information and Experiential Reality

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Abstract

There is a huge gulf between the paradigms and ontology of twentieth century physics and the concepts, insights and wisdom expressed in Process Philosophy, especially by Whitehead, and by philosophy in general. It is an issue of *Process* versus *non-Process,* as the latter is the nature of time mandated by current mainstream physics. So what is the cause of this deep unresolved dispute between the two camps? As discussed here the problem is manifold, but it began with the very deficient geometrical models of the phenomena of time and space; but so successful that physicists came to identify time with the model itself, and as well finally to totally deny the reality of space. This denial arose when Einstein amalgamated the geometrical modelling of time with the geometrical model of space, giving us the spacetime ontology. However recently in 2002 it was discovered that the putative experimental evidence for the spacetime ontology had been seriously misunderstood, and that this extensive evidence was in fact contrary to the spacetime ontology, and that the last 100 years of physics had been essentially an enormous bungle. A new *Process Physics*[1] modelling of reality has now emerged which accounts for *all* the experimental evidence, and not just the carefully selected evidence that the physicists chose to accept. This model has a non-geometric model of time that now is in accord with our experiences. It also introduces into physics,

[1] RT Cahill, Process Physics: From Information Theory to Quantum Space and Matter, Nova Science Pub., NY, 2005. An extensive collection of Process Physics papers are available at the two website: http://www.scieng.flinders.edu.au/cpes/people/cahill_r/processphysics.html http://www.mountainman.com.au/process_physics/

for the first time, the dynamical effects of space upon quantum systems. This model of reality, which is profoundly different from the current model, is based on deep issues involving the notion that reality is self-referential 'information'. This leads us to the notion that reality is essentially *mind-like,* and that from this arises a new account of space and the quantum, as well as new notions about the possible nature of consciousness. Most importantly all the experiments that the physicists have carried out over the last century and more superbly support this new theory. It will be shown that the Process Philosophers were correct all along; and that the mainstream physicists, for reasons that are now easy to understand, got it very wrong, and misled themselves even more so than they misled others.

Modelling Time

At the beginning of the modern era in physics Galileo introduced a simple mathematical model of time – the geometrical or real number line. But what does geometry have to do with time? The answer is: Not much. A geometrical line has ordered points, that is, if point A is to the left of point B, and point B is to the left of point C, then A is to the left of C. But nothing happens to the line – it is totally unchanging, it is static. *Time* in contrast is all about change, about process, in which we experience the present moment effect, the 'now', in which the events of past 'nows' may have been partially recorded, and from which expectations of the experience of future 'nows' may be predicted, but only crudely. One aspect to the nature of this phenomenon is that of *before* and *after*; this ordered sequencing of events is the one aspect that time shares with the real line, and of course it was this aspect that prompted Galileo towards his geometrical model of time. In fact Galileo was influenced by his father Vincenzo who as a musician was faced with the task of synchronising poly-symphonic singing, and probably was led to the line model as a solution to that planning task. But even at this minimal level the model fails, for while *before* and *after* have a unique meaning whose roles cannot be reversed, the geometrical line has no such preferred order; we can read the line from *left* to *right* or *right* to *left*. So when using this model physicists must always imagine that a point

on the line is moving, say, from left to right. While this metarule is not a part of the model and plays no role in the mathematics, it has led physicists to overestimate the faithfulness of the model to the phenomenon of time. Much has been written in physics about this inability to model the observed difference between *before* and *after*, and that usually invoked some circular argument from the 2nd Law of Thermodynamics. Despite its crudity and manifest failings this geometrical model of time has proven incredibly useful, and the consequent ontology still totally dominates the mindset of physicists. In passing we should note that this model is best thought of as a static or frozen 'history book' modelling of reality, for then the numbered points of the line can be thought of as paginations of a 'history book'. Then the metarule tells us which way to read the book; and as well books don't have a present moment. So using this model physicists are always considering what form the history of events might be, rather than modelling the events themselves. For this reason we categorise the present modelling of reality by physicists as *non-Process* or *historical.* But why did the physicists never acknowledge the feebleness of this model? What turn of events locked them into even more bizarre confusions? Before answering that we first must review another key model: the modelling of *space*.

Modelling Space

Although thoughts about space have a long history it was Newton who first utilised the Euclidean three-dimensional geometrical model of *space*. This model then attributes to *space* the properties of infinitesimal points, infinitely thin lines, absolute smoothness, and various other properties that follow from Euclid's 3rd Century BC axioms. As understood by Newton this space was undetectable, as motion relative to it had no observable effects; it had after all no structure to which motion could be related. Somehow matter moved through this undetectable space, and indeed one of the truly remarkable properties was that motion in the absence of any outside influence resulted in ongoing unchanging motion: this unexplained phenomenon is what we know of as inertia. Physicists long ago forgot that they had never explained this. This model in conjunction with the

geometrical time model led to the most extraordinary revolution in science, and one which continues with essentially the same consequent ontology. So successful has this geometrical modelling been that to many physicists the essence of reality is geometry, and nothing more. In the end the hubris of physicists even denied the reality of the many phenomenon that didn't fit into this ontology, and so stalling not only the development of physics by probably a 100 years, but having as well an appalling impact on the deeper human aspects to comprehending and evolving what we might put under the name of philosophy. But if these models are so flawed why didn't the experimental method reveal that, apart from the obvious failure to faithfully model the experiential aspects of time? The answer is that in the late 19th century a most fateful and misunderstood experiment was carried out: it quickly locked the physicists into the most bizarre and dysfunctional ontology that one could imagine; that reality was a piece of unchanging four-dimensional geometry, and in which even the order of events had, in the main, to be denied. This model then absolutely denied all the experiential properties of time; it was the ultimate expression of the *non-Process* mindset, and it dominates all of physics, and has contaminated most other areas of thought. As we speak the world of physics is celebrating the one-hundredth year since Einstein gave us this ontology in 1905.

