Quantum Realism Part I. Physical Reality

Chapter 2. Simulating Space and Time[1]

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"To me every hour of the light and dark is a miracle,
Every cubic inch of space is a miracle"

Walt Whitman

2.1. INTRODUCTION

2.1.1. Overview

This chapter asks if a virtual space-time could appear to those within it as our space-time does to us.

2.1.2. The quantum network

The idea that the physical world arises like a computer simulation is radical but it isn't new:

1. *Fredkin.* Says that the physical world as a processing output "*…only requires one far-fetched assumption: there is this place, Other, that hosts the engine that "runs" the physics*." (Fredkin, 2005) p275.
2. *Wilczek.* Proposed that beyond the physical is "*… the Grid, that ur-stuff that underlies physical reality*" (Wilczek, 2008 p111).
3. *Wheeler*. His phrase "*It from Bit*" implies that at a quantum level, matter is an output.
4. *D'Espagnat*. Proposes a "*veiled reality*", beyond time, space, matter and energy (D'Espagnat, 1995).
5. *Campbell.* Proposes that "*The Big Computer*" runs everything (Campbell, 2003).
6. *Barbour*. Imagines a quantum reality where "*The mists come and go, changing constantly over a landscape that itself never changes*" (Barbour, 1999) p230.

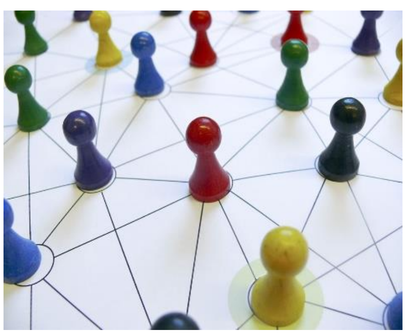

Figure 2.1. A network of nodes

Now let quantum reality be Fredkin's *Other*, Wilczek's *Grid*, Wheeler's *Bit*, D'Espagnat's *veiled reality*, Campbell's *big computer* and Barbour's *landscape that doesn't change*. In this model, the "other" is a *quantum network* of quantum processing nodes (Figure 2.1). This *primal reality* is no more physical than quantum processing is classical, but it has network properties like:

a. *Density*. The number of connections per node.
b. *Capacity*. Node processing measured in cycles per second (Hertz).
c. *Protocols.* What happens when a node overloads (its capacity) or interrupts another.

Processing by definition doesn't need to be physically based, as is now explained.

[1] For the latest chapter versions see http://thephysicalworldisvirtual.com/ First published as: Whitworth, B., 2010, Simulating space and time, Prespacetime Journal, March, Vol. 1, Issue 2, p218-243, and at http://arxiv.org/abs/1011.5499.

2.2. DIGITIZING SPACE AND TIME

2.2.1. What is processing?

Modern information theory began with Shannon and Weaver, who defined *information* as the number of *choice* options expressed as a power of two[2] (Shannon & Weaver, 1949). By this logic, a choice between two physical options is one bit, between 256 options is 8 bits (one byte) and a choice of one option, which is no choice at all, is zero bits. *Processing* was then defined as changing information, i.e. making a new choice.

So the amount of information in a physical state depends on the number of options it was chosen from, which is contextual, e.g. a physical book "contains" information yet is fixed one physical way, so in itself it has *zero* information. This seems wrong but it isn't, as hieroglyphics no-one can decipher indeed contain no information. A book only gives information when a *reader* decodes it, and the information result *depends entirely on that decoding,* e.g. reading every 10th letter of a book, as in a secret code, gives a different message and different information.

Information requires a *decoding context*, e.g. one electronic pulse sent down a wire can represent one bit, or as ASCII "1" can be one byte, or as the first word in a dictionary, say Aardvark, is many bytes. The information "in" a physical message is undefined if the decoding context isn't known. How else does data compression store more data in same physical signal? It is by more efficient encoding/decoding which has nothing at all to do with the signal. Without a reader/observer, the information in a physical signal is undefined. Only when a writer and reader use the same encoding-decoding process do they agree on the amount of information a signal "contains".

Information as represented by a physical symbol is essentially *static* until it is *dynamically* extracted by a known decoding context like the English language, and likewise the creation of information by processing is dynamic. *Writing* a book is dynamic, as one can write it in many ways, and *reading* a book is dynamic, as one can read in many ways, but the book itself, being just one way and no other, is static, i.e. "empty" of information.

Not understanding the dynamic side of information leads some to talk of downloading and uploading universes as data, but imagine our universe frozen in a static state at a moment in time, who could "read" it? Not us, as we would be frozen too! A frozen world without an observer would be as empty of information as this page without a reader, as one can't save data without data structures. A frozen universe would be dead – forever! Whoever saves a universe must not only know it entirely but also exist outside it!

The same problem faces trans-humanists like Minsky who want to live forever by uploading their mind and downloading it to a new body. They assume an observer who can "read" the brain as one reads English text, but in neurology the brain is dynamic. Computers store data in fixed locations but human memory is based not on neurons but their *connections*, which even a perfect brain scan doesn't show. Even a perfect copy of a brain's physical state at a moment, is like taking a photo of a movie and reloading it on the screen. It isn't the movie because a static state isn't a dynamic process.

Yet we do in fact store movies in various formats to replay later, so processing can be stored as a static *program* to be run later. Classical processing can reduce to physical states because an information bit is a physical choice, but quantum processing is not based on physical states. And classical processing can't create our physical world because that would need a designer to "write" it. As McCabe says:

> *"All our digital simulations need an interpretive context to define what represents what. All these contexts derive from the physical world. Hence the physical world cannot also be the output of such a simulation."* (McCabe, 2005).

A big physical computer running a big program can't output the physical world as information because that requires a physical context, and the same thing can't be both input and output. Quantum processing *can't* be based on the physical states it creates, hence it isn't classical processing and qubits aren't classical bits. Quantum processing is *dynamic processing* - the creation of processing just as processing is the creation of information.

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[2] Mathematically, Information $I = \text{Log}_2(N)$, for N options in a choice.

If quantum processing creates physical reality as quantum theory says, it can't be saved or uploaded by the *quantum no-cloning theorem*. A virtual world is events pretending to be things, and the only way to "save" a pixel event is to run it again. In Chapter 4, matter is pixels that repeat not a vessel one can pour into. Chapter 6 explores consciousness based on quantum events not things, so a copy of me isn't me because it is another event. A copy of "me" has another experience, and that isn't me if I don't experience it. One can save and recover static data but not dynamic processing because the act of storing it is another event. We download and upload data to hardware vessels but what vessel can hold quantum processing? Classical processing can be stored given a physical context but quantum processing can't be stored, nor does it allow static memory of any sort, i.e. no caches or buffers. All our computing devices, from servers to cell-phones, use storage, but quantum processing doesn't. It doesn't have to because while *classical processing* must choose one option *quantum processing* takes them all at once in superposition. A quantum computer with a few qubits is better than a classical computer of thousands of bits because it is *processing creating processing*. Being dynamic, it is not based on any context so McCabe's argument doesn't apply.

Is this just another God theory? God theories "explain" by an all-powerful God but don't predict because anything is possible. In contrast, quantum processing is finite and the principles of processing are known. Reverse engineering is about understanding the underlying system to predict, so when the process is understood its future output is predicted. In Chapter 4 reverse engineering predicts what current physics denies - *that light can collide*.

