Quantum Realism Part I. The Observed Reality

Chapter 1. The Physical World as a Virtual Reality

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"Not only is the universe stranger than we imagine, it is stranger than we can imagine."

Sir Arthur Eddington

We take our world to be an objective reality, but is it? The assumption that the physical world exists in and of itself has struggled to assimilate the findings of modern physics for some time now. An objective space and time should just "be", but in our world space contracts and time dilates. Objective things should inherently exist but in our world, electrons are probability of existence smears that spread, tunnel, superpose and entangle in physically impossible ways. Cosmology now adds that our universe just popped out of nothing about 14 billion years ago. This is *not* how an objective reality should behave!

1.1. STRANGE WORLD

This book explores a possibility normally dismissed out of hand, that the physical world is a quantum processing output and thus virtual. The reader is asked to keep an open mind, as it will be shown that what is proposed is neither illogical, unscientific nor incompatible with physics. Nor is it a modern concept, as its roots go back thousands of years. It is relevant today because modern physics has discovered that we live in a very strange world.

1.1.1. Strange physics

Strange theories abound in modern physics, e.g. in many-worlds theory each quantum event divides all reality, so everything that can happen does happen in an inconceivable multiverse of parallel worlds (Everett, 1957). In the inflationary model, the physical universe is just one of many bubble universes (Guth, 1998) and according to string theory reality has six extra dimensions curled up, hidden from view. In M-theory, our universe floats on a fifth dimension "brane" we can't see (Gribbin, 2000) p177-180 and in ekpyrotic theory our universe is one of two universes that collide and retreat in an eternal cycle (J. Khoury, 2001). The days when physics just described the physical world we see are long gone.

These theories seek to make sense of the equally strange findings of physics: that the sun bends light by curving the space around it, that the earth's gravity slows down time and that clocks tick faster on tall buildings than on the ground. Movement also dilates time, so an atomic clock on a plane ticks slower than a synchronized one on the ground (Hafele & Keating, 1972) and is heavier as well. In our world, reality basics like space, time and mass vary with speed, while the speed of light is strangely constant.

If relativity is strange then quantum theory is just as strange: in Young's experiment *one* electron goes through *two* slits at once to interfere with itself; entangled photons ignore speed of light limits; the vacuum of space exerts pressure; and gamma radiation is entirely random, i.e. physically uncaused. Einstein, who was as open to new ideas as anyone, thought quantum theory made no sense, and it doesn't. Physics has polled our reality and the results are in:

"*... the weirdness of the quantum world is real, whether we like it or not.*"

(Tegmark & Wheeler, 2001) p4.

In conclusion, physics theory is strange because our world is strange.

1.1.2. A hollow science

Quantum mechanics and relativity theory are the crown jewels of modern physics that have quite simply never been proved wrong. It all began with Maxwell's wave equations in the 1860s, followed by Planck's constant in 1900, Einstein's special relativity in 1905, general relativity in 1915 and Schrödinger's wave equation in 1925. Despite initial skepticism, these theories met every logical and experimental test their critics could devise and amazed even their advocates, as Fermi predicted the neutrino in 1933 before it was found in 1953 and Dirac predicted anti-matter before it too was confirmed. Yet a century later, *the theory still doesn't make any sense.* As Ford says:

> *"Its just that the theory lacks a rationale. 'How come the quantum' John Wheeler likes to ask. 'If your head doesn't swim when you think about the quantum,' Niels Bohr reportedly said, 'you haven't understood it.' And Richard Feynman … who understood quantum mechanics as deeply as anyone, wrote: 'My physics students don't understand it either. That is because I don't understand it.'"* (Ford, 2004) p98

For the first time in history, the scholars of a discipline don't actually believe what their reigning theories say! They accept the calculations are correct but deny that they represent reality. This is, to say the least, an unusual state of affairs. The problem isn't inexperience, as these theories are used in a host of technologies that define life today, from cell phones to space exploration, yet:

> "*… physicists who work with the theory every day don't really know quite what to make of it. They fill blackboards with quantum calculations and acknowledge that it is probably the most powerful, accurate, and predictive scientific theory ever developed. But … the very suggestion that it may be literally true as a description of nature is still greeted with cynicism, incomprehension, and even anger*." (Vacca, 2005) p116

There are equations, tests and applications but what is described makes no physical sense, e.g. in Feynman's sum over histories an electron travels *all* possible paths between two points at once but how can *one* electron do that? Theory usually increases understanding but in fundamental physics it seems to take it away, e.g. wave-particle duality lets waves morph into particles, which denies the very idea of what waves and particles *are*. Given a choice between meaning and mathematics, physics long ago chose the latter and the consequences can be seen today, e.g. quantum theory still isn't taught in high schools as who can teach what makes no sense? Modern physics is a mathematical feast whose core is empty of meaning, a *hollow science* built on impressive equations about quantum states that everyone agrees don't exist! And this *way of no meaning* is a deliberate strategy:

> "*… we have locked up quantum physics in "black boxes", which we can handle and operate without knowing what is going on inside*. (Audretsch, 2004) (Preface, p x).

The result is what some now call a *fairy tale physics* (Baggot, 2013), where virtual particles arise ex nihilo from invisible fields in empty space to fit equations that work but make no sense. When physics stopped trying to make sense of its findings, the result was an evident lack of progress:

> "*How unusual it is for three decades to pass without major progress in fundamental physics? Even if we look back more than two hundred years…it is unprecedented*." (Smolin, 2006) p viii

The issue is not a few anomalies in an otherwise perfect vision. Quantum theory rules the micro-cosmic world from which reality emerges and relativity rules the cosmic world around it. These theories *are* the bedrock of physics which is fundamental to science, so for them to make no sense at all is not acceptable. Yet relativity and quantum mechanics contradict at their core. Each works in its domain, relativity for cosmic events and quantum theory for atomic events, but together they clash:

"*The problem … is that when the equations of general relativity commingle with those of quantum mechanics, the result is disastrous*." (Greene, 2004, p15)

This conflict tells us something is wrong. The barren desert of particle physics today began with the Copenhagen "*shut up and calculate*" policy that effectively banned discussions of meaning. It is time to return to the question that physics tried to ignore decades ago:

"*… the main reason for the existence of myths in QM {quantum mechanics} is the fact that QM does not give a clear answer to the question of what, if anything, objective reality is.*" (Nikoli, 2008) p43

This is the original "hard" question of physics - *What is reality?*

1.2. THE REALITY QUESTION

For thousands of years, people have wondered what is reality? What began as *materialism*, that only physical matter is real, evolved into *physicalism*, that the physical events we see are all that there is. Its contrast was *idealism,* that what we see reflects something else. Logically, one of these world views *must* be wrong and orthodox science and orthodox religion have taken opposite sides on this issue.

1.2.1. Idealism vs. physicalism

Aristotle was a student of Plato who was a student of Socrates, an ancient Greek *philosopher* who lived when that word meant literally lover (*philo*) of wisdom (*sophia*). Plato followed Socrates to argue that the physical things we see are based on pre-existing *ideal forms* that exist apart from them. Aristotle did not deny this but taught that Plato's forms were abstractions of physical things, so their causes were to be sought not in the abstract world of forms but in other physical things. Science based on outer observation developed from Aristotle's view that the causes of the physical world were to be found in itself, while religion based on inner belief sided with Plato that something non-physical caused it. Orthodox religion's vivid depictions of a heaven and hell beyond this life dominated thought in the west for the next two thousand years until science rose to challenge this view.

In the West, some held to Plato's original idea, that the physical world is like shadows flickering on a wall[1], e.g. Gnostics saw the world as a *lie,* created by a demiurge who was ignorant of the original reality[2]. In the East, the same idea survived better as in Chan Buddhism a universal *essence of mind* creates the observed world like bubbles on a sea, and in Hinduism the physical world is *Maya,* an illusion created by God's "play" (*Lila)*. Yet at any time, whether in science or religion, only a tiny few ever truly believed that the physical world wasn't real in itself.

1.2.2. Dualism

In the west, as the ideological war between science and religion grew, Descartes proposed the truce of *dualism* based on "*I think, therefore I am*". Why not have mind *and* body, the spirituality of religion *and* the physicality of science? This divided scientists into *atheists* who believed *only* in the physical world, *theists* who believed in a world beyond it as well, and *agnostics* who couldn't decide. This marriage of convenience worked for a while but it didn't last, as now science in general denies the spiritual.

The problem for dualism is how can two *distinct realities co-exist?* If mind and body don't interact they aren't relevant to each other. What use is a mind that can't affect the body? Or if they do interact which came first? A mind that *emerges* from a physical brain is like a superfluous gas given off by a physical

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[1] In his analogy, people tied up in a dark cave with their backs to its exit see their shadows on the cave wall, created by sunlight from the outside, and take them to be reality.

[2] In this story, the original "fullness" (Pistis Sophia) tries to make something new from herself but accidently creates a monstrous *demiurge* (lesser god). Ashamed she quarantines him. He being alone and thinking only he existed, creates our world in his own image, entrapping Sophia's essence in a false physical world.

heap, while if a non-physical mind creates the world, why is it such a mess? Either way, if one is real then the other isn't, or at best it is irrelevant. And if the two realities are in conflict, why hasn't heaven purged earth already or earth corrupted heaven? If mind and body are sides of the same coin, what is the coin?