Detecting Space

The fateful experiment is the most celebrated of all physics experiments; it was the Michelson-Morley interferometer experiment of 1887, performed in Cleveland, Ohio. In the mid-1800s Maxwell had proposed a mathematical model for electromagnetic fields. One consequence was, and this assumed from the beginning that Maxwell had got the right equations[2], that it correctly predicted the speed of light. But what did this mean? The Newtonian undetectable three-space had no structure, so against what reference structure was the speed of light to be measured? The idea

[2] Hertz in the 19th century had suggested a modification to the Maxwell equations in which the speed of light was relative to a real space. This modification now turns out to be essentially correct.

was then reactivated from the times of Aristotle that the geometrical space was occupied by some dispersed substance, the aether, and that the speed of light was to be relative to this aether substratum.

Maxwell did analyses of the technical difficulties in detecting this substratum using light speed measurements, and considered the effects to be too small to be detectable; the idea being to measure the speed of light in different directions. Then because the earth was surely in motion, the speed of light should be different in different directions, and the magnitude of that difference should reveal the speed and direction of motion of the earth relative to the ether substratum. However Michelson invented a brilliant way to measure the incredibly small effect. The idea involved sending light from a single source in two orthogonal directions, then reflecting the light back from two mirrors, and letting the two beams produce interference fringes. On rotation the relative travel times in the two arms would change, and as a consequence the fringe pattern would shift back and forth on the detecting screen. The magnitude of the fringe shift back and forth then allowed the speed of the earth through the ether to be calculated. There was one critical aspect to the experiment - a theory for the device was needed so that the instrument could be calibrated; this allows one to compute the speed from the observed magnitude of the fringe shifts. To this end Michelson used the Newtonian physics. In hindsight we now understand that the experiment was really checking two things, first the question of whether motion relative to the ether, now called absolute motion, could be seen, i.e. whether fringe shifts were indeed seen, and whether space itself could be detected, and second, whether Newtonian physics gave a sensible value for the speed, for the earth had at least a speed of 30km/s from its orbital motion about the sun. Surely at least that speed should be detectable, and this speed determined the specifications for the arm lengths of the Michelson interferometer. Over four fateful days in July 1887 Michelson and Morley ever so carefully rotated the device, a mere 36 times only, and their observations were to lock physics into more than a hundred years of nonsense about the nature of time and space. They did detect the fringe shifts, and their paper has a table of

the values. But all physics books incorrectly claim they saw nothing, that is was a *null* experiment. On analysing their fringe shift data they deduced, using the Newtonian physics for the instrument calibration, that the fringe shifts corresponded to the earth having a speed of some 8km/s. A reasonable and logical conclusion would have been that absolute motion had been detected, that the aether, or at least some structure to space, had been detected, but that the Newtonian calibration scheme had failed; that there were fundamental problems with the whole Newtonian theory. That would have been a dramatic outcome, and would have led to enormous activity and re-analysis of the fundamental assumptions underlying Newtonian physics. But that didn't happen. Michelson had, apparently, complete faith in Newtonian physics, and concluded that the fringe shifts must have been spurious, mere instrumental defects!

This critical experiment then became the key turning point in the whole history of physics, and from which the whole Einstein spacetime ontology followed. The experiment, according to the physicists, was showing that absolute motion, that is motion relative to an ether substratum, or even relative to some structure to space itself, was undetectable. In 1905 Einstein turned the story around, and adopted the misunderstood absence of absolute motion as one of the key postulates of the Special Theory of Relativity, and to this day any discussion of absolute motion is a banned topic, punishable by immediate excommunication from the brotherhood of physicists. In this theory the geometrical model of time became amalgamated with the geometrical model of space, but most significantly the notion of a 3-space was merely a perspective-like effect, it was not real, meaning that in general different observers 'saw' different 3-spaces, but none of which was real. So unlike Newton who merely denied the detectability of 3-space, Einstein denied its very existence. That for 100 years mainstream physicists have denied the existence of this most prevalent and detectable aspect to reality is almost beyond comprehension. It also means that they have totally missed all the dynamical effects upon quantum matter. So this resulted in the ontology that the phenomenon of time was essentially an inseparable aspect to space itself; that reality was an

unchanging piece of geometry. In this ontology there is no notion of change, no notion of becoming, no notion of any of the experiential aspects to time. As one physicist put it, these experiences were to be studied by psychologists, and not by physicists, as though they were some consequence of a dysfunctional human brain. This1905 *flat*-spacetime ontology was extended by Hilbert and Einstein in 1916 to a *curved*-spacetime, with the curvature now claimed to offer an account of the phenomenon of gravity, and which was to replace the Newtonian account in which gravity was caused by an acceleration field that somehow resided in space. This 1916 ontology is known as General Relativity (GR). Again the physicists claimed they had experimental and observational evidence for this ontology. But again they had to be selective in their choice of evidence, for not all the evidence was in agreement with the model, and one reliable disagreement with observation is enough to falsify the model. We need to acknowledge the key contribution of Lorentz and others who, following the bungled reporting by Michelson and Morley of their experiment, suggested that, contrary to Einstein's later notions, that absolute motion was real, but that it affected the length of rods and the ticking rate of clocks in motion through space. The Lorentz theory then predicted that no fringe shifts should have been seen at all, which was, however, in conflict with the fact that fringe shifts had been detected. It wasn't until 2002[3] that *all* the evidence was taken into account and the 100-year era of confusion in physics was sorted out. My subsequent excommunication from the world of physics took only hours!