2.2.2. Continuum problems

Continuum problems have plagued physics since Zeno's paradoxes two thousand years ago (Mazur, 2008):

1. If a tortoise running from a hare sequentially occupies infinite points of space, how can the hare catch it? Every time it gets to where the tortoise was, the tortoise has moved a little further on.
2. OR If space-time is *not* infinitely divisible, there must be an instant when the arrow from a bow is in a fixed unmoving position. If so, how can many such instants beget movement?

To deny the first paradox exposes one to the second, and vice-versa. Zeno's paradoxes resurface today as infinities in physics equations, such as the classical problem that light has no mass so it should go infinitely fast[3]. Relativity resolves this by giving a photon relativistic mass after the fact. The infinities of quantum field theory were likewise resolved by the mathematical trick of "renormalization", of which Dirac wrote:

> "*Sensible mathematics involves neglecting a quantity when it turns out to be small - not neglecting it just because it is infinitely great and you do not want it!*"

Feynman said the same even more bluntly:

> *"No matter how clever the word, it is what I call a dippy process! ... I suspect that renormalization is not mathematically legitimate."*

We sometimes forget that continuity is a mathematical convenience, not an empirical reality:

> "*... although we habitually assume that there is a continuum of points of space and time this is just an assumption that is ... convenient ... There is no deep reason to believe that that space and time are continuous, rather than discrete...*" (Barrow, 2007) p57

Computing has no "half pixels" or "half cycles" so a virtual reality can't be continuous, giving Zeno's question a clear answer. There is indeed an instant when the arrow is in a fixed, unmoving position, until another quantum tick generates the next instant. Our reality is a series of sequential images strung together, as in a movie. Denying the infinitely small avoids the infinitely large, so a digital world of irreducible pixels and indivisible ticks makes the infinities of field theory disappear, like ghosts in the day. Processing as a choice from a finite set doesn't give

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[3] In classical physics, $F = m.a$ where F is force, m is mass and $\underline{a}$ is acceleration, so if $a=F/m$, a force acting on a zero mass photon should give infinite acceleration.

infinite output values. Our world is finite because repeatedly dividing a digital space gives a pixel that can't be split and repeatedly dividing a digital time gives a cycle that can't be paused.

The continuity we see breaks down at the order of Planck length and time. To study these limits needs short wavelength light, which is high energy light, but putting too much energy into a space gives a black hole that screens information from us. If you probe the black hole with more energy it expands its horizon to reveal no more so below the Planck length is unknown. Just as closely inspecting a TV screen reveals only dots so closely inspecting our world reveals only Planck pixels. If our world is an image, physicists know the resolution and refresh rate of the screen [4].

2.3. SPACE CALCULATES

2.3.1. Is space nothing?

The question of whether or not space itself exists has concerned the greatest minds of physics. Simply put:

If every object in the universe disappeared, would space still be there?

Newton saw space as the canvas upon which God painted that still exists even without objects. To Leibniz, a substance without properties was unthinkable so he saw space as a deduction based on object relations. Objects only "moved" with respect to each other, so without matter there would be no space. In this view, an empty space has no "where" to put things and distance is just the length between two marks on a platinum-iridium bar in Paris.

Newton's reply to Leibniz was a hanging bucket of water that spun around (Figure 2.2). First the bucket spins, not the water, then the water also spins and presses up against the side to make a concave surface. If the water spins with respect to another object, what is it? It can't be the bucket, because when it initially spins relative to the water the surface is flat, and when later it is concave, the bucket and the water are spinning at the same speed. In a universe where all movement is relative, a spinning bucket should be indistinguishable from one that is still. If an ice skater spins in a stadium their arms splay out by the spin. One *could* see this as relative movement, as the stadium spinning round the skater, but why then do the skater's arms splay? We conclude that the skater *really is spinning* in space (Greene, 2004) p32.

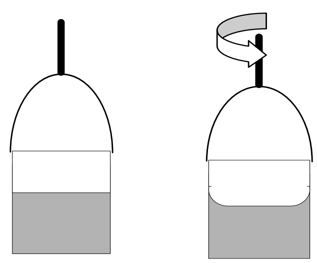

Figure 2.2 Newton's' bucket.

This seemed to settle the matter, until Einstein showed that objects really do only move *relative* to each other. Mach then tried to resurrect Leibniz's idea, arguing that the water in Newton's bucket rotated with respect to all the matter of the universe. In a truly empty universe Newton's bucket would stay flat and a spinning skater's arms would not splay, but this is untestable as we can't empty the universe. This willingness to invoke zombie theories reflects how disturbing some physicists find the idea of a space that is:

"…*substantial enough to provide the ultimate absolute benchmark for motion.*" (Greene, 2004) p37

In contrast, a simulation could handle object interactions two ways:

1. *Centralized.* In this option each photon has an *absolute* position and every cycle all positions are compared to see if any are equal, i.e. if a collision has occurred. For the inhabitants of this virtual reality, space would indeed be truly nothing and potentially continuous. Yet from a processing perspective, it is inefficient as every point is compared to every other point every quantum cycle, and as the number of interactions grows geometrically, for a simulation the size of our universe it is unimaginable.
2. *Distributed.* In this option, each point of space is a node with a fixed processing capacity to handle any load given it. Now collisions aren't based on central calculations but on local overloads, that occur if a node gets more processing than it can handle. For the inhabitants of this virtual reality, space is not continuous and exists apart from the objects in it.

[4] Planck length of 10^{-33} meter is the pixel resolution. Planck time gives 10^{43} times per second as the refresh rate.

In reverse engineering the best option is preferred, and it is also the current verdict of physics that:

"*space-time is a something*" (Greene, 2004) p75

Space as a processing network is neither the passive canvas of Newton nor the nothing of Leibniz, because *null processing* is active even while generating "nothing".

2.3.2. Euclidian space

That space is a "something" raises the question *What does it do?* It seems strange to talk of what space "does", but computer simulations of it do just that:

> "*…we think of empty spacetime as some immaterial substance, consisting of a very large number of minute, structureless pieces, and if we let these … interact with one another according to simple rules … they will spontaneously arrange themselves into a whole that in many ways looks like the observed universe.*" (Ambjorn, Jurkiewicz, & Loll, 2008) p25.

Euclid defined the structure of our space many years ago. He began with a *point* that was extended continuously as a *line* that was extended at right angles be a *plane* that extended again became a *cube*. Space could then be thought of as a set of cube volumes in three dimensions, i.e. a *Euclidian space*.

Yet war-gamers didn't like Euclid's space, as it only gives four directions to attack the enemy, so they divide their maps into hexagons not squares, to give more *interaction directions*. So a space in general requires:

1. *Dimensions*. Dimensions define the number of "degrees of freedom" needed to create it.
2. *Locations*. Location coordinates define whether two objects are "in the same place", i.e. interact.
3. *Directions*. Directions define the number of ways a point can interact with its neighbors.

A Euclidean space with three orthogonal dimensions represented by Cartesian coordinates has locations defined by three real numbers (x,y,z), with any number of interaction directions.

2.3.3. Scalability

Simulating space as a network isn't a new idea. In Wilson's networks each node is a volume of space, and in Penrose's *spin networks* each node is an event with two inputs and an output (Penrose, 1972). However models that map nodes to Cartesian points, like loop quantum gravity (Smolin, 2001), cellular automata (Wolfram, 2002) and lattice simulations (Case, Rajan, & Shende, 2001) encounter the problem of *scalability*.