Facing such challenges, *dualism* is currently in retreat before the *monism* that there is only one reality and it is physical. Monism is simpler than dualism, so when scientists say the physical world they study right now is real and theologians say a future spiritual world is real, many people prefer now to later.

1.2.3. Virtualism

Yet as science and religion fight their thousand year ideological battle, another monism stands on the sidelines ignored by all, namely *virtualism* (Raspanti, 2000), that physical world is a processing output created by some "other". This idea seems new but Pythagoras saw numbers as the non-material essence of the world, Plato felt that God geometrizes and Gauss believed that God does arithmetic (Svozil, 2005), just as Blake's *Ancient of Days* measures the world with his compass (Figure 1.1).

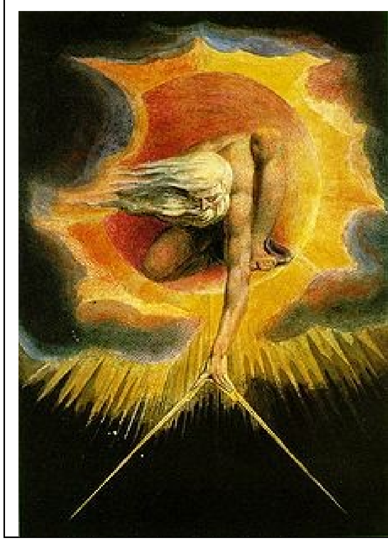

Figure 1.1. The Ancient of Days *calculates the universe* [3]

Computers today create virtual worlds but that the physical world is virtual is usually a topic of fiction not physics. Yet that physical reality is a processing output leads to ideas like that *space calculates* (Zuse, 1969) and that *reality computes* (Fredkin, 1990), (Schmidhuber, 1997), (Rhodes, 2001), (Wolfram, 2002), (Lloyd, 2006), (Tegmark, 2007). Plato's radical view is no less so today.

In *physicalism* only the physical world exists, in *dualism* a higher reality also exists and in *virtualism* physical reality is a processing output. The latter denies the *presumed* "prime axiom" of physics that:

There is nothing outside the physical universe (Smolin, 2001).

Proposing instead its antithesis that:

Nothing in the physical universe exists objectively, i.e. of or by itself.

Thus virtualism gives the *virtual reality conjecture* that:

The physical world is a set of events output by some processing without which it would not exist at all.

Physicalism in contrast proposes the opposite, that the physical world is an objective reality that exists in and of itself that needs nothing other than itself to exist.

These are mutually exclusive statements. An objective world that is inherently real can't be a virtual world and vice-versa. One can't logically prove reality statements (Esfeld, 2004) so that the world is virtual isn't provable but by the same logic neither can one prove that the physical world is an objective reality. It follows that to demand of a new theory what the old one can't deliver either is bias not science.

1.2.4. The reality options

We can reduce the reality options to three:

1. *Physical realism.* That only the physical world exists and it does so by itself alone.
2. *Dualism.* That the physical world exists but there is also a higher reality beyond it.
3. *Virtualism.* That the physical world is a construct created by something outside itself.

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[3] The Ancient of Days by William Blake, 1794.

In *physical realism,* a self-existent physical world observes itself just as it is. In such a world, random events like radioactivity that by definition aren't predicted by prior physical events shouldn't happen.

In *dualism*, a real physical world exists but another reality beyond it also observes, giving a heaven, hell or spirit world. The result is a *God of the gaps,* as the other reality only explains what is left after science advances, which every day gets smaller.

In *virtualism,* another reality generates the physical world we see like images on a screen, so the latter doesn't really exist at all but only appears to. Opinion is now divided on what this "other" is:

1. *Physical*. In The Matrix movie, a virtual reality looked real to its inhabitants because they only knew it as information, *just as we know ours*. When the hero disconnects from the matrix he falls back into another world, to see post-nuclear machines feeding people virtual input while farming them in vats for energy. The physical world he previously knew was a *construct* created by programs in another physical world. *In theory,* this is possible as by the Church-Turing thesis a finite program can simulate any specifiable output (Tegmark, 2007) but *in practice,* trying to simulate even a few hundred atoms with a conventional computer[4]:

   > "… *would need more memory space that there are atoms in the universe as a whole, and would take more time to complete the task than the current age of the universe.*" (Lloyd, 2006) p53.

   Since even a computer as big as our universe couldn't remotely do the job, this option is unlikely.

2. *Mental.* In this view, the physical world is a dream of the mind, e.g. in *solipsism* a self-existing observer dreams a world that isn't there at all. The *esse est percipi*[5] thesis, that the mind creates reality, is shown by optical illusions but that doesn't mean there's no reality out there. As Einstein said, surely the moon exists when no-one watches it? Solipsism doesn't generalize well because if I'm dreaming you, you're just my pixels. It solves the quantum observer effect[6] by making everything an observer effect, but if no tree falls in a forest when no-one watches how does history arise? Do we fabricate the millions of years of dinosaurs before we came along? And if I am dreaming, why can't I dream the body I want? For these and other reasons this option is unlikely.

3. *Quantum.* In this view, quantum processing[7] creates physical events that otherwise wouldn't exist. Physics currently rejects this option because it gives:

   > *"…no means of understanding the hardware upon which that software is running. So we have no way of understanding the real physics of reality.*" (Deutsch, 1997)

That only the physical is real and so what isn't physical can't be real is the sort of circular logic that science warns us against. To assume an answer then prove it using that assumption is illogical. We know that quantum entities aren't physical because they appear and disappear in physically impossible ways, tunnel through physically impassable barriers, ignore the speed of light limit on physical interactions and superpose in physically impossible ways, e.g. quantum theory describes currents going both ways round a circuit at once, which never happens in the physical world. But that quantum waves aren't physical doesn't mean they don't exist nor does that we can't see something mean we can't study it, e.g. we study gravity but we can't see it. To expect the quantum "hardware" that creates physical reality to follow the rules of

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[4] As Yogi Berra said: *"In theory there is no difference between theory and practice. In practice there is."*

[5] "Existence is perception", i.e. what is real is created by what we see.

[6] In quantum theory, observing a spreading quantum wave makes it take a physical point state, so the quantum observer effect is that observation creates the physical event.

[7] *Information* is defined as choosing a value from a set (Shannon & Weaver, 1949) and *processing* is defined as changing information.

what it creates makes no sense. The qubit of quantum processing is not the bit of physical processing for this reason.

1.2.5. Quantum realism

Quantum realism is the theory that the ghostly quantum world is real *on its own terms*. It isn't The Matrix movie idea that another physical world is creating ours because even computing *one* electron wave function that can spread over a galaxy then collapse to any point in it is beyond any physical computer [8]. Only quantum processing has the power to output the physical reality we see. Nor is it that we are dreaming because if I am dreaming you then you don't exist, leading to the solipsist view that only I exist.

In quantum realism, you and I are real and the physical world is the *interface* between us. So there is a real world out there but it isn't the physical one you see. The physical world *mediates* quantum reality as email *mediates* people. An email *represents* a person but isn't a person in itself and likewise the physical world *represents* reality but it is not in itself real.

Quantum realism is a *monism* just as physical realism is, except that for it the only reality is quantum. In this view, physical reality only arises when quantum reality interacts with itself to give an *observer* and an *observed*. Since the interaction is mutual, it follows that when we observe a photon, it is also "observing" us, as evidenced by the observer effect in physics. Later chapters address how a quantum reality could provide the ability to observe, but for now note that a tree can't fall in a forest unseen because the ground it hits "sees" it[9].

The reality options in computer game terms are:

- *Physical realism.* A game running itself with no-one in charge.
- *Dualism* is like a game running itself with the programmer vainly trying to regain control.
- *Solipsism* is like a single player game that exists only for one person.
- *Quantum realism* is like a massively multi-player game with every photon a "player".

Figure 1.2 compares the reality candidates based on Wheeler's universal observing eye. In physical realism, a physical reality somehow observes itself although matter offers no basis at all for observation. In dualism, a higher reality observes the physical, although no basis has ever been proposed for how two different realities can co-exist. In quantum realism, a quantum reality observes itself via a physical world interface, so there is only one reality and it inherently observes.

In sum, physical realism denies any reality that isn't physical, dualism lets us have physical and non-physical realities at the same time, and quantum realism regards the physical as a generated interface that is not in itself real. Let us now choose between these options based on science not bias.

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[8] A Milky Way volume of 1.6 x10^{60} cubic meters divided by a Planck volume of 4.2 x10^{-105} cubic meters is about 551 bits, which for a 10^{-43} seconds Planck time is over 5x10^{45}Hertz of processing power for one quantum event. Even our best supercomputers are only just breaking the PetaHertz barrier (10^{15}Hertz) so to calculate even this one quantum event is beyond all our best computers.