Quantum Theory and Measurements

Another source of clues about the nature of reality began to emerge in the late 1920's with the discovery of the quantum theory of matter. This theory involved wave functions attached to the non-dynamical flat-spacetime construct. While correctly predicting the energies of atomic transitions and such, it failed to explain what happened during the measurement process, for while the theory dealt exclusively with wave functions, measurements in special detectors yielded,

[3] RT Cahill and K. Kitto, Michelson-Morley Experiments Revisted, Apeiron **10,** 104-117(2003).

always, localised spots on, say, photographic emulsions. In fact it is not commonly understood within physics that all quantum measurements involve in the end position measurements, that is, with the localisation of the wave function to a small spatial region of a sensitised detecting device. This collapse or localisation process has been the subject of endless debate and interpretation, until, eventually tired of the debate, most quantum theory texts now simply ignore the whole problem. The fix-up by Born in the 1930's was to introduce yet another metarule, that is, one that is not part of the theory. He proposed that the probability of localisation was proportional to the square of the wave function. So when a wave function interacted with such a sensitised detector, but not otherwise, the quantum theory itself actually failed to predict the outcome, and the metarule had to be invoked. Only does the metarule involve the notion of probability; there is no notion of probability within the quantum theory itself. There are interpretations of the quantum theory that attempt to transfer the probability notion to the theory itself; this is in fact the most common interpretation, namely that reality has some kind of duality, with both localised particles and extended wave functions. It is then claimed that the wave function gives the probability for the possible actual property of a particle such as its momentum or location in space; that the particle really is a Democritean particle with definitive properties, but we simply don't know the values of these quantities. So in this interpretation the probability associated with an actual detecting device process is extended away from the detection process. This interpretation immediately fails on one specific account; it does not explain why all actual measurement procedures involve spatial localisation events. Even to measure linear momentum we must, by design, influence the wave function in such a way that the eventual localisation positions may be used, statistically, to infer the supposed linear momentum probability. What the physicists have been overlooking is that space itself, in conjunction with the sensitised detector, has some real role in the measurement procedure; that space is actually a dynamical system, and not some passive piece of geometry. The Born metarule is needed so long as we ignore this dynamical role of space.

The history of these confused interpretations illustrates very well the notion of *misplaced concreteness* that Whitehead had clearly identified as a reoccurring failure of physics. Despite the ongoing habit of physicists to ignore the evidence, even if it was subtle, the subject has nevertheless achieved, despite its worst efforts, remarkable technological outcomes. One reason why these dysfunctional models/interpretations/ontologies survive is that physics is incredibly censored, and in such a way that only experimental and theoretical outcomes that are consistent with these beliefs are now acceptable. So these beliefs have become self-fulfilling, and the physicists have failed to comprehend that the most valuable experiment is one that is the exception, the one that does not fit. By denying such critical evidence the physicists have almost rendered physics a non-science.

Process Physics

The deepest "successful" theory of physics is the quantum field theory. It gives a mathematically abstract account of the behaviour of 'elementary particles' in the background of the unchanging spacetime construct, and so implicitly somehow includes the various relativistic effects that Lorentz had suggested. But if it so successful then surely it must offer some deep insights into the nature of reality at this deepest level that physics has so far reached? The mathematics can be cast in various equivalent forms, but to get some intuitive insights one needs to use the most explicit and revealing formalism, and this is the functional integral formalism that developed from early ideas by Dirac and Feynman. Again the physicists were quick to put a bizarre interpretation on even this formalism, namely that it was claimed that it described a particle as having alternative and interfering world lines in the spacetime. However Parisi and Wu discovered that there was yet another formalism that underlay this functional integral formalism, namely that of a stochastic system, where one artificially introduced randomness. This formalism was meant only to provide a better way of computing properties of particles within quantum field theory, and no actuality was attached to this randomness; it was merely a computational aid: it permitted the computations to explore various configurations.