Berners-Lee defined a *scalable* system as one that doesn't lose performance as it grows, however big it gets (Berners-Lee, 2000). He designed the World Wide Web to this principle, that growth should increase demand and supply in tandem. If every new ISP[5] demand also increase the processing to handle it, the system can grow forever. Such a system has to be distributed but when the idea of a decentralized Internet was first mooted, pundits predicted that it would collapse into chaos due to lack of control. It didn't and it was *because* it had no central control.

As computer scientists later discovered, an infinity anywhere in a centralized system can crash it, but distributed systems can carry on despite a *local crash*. Our brain as a biological processor evolved according to this principle as it has no central processing unit or CPU (Whitworth, 2008). The cortical hemispheres, the highest brain systems, are duplicated so if one fails the other can carry on, like a brain in itself. Likewise, when "constructing" space decentralization is better. Cartesian coordinates work for small spaces but aren't *scalable* because they require:

1. *A known size:* A known size is necessary to define the coordinate memory allocation[6].
2. *A zero-point origin*: An absolute origin, i.e. a central (0,0,0) point.

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[5] The nodes of the Internet network are Internet Service providers, or ISPs.

[6] A point in a 9 unit cube is stored as (2,9,8) but in a 999 unit cube is stored as (002,009,008), i.e. more memory.

The bigger a space the more memory its coordinates require, so a Cartesian space expanding like ours is would need its maximum size defined *before the first event* to avoid a Y2K problem[7], and a defined center origin point from which it all expands. Hubble data reveals that every star and galaxy is receding from us but how can a planet earth created so recently be the zero-point? The alternative is that our space is expanding *with no absolute center*.

The performance of space hasn't changed much after expanding for billions of years so it's scalable like the Internet, i.e. expansion adds processing supply as it adds work demand. Space as a processing network expands like the Internet, as adding more nodes increases supply and demand. It is a distributed network with local limits:

"…recent observations favor cosmological models in which there are fundamental upper bounds on both the information content and information processing rate." (P. Davies, 2004) p13.

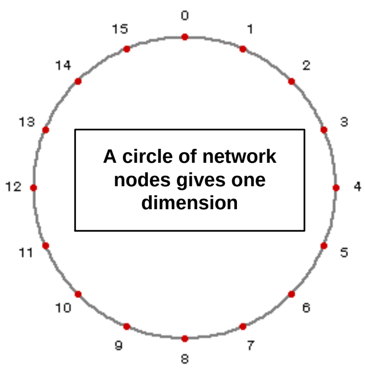


Figure 2.3. A circle surface is 1D

Black holes then expand as matter falls into them because a black hole is the processing limit of space, i.e. its "bandwidth".

2.3.4. A rotational architecture

Euclidian space is so deeply ingrained in western thought that some think it is the only way a space can be but one can derive *polar coordinates*[8] based on rotations rather than straight lines. Instead of beginning with a point that makes a line one can begin with a point that creates a circle and continue from there. In network or mathematical terms a circle is one-dimension, as every node has two neighbors, giving left and right directions (Figure 2.2). Just as we measure Web distances in mouse clicks not screen inches, so in a network "distance" and "direction" derive from *architecture*, i.e. how the nodes connect, so a node directly linked to another is "near" but one many links away is "far".

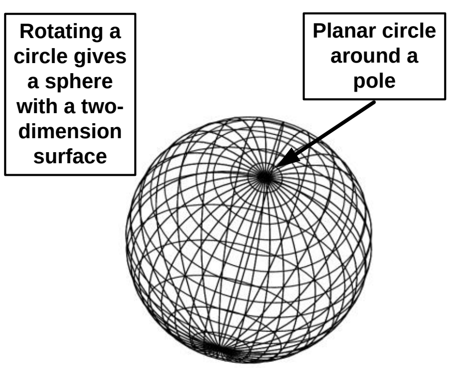


Figure 2.4. A sphere surface is 2D

Now just as Euclid did for a line, the circle in Figure 2.3 can be extended at right angles to give a two dimensional sphere (Figure 2.4). A "Flatlander" confined to this surface would see a space that is:

1. *Finite.* Has finite number of points.
2. *Unbounded.* Moving in any direction never ends.
3. *Has no center.* No point is the center of the sphere surface.
4. *Approximately flat.* If the sphere is large enough.
5. *Simply connected.* Any loop on it can shrink to a point.

This surface is like our space except with only two dimensions, but another rotation makes it a three-dimensional surface. One rotation gives a circle with a one-dimension surface, two rotations gives a sphere with a two-dimension surface and three rotations gives a *hyper-sphere* with a three-dimensional surface (Figure 2.5). A hyper-sphere is what you get when you rotate a sphere, just as a sphere is what you get when you rotate a circle. It is well defined mathematically, but while a sphere surface has only two dimensions, a hyper-sphere surface has three. The mathematician Riemann centuries ago speculated that our space was a hyper-sphere *surface* because the facts fit: a hyper-sphere surface is unbounded, simply connected and three-dimensional just as our space is. The logic today is even more convincing as Einstein

[7] Before 2000 older computers stored years as two digits to save memory, e.g. 1949 was stored as "49". The "Y2K" problem was that the year after 1999 was "00", which was used for 1900. A lot of money was spent fixing this problem.

[8] Cartesian coordinates are represented by (x, y, z) values, but polar coordinates are represented by (r, θ, φ), where r is the radius from a fixed point in the angular directions theta and phi. Both systems need a (0,0,0) point.

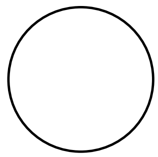
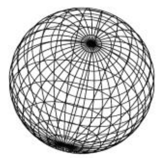
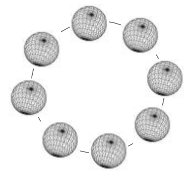
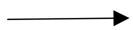
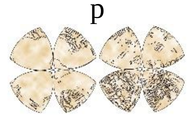
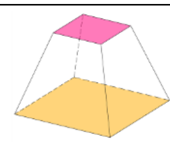
	Circle (rotated point)	**Sphere** (rotated circle)	**Hyper-sphere** (rotated sphere)
Shape			
Surface	 *A 1D line*	p  A 2D sheet	 A 3D space

Figure 2.5. A hyper-sphere surface has three dimensions

says that space curves like a surface and cosmology says it expands everywhere at once just like a balloon surface expanding would. Logically, our three-dimensional space could be the surface of a four-dimensional sphere:

"*When it comes to the visible universe the situation could be subtle. The three-dimensional volume of space might be the surface area of a four dimensional volume*" (Barrow, 2007) p180

Why then does space appear flat not curved? If you expand a sphere enough, and our universe has done that, it can approximate any degree of flatness you require.

2.3.5. A relative space

This approach suggests a space based on polar coordinates that like Cartesian coordinates need an absolute zero-point which doesn't allow a relative space, but one feature of a circle (Figure 2.3) is that any point can "begin" it, and likewise the "pole" axis chosen to turn a circle into a sphere is arbitrary. Any node on the sphere surface could be a pole depending on the rotation axes used to create the sphere. A sphere surface has as many different sets of polar coordinates as there are axis poles, but each set maps the same surface and in network terms this just changes how the nodes connect.

Now for a connected network to alter its local links is easy, e.g. cell phone networks routinely change their connections to improve efficiency. If each node *locally configures* its own connections as if it were the center of every rotation, it can "paint" its own coordinates. That every node in the network uses polar coordinates with a different zero-point doesn't allow an objective view, but as will be seen this system has no need for that.

A network that distributes control lets every node choose its neighbors as if it were the center of all space. It gets a slightly different view but that doesn't matter if every view is equivalent. Quantum nodes decide themselves which nodes are neighbors as a web page decides which other pages to link to. In this way distributed polar coordinates allow a *relative space*, where every node has its own "frame of reference".