[9] Knox's limerick on solipsism was: *There was a young man who said, "God, must think it exceedingly odd, if he finds that this tree continues to be, when there's no one about in the Quad."*
The anonymous reply was: "*Dear Sir: Your astonishment's odd: I am always about in the Quad. And that's why the tree, will continue to be, since observed by yours faithfully, God.*"

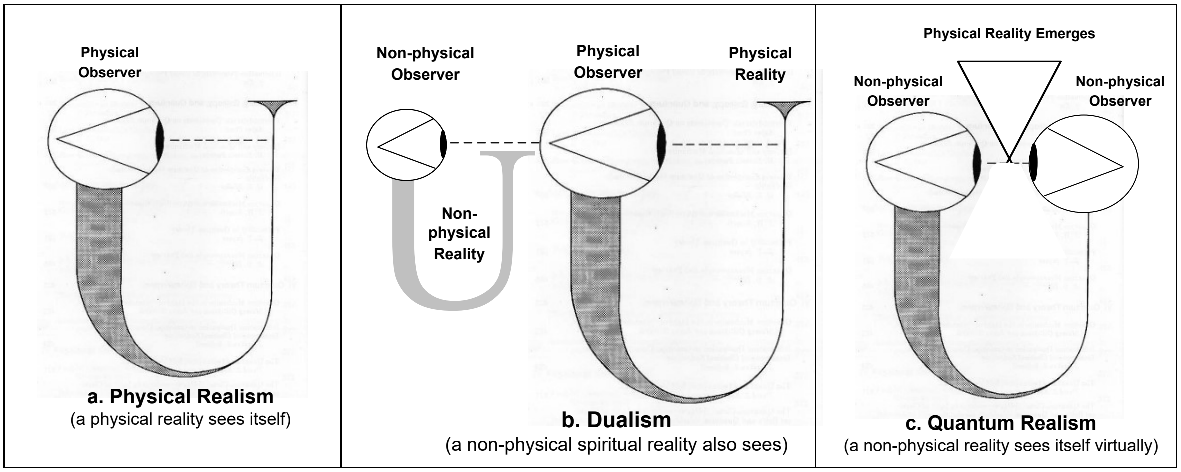

Figure 1.2. Comparing the reality options

1.2.6. The end of science?

If it turned out that we do live in a virtual reality, would that mean the end of science? Suppose some NPCs in The Sims started to wonder if their world was virtual? They could test that theory against the data of their world just as we can. If they found they lived in a non-continuous world of pixels, that their time and space could expand and contract, and that everything in their world began at a specific moment in the past, they might conclude it was true. They couldn't *perceive* the processing behind their world but they could *conceive* it, as we now do. So science would go on as already quantum theory is based on quantum states that are patently not physical at all, but it is still science. To study a reality, science only requires feedback from it, so the physical world as an *interface to reality* is enough to test theories.

Quantum realism proposes that we occupy a *local reality,* one that seems real to its inhabitants but is actually within another reality that generates it[10]. A local reality is real from within but not from without, e.g. Monopoly money is unreal outside the game but in the game, it affects what you can buy. In general, *pixels are real to pixels* because they are of the same nature. In the same way the earth is "solid" to us, who are made of earthy stuff but to a speeding neutrino from the sun our whole planet is just a ghostly shadow through which it flies. In this view, the physical world is real to our physical bodies but the observer exists outside it.

1.3. THE EVIDENCE

How can one know if a world is a digital construct or not? Just looking isn't enough. A game world seems real because when I look left, a left view is shown and when I look right, a right view is shown. Wherever I look, the game world presents but the catch is only when I look. In contrast, an objective reality exists whether I look or not, so it shouldn't change depending on how I look. Yet quantum theory says *this is not true of physical reality* and the evidence agrees. It predicts an *observer effect* and photons in delayed choice experiments do indeed choose a physical path to a detector after they arrive. How you look affects what you see in our world just as in a virtual reality. So does our physical world manifest other tell-tale signs of being a virtual reality?

1.3.1. Some evidence for virtualism

Modern physics considers the following properties of our physical reality to be true:

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[10] In contrast, an objective reality exists in and of itself and is not contained by anything.

1. *The universe began.* Since all the stars and galaxies are receding from us at known rates, we can calculate back to conclude that our universe started up[11] about fourteen billion years ago. This first event began not only our universe but also its space and time. Yet a *complete* physical universe can't *begin,* as by definition there is nothing outside itself to create it. To create itself, it would have to exist before it began, which is impossible. Physics speculates on D-branes, wormholes, alternate universes, teleporting worlds and big bang oscillation theories but every virtual reality has a boot up that creates its space-time operating system based on *nothing within itself* (see QR1.4.2).
2. *There is a maximum speed.* In our world, nothing can travel faster than light, so a light shone from a spaceship moving at almost the speed of light still leaves the ship at the speed of light. This is not possible in an objective reality. Einstein proved that the speed of light is a maximum but gave no reason for it to be so. The equations work but they don't explain why. In contrast, a photon as a screen pixel can only move from point-to-point as fast as the screen refresh rate allows. In a virtual reality, the screen cycle rate defines a maximum pixel transfer speed across a screen (see QR3.2.4).
3. *Time and space are quantized.* At the quantum level, everything is quantized including time and space. Field theory needs continuity but avoids the infinities it implies by a mathematical trick called renormalization. We *pretend* our world has no gaps but actually Planck length and Planck time are the irreducible pixels and cycles of our reality, as expected in a virtual reality (see QR2.2.1).
4. *Quantum tunneling.* Quantum tunneling occurs when an electron suddenly appears outside a field barrier it can't pass through, like a coin in a perfectly sealed glass bottle suddenly appearing outside it. That quantum theory permits this in no way *explains* how a physical "thing" can move to where no intervening path is possible. In contrast, a virtual reality can easily "cut" between one frame and another (see QR5.3.1).
5. *Entanglement.* Entangled photons maintain opposite spins no matter how far apart they are but an objective reality limited by the speed of light can't do this. Einstein called this *spooky action at a distance*. In contrast, a program can easily change any pixel anywhere on a screen instantly. In this view, all points on the screen of our universe are equidistant to a quantum server (see QR3.8.5).
6. *Space curves*. According to Einstein, the sun keeps the earth in orbit by "curving" the space around it but what can space curve into? It needs another dimension to do this, but string theory's "curled up" extra dimensions don't allow this. In a virtual reality, space as a 3D "surface" can easily curve into a fourth dimension (see QR2.4.1).
7. *Time dilates.* In Einstein's twin paradox, one twin who travels the universe for a year then returns finds his brother on earth to be an old man of eighty! Relativity tells us that in our world *time slows down* when you travel at high speeds. In an objective world, time doesn't vary like this but in our world it does. Yet every gamer knows that when the computer is busy the frame-rate drops, giving a slow-motion screen, i.e. *game time slows down when the server is busy* (see QR5.2.4).
8. *Randomness*. In our world, radioactive atoms emit alpha particles randomly, i.e. in a way that no prior physical "story" can explain, which implies a cause beyond physicality. The many-worlds fantasy of a multiverse was invented solely to deny quantum randomness. In contrast, in a virtual reality quantum randomness can be attributed to quantum server choices (see QR3.5.3).
9. *Empty space is not empty*. An objective space should be a void but our space exerts a pressure! In the *Casimir effect,* flat plates close together in a vacuum experience a force pushing them in. Current physics has to explain this by inventing virtual particles but in a virtual reality space is something not nothing, giving a simpler explanation (see QR2.4.5).

[11] Colloquially called the "big bang", as if it were an explosion in an existing time and space, which it was not.

10. *Waves are particles*. In Young's two-slit experiment, an electron goes through *two* slits to interfere with itself to give an interference pattern, even though it always arrives at *one* screen point. A particle can't do this but a processing wave can interfere with itself like a wave and still reboot at a point (quantum collapse) to arrive like a particle in one place (see QR3.5.2).
11. *Black holes.* General relativity predicts that a large enough mass in a small enough space collapses to a point of infinite density called a *singularity.* This defines a black hole but in physics, an infinite value usually indicates that something is wrong. In contrast, in a virtual reality, a black hole merely represents the *bandwidth of space*, so there is no singularity (see QR5.4.6).
12. *Quantum superposition*. In quantum theory, currents can simultaneously flow both ways around a superconducting ring (Cho, 2000). This isn't physically possible so in current physics quantum states don't exist. In a virtual reality, quantum processing can divide to explore all possible options (see QR3.8.1).
13. *Non-physical detection.* Imagine a bomb so sensitive that even one photon will set it off. It should be impossible to detect but a Mach-Zehnder interferometer does just that (Kwiat, Weinfurter, Herzog, Zeilinger, & Kasevich, 1995). Current physics has to attribute this to quantum acts it says don't occur, but in a virtual reality they do (see QR3.8.4).
14. *Retrospective action.* If the future can affect the past, causality fails and with it physics. Yet in delayed choice experiments, an observation made *after* a photon takes a path defines the path it took *before* the observation. This has led some to speculate that all time, like all space, already exists, allowing time travel and all the paradoxes it implies. In a virtual reality, processing can spread to take *all* paths until an observation picks a physical event, so there is no time travel (see QR3.8.3).
15. *Anti-matter exists.* Quantum equations predicted anti-matter but no reason has ever been given why matter should have an inverse of the same mass but opposite charge. In contrast, matter created by processing inevitably implies anti-matter created by anti-processing (see QR4.3.5).