However exploring this the author noticed that introducing randomness into a system in which time was initially modelled by geometry had a remarkable outcome; namely time acquired all the experiential properties that we know of, but which the physicists had come to deny. Such systems evolve in a time-like manner by means, not of solving some differential geometry property, but by means of iterations. In iterative systems, one substitutes the outcome of a computation back into the computation process, and this is repeated again and again. Now if there is randomness in that computation process, and now this randomness is taken as a fundamental attribute of reality, then at each iteration step the outcome is not computable without choosing, in the model computations, randomly some of the numbers involved in the computation. Such systems have the following properties; there is a present moment effect, namely the actual iteration being computed; the outcomes of the past computations may be partially recorded, only subject to memory resources; and the future is not computable, it is not contained within the present, but must be worked towards iteration by iteration. As well the computations cannot be reversed, for this would involve the notion that the fundamental actual randomness was itself exactly recordable or knowable at all time steps. But in the Parisi-Wu stochastic formalism there is both the geometrical model of time as well as an additional stochastic/randomised iterative procedure, and so this randomness is not being used to model time, rather it is serving the purpose of essentially randomly sampling system configurations. However if stochastic iterative systems have essentially time-like properties, then why not abandon the underlying static spacetime upon which quantum field theory is constructed, and keep only the stochastic iterative process. Then we would have a system with no notion of an *a priori* space, no notion of place or even of spatial dimension. This step also abandons all the wave function apparatus as now there is no space to which they can be attached. The measurement localisation procedure is then also abandoned, as location no longer has an *a priori* meaning. But have we thrown out the baby with the water? What kind of mathematical system remains, and does it have any usefulness within physics in accounting for reality? Can it replace the present

paradigms and at the same time account for all the experimental and experiential aspects of reality, including even those that have been banned, and then go on to explain even more? The emerging answer is that it does all these. Because it involves a modelling of time which matches its experiential properties this radical new modelling of reality is called *Process Physics*. Such a modelling has been long considered by the *Process Philosophers*, dating back at least, in the west, to Heraclitus of Ephesus in the late 6th century BCE, who gave us the insight *ta panta rei* – all is flux.

So *Process Physics* uses a stochastic iterative model of time, so that time is modelled not by some fundamentally different system, such as by a geometry, but by a time-like process itself. Thus unlike space and matter, which are emergent within this system, which means here -- not put in by hand, we take time to be inexplicable in terms of any other notions. This breaking of the connection between time and space has significant implications, namely that of multi- universe model of reality, and which individually have the property of having their origins, their 'big bangs' if you will, at different times. This then permits us to overcome the problem of existence *ex nihili*, which arises if we consider our 'universe' as the only one that exists, for now we can take time to be without a beginning and without end in the total system, Of course one must then search for observational evidence to support such a notion, if it is to be a part of a science, and not a just part of a belief system. This iterative model of time does not directly give us all of the experiential properties of time, for one must explore how time would be experienced from within such as system, and apart from the manifest distinctions between past, present and future, we must also account for the relativistic effects which describe the slowing down of moving clocks, but not by means of the bizarre spacetime construct. As well we must emphasize that reality is not being identified with this model; we are not going to make Whitehead's 'misplaced concreteness' mistake yet again: this is just a model that might help us move forward in our comprehension of reality, and

having less phenomena put in 'by hand' we may uncover the deeper connectivity and processual nature of reality, which could also involve deep insights into our spiritual nature.

Before we describe in some detail what is now known about the science coming from this stochastic iterative model of reality we must ask the most dramatic question of all: what is it *really* about; what ontology are we being led to? To that end we must consider the content of this model[4]- it involves a stochastic iteration model containing no notion of space or matter, but that these phenomena will be seen to be emergent: it has the form that is very analogous to stochastic neural networks. Such networks were inspired by the supposed workings of the neural networks of brains. In such networks in*form*ation is stored in the *form* of patterns of the neural connections, and not by symbols, and so we call this mathematical model of reality a Stochastic Neural Network (SNN) model. Of course in brains we normally only decompose the system to the level of neurons, whereas in the SNN model there is no such underlying support, it is all patterns. Then even the nodes and linkage values are themselves to be understood as deeper informational patterns, i.e. it must have a fractal structure. The key property of SNN is that (i) new information may be generated from the noise, (ii) information patterns interact, (iii) some information is permanently stored (memory), (iv) all process are actual, i.e. involve processing in the system by evolving the connectivity patterns, (v) the system has all the experiential properties of time, namely a present moment effect, partial records of past states, and some limited predictability of future behaviour. If such a SNN model of reality proves as successful as is now being claimed then we could, with some licence, adopt the ontology that reality is *mind-like*. In particular it seems that the fundamental *self-referential* aspects are modelling a deep form of primitive *self-awareness*, and as such with

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[4] The iteration system has the form $B_{ij} \to B_{ij} - a(B + B^{-1})_{ij} + w_{ij}$. Here B_{ij} is a square array of real numbers giving some relational link between nodes i and j. Here B^{-1} is the inverse of this array: to compute this all the values B_{ij} are needed: in this sense the system is totally self-referential. As well at each iteration step, in which the current values of B_{ij} are replaced by the values computed on the RHS, the random numbers w_{ij} are included: this enables the iteration process to model all aspects of time. These random numbers are called self-referential noise (SRN) as they limit the precision of the self-referencing. Without the SRN the system is deterministic and reversible, and loses all the experiential properties of time.

intrinsic limitations to that by means of the SRN. As we shall review next, from this arises within the SNN the phenomenon of quantum space and matter, so that an intrinsic form of consciousness is the explanation of these higher level phenomena, but now being described with a fully inclusive model of experiential time. This all suggests that reality is experiential at all levels, as suggested by Whitehead, and that higher levels of consciousness, as in humans and other life forms, may be exploiting this intrinsic self-awareness. We have called this particular form of deep information *sematic information,* because it has meaning within the system itself, unlike conventional physics where the system is modelled by syntactical information, and which has no meaning within the system. This notion of *semantic information* has been called *active information* by David Bohm.