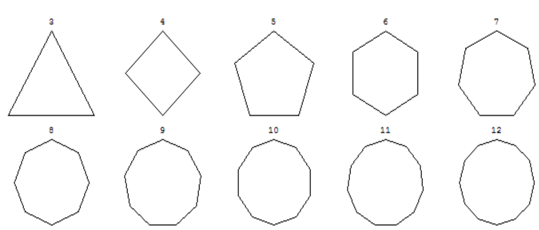


Figure 2.6. Discrete rotations, N = 3-12

2.3.6. The density of space

Space as a network must have a *density*, the number of connections each node has to others. In the above derivation this density is the number of steps in each rotation that creates the space. A discrete rotation can have any number of steps, so if a perfect circle has infinite steps, a triangle is a "3-circle", a square a "4-circle", a pentagon a "5-circle" and so on (Figure 2.6). These N-circles approximate an ideal circle as N increases. It might seem that more rotation steps is better to create a space but war-gamers avoid octagonal nodes because they don't "fill" the board, i.e. placed side-by-side octagons leave gaps. Yet while Euclidian squares do fill the board they only give four interaction directions, so hexagons are preferred as they fill the board and give more interaction directions.

More network density gives more spatial directions but a large N-circle can't fill a Euclidian space so not all paths in such a space are reversible, i.e. retracing a route taken may not return to the same node though it will be a true vicinity. In essence, a discrete space based on polar coordinates will have "holes" in it, so billiard ball point particles could pass right through each other! This might seem to disqualify a space based on discrete rotations as a match for our space, but our world is better described by quantum clouds than Newton's billiard balls. When quantum entities "collide" they overlap over an area, so a space with a few holes in it doesn't matter. *That quantum entities exist inexactly avoids the problems of an incomplete discrete space.* Even so, this model predicts that space as a network has a finite density, giving a finite number of directions for any quantum event. If direction, like length, is quantized, there will be a minimum *Planck angle*[9].

2.3.7. Space as a hyper-surface

In 1919, Kaluza derived Maxwell's equations by expressing Einstein's relativity equations in four dimensions, but his peers saw his extra dimension as a real one. If there was a fourth dimension, gravity would vary as an inverse cube and the solar system would collapse, so they dismissed his idea. Yet mathematics already had *complex numbers* that explained electro-magnetism as a rotation into a fourth dimension, but it was "imaginary" so physical realism wasn't contradicted.

Klein then suggested that perhaps Kaluza's dimension was *compactified*, curled up in a tiny circle so entering it returned you to the start, but he also was ignored - until years later string theorists needed to explain their six extra dimensions. Today, they maintain that space contains their extra dimensions *within it*, but why would Nature have extra dimensions that do nothing except make our equations work?

In this model, every virtual reality presents on a screen, so an extra dimension is needed to contain that surface. If space is our screen, its three *transfer dimensions* must be contained by another, but unlike string theory, it *wraps around* our reality rather than *curls up* within it, i.e. it is too large for us see not too small.

Today, physicists like Randall and Sundrum use the idea of extra dimension *sequestered* from our space to explain gravity (Randall & Sundrum, 1999), where our space is a *brane* in a higher-dimensional *bulk*:

> "*Physicists have now returned to the idea that the three-dimensional world that surrounds us could be a three-dimensional slice of a higher dimensional world.*" (L. Randall, 2005) p52

2.3.8. Quantum space

In current physics, light is a transverse wave whose amplitude is said to be "imaginary" but in quantum realism light vibrates in a 4D quantum space. Light as a transverse wave needs a surface to vibrate up and down on so our three-dimensional space must be a surface. If a pool top is sealed in concrete no waves can travel on it because the water molecules can't move up and down. Every wave needs a dimension orthogonal to its movement direction to vibrate into, and it is "sequestered" from that dimension because it cannot leave the surface it vibrates upon.

Imagine a pond of water with waves on its surface - there is the movement of the waves and the movement of the water. The waves move on the surface horizontally, but the water just moves up and down transversely so a cork just bobs up and down as a wave passes. What moves horizontally is a pattern of *transverse changes*. So a photon as a transverse wave on the surface of a space can't move in the quantum direction it vibrates into. Likewise, we can no more enter the "imaginary" quantum dimension than an avatar can leave a computer screen.

That we are necessarily sequestered from the quantum dimension into which light vibrates doesn't mean it doesn't exist. A photon wave arises from displacements just as a water wave does, but the positive and negative values of electro-magnetism occur outside our space, i.e. they aren't physical displacements. Current physics calls electro-magnetism a rotation into an "unreal" dimension that quantum realism calls real. A rotation transverse to space is the base of this model: *Planck processing sets a circle of values transverse to space.*

Processing that sets a circle of values is efficient because the end also begins another cycle. This fundamental network command either runs or it doesn't, but like Monopoly money the values set have no value outside the virtual reality. Confined to one node the equal and opposite displacements of this *Planck program* cancel to empty space, but the same distributed over many nodes becomes light (Figure 2.7).

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[9] If a node has N neighbors in a circle around it, the minimum Planck event angle is 360°/N.

The idea of a rotation into a dimension we cannot see seems strange, but complex numbers that do just that are basic to quantum theory. Schrödinger's equation describes an electron as a three-dimensional wave whose value at any point the mathematics *defines as imaginary*. He called it a matter density wave, because high values make matter more likely to exist there, but quantum waves act nothing like matter. Born called it a probability wave, because its amplitude squared is the probability the entity exists there, but a probability is just a number. One might expect the ultimate formula of our reality to be something physical, but it isn't. As far as we can tell, the quantum amplitude that predicts physical events isn't based on mass, momentum, velocity or any other physical property. *That the unreal creates the real* makes no sense, but physicists accept it on faith to do physics[10]. Quantum realism concludes that a quantum reality we don't see creates the physical reality we do, so the *substantial arises from the insubstantial*.

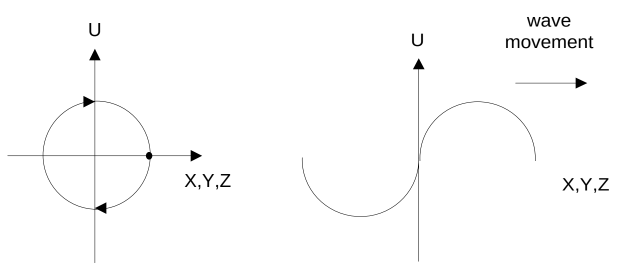

Figure 2.7. A Planck program as a. Space and b. Light

2.3.9. Planar circles

On a flat surface, a straight line is the shortest distance between two points. The general term is *geodesic* since on a curved surface like the earth the shortest distance between two poles is a curved longitude. In general, a "straight line" is the shortest path between two points, or the lines that things naturally move along. Einstein's gravity acts by somehow curving the surface of space to change the geodesics while Newton' gravity is the earth somehow attracting an apple, Einstein saw it as the earth somehow bending space-time so the apple naturally "falls" to earth. In both cases, no reason is given but that it is so, as the equations work.