None of the above findings are physically expected so they don't support physical realism. Since the physical world as a virtual reality better explains them, it should be accepted by the duck principle:

If it looks like a duck and quacks like a duck, then it probably is a duck.

If the facts of physics deny physical realism, surely the Sherlock Holmes dictum applies:

W*hen you have excluded the impossible, whatever remains, however improbable, must be the truth.*

Quantum realism applies this principle to conclude that our physical reality is probably virtual.

1.3.2. A prima facie case

Despite the physical evidence to the contrary, physicists seem to just *know* that our physical world isn't a virtual reality, e.g. Stephen Hawking understands the possibility when he says:

> "*But maybe we are all linked in to a giant computer simulation that sends a signal of pain when we send a motor signal to swing an imaginary foot at an imaginary stone. Maybe we are characters in a computer game played by aliens."* in (Vacca, 2005) p131

but then his next sentence is "*Joking apart…"*. Since quantum theory in effect says the physical world is output on demand, why is virtualism inevitably a joke? Is this option dismissed out of hand based on the *belief* that the world we see is real in itself or is it just a response to the fantasy movie The Matrix?

Discussions of virtualism in academic circles are disappointing in their naivety, e.g. in the 2016 Isaac Asimov Memorial Debate "*Is the Universe a Simulation?*", experts repeatedly attack the naïve physical virtualism of The Matrix movie, even though they know that quantum events create physical events in quantum theory in physically impossible ways. The obvious conclusion is that non-physical quantum waves create physical events, but instead they attack a straw man based on a fantasy movie. Quantum realism, that real quantum events create the physical world as a virtual reality, isn't even addressed.

In an objective reality time doesn't dilate, space doesn't bend, objects don't teleport, empty space is empty and universes don't pop out of nowhere. No-one would doubt that the physical world was objectively real - if only it behaved so. Even so, a few facts are not enough for a scientific conclusion. But they do present a *prima facie case*, of *circumstantial evidence* that a court would consider enough to warrant further investigation. What has been presented is not proof but it is evidence that there is a case to answer that is worth looking at.

The rest of this book aims to do just that. Using the method of *reverse engineering*, it develops a picture of how quantum processing creates physical events based on our knowledge of both. The desired result is a prediction that contradicts current theory and is testable by experiment.

1.4. SOME IMPLICATIONS

Quantum realism is that a quantum reality generates observed physical reality as a processing output. The physical world is virtual in the sense that quantum processing generates what is seen, just as physical processing generates what is seen in a virtual reality. That the physical world is a virtual reality implies:

1. *Processing*. Every virtual reality is generated by processing.
2. *A boot-up*. Every virtual reality has to boot-up.
3. *Null processing*. Every virtual reality runs null processing when idle.
4. *A screen refresh rate*. Every virtual reality presents on a screen with a refresh rate.

Does the current evidence from physics support these implications?

1.4.1. Processing

To explain the data, some suggest that the physical word is both the processor *and* its output:

"*The universe is not a program running somewhere else. It is a universal computer, and there is nothing outside it.*" (Kelly, 2002)

Yet while computers process input to give output, most of the universe doesn't (Piccinini, 2007), e.g. the sun inputs and outputs physical events not information. Computers input and output information but physical systems have physical input and output, so the universe mostly doesn't compute anything at all.

Also, that the physical world generates a program that generates the physical world is impossibly circular. A program is processing stored as information that is later read and executed, so the physical world cant be a program, what executes it, and the output all at once. In any virtual reality, the processor is always outside the world created. It is no more possible for the physical world to compute itself than it is possible for two hands to draw each other (Figure 1.3).

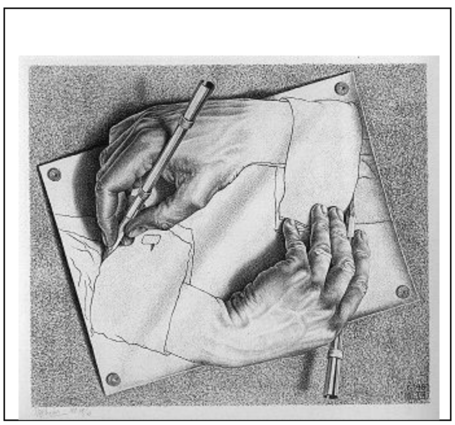

Figure 1.3. A physical world can't do this [12]

It is equally glib for physicists to talk of quantum processing occurring in *our* spacetime:

"*Imagine the quantum computation embedded in space and time. Each logic gate now sites at a point in space and time, and the wires represent physical paths along which the quantum bits flow from one point to another.*" (Lloyd, 1999) p172.

[12] "Drawing Hands" by M. C. Escher, 1948

To embed quantum processing in a fixed space and time contradicts relativity, which states that there is no fixed space or time. Conversely, if quantum processing creates a virtual physical world *and* its space and time, that processing can't exist in the space-time it created.

If our universe is virtual it must be finite because what is infinite can't be computed, and indeed it is. Equally all the laws of physics must be calculable which again they are. An abstract like π can be infinite as long as it doesn't represent a physical thing, which it doesn't. This allows three hypotheses:

1. *Calculable universe:* That processing *could* calculate physical reality is accepted by most scientists based on the Church-Turing thesis that a finite program can simulate any specifiable output (Tegmark, 2007). It doesn't imply determinism as not all definable mathematics is calculable, e.g. an infinite series. If our world is specifiable, even probabilistically, in theory a program could output it. The idea is not that the universe *is* a computer simulation but that it *could* be. That our world is a virtual reality could easily be falsified by a non-computable law of physics but none has ever been found. Indeed, our world has an algorithmic simplicity beyond all expectations:

   > "*The enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and there is no rational explanation for it*." (Wigner, 1960)

2. *Calculating universe*: Supporters of the idea that some sort of calculation creates physical events include main-stream physicists like Wheeler, whose "*It from Bit"* statement implies that processing (bit) somehow creates physical things (it). Now processing doesn't just *model* the universe, it *causes* it (Piccinini, 2007).
3. *Calculated universe:* That processing actually does calculate physical reality is the final step. Now the physical world is just an output but few in physics support this "strong" view (Fredkin, 1990).

These statements cumulate, as each assumes the previous, so that which isn't calculable can't arise from some calculation, and that which can't come from some calculation can't be calculated reality. It is a slippery slope as a *calculable* physical reality that can be caused by some *calculating* could be *calculated*, i.e. virtual. And while the second option, that **It** does indeed come from **Bit**, sounds good, it is impossible for a physical world to compute itself. So logic reduces the three options above to two: either the physical world exists by itself alone and just happens to be very mathematically calculable, or it is in fact calculated and thus virtual. *There is no middle ground*.

Thus the quantum realism conjecture that physical reality is a processing output requires that processing to be *quantum processing*, which physics agrees cannot have a physical basis.

1.4.2. The system boot-up

Last century science thought the physical universe was *complete* so while its parts could transform, the whole had to remain in a *steady state.* "Big bang" theorists then challenged this view on the stage of science, arguing against respected scientists who reasonably felt that a universe "exploding" out of nothing was highly unlikely. Then Hubble found that all the galaxies are receding from a first event that occurred billions of years ago, and finding that the cosmic background afterglow of the first event was still visible all around us sealed the deal.

This left physical realism in a quandary, as a physical universe that *began* was either created by something else or it created itself. If it was created by something else, as a child is from its parents, then it wasn't complete. If it created itself, it had to exist before its own creation which is impossible. It is clear that a *complete* system can't just magically *begin*.

Yet that our universe is both *complete* and also *began* is oddly enough what most physicists believe today. Parmenides concluded that "*Nihil fit ex nihilo"* or "*From nothing, nothing comes*" but physics now concludes that from nothing everything came. Calling this nothing "*something that fluctuates*" (Atkins,

2011) doesn't help because "nothing" doesn't fluctuate. The first event wasn't a "*quantum fluctuation of the vacuum*" because it also began our space, so if matter just popped out of space, what did space pop out of? Rewriting physics to allow something to come from nothing is hardly an explanation. A better story is needed than that nothing "exploded" from a dimensionless point to create everything.

Current physics answers the question "*What was there before the big bang?*" by saying that there was no time before the big bang. But "defining away" the question like this isn't an explanation. A universe that *began* had to be made, so it is valid to ask "*What made it?*" For if our time and space began, by the same logic could they suddenly stop today? The questions current physics is trying to ignore are:

1. How could matter begin if there was no time or space for it to exist in?
2. How could space begin if there was no time for it to begin in?
3. How could time begin if there was no space for it to flow in?

That the physical world created itself is impossible and that it came from nothing is not just impossible but inconceivable. Our universe can't be a massive quantum fluctuation still adjusting because that would need a space and time that didn't exist before the first event.