Emergent Space

So given that we have a very radical non-materialistic self-processing and self-organising *information-theoretic* model of reality we must expose this model to experimental and observational checking. This is highly non-trivial mathematical task. The first effect to be uncovered was the generic manner in which the system 'constructs' and processes informational patterns. To visualise this we represent both the link variables and noise variables in terms of graphs. Indicate each node by a dot, and the strength of each link by a line, with that strength indicated by the thickness of the line, as shown in Fig.1. We do not indicate the very weak links. Then we can picture the SNN evolving by having line thicknesses change. Remember however that the space (the page) in which this graph is drawn plays no role within the system. This graphical representation also nicely illustrates the neural network analogy. In this representation the system operates by means of the SRN generating such random graphs, which are then evolved into new graphs by means of the mathematical operations specified in the iteration process.

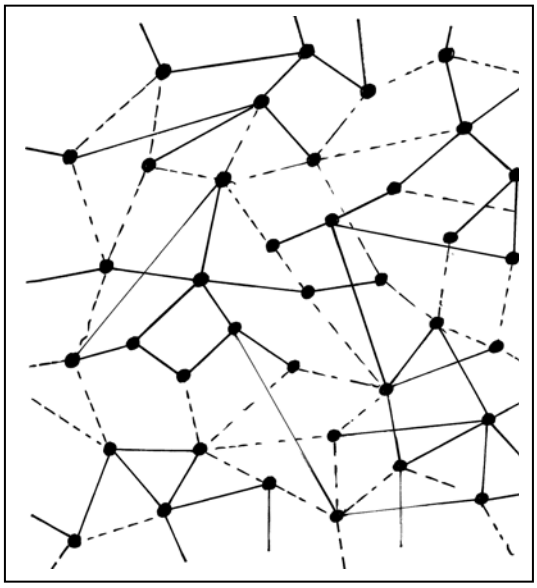

Fig.1 Graphical representation of the network structure from the SRN and the network itself. Thick lines indicate strong connections. Internal information is in the patterns of weak and strong links, just as in a neural system. Over iteration steps this information is processed, but to do so each new state involves the system 'knowing' all the connection patterns, so that the system is holistic and self-aware. In this form the relationship of the model to reality is far from apparent, except for the time-like properties of the iteration process.

The generic behaviour follows from noting that the SRN generates states, like that in Fig.1, with the key feature being the appearance of essentially disconnected graphs, i.e parts of the total that are internally strongly connected, but which have no strong links to other parts of the whole system. These disconnected components are called *gebits* for mathematical analysis has shown that their internal connectivity permits their interpretation as quasi three-dimensional geometric structures, they are *bits* of geometry. But the geometry approximates that of a three-sphere. This is like Euclidean three-geometry over small regions, but, unlike Euclidean 3-space, is finite and has no boundary or surface; all points in the space are equivalent. While this in itself is a stunning

discovery, for here we see the first indication that the phenomenon of space and its dimensionality may be arising within a system in which the limits to self-awareness are fundamental. But the next major discovery is that when these gebits are incorporated into the iterator process, in particular when acted upon by the network inverse operation, these gebits are assembled into a network of gebits, which itself forms a larger three-sphere. A graphical representation of this is shown in Fig.2.

As well the self-assembly of this higher level network is not precise, rather it is fuzzy and imperfect, and so the connectivity, as illustrated in Fig.2, is better characterised as a quantum foam, for it appears that the connectivity is best described by a wave-functional formalism. Although to the extent that these emergent modes of behaviour have yet to be rigorously established, they do suggest that the SNN is leading to the most fundamental aspect of reality, namely that of a quasi three-dimensional space, and that it is emerging via a gebit polymerisation process, or if you will, the connecting together of random information within the system. Note that we do not arrive at either the Newtonian structure-less three-dimensional Euclidean geometry model of space, nor at the four-dimensional spacetime geometry of Einstein; rather we arrive at a form of 'space' which is quantum-dynamical and experiential at every level; *space* is in fact the connectivity pattern of actual occasions, to use Whitehead's language, which is forming what we experience as space. So the deepest quantum behaviour, it is being argued herein, arises from a self-referential information system, with limitations on that self-referencing. Only then do we see the emergence of the phenomenon of space, and with a cellular structure.

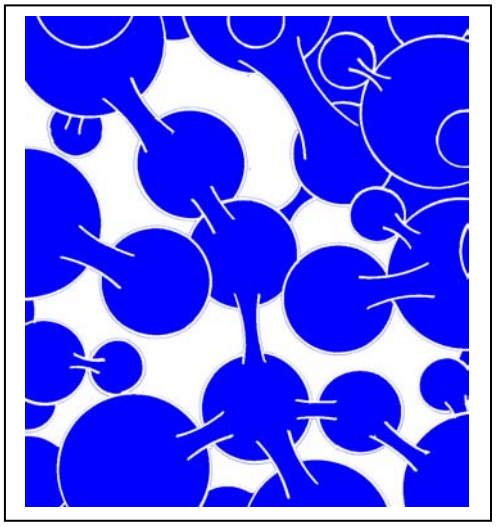

Fig.2 Artistic representation of the self-assembly or polymerisation of gebits to from a fractal quasi-three-dimensional space: within each gebit, represented, by a small sphere, the network is three-dimensional, and these

gebits are connected to form a higher level network which is itself essentially three-dimensional. Dimensionality refers to the manner in which the number of nearest neighbours, next nearest neighbours etc, grows with the number of intervening links. Modelling the differential flow of these patterns, gives the velocity field model of space. Such a 'flow' of space has been detected in numerous experiments, and observed fluctuations are shown in Fig.3.