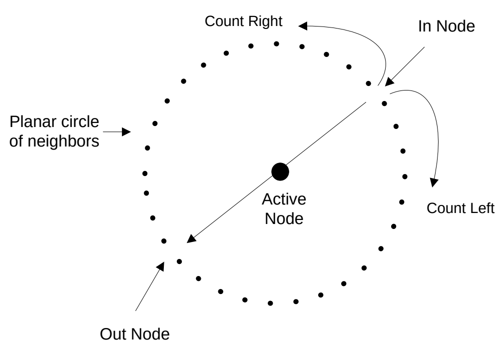

Figure 2.8. Planar circle transfers

This model approaches the issue of movement direction from a processing perspective, given a quantum network connected in four dimensions that contains our space as a 3D surface. Any node on this surface is a point of space that can receive and pass on a Planck program, i.e. a photon. Now in current physics:

"*A point in spacetime is … represented by the set of light rays that passes through it.*" (S. Hawking & Penrose, 1996) p110

So how nodes receive and pass on programs defines the geodesics that Einstein says defines gravity. The directions of space arise as each node links to neighbors by transfer channels, where each node must define how it passes on processing from a given neighbor. Every photon has a polarization plane that affects the filters that block it, and in this model that plane defines its transverse oscillation on space, i.e. a transfer *channel*.

For any axis, by the previous every node defines polar connections, like the longitudes radiating from *pole* of a sphere. Let a *planar circle* be the set of neighbor connections for any polarization plane (Figure 2.8). Just as two-dimensional *anyons* simplify problems like the quantum Hall effect (Collins, 2006), planar circles reduce the above transfer problem to finding the out node for any planar circle in node. A simple algorithm would be to count both

[10] As they must accept that an electron is a wave *and* a particle, that space is finite *and* continuous, that the universe began *and* is all there is, and so on until they get inured to illogic.

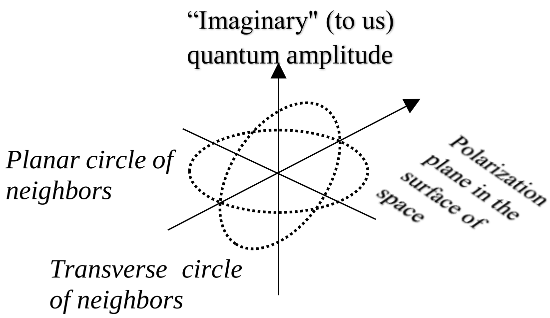

Figure 2.9. Planar and transverse circles

ways from the entry node until an overlap defines the exit node. If input from any node in a planar circle is output to the *opposite* node, the transfers will be minimized for any two points, i.e. a straight line. A network that maximizes the "distance" of entry and exit nodes in planar circles will also create geodesics.

So for *one node* receiving *one photon*, there is a *planar circle* that defines its transfer direction and a *transverse circle* that defines its processing direction (Figure 2.9). Of course quantum spin complicates this, but for now the first gives the geodesics of space while the second allows the processing that defines time.

2.4. PROCESSING TIME

In quantum realism, time is not a dimension as such but simply a side-effect of processing.

2.4.1. Virtual Time

An objective time passes inevitably by its own nature, needing nothing else, but a virtual time depends on processing cycles, e.g. in Conway's Life simulation (Figure 2.10) pixel patterns are born, grow and die in a simulation where their "lifetime" depends entirely on processing events. A pattern lives a long time if many processing cycles repeat it and a short time if few do, and it is interesting that time is measured the same way in our world, as atomic clocks just count atomic events. If a Life pattern that repeats for twenty minutes is run on a faster computer it might only repeat for a few seconds, but its virtual life would be the same because the same number of processing events occurred. Virtual time entirely depends on *the processing cycles that occur* so again note that according to Einstein time works exactly the same way in our world.

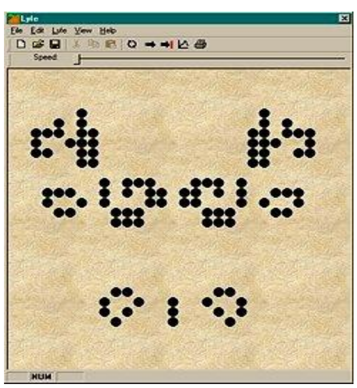

Figure 2.10. [Conway's Life]

In Einstein's twin paradox, a twin travels the universe in a rocket at near the speed of light but returns a year later to find his brother an old man of eighty. Neither twin was aware that their time ran differently, but one twin's life is nearly done while the other's is just beginning. Yet the eighty-year-old twin wasn't cheated in any way, as he got eighty years of heart beats. One sees the same effect when a computer game slows down in a big battle, the screen lags but there are still the same number of choices. If our bodies are avatars when the system slows down under load *they also slow down*. So if time is virtual we wouldn't know if it slowed down, and indeed relative changes in space-time are undetectable to the parties affected, who only see it when they later compare.

In the twin paradox, the rocket twin was moving so fast that the system could only process a year's worth of his events so he only aged a year, but for the twin on earth eighty years of his life cycled by in the usual way. Only when the two re-united was it apparent that their virtual times had run differently. When people first hear Einstein's idea that time is malleable they suspect a trick, that only *perceived time* changes, but *actual* time as measured by instruments changes, so it's no trick. It's not just theory, as short-lived particles when accelerated live many times longer than they usually do. This is only possible if our time is virtual.

In this model, the processing cycles of matter are time passing for it, so where the network is busier time passes more slowly than where it is not, just as observed.

2.4.2. Specifying time

For a system to simulate a time like ours requires:

1. *Sequence*. Time defines a sequence of events.
2. *Causality*. Time allows one event to cause another.
3. *Unpredictability*. Future time is not predictable.
4. *Irreversibility*. Time cannot go backwards[11].

A virtual time that acts like ours must be sequential, causal, unpredictable and irreversible. Processing can satisfy these requirements as follows.

1. Sequence

Could time derive from a sequence of pre-existing states as a movie is a sequence of pre-existing pictures? In this "time capsule" states could be browsed like the pages of a book (Barbour, 1999) p31, but if past, present and future states already exist in a "timeless time", *then life is a movie already made*. From a processing perspective, deriving time from a set of static states in a big database has two problems:

a) *Size*. The universe's quantum states at any moment are innumerable and its cycle rate unimaginable, so the storage needed is unbelievable.
b) *Inefficiency*. Why store in a database *quantum events* that almost never occur? Why even store all physical events, as who want to read a "history" World War II as atomic events, let alone quark events? Or if only what is important is put on the record, how are those events selected[12]?

Quantum processing doesn't allow static storage but perhaps the physical world is the next best thing. If one physical state arises from countless quantum states, a physical event does select what is important from quantum possibilities. The lawful generation of a series of static states is in essence a report. We query quantum processing to get the status update we call the physical world, which contains not only the present but also the past, whether as neural memories that exist *now* or as dinosaur fossils that exist *today*. DNA is a memory not just of our ancestors but of all life on earth. In this system, *genes* (Dawkins, 1989), *memes* (Heylighen, Francis & Chielens, K., 2009) and *norms* (Whitworth & deMoor, 2003) survive by their generative power, while that which lives for itself alone passes away. The physical world is then the quantum world's solution to its storage problem.

2. Causality

Time as a processing byproduct allows each event to cause the next, so quantum states:

"*… evolve to a finite number of possible successor states*" (Kauffman & Smolin, 1997) p1

Causality then arises not from static states but from quantum events:

"*Past, present, and future are not properties of four-dimensional space-time but notions describing how individual IGUSs {information gathering and utilizing systems} process information.*" (Hartle, 2005) p101

Processing implies state outputs, but to see them as causes is to see reality backwards. If each set of processing events defines the next no intervening states are necessary. In processing terms, what current physics calls an evolution of states is better seen as an evolution of events.