In contrast, a quantum realism *requires* a "big bang", as every virtual reality has to start up not only the processing that generates it but also its virtual space and time. When virtual world like Sim City starts up, it comes from nothing *in that world,* and before it began the time or space *of that world* did not exist. In quantum realism, the "big bang" was just when our physical universe booted up.

1.4.3. Null processing

Water waves move as fast as the elasticity of the water medium allows and the same is true of every wave in every physical medium. So at the end of the nineteenth century it was expected that light, as a wave, would move at a speed defined by the elasticity of an *ether* that fills all space. As the earth orbits the sun at 108,000 km per hour and orbits the galaxy even faster, we can't be stationary in such an ether (Figure 1.4), so the speed of light should vary with direction but in 1887 Michelson and Morley found that it was the same in every direction, so there could not be a physical ether.

Einstein then traded Newton's absolute space and absolute time for an equally absolute space-time:

> *"…absolute space-time is as absolute for special relativity as absolute space and absolute time were for Newton …" (Greene, 2004, p51)*

He changed the issue from how light vibrates empty space to how it vibrates a space-time matrix, but the latter gives no basis for elasticity either. So in the usual reverse logic, the speed of light is now said to define the elasticity of space, i.e. *the wave defines the medium it passes through!* This readiness to apply logic in reverse to fit the facts is why modern physics is in a rut.

Consider the logic of a space that contains things as an ocean contains fishes:

1. Any object in that space needs a not-that-object boundary to exist.
2. Unless a world is entirely objects, it must contain a "not-any-object", i.e. space.
3. If that space is nothing at all, the world is only objects and so has no basis for movement.
4. If that space exists as objects do, the logic returns to #1, so it needs another "space" to exist in.

A thing needs a not-itself boundary to exist but if that is also a thing then nothing can move. The buck of "thingness" must stop somewhere and for us space is it. It follows that space cannot exist as the objects it contains do but neither can it be nothing. Space isn't a physical thing so in a purely physical world it is "nothing" but both Einstein and Newton saw that space must be something for objects to move in it:

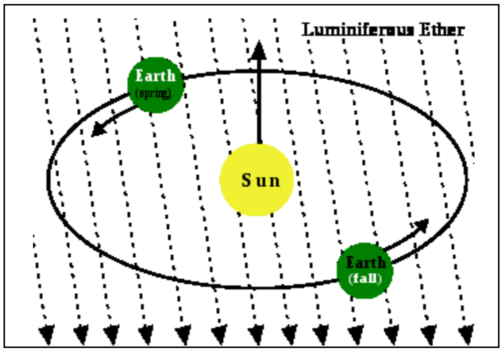

Figure 1.4. A physical ether[13]

"According to the general theory of relativity space without ether is unthinkable; for in such a space there would not only be no propagation of light, but also no possibility of existence for standards of space and time ..." (Einstein, 1920, in May 5th address at the University of Leyden)

His term "ether" isn't the physical ether that Michelson and Morley dismissed but a way to describe that which *acts like nothing*. So while a physical ether has been discredited, a non-physical one has not:

"*Since 1905 when Einstein first did away with the luminiferous aether, the idea that space is filled with invisible substances has waged a vigorous comeback*." (Greene, 2004) p76

The paradox is that while space physically acts like nothing, it must actually be something. Oddly enough, the finding that our space exerts a "pressure", called the Casimir effect, supports this.

In quantum realism, space occurs when the quantum network is null processing. When a computer processor has nothing to do it doesn't sit idle but runs a *null process*[14]. If one isn't pressing keys or moving the mouse, a 4 GHz computer still processes about 4,000 times a second, so "empty" space is null processing not nothing. Null processing is nothing only in the sense that it has no output but it is something because it is an activity. Such a space doesn't need to exist in another space because it is something itself, namely quantum processing.

In this view, empty space is a quantum processing output that only differs from an electron or a photon in that it happens to be null. As a fundamental quantum entity, space is *the null element*. Whether quantum processing outputs an electron or space is like whether a point on a screen is a pixel or blank. Even if the entire screen is blank, with no images on it, it still refreshes at some cycle rate and so is not nothing. If one turns a screen off, to see it in itself, that destroys the images upon it, in this case our bodies. If the quantum screen turned off, the physical universe and its space and time would disappear instantly.

1.4.4. The screen refresh rate

This project began when I wondered why our world has a maximum speed? Einstein *deduced* that nothing goes faster than light from how things are but *he didn't say why*. In an objective world, things could just go faster and faster, so why don't they? The thought then occurred that perhaps the speed of light reflects a processing limit, just as my computer can only run a game at a certain frame rate.

In a virtual world, distance is measured in pixels and time in cycles. A simulation has no time but its cycles and no space but its pixels. Asking about the time between cycles or the space between pixels is like asking about a movie between its frames or a picture between its dots. The answer is that neither the movie or the picture exist then. A movie running 70 frames a second *seems* continuous because our eyes only refresh 30 times a second. Likewise, a physical universe that refreshes 10^{44} times a second seemed continuous to our instruments, until recently. We now know that there is a Planck length and a Planck time that it is impossible to divide, i.e. there are pixels and cycles.

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[13] See Wikipedia http://en.wikipedia.org/wiki/File:AetherWind.svg

[14] Null processing is the program a central processing unit (CPU) runs when it is doing "nothing".

It follows that in our universe the speed of light is always *one pixel per cycle,* which is Planck length divided by Planck time. The values we use, like 186,000 miles per second or 299,792,458 meters per second, just reflect our units. In quantum units, the speed of light is just *one*.

1.4.5. Reality emerges

Is a virtual world necessarily fake? Consider the following case:

"*In June 2005, Qiu Chengwei, a Chinese national, won a virtual sword in the online game **Legend of Mir 3**. He lent the sword to a fellow gamer Zhu Caoyuan who subsequently sold it [on eBay]. When Qiu reported the incident to the police he was told a virtual sword was not real property and was not protected by law. Qiu went to the home of Zhu and stabbed him to death in a very real crime for which he is now serving a life sentence.*" (Power, 2010) p188

The stolen sword didn't physically exist but it was real enough for those involved to sell, buy and kill for. It follows that for all intents and purpose, the Mir sword was real even though was just an information entity. As another example, Bitcoin is worth billions yet what it produces is not physical. This requires us to redefine reality from "What exists" [15] to "*What exists to an observer*", which applies equally to physical things by the observer effect in physics.

Adding the observer to the definition of reality is consistent with current physics. It doesn't mean that we unilaterally create reality as in solipsism, but that *every reality event is an observer-observed interaction.* The benefit of this definition is that it allows disciplines like sociology, psychology and computing to study social, human and information systems that are *real*. For if information wasn't real[16], or if cognition wasn't real, or if society wasn't real, the sciences of computing, psychology and sociology would be the study of unreality. It is argued elsewhere that social, personal and information levels *emerge* from the physical level (Whitworth & Ahmad, 2013, Ch1). Quantum realism then proposes that the physical world that physics studies *emerges in exactly the same way, as an observer view*.

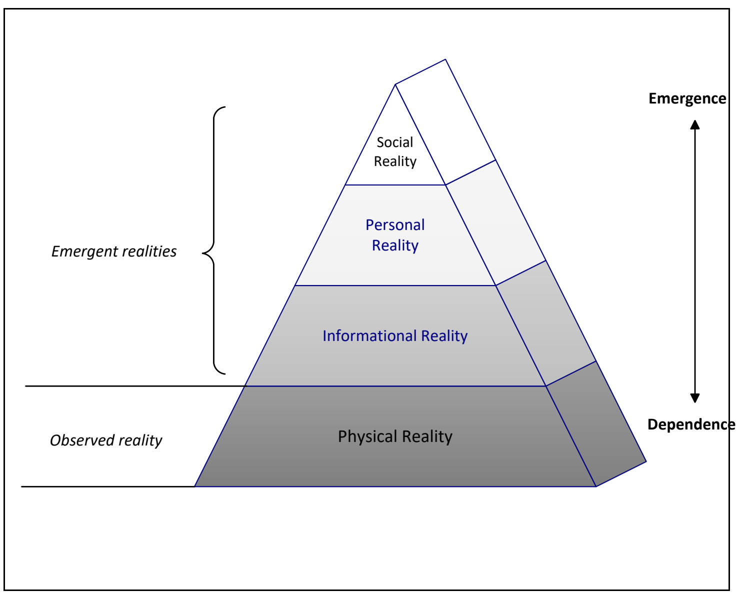

*Figure 1.5. Scientific realities **emerge** from physical reality*

In Figure 1.5, each level is an observer *world view.* This allows sociology to study social systems, psychology to study human systems and computer science to study information systems *that are real*. It also allows different views of reality to exist *at the same time*, e.g. a cell phone is hardware *and* software at the same time. Describing the hardware doesn't define the software and describing the software doesn't define the hardware. *Software and hardware are just different ways to view the same reality*. The observer *chooses* the hardware view to address a hardware problem and *chooses* a software view to address a software problem. In the figure, each reality level *emerges* from the last as a way to interact with reality better. Social structures emerged from human meaning (Bone, 2005) that emerged from neural data that emerged from physical brain events because seeing reality in social terms improved survival (Hogg, 1990).