So the SRN should not be thought of as having no intrinsic order, on the contrary it has intrinsic order, the *gebits*, relative to the ordering part of the iteration process, namely the *inverse* operation. Together these two components act as an order/disorder system, which we have come to recognise as the key nature of complex self-evolving systems. The gebit connectivity pattern is continually changing because the iterator eventually washes away each gebit, and they are being replaced in an on-going process by new gebits from the SRN. Indeed this multi-cellular processing quantum-foam/space is remarkably analogous to the cellular structure of living organisms with their ongoing replacements, and for the same reasons: complex parallel processing systems do not run centrally, they evolve quasi-locally, in the main. Of course we now note that we can use the concept of *local*, because we now have a space to which that word 'location' has meaning, albeit fuzzy.

Emergent Quantum 'Matter'

Quantum matter also appears to be inherent in this SNN system. Matter is those deep informational patterns that are preserved, at least in some form. In the emerging quantum-foam/space there will be topological defects embedded in the space; these are connectivity patterns which do not have the connectivity of the space itself – so they cannot act like space or be interpreted as space. These defects will be embedded in the space in various ways which appear to be characterised by their different distinct embeddings, and if they have non-trivial embeddings, and also have a fractal

structure, then there is a case that can be put that the information characterising these embeddings is preserved over time, even though the individual gebits that form the defect are continually replaced, as in space itself. And also like space, it is argued that these embeddings are describable by a quantum wave functional formalism. So the topological defects appear to have all the characteristics that we know as quantum matter. Furthermore because these defects have a different structure to space their gebit refreshment/replacement rate will be different from that of space, and again it has been argued that the net effect of these different replication rates is that space will essentially flow into matter. Of course we have here the first hint of a process physics explanation for the necessity of the phenomenon of gravity, namely that gravity will be described by the coarse-grained time variations and inhomogeneities of the velocity field of the gebits[5]. This means that Newton's theory of gravity may have actually been closer to the truth than any advocates of 20th-century mainstream physics had suspected; his abstract and unexplained acceleration field may turn out to be the actual acceleration of the quantum foam structure to space. But is there any experimental evidence that space flows, that accelerations of that flow account for gravity, and that space has quantum behaviour? Confirmation of all of these effects would strongly support the contention that our experiential reality arises from restricted self-referential information - an inherently self-aware reality. Let us now briefly review the evidence.

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[5] In the special case of zero vorticity the equation describing the differential flow of space is

$\frac{\partial}{\partial t}(\nabla.\mathbf{v}) + \nabla.((\mathbf{v}.\nabla)\mathbf{v}) + C(\mathbf{v}) = -4\pi G\rho$ where $C(\mathbf{v}) = \frac{\alpha}{8}\left((trD)^2 - tr(D^2)\right)$; $D_{ij} = \frac{1}{2}\left(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i}\right)$.

Here $\mathbf{v}(\mathbf{r}, t)$ is the velocity field description of space, relative to some observer. The spatial coordinates are only labels, and are not a description of space. Here G is Newton's gravitational constant, α is the fine structure constant, and ρ is the matter density. This equation has black hole solutions. The gravitational acceleration is then given, in this special case, by $g = \frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v}.\nabla)\mathbf{v}$. This modelling of space has been confirmed by numerous experiments and observations, and agrees with GR in those restricted cases where it appeared to have been validated. See papers at Process Physics website. In the case of vorticity in the flow the above needs generalisation, but the vorticity is given by $\nabla \times (\nabla \times \mathbf{v}) = \frac{8\pi G\rho}{c^2}\mathbf{v}_R$, where $\mathbf{v}_R$ is the velocity, relative to space, of the matter generating the vorticity. This vorticity is being observed by the Stanford-NASA Gravity Probe B satellite gyroscope experiment.

The Physics of Space and the Phenomena of Gravity

That space is totally unlike time, that it is a system with inherent complex structure, suggested that motion of matter through that structure should be detectable, namely that absolute motion should be real and observable; which would of course completely contradict the whole basis of 20th century physics. As already discussed, Michelson and Morley detected such absolute motion in 1887, but misreported the discovery because they failed to comprehend that the calibration of their instrument was wrong. In 2002 it was discovered by Cahill and Kitto that by taking account not only of the motion effect upon the arm travel times that Michelson knew about, but also the later Lorentz-Fitzgerald length contraction effect of the arms of the interferometer, and most significantly the effect of the air present in the light path that ever so slightly slowed down the speed of light, then one obtained a much different calibration. From this analysis we learn that the interferometer is much less sensitive than Michelson had believed and that the observed rotation induced fringe shifts correspond to a speed in excess of 300km/s. As this is much larger than the orbital speed of the earth of 30km/s, Michelson's argument that the fringe shifts must have been spurious effects simple vanishes; the famous 1887 experiment had indeed discovered absolute motion of the solar system and that the Newtonian physics was wrong; space was detectable. It also implied that the whole Einstein spacetime formalism and ontology, based as it was on the assumption that the 1887 experiment did not detect absolute motion, was in tatters. Of course one experiment is not enough to disprove a theory; and so a search of the scientific literature was undertaken to find other corroborating experiments, and another six experiments were found, with the last being by a Belgium telephone technician named Roland DeWitte who in 1991 accidentally discovered that the speed of radio waves travelling through a coaxial cable buried beneath the streets of Brussells varied as the earth rotated, and that the effect tracked sidereal time and not solar time; this simply means that it was the orientation of the cable with respect to the stars that determined the effect, and not the position of the sun. Remarkablly DeWitte's results agreed with all the earlier six

experiments, and so the absolute motion speed of the solar system of some 420km/s and the direction of motion is now known with some precision.
As well DeWitte detected the turbulence or fluctuations in this flow, as shown in Fig.3.