3. Unpredictability

Any choice that creates information has by definition a "before" and "after": before there are many options but after there is only one. The option chosen isn't by definition a choice, so in itself it has no information. So if the physical world is virtual the quantum collapse behind a physical event must be a free choice, as indeed it is. In quantum theory, a physical event is just a probability until it is *randomly* chosen, where randomly means that *nothing in physical history can predict it*. So even knowing every physically knowable thing, we can't predict

[11] The special case of anti-matter is considered in Chapter 4.

[12] A human eye can detect one photon, and one person can change the world, so a photon could change the world. If every photon is potentially "important", how to know which ones actually are? As in chaos theory, little things can have big effects.

when a radio-active atom will emit a photon. We know the probability it will do so, but the choice to actually do it is not made in this physical world. Even for overwhelming probabilities, *every* physical event involves a random quantum collapse that no prior physical "story" can explain. So if the world is a machine, it is one with:

"*...roulettes for wheels and dice for gears.*" (Walker, 2000) p87

The physical world may seem ordered but it is only probably so. Quantum waves spread mechanically but then collapse randomly to a point no-one can guarantee when observed. Quantum randomness denies the clockwork universe of physical realism but in processing terms *quantum collapse is a server choice* outside the virtual reality.

4. *Irreversibility*

The laws of physics are time reversible so physicists wonder if time can run backwards? If reality is a sequence of static states, why does time always go forward? Again, paradoxes show why in our world this must be so:

a. *The grandfather paradox:* A man travels back in time to kill his grandfather, so he could not be borne, so he could not kill him. One can have causality or going back in time, but not both.

b. *The marmite paradox.* I see forward in time me having marmite on toast for breakfast but next morning decide not to, I so didn't see forward in time. One can have choice or going forward in time, but not both.

In this model, every physical event comes from a quantum collapse and a quantum collapse is a node reboot. Now a reboot is a processor restarting from scratch, e.g. turning a computer off and on reboots it, which loses any work you were doing, unless you saved it! One can't *undo* a reboot when a processor restarts it loses its previous sequence of events. When a computer reboots whatever it was doing before is gone forever, and likewise when a node reboots what was before is gone so it cannot reverse. Quantum collapse creates the arrow of time.

2.4.3. Time is processing

Newton saw time as a stream that carried all before it and space as the canvas upon which God painted reality, but that view hasn't worn well. It works for ordinary life, but how can a time that defines all change, itself change[13], or how can a space that defines all directions itself "curve", as Einstein says? Today we conclude that time and space aren't fundamental:

> "*... many of today's leading physicists suspect that space and time, although pervasive, may not be truly fundamental.*" (Greene, 2004) p471.

Quantum processing punctuated by an occasional reboot collapse gives a time that is sequential, causal, unpredictable and irreversible just like ours. What now "passes" is processing, with time just the byproduct, so when processing slows down so does time. Dynamic processing exists is an event not a substance, so this "*Physics of Now"* (Hartle, 2005) p101 has no past or future and no time travel, only *an ever-present here and eternal now.*

2.5. IMPLICATIONS

That our space and time are virtual has implications for physics.

2.5.1. The big bang?

In 1929 the astronomer Hubble found that all the galaxies were expanding away from us, implying a "big bang" in space-time about 14.5 billion years ago. Finding cosmic background radiation all around us, as static on our TV screens, confirmed that not only did our universe begin, but that space and time did too. Yet if the universe is expanding, what is it expanding into? And if everything exploded "out", why is the cosmic background radiation from the first light still all around us today? To such questions physicists reply that the big bang wasn't really a bang, but if so why do they still call it that?

[13] That time changes gives *dt/dt*, which must be a constant, so that time itself changes is impossible.

In current physics, *in the beginning* our universe came from nowhere as a singularity of all the stars and galaxies at a point, but as a "big crunch" universe collapses to a black hole, why didn't so much energy at a point form a black hole from which nothing emerges, making the creation stillborn?

Then according to inflation theory (Guth, 1998) an immense anti-gravity field also from nowhere expanded the universe faster than light for 10^{-32} seconds, then vanished to play no further part in the universe. In today's creation myth, nothing created everything as a point singularity that didn't form a black hole but inflated faster than light until it stopped for no reason, giving the galaxies, stars and us. It isn't a very convincing story.

The option presented here is that *in the beginning* a quantum reality we don't understand generated the physical world from itself. A processing network linked in four-dimensions can emulate our space as the *inner surface* of an expanding hypersphere that like the surface of a balloon being blown up has no center or edge and is expanding everywhere at once. The waves that move on its surface in any direction wrap around, so the first light that went "out" then wrapped around to end up everywhere as cosmic back-ground radiation. Space as the *inner surface* of an expanding 4D bubble (Figure 2.11) answers questions like:

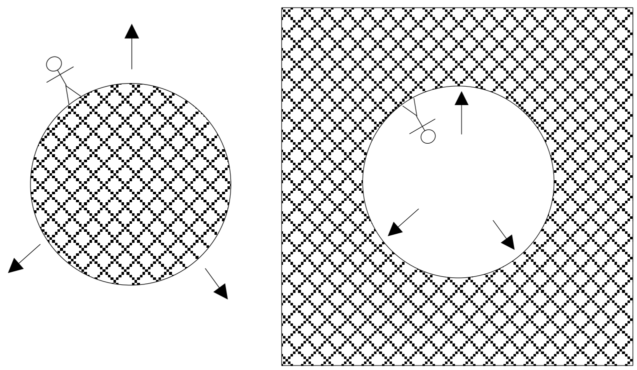

Figure 2.11a. A "big bang" b. A little rip

1. *What is space expanding into?* It is expanding into the surrounding four-dimensional *bulk*.
2. *Where is space expanding?* Everywhere, as the bulk fills "gaps" that arise everywhere.
3. *Where does new space come from?* From the quantum bulk that contains the bubble.
4. *Are we expanding too?* No, existing matter isn't affected as new space is added.
5. *Did the universe begin at a point singularity?* No. It began as one photon only (see next section).

2.5.2. The little rip

In a client-server relation, a *server* has many *clients*, e.g. for a terminal each keystroke request is sent to a network server that can handle hundreds of client terminals because it is so fast. Even if I type as fast as I can, in-between each key the server might handle hundreds of other people also typing. Now consider the first event as setting up a client-server relation, where the server cycle is *much* faster than the client cycle.

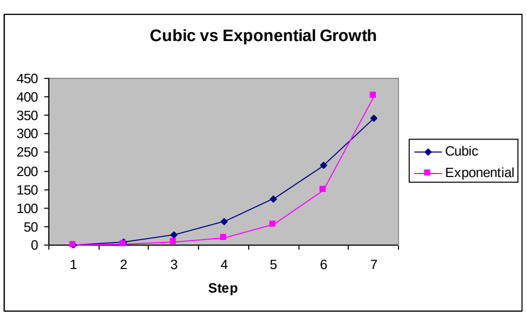

Figure 2.12. Cubic vs. exponential growth.

In this model, our universe didn't come from nothing but from a quantum network that existed before. Let the first event be when one node became a server by passing it's processing to its neighbors, creating what we might call the *first photon* in the *first unit of space*. No black hole occurred because the first event only created one photon, but it triggered its neighbors to do the same in the *chain reaction* physics calls inflation. A tiny injury to the quantum fabric quickly became huge just as a pinprick can rip a taught fabric apart. This "ripping" occurred at a *server rate* not the *client rate* that defines our speed of light.