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[15] At https://en.wikipedia.org/wiki/Reality reality is that which exists, but every case has an observer.

[16] Also called *mathematical realism* (Penrose, 2005).

The Mir sword didn't exist physically but it was an information entity in the Mir database, it was a cognitive entity in the mind of its owner, and it existed to the Mir community, so by this new definition it was real. If a fantasy is real to only one person, the Mir sword was not that. It existed by common consent and was even a *scientifically real* subject of online research. In a society, for one to sell what one doesn't own is unjust, and as the police had no remedy the owner took justice into his own hands.

If social constructs emerge from human thoughts that emerge from neural information based on physical events, is the physical world the end of the line? *Physical realism* says it is, arguing that everything reduces[17] to physical events so only the physical *really* exists. Yet if physics was the end of the reality line, it would be observer free, which it isn't. In quantum realism, which is based on quantum theory, real quantum waves only become physical when observed, not before. It follows that physics, like the other sciences, is just *another way to view reality*. As the great eighteenth century philosopher Kant concludes, we don't see *things as they are in themselves* (Kant, 1781/2002). We see a *phenomenon* or view not the *noumenon* or thing in itself. If the quantum world is real, physical reality emerges from quantum reality in the same way that information emerges from physical reality, *as an observer effect* (Figure 1.6).

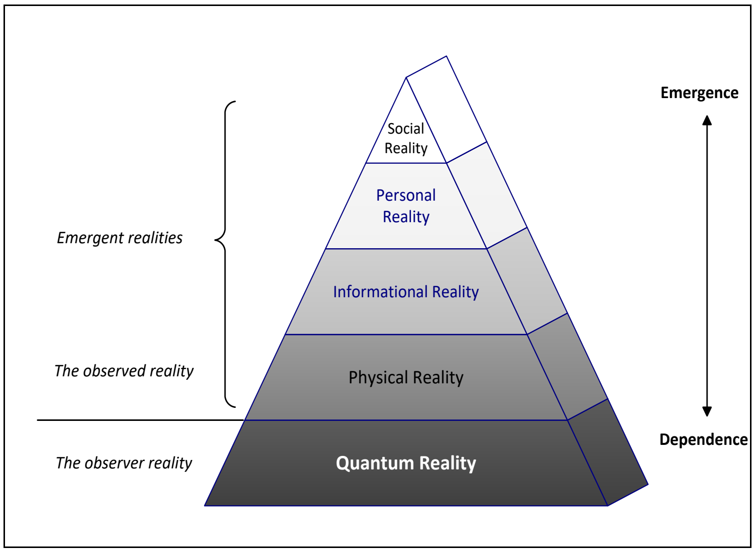

Figure 1.6. Physical reality emerges from quantum reality

My mirror image is unreal because it only exists when I look. My body still exists even when I don't look but the image only happens when I stand in from of the mirror and look. I am seeing reality by means of an image that is not in itself real. Quantum realism is that we see the entire world in the same way, that *the physical world we see is created by a quantum world we don't see*.

1.5. EVALUATION

This section considers how quantum realism can be evaluated. It is argued that based on science, it is possible to reverse engineer physical reality to discover evidence to support or deny it.

1.5.1. Science and quantum realism

Science is a way to ask questions of reality not a set of fixed ideas:

"*Science is not about building a body of known 'facts'. It is a method for asking awkward questions and subjecting them to a reality-check, thus avoiding the human tendency to believe whatever makes us feel good.*" (Pratchett, Stewart, & Cohen, 1999)

It limits not the questions we ask but how we answer them, so to question physical reality doesn't deny science but engages its spirit of inquiry. Quantum realism as a *query of everything* is a question about this world, not some meta-physical one, unlike untestable speculations on universes beyond ours (Tegmark, 1997), that virtual universes can be saved and restored (Schmidhuber, 1997) and visions of virtual realities making each other (Bostrom, 2002). These are beyond the scope of science but quantum realism is not because *it is a statement about the world we see*. Quantum realism is a theory about *this* world that is open

[17] Physical reductionism is based on *logical positivism*, a nineteenth century ideology that only what is observed is real, which today masquerades as an axiom of science. It falsely holds that science should only *reference* the physical, unlike the *empiricism* of Locke and Hume that theories must be *tested* by physical observables.

to a *scientific method* that puts a thesis about the world, defines its anti-thesis, then picks the one that best fits the evidence.

Science doesn't test theories in isolation but forms mutually exclusive hypotheses to *reject the least likely*. It doesn't "prove" theories but given two falsifiable alternatives, picks the best. Quantum realism is *falsifiable* because any incomputable physics would disprove it:

> "*… the hypothesis that our universe is a program running on a digital computer in another universe generates empirical predictions, and is therefore falsifiable*" (McCabe, 2005) p1

If the physical world wasn't computable it couldn't be virtual, but it is. Physical realism is falsifiable too but its falsification has been overlooked (Aspect, Grangier, & Roger, 1982).

The part of science we call quantum theory is based on quantum states that aren't by definition physical, hence physical observability is not a demand of science and never has been:

> "*Atomism began life as a philosophical idea that would fail virtually every contemporary test of what should be regarded as 'scientific'; yet, eventually, it became the cornerstone of physical science."* (Barrow, 2007) p3

The current physics of unseeable quarks, invisible fields and virtual particles can hardly make visibility a demand of science. There is no need, as what must be observed are the theory's predictions not its parts. A big bang we can never see is now accepted based on the evidence we can. If science can decide there was a first event, it can decide if physical reality is virtual or not. Quantum realism doesn't contradict science but denying it does. Science should evaluate hypotheses not assume they are wrong.

1.5.2. **Reverse engineering physical reality**

The scientific method, in a nutshell, is to make an assumption then test it against evidence to increase knowledge. To evaluate a scientific theory, I first assume it is true then *follow the logic* to see if it fits the facts. In computing, implementing an information system involves first *design,* to create a logical model, then building and *testing* to validate it.

Design science then follows science in first designing an information system in theory and then testing it against requirements in an iterative way (Hevner, March, & Park, 2004). *Reverse engineering* is a subset of design science, where given an output, one deduces the processing behind it. The *method* in this case is to first best-guess the processing involved, then test its output against the observed output, and repeat until it consistently simulates. Scientists that run quantum simulations to predict physical results use this method.

Quantum realism puts the research question "*Does quantum processing generate physical reality?*" and uses the method of reverse engineering to answer it as follows:

1. *Specify*: Specify the output of the physical world (physics).
2. *Design*: Design quantum processing to satisfy those requirements (computer science).
3. *Validate*: Validate the expected output against the actual output (science).
4. *Repeat:* Given no invalidation or inconsistency, repeat until a feasible design is achieved (quantum realism).

The consistency constraint is critical, as while one can easily "fit" a system to one requirement, satisfying many is much harder. In addition, the design should:

1. *Follow computing best practice.* Based on established computer science principles.
2. *Satisfy Occam's razor.* Given a design choice, take the simpler option.

The aim of quantum realism is to *reverse engineer* the physical world, to derive the laws of physics from information first principles in a "*Physics from scratch"* approach (Tegmark, 2007 p6). Cherry-picking cases, so that selected programs mimic some world properties is not a new kind of science but an old kind of bias (Wolfram, 2002). Science can't *choose* what a model explains, so quantum realism must explain *all* of physics including space, time, energy, matter, gravity, magnetism, spin and charge.

Reverse engineering physical reality could reveal quantum realism to be:

1. *Spurious*. A spurious model adds no value because it needs new assumptions or parameters to explain every new fact. Spurious models always have a back-door excuse.
2. *Coincidence*. Coincidental models work for a while by luck but fail over time as supporters have to cherry-pick cases to support the model and ignore those that contradict it.
3. *Useful*. A useful model isn't necessarily entirely true but it opens up productive new research that leads to a better model. It is a useful stepping-stone.
4. *True*. A true model is based on essentially valid assumptions about reality. Given a few assumptions, it matches observed reality in many ways and predicts something new that contradicts established models but is later found to be true.

Given the circumstantial case presented earlier, that quantum realism warrants further investigation, even if it is not entirely true it may provide useful insights. The aim is to attribute the results of current physics to quantum processing based on quantum theory and general computer science. If physics describes physical events and computer science describes processing events, whether quantum processing could produce physical events is a question design science can evaluate. Whatever the outcome, quantum realism poses a question that science can answer, but only by exploration can that answer be discovered. To reject the question out of hand is not science.

1.6. DISCUSSION

This section considers the broader implications of quantum realism compared to physical realism. Based on Occam's razor and the unsound nature of physical realism, it suggests a new foundation for physics whose main obstacle is the ego barrier.