Of course since all these experiments totally contradict the Einstien foundations of current physics any discussion or analysis of these experiments is totally banned by physics journals and scientific societies.

Now that we know how to calibrate Michelson interferometers it has been possible to reanalyse the enormous amount of data collected by Dayton Miller who operated a huge interferometer atop Mt Wilson in the years 1925-26. Because he took some 20,000 rotations over four months of the year it is possible to extract from his data the effect of the sun on the speed and direction of space past the earth, and one finds that this changes over a year in such a way that a component spatial in-flow towards the sun can be extracted from the data, and which is in agreement with the in-flow expected from the new in-flow theory of gravity. So absolute motion through space has been repeatedly observed over the last 100 years, and the in-flow of space associated with gravity has been sitting in published experimental data since 1933, the year Miller published his findings.

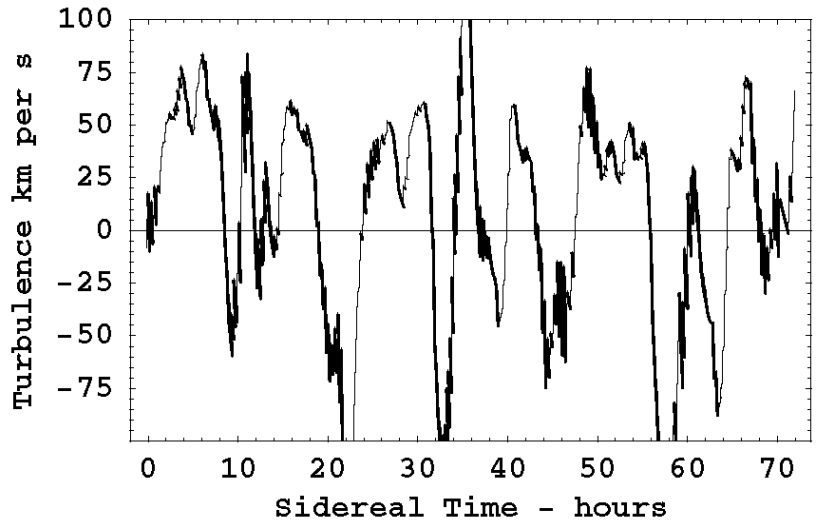

Fig.3 From the DeWitte co-axial cable experiment in 1991 showing the observed fluctuations in the flow of space past the earth, over a 72 hour period, relative to the average speed of some 420km/sec. This spatial dynamics must be included in the Schrodinger equation, and the other equations of physics. These fluctuations reveal the process nature of space, and that space is not merely geometry. The data suggests that the fluctuations are fractal, as expected from the deeper nature of space, as shown in Fig.2. These fluctuations cause dynamical effects, as in the Shnoll effect, where the reaction rates of quantum processes are affected, and presumably in the quantum measurement dynamics, explaining why all quantum measurements are spatial localisation events. At the deepest level we see Whiteheadian processes and actual occasions. These fluctuations have gravitational effects, and they constitute the discovery of the much-sort-after gravitational waves. However they are completely different in character to those gravitational waves that arise within GR.

Quantum Space

But what about evidence for the quantum nature of space? Has that been seen? Yes! It turns out, not unexpectedly that there are various so-called gravitational anomalies. This is the politically

correct term to describe observations and/or experiments that are in conflict with the prevailing theory of gravity, either Newtonian or General Relativity, as in many low speed situations the two converge in their predictions. One anomaly was discovered in the 1980's, namely that the gravitational acceleration, which gives us the weight of objects,
does not vary with depth as we go down a mine shaft in the manner that Newton's theory or GR demands, and which is computable if we know the local density of the matter forming the earth. However the new theory of gravity that arises within Process Physics predicts just such a bore hole effect different from the Newtonian theory and GR. This new theory introduced a new parameter describing the magnitude of the new self-interaction process of the quantum foam, but with the magnitude of this parameter as yet not determined from the deeper theory. But using the borehole data from the Greenland Iceshelf it was found that the data implied that this new parameter was none other than the fine structure constant, which has the value of approximately 1/137. But this is the very same number that determines the interaction of photons with electrons, and so determines the quantum structure of atoms. So the same number is now turning up in the quantum theory of atoms and also in the self-interaction dynamics of space. Surely this suggests that space is itself a quantum system. Clearly we see here the first clues that we have uncovered the deep connection between gravity and the quantum theory; we have essentially a quantum gravity, and that these quantum effects are accessible experimentally. As well we note that even the quantum theory equations such as the Schrodinger equation[6], Dirac equation and the Maxwell equations for electromagnetic fields, need to be modified to include the dynamical effects of space.