What stopped the quantum network ripping apart forever? Each new photon also made new space that inserted into a photon wavelength diluted its power. The photon chain reaction grew exponentially but space as a hypersphere was growing as a cubic function, and a cubic growth will overpower an exponential one if the resolution is quick (Figure 2.12), and by some estimates inflation was over in less than a millionth of a second. The expansion of space that healed the original injury also reduced the first light to the lower and lower frequencies necessary for life, so cosmic background radiation that was white hot at the dawn of time is now cold. One might think the expansion of space is just an oddity of physics, but in fact without it life could not have evolved at all.

The separation into server and client that created all the *free processing* behind our virtual reality was a once only event that hasn't repeated (Davies, 1979). Galaxies have come and gone, but since inflation the net processing of the universe has been constant. In the first event *one* grid node *separated* to create one photon in one volume of space. This separation then cascaded in the faster-than-light expansion physicists call *inflation*[14] but each photon creation also made a point of space that expanded to weaken the chain reaction until it stopped. The grid tore itself apart to create all the free processing of our universe, giving an initial plasma that was:

"… essentially inhabited by massless entities, perhaps largely photons." (Penrose, 2010) p176

So the "big bang" wasn't big, at first anyway, as the first event was one photon at a point not a singularity of every galaxy at a point that would have created a stillborn black hole. It was a "rip" in the quantum fabric not an explosion into some pre-existing space, so our universe came from something not nothing.

Does a four-dimensional network plus time mean five dimensions in all? No, because the fourth dimension allows the quantum cycles that create time as a byproduct. Initially the quantum network had four equal dimensions of connection but the first event broke that symmetry, when *one of four equivalent dimensions became time and the rest became space* (Hawking & Hartle, 1983). Three of the original four dimensions became the surface we call space while the other supported the transverse vibrations whose cycles we call time. Space and time, like everything else, come from quantum reality.

2.5.3. Transfer protocols

When two processors transfer information they must work together because if what is sent isn't received it is lost. Protocols are required to avoid *transfer deadlock,* where A waits for B that waits for C that is waiting for A (Figure 2.13) - *forever*. Computer science currently addresses this problem in two ways:

1. *Centralization*. A central processing unit (CPU) synchronizes all transfers to a common clock.

2. *Buffers*. Each node has a memory buffer to store any overloads, as the Internet does.

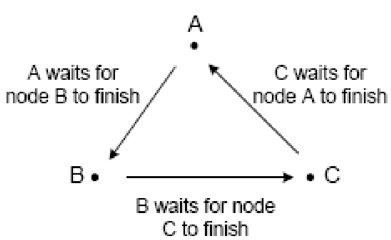

Figure 2.13. Transfer deadlock

When a central processing unit (CPU) that is very fast issues a command to move data from memory into a register how many cycles does it wait for that to happen? If it carries on to use the register too soon it gets whatever garbage was in it from the last command, but waiting too long wastes its own cycles. It can't "look" to see if the data is there because that is another command that needs another register that would also need checking!

Most computers today solve this problem by a central clock whose *clock rate* is the number of cycles to wait for any task to be done. When a CPU issues a command it then waits that many cycles before carrying on, e.g. to read the register. The clock rate is usually the speed of the slowest component plus some slack, so one can "over-clock" a computer by reducing the wait cycles from the manufacturer default to make it run faster - until at some point this gives fatal errors. Centralization works, but a universe ran by a central clock would cycle at the rate of its slowest node say a black hole, which would be massively inefficient.

[14] In Guth's theory, an immensely strong anti-gravity field pulled the physical universe from the size of a proton to the size of a baseball faster than the speed of light, then 10^{-32} of a second later that field conveniently disappeared forever from the universe.

Network protocols like Ethernet[15] improve efficiency tenfold by letting nodes run at their own rate, with buffers handling any excess. If a node is busy when another transmits, the buffer stores the data until it is free. A buffer lets a fast device work with a slow one, e.g. if a computer (fast device) sends a document to a printer (slow device), it goes to a *printer buffer,* which allows you to carry on using your computer while the document prints. Yet planning is needed as too big buffers waste memory while too small buffers can overflow. Networks like the Internet fit buffer size to load, with big buffers for backbone servers like New York and little buffers for backwaters like New Zealand. Galaxies are the "big cities" of our universe but where they occur is hardly predictable, and allocating even small buffers to the vastness of space is pointless. One can manage transfers by central control or buffers but the quantum network proposed isn't centralized and has no static memory, how does it manage?

2.5.4. The pass-it-on protocol

If the processing of a virtual reality like SimCity "leaks" then a building in it might suddenly disappear. Imagine if our world did that! Our universe has run for billions of years with no evidence that even a photon has been lost so what ensures this? Centralization is inefficient and buffers are unreliable but neither option is usable by a dynamic distributed network anyway, so how does it manage?

If node transfers waited for destination nodes to finish their cycle, the speed of light could vary for the same route, which it doesn't. That light doesn't wait implies a *pass-it-on protocol:* that nodes immediately receive any input as an *interrupt*. Won't this lose the processing they are currently doing? Not if every node passes it's processing to its neighbors *then* processes what it receives. This could create an infinite regress, except that space is expanding, i.e. adding new nodes, so any pass-it-forward ripple will stop if it meets a new node that accepts the extra processing without passing anything on.

In this protocol, nothing ever waits so there is no need for static buffers. Light moves on one node every cycle, every transfer is accepted, and expanding space nullifies infinite pass-it-on loops.

2.5.5. Empty space is full

If empty space was really empty it would be empty of energy, but in quantum theory:

"*… space, which has so much energy, is full rather than empty.*" (Bohm, 1980) p242.

In this model, empty space is null processing, like an idle computer that is actively running a *null cycle* over and over. So *empty space isn't empty* (Cole, 2001), as illustrated by:

a. *The Casimir effect.* Two uncharged flat plates nearby in a vacuum feel a force pushing them in. Currently, this *vacuum pressure* is attributed to virtual particles around them but emptiness can't create particles! Rather quantum theory predicts it based on non-zero values for the electro-magnetic oscillation of space.
b. *Vacuum energy*. In physics, the *energy of the vacuum* arises because a quantum point can't constantly have zero energy. A space of truly nothing wouldn't have this property but null processing does. A cycle of positive and negative values can *average* zero, but it can't be constantly null.
c. *The medium of light.* How can light vibrate transversely in "empty" space? Space mediates light waves so it can't be nothing. As a screen, space can be blank (nothing) or mediate an image (something).

Empty space isn't a *physical* something but as Einstein said it has to be something for relativity to work:

"…there is a weighty argument to be adduced in favour of the ether hypothesis." (Einstein, 1920).

Indeed quantum theory itself implies some sort of *quantum ether*:

"*The ether, the mythical substance that nineteenth-century scientists believed filled the void, is a reality, according to quantum field theory*" (Watson, 2004) p370.

[15] Or CSMA/CD – Carrier Sense Multiple Access/ Collision Detect. In this democratic protocol, *multiple* clients *access* the network *carrier* if they *sense* no activity, but withdraw gracefully if they *detect* a *collision*.

In this model, space that seems empty to us is actually *full* of processing. This "fullness" is the quantum network that mediates light, generates vacuum energy and gives the Casimir effect. There isn't a physical ether but there is a non-physical quantum network that mediates all physical events.

Imagine a large window with a view - one sees the view not the glass transmitting it. One only sees the glass if it has imperfections, if it has a frame around it or if one touches it. The "glass" that transmits physical reality has no imperfections so it isn't seen directly, it is all around so there is no frame to detect it by, and it transmits matter as well so we can't touch it. Like a network of *perfect diamonds,* quantum reality flawlessly reflects the images of physical reality within itself.