1.6.1. Occam's razor

Occam's razor is not to multiply causes unnecessarily, i.e. to prefer the simpler theory. A century ago, Bertrand Russell denied the virtual reality idea by appealing to common sense and Occam's razor:

"*There is no logical impossibility in the supposition that the whole of life is a dream, in which we ourselves create all the objects that come before us. But although this is not logically impossible, there is no reason whatever to suppose that it is true; and it is, in fact, a less simple hypothesis, viewed as a means of accounting for the facts of our own life, than the common-sense hypothesis that there really are objects independent of us, whose action on us causes our sensations*." (Russell, 1912)

However, when space curves, quantum entities teleport and time dilates, the theories of physics today are far from common-sense. That a universe of matter exploded from a dimensionless point *singularity* is not common-sense nor is it common-sense that light waves move by vibrating *nothing*. In contrast, in today's online world, common-sense can accept that a virtual universe began by booting-up and that light waves travel on space as a 3D screen.

Nor is physical realism today a simple theory. To explain even the basics of modern physics, the standard model needs forty-eight fundamental particles, twenty-four fitted properties, five invisible fields and fourteen virtual particles that pop in and out of existence on demand, anywhere, anytime. And *it isn't finished yet*, e.g. to explain inflation needs a new field. And M-theory requires eleven dimensions to explain what we see. It's hard to imagine anything more complex, so if physical realism is preferred, it isn't based on simplicity! In contrast, a quantum processing explanation requires only one fundamental process, one extra dimension and one quantum field to explain the same facts, as will be seen.

If we ask which is simpler today, physical realism or quantum realism, the answer isn't physical realism. Fast forward a hundred years from Russell's comment and there is evidence suggest that the physical world is virtual *and* this is the simpler theory, i.e. *Occam's razor now cuts the other way*.

1.6.2. The pillars of physical realism

Science began when Aristotle concluded that for all practical purposes, physical events caused physical events, where "physical" meant material not the nothing of space. Over time, matter was assumed to exist by its own substantiality even when it obeyed "God's Laws". Today physics takes the term "physical" to include energy even though light has no mass by saying that energy can transform into matter and giving light a relativistic mass. It sees a physical world of matter/energy that exists by and of itself in a space-time context that is also seen as real in itself by some.

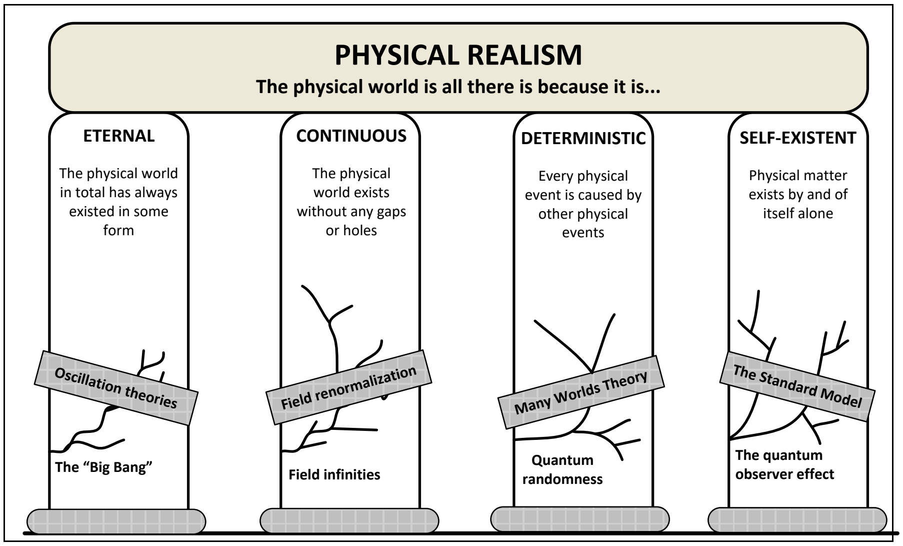

Figure 1.7 The four pillars of physical realism

In physical realism, there is a real world out there, apart from us, and it is physical. *The physical universe is seen to be all there is because it is real in itself,* and so it needs nothing else to sustain it. This ideological belief, that no reality exists beyond physical reality, is sustained by four statements about the physical world, namely that it is:

1. *Eternal*. What exists by its own substance can be *transformed*, as when a potter turns clay into a bowl, but cannot be *made or unmade* by external means. A physical world that was made implies something beyond it, contradicting physical realism. The failure of steady state theory to compete with big bang theory last century cracked this pillar, so supporters patched it by speculating that the physical universe magically arose from nothing or oscillates in a big bounce[18].
2. *Continuous*. Matter that self-exists by its own substance must do so in a continuous space and time, or something else would be needed to explain the gaps, again contradicting physical realism. This continuity creates infinities, so supporters had to invent the mathematical trick of *renormalization* to patch up the problem, a technique Feynman called a "dippy process".
3. *Deterministic*. If the physical world is all there is, then everything must have a physical cause. This denies random events such as atomic decay, as a random event by definition has no physical cause. It also denies quantum theory, which implies that *every* physical event is random to some degree. The patch to this was very creative, being the many-worlds or multi-verse fairy story that every quantum event creates an entire new universe.
4. *Self-existing*. A physical world that is all there is must self-exist, as that anything else creates it contradicts physical realism. Yet quantum theory predicts that physical events only occur when quantum waves interact, so the observation alters the effect and the evidence supports this. The

[18] In Big bounce theory a big crunch follows a big bang in an ongoing oscillation that is in effect steady state.

standard model pastes over this crack by postulating virtual particles that appear from nowhere to explain whatever an observer sees

The four pillars of physical realism and their patches are shown in Figure 1.7. It is interesting that instead of saying that God is *eternal, all-pervading, all-powerful* and *unbegotten*, we now say that physicality is always *conserved, continuous, universal and made of fundamental particles*. The terms are different but the effect is much the same. One might as well say the physical world is *eternal, all-pervading, all-powerful* and *self-existing*. Physical realism seems more an *ideology* accepted by scientists than a conclusion of science itself.

Physical realism isn't scientific if it doesn't handle the evidence well, and it doesnt. To believe this today one must also believe that our universe sprang into existence from nothing, that the infinities of continuity can be removed by a mathematical trick, that any photon can spawn another universe and that virtual particles from empty space make things happen. To say that physical realism has a shaky foundation is an understatement, so its time to at least consider a quantum foundation for physics.

1.6.3. A quantum foundation

Quantum realism doesn't change the equations of physics that are based on evidence, it just changes their *interpretation*, e.g. Schrödinger's equation is the same but now it describes what is real not fictional. What difference does a mere interpretation make? *Everything, as it allows new directions*. Just as knowing that the stars don't revolve around the earth gave new directions in cosmology, knowing that the physical world is generated by quantum processing allows new directions in physics.

Kuhn called changing the foundations of a scientific theory a *paradigm shift* (Kuhn, 1970). He noted that just as a house is built on foundations, so a theory is built on foundational *axioms*. The axioms of a theory are *that upon which it is built*, so changing them changes what the theory can do, e.g. Euclid's geometry included the axiom that parallel lines can't converge but removing that allowed *hyper-geometries* that work on curved surfaces like the earth where parallel longitudes do converge (at the poles). Changing the axioms of geometry that dominated thought for a thousand years made Euclid's geometry just the zero-curvature case.

Chaitin, following Gödel, argued that axioms work better if they explain more than they assume (Chaitin, 2006). In this respect, the standard model with all its "fitted" parameters is struggling. Currently, nearly everything in physics is just *assumed to exist because it does*, including time, space, matter, light, charge, magnetism, spin, gravity and energy. Every time a new effect is found, such as the weak force that causes radioactive decay, new parameters have to be invented to explain it. This is necessary because a theory, like a house, needs a foundation at all times, but it is not ideal.

Quantum realism offers a better foundation because it can for example derive the weak force without adding new parameters (see 4.4.6). It does so by extending Wheeler's "It from bit" to be "*It from qubit*". Quantum realism is the *disruptive innovation* (Sandström, 2010) that physics needs to advance but it faces the obstacle of the hubris that physics already has all the answers.

1.6.4. The ego barrier

Throughout history, science has fought not only superstition but also the human ego:

"*Since our earliest ancestors admired the stars, our human egos have suffered a series of blows*." (Tegmark, 2007)

When Galileo challenged the paradigm that the Earth is the center of the universe he also challenged our ego. We now know that we are on a little planet circling a small star, two-thirds of the way out of an average galaxy that has a hundred billion stars, in a universe of at least that many galaxies, i.e. we aren't the *physical center* of the universe as was once thought.

When Darwin challenged the paradigm that we are the pinnacle of a biology built for us he also challenged the human ego. We now know that humans have only existed on this planet for about three million years and were a minor species for most of that time. In contrast, dinosaurs ruled the earth for two-hundred million years before being wiped out sixty-five million years ago, apart from the birds. As 99.9% of all species that have ever lived are now extinct, our chances of dominating the earth for any length of time aren't high. Even today, insects and plants exceed us in biomass, often have more genes and are much more likely to survive a disaster. We are almost certainly not the last evolutionary word. If the evolutionary tree had a "top", we wouldn't be it, so we aren't the *biological center* of life either.

Today, neuroscience again challenges the ego belief that we have a unitary "self", as it sees the brain as a set of autonomous neural assemblies that interact to maintain the convenient fiction of a self. The brain has no CPU (Central Processing Unit) because if the cortical hemispheres are surgically split, each takes itself to be "I" (Sperry & Gazzaniga, 1967). The conclusion is that even the ego self is an illusion, as we don't have a *psychological center* either.

The trend is clear. The ego repeatedly makes us *see ourselves at the center of things* and science repeatedly finds that we aren't. We see that every generation thinks itself smart - until the next one discovers that it isn't. So is *now,* finally, the end of the line for ego fallacies? Do we at last see true, thanks to science, or is ego still operating? Is it that surprising to find one last ego fallacy blinding us - the idea that *we see reality as it is*. Think for a moment, what qualifies us to define reality? Isn't it ego to say that reality is what we see because we see it? What makes us the *existential center* of the universe?

Quantum realism shocks the ego but fits the physics, as Table 1.1 suggests. It isn't the Matrix brain in a vat, or that life is a dream, or that we live in a fake SimCity world. It is that life is real but what you see isn't. Kicking a rock hurts because *pixels are real to pixels* in a local reality. The shock is that if the physical world is virtual, we fight, hoard and die for pixels not things, and we can no more change this than a goldfish can change the bowl of water it lives in. It is a sobering thought, but if this really is our situation, isn't it better to know than to not know?

Table 1.1. Chapter 1 summary: physical realism vs. quantum realism

Physical realism	**Quantum realism**
The big bang. The universe arose from nothing in a "big bang" that also made our time and space	*The boot-up.* The universe began when it was booted up, which also made our time and space
Quantization. Mass, energy, time and space are quantized at the Planck level, for no known reason	*Digitization.* Mass, energy, time and space are quantized because the universe is a digital system
Maximum speed. The speed of light is a universal limit for no known reason	*Maximum rate.* The processing capacity of the quantum network defines the speed of light
Wave function collapse. Quantum waves collapse faster than light, which is physically impossible	*Program restart.* Quantum collapse as a program restart instantly affects every screen part
Time dilates. Time dilates near massive bodies and at high speeds for some reason	*Processing slows*. Processing slows near massive bodies and at high speeds as the load increases
Mass curves space. Space "curves" around a massive body, for no known reason	*Mass biases processing.* Space curves because mass creates a processing gradient around itself
Physical laws are simple. The laws of physics are algorithmically simple for no known reason	*Physical laws are calculated.* Physical laws are simple because they are quantum calculations
Physical randomness. Beta decay is random, i.e. not predicted by *any* prior physical event(s)	*Server choices*. What is random to us arises from quantum server processing choices
Complementarity. Quantum entities can't have both an exact position and momentum at once	*Common data*. If the same processing gives position and momentum, it can't give both
Quantum equivalence. Every electron is identical to every other one, for some reason	*Digital equivalence*. The quantum processing that creates an electron is always the same
Quantum tunneling. A physical quantum entity can suddenly appear past an impassible barrier	*State transitions*. Quantum processing spread across a network can restart at any point

DISCUSSION QUESTIONS

The following questions are addressed in this chapter. They are better discussed in a group to allow a variety of opinions to emerge. The relevant section link is given after each question:

1. In what sense is current physics a "hollow science"? What is missing? (1.1.2)
2. Why is it hard to argue for dualism, for a spiritual world as well as a physical one? (1.2.2)
3. How does an objective reality differ from a virtual reality? (1.2.3)
4. Has science proved that the physical world is an objective reality? (1.2.3)
5. How does quantum realism agree with The Matrix? How does it differ? (1.2.5)
6. How are quantum realism and physical realism the same? What is the difference? (1.2.5)
7. Could science still operate in a virtual reality? (1.2.6)
8. What physical evidence fits the theory that the physical world is a virtual reality? (1.3.1)
9. Why do many physicists deny that quantum events cause physical events? (1.3.2)
10. Is the physical world computing itself? (1.4.1)
11. Did the physical universe create itself in the "big bang"? (1.4.2)

12. How did our space "begin" if there was no "somewhere" for it to begin at? (1.4.2)
13. How did our time begin if there was no time "moment" for it to begin at? (1.4.2)
14. How can space be both nothing and something? (1.4.3)
15. Why can't anything go faster than light? (1.4.4)
16. Is physics more "scientific" because it studies physical reality? (1.4.5)
17. Is quantum realism falsifiable? Is physical realism falsifiable? (1.5.1)
18. How can quantum realism be evaluated scientifically? (1.5.2)
19. What is Occam's razor? Does it support physical realism? (1.6.1)
20. What evidence suggests that the physical world *not* eternal, all-pervasive, all-powerful or self-existing? (1.6.2)
21. Does quantum realism challenge the correctness of physics equations? If not, what does it challenge? (1.6.3)
22. How has science challenged our ego in the past? What ego-fallacy does quantum realism challenge? (1.6.4)

Chapter 2. Simulating Space and Time

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

Walt Whitman

Every virtual world represents a space and time to those operating within it. This chapter reviews the evidence that our space and time are virtual and deduces the processing a virtual world would need to generate a space and time that that would appear to its inhabitants as ours does to us.

2.1. THE PRIMAL REALITY

Quantum realism proposes that quantum processing generates the physical world as a virtual reality, where quantum processing is as defined by quantum theory. This section contrasts the quantum processing of quantum theory with the physical processing we are familiar with. The *primal reality* that generates quantum processing is proposed to originate from a *quantum network*.

2.1.1. The quantum network

The idea that the physical world is the *output* of something else is radical but it isn't new:

1. *Fredkin.* Says that the physical world as an 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 matter is in some way a processing output.
4. *D'Espagnat*. Suggests a "*veiled reality*" that generates time, space, matter and energy (D'Espagnat, 1995).
5. *Campbell.* Proposes that "*The Big Computer*" outputs 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.

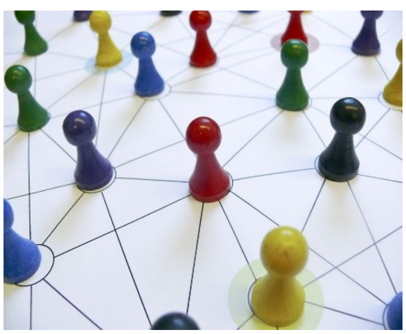

Figure 2.1. A network of nodes

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* all suggest "something" beyond the physical world is generating it. Quantum realism envisages this *primal reality* as a *network of nodes* (Figure 2.1). As Hiley said:

> "*I remember … Richard Feynman … saying that he thought of a point in space-time as being like a computer with an input and output connecting neighboring points*" (P. Davies & Brown, 1999) p138

The quantum network proposed is not physical, as after all, physical reality is what it generates. Nonetheless, it is expected to have properties like:

a. *Density*. Depending on the number of connections per node.
b. *Bandwidth*. The processing capacity of its node channels.

c. *Protocols.* That decide what happens if an overload occurs.

2.1.2. Information theory

The proposed quantum network can be understood in terms of information theory. Modern information theory began with Shannon and Weaver, who defined *information* as the number of *choice options* as a power of two[19] (Shannon & Weaver, 1949). By this logic, a choice between two physical options is one bit, a choice 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. the *event* of making a new choice.

A bit as the *choice* between two physical states means that while a physical state can be *seen* as a bit, by information theory it holds no information at all in itself as it is just one way. A book can "contain" information but in itself has *zero information* because it is fixed in one way. This seems wrong but it isn't, as hieroglyphics no-one can decipher indeed contain no information. Writing only gives information when a *reader* decodes it, and that depends entirely on the *decoding context,* e.g. reading every 10th letter of a book, as in a secret code, gives a different message with different information.

It follows that the amount of information "in" a physical state depends on the *assumed* number of physical states it was chosen from. Hence one electronic pulse sent down a wire can represent one bit, or as ASCII "1" it can be one byte, or as the first word in a dictionary, say Aardvark, can be many bytes. That the information in a physical message depends on the *decoding context* lets data compression store the same data in a smaller signal using more efficient encoding. If information was purely physical, data compression couldn't pack the same data into a physically smaller signal! In general, the information in a physical signal is undefined until a reader decodes it. Only when sender and receiver agree on the encoding-decoding context can they agree on the information in a signal, and thus communicate.

Information only emerges from a physical state when an observer is added. When we store information as a set of physical states in a book or database the same applies - those states in themselves contain no information at all. But when one writes a book in English say, the writer provides the encoding context and a reader can use the same context to extract the same information.

Since processing is defined as creating information, *writing a book is processing*, as one can write it in many ways, and *reading a book is also processing*, as one can read in many ways, but the book itself, being just one way and no other, is empty of information. So information doesn't exist without processing which consists of dynamic events not static physical states. By Shannon and Weaver's definition, *processing is the dynamic means by which static information is encoded and decoded*.

2.1.3. Reloading reality?

Information theory clarifies why a physical world can't be its own processing output – it would require a context specified in advance based on physical output that is not yet produced. 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 physical world that is all there is can't be both processor and output but can one part save and reload another? Those unfamiliar with information theory argue that since we save and reload information, we could do the same for physical reality. If one can save a game scenario, why not a scenario from our world? Yet as any programmer will tell you, a game save requires a pre-defined data structure, hence