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[6] The original Schrodinger equation had the form $i\hbar\frac{\partial\psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi + V(x)\psi$, but to include the dynamical effects of space it must modified to $i\hbar\frac{\partial\psi}{\partial t} = -i\hbar(\mathbf{v}.\nabla + \frac{1}{2}\nabla.\mathbf{v}) - \frac{\hbar^2}{2m}\nabla^2\psi + V(x)\psi$. This couples the quantum system to the dynamical space, as described by the velocity field. This quantum-matter – space coupling leads to the derivation of the equivalence principle from the wave nature of matter, and other effects.

To further confirm this quantum-foam aspect to space we note in passing that the new in-flow theory of gravity now readily explains the so-called ‘dark matter’ effect. This was one of the many gravitational anomalies in which the stars in the outer regions of spiral galaxies orbit much faster than could be explained by either Newtonian or Einsteinian gravity. To save the Einstein curved spacetime theory at all costs the astronomers and physicists chose to invent a new form of unseen and undetected matter, the ‘dark matter’, so as to supply the extra gravitational pull required to sustain the high orbital speeds. But this anomaly turns out now to be simply explained by the new self-interaction dynamics of the quantum foam that is space, and which significantly can be studied in laboratory Cavendish-type lead-ball – lead-ball gravity experiments, and indeed such experiments have displayed this effect.

Finally we mention briefly that the quantum measurement process acquires also an explanation that is consistent with what actually happens in experiments. Namely that when, say, a photon impinges on a suitably constructed detector, the non-local character of the photon, as say arises in a double slit apparatus, puts the detector into a non-local state, and that this is restored to its more stable localised state by the quantum behaviour of space itself. This is because space is the dominant system, and its main mode is that of quasi-three-dimensionality, which implies minimal non-locality. So it is suggested that the Born measurement metarule finally obtains an explanation in turns of the deeper experiential processing of space itself. At the same time we are led to a definite ‘interpretation’, that becomes now an explanation, of the quantum nature of matter. Clearly what had gone unnoticed was the significance of the role of the quantum nature of space, a significance that was barred by the nonsensical spacetime geometrical basis of current physics.

Conclusions

The evidence is, and that involves taking account of *all* the experimental and experiential evidence, that the foundations of physics are profoundly and disturbingly flawed. Then the ontology that is

now the standard model in physics is totally wrong; but at the same time much of the theoretical computational successes may be taken over from these models, such as the relativistic effects in quantum field theory, and positioned within the new ontology. So not only are the past successes retained, we now see that the various *ad hoc* metarules, anomalies, and conflicts with reality as experienced, are now explained. We now have a simpler and more comprehensive model of reality, and one that does not require some experimental evidence, observations and experiences be denied and even worse, suppressed. By itself these new insights represent an exciting and challenging development for physics, and it must be exphasised that we are only at the beginning of this story; as much needs to be done. This new model will, when the suppression ceases, lead to a whole new era in physics. It means that what we experience every day as space is real and detectable, which is in conflict with the spacetime ontology of Einstein, and with also the older notion by Newton that space is undetectable. This 'space' has a complex dynamics that affects all systems that are embedded within this dynamics. The dynamics of this space, it is now becoming clear, has been observed again and again over the last 100 years and more. As well we now understand that the phenomenon of time is about process and change, and not about geometry, although at higher level descriptions we may use the cruder geometrical-line model for ease of computation. The experimental evidence is that Einstein's postulates about the speed of light have always been in disagreement with experiment, and that the existence of space, and of the motion of matter through that space, notions denied by current physics, are consistent with the so-called relativistic effects. Indeed it now emerges that the idea of Lorentz that absolute motion of matter causes these relativistic effects was fundamentally correct. The experimental evidence is now conclusive: Einstein had asserted that we either had absolute motion OR (exclusively) relativistic effects, whereas reality is displaying absolute motion AND relativistic effects. Because both effects occur it has been necessary to reconstruct much of physics, as illustrated by the case of the Schrodinger equation.

This new physics is emerging from a radically different comprehension of the nature of reality, namely that of a self-referential information system, where the information is semantic and active, that is, information that has meaning in the system itself, and because of that the system evolves in a manner determined by that meaning, and so is experienced by the system. This amounts to the assertion that reality is *self-aware* at all levels, though clearly that self-awareness is of a very limited form in most systems, but is there even at the level of quantum matter. So process physics gives a possible realisation of the notion of panexperientialism that is fundamental to Whitehead's process philosophy. It also appears that space and quantum behaviour are emerging from a form of *proto-consciouness*, and not visa versa, as is often suggested. So the new physics is providing a unification and explanation of various phenomena within physics and with other deep phenomena such as human consciousness. That such consciousness is deeply related to reality has been repeatedly demonstrated by the so-called paranormal, and so such studies will become, in time, a part of the experimental and theoretical programs of mainstream physics. Biologists long ago discovered the cellular structure of living systems using the light microscope, and more recently the information-theoretic basis of these systems. But the physicists totally missed the analogous discovery of the structure of space, even when they had available the light-based instrument invented by Michelson – they simply failed to comprehend what they were seeing, and since then they have been in total denial. More than a 100 years after Michelson physicists still do not understand how such an instrument is to be operated, and don't understand that to detect the existence of space, this instrument must be operated with a gas in the light path. As outlined herein it is only very recently that within Process Physics do we have the analogous discovery that all of reality is information-theoretic.