2.6. THE DESERT OF PHYSICS

A century ago, physics left the haven of classical mechanics for the promised lands of relativity and quantum theory. It discovered quantum waves, higher dimensions, time dilation, curved space and other wonders, but now stagnates in the desert of physical realism, convinced that *this is all there is*. *The Trouble with Physics* (Smolin, 2006b) is that no theories grow in this place. What puzzled Feynman fifty years ago still puzzles us today. Experts write notional papers about strings, multi-verses, supersymmetry and WIMPs to rally the troops but are *Not Even Wrong* (Woit, 2007). Even the weeds of error don't grow here! The crisis of physics today is that without new ideas the next fifty years will be like the last – theoretically barren.

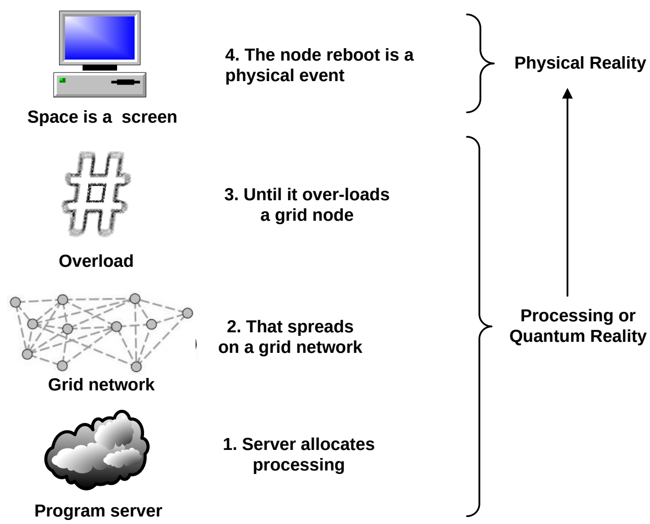

Figure 2.14. Quantum processing gives physical reality

Reverse engineering physical reality offers an alternative to physical realism that quantum theory has already described and quantum computing already uses. We can't see it but we can conceive and test it by simulations. This approach doesn't deny the equations but promotes them to being *literally true*:

1. *Quantum randomness* occurs because it is from a server outside physical reality.
2. *Complex numbers* work because light really does rotate into another dimension.
3. *Kaluza's dimension* unites relativity and Maxwell's theory because it actually exists.
4. *Planck limits* exist because space and time are indeed digital.
5. *Feynman's sum over histories* works because quantum entities really do take every path.
6. *General relativity* lets our space curve because it is indeed a "screen".
7. *Cosmic background radiation* is still here because a hyper-sphere surface has no edge.

Calculus, used throughout science, works because infinitesimals "in the limit" predict physical reality. It began as a thought experiment like quantum theory but by its success should be a reality description since things do indeed change in infinitesimal pixel steps (dx) and time cycles (dt)! Zeno concluded correctly that a sequence of static states can't create movement but the dynamic events behind them can. We can replace time in our equations with a delta time because processing cycles create physical states[16].

The bottom line is that if the equations of quantum and relativity theory are good enough to use, they are good enough to believe! Figure 2.14 summarizes the model, where quantum servers distribute processing on a network

[16] For any calculus involving time, replace *dt by ds*, the state *difference*. Now *ds*, the number of intervening cycles, can indeed "tend to zero", when one cycle gives the next with none in-between.

until a node overloads and reboots to give what we call a physical event. Table 1 compares quantum realism and physical realism for space and time, so the reader can decide for themselves. In one view, physical events in a bendable space and a malleable time are considered complete in themselves, while in the other time and space change because they are virtual, i.e. created by something outside the viewed reality.

QUESTIONS

The following discussion questions arise from this chapter:

1. If the physical world is a virtual reality, what is the screen?
2. If the physical world is an image, what is its resolution and refresh rate?
3. Why doesn't the ongoing flux of our world ever stop?
4. If physical reality is virtual, can we one day download and upload it?
5. How does a dimension "curled up" in space differ from one that is "wrapped around" space?
6. Is space something or nothing? If it is nothing, what transmits light? If it is something, what is it?
7. Would one expect a network simulating our universe to be centralized or distributed?
8. How is our space like a hyper-sphere surface?

Table 1. Space and time as explained by physical realism and quantum realism

Physical Realism	Quantum Realism
Flux. The inert physical world is constantly in flux for some unknown reason	***Processing***. The physical world is constantly in flux because it is being created by quantum processing
A space. The "canvas" of space is: a) *Empty*. But filled by fields and virtual particles b) *Continuous*. Despite the Planck length limit c) *Complete*. Despite the imaginary dimension of light d) *Expanding*. For no reason at all e) *Absolute*. As each point has cartesian coordinates	***A network***. The quantum network is: a) *Null processing*. No output looks empty b) *Discrete*. A point is an infinitesimal something c) *Contained*. It is the surface that light vibrates on d) *Expanding*. Like a bubble in a larger bulk e) *Relative*. Each node "paints" its polar links
Time. The flow of time is: a) *Continuous*. Despite the Planck time limit b) *Affected* by speed and mass for some reason c) *Defined* by a sequence of static quantum states d) *Reversible* in every law of physics	***Processing.*** Quantum processing cycles as time are: a) *Discrete*. Planck time is one processing cycle b) *Affected* by the local processing load c) *Defined* by a sequence of choice events d) *Irreversible* as a physical event is a reboot
Empty space. Is nothing yet it: a) *Manifests* non-zero energy for some reason b) *Spawns* matter and anti-matter particles c) *Mediates* light as a "wave of nothing" d) *Has limits* as black holes expand with new matter	***Asynchronous null processing.*** No net output but is: a) *Active*. Its output is only zero on average b) *Processing*. That can split into opposing cycles c) *Available*. To process photon programs d) *Finite*. A black hole is the bandwidth of space
Spatial directions. Objects move in: a) *Straight lines* for some reason b) *That gravity bends* for some reason c) *In directions* that exist for every angle	***Network connections***. Processing transfers along: a) *Least transfer routes* (straight lines) b) *That alter* with a load differential (gravity) c) *In directions* that are discrete for a quantum event
The big bang. The universe began as a big bang that: a) *Came from* nothing at all	***The little rip***. The universe began as a little rip that: a) *Came from* a previously existing quantum grid

b) *Began as a singularity* of the universe at a point	b) *Began as one photon* in one volume of space
c) *Expanded "out"* so cosmic back-ground radiation should be far away by now, at the cosmic edges	c) *Expanded "out"* on a sphere surface, so cosmic background radiation is still all around us today
d) *Inflated* faster than light, due to a massive anti-gravity field that came and went for no reason	d) *The initial chain reaction* created free processing until *the expansion of space* stopped it

9. If light moves by a grid transfers, what are "straight lines" in network terms?
10. If our time is virtual, how do we know that it changes?
11. If time is a sequence of choices, why can't we run them backwards, i.e. reverse time?
12. If our space is expanding, what is it expanding into?
13. Why is it impossible for our universe to ever have existed as a point singularity?
14. If time began at the first event, what made it begin? How can time itself "begin"?
15. Why is cosmic background radiation from after the first event still all around us, not far away?
16. If the net free processing of the universe was created by inflation, can it still change today?
17. How does the quantum network handle the network transfer problem when it has no buffers?
18. How can quantum events that don't exist predict physical events that do?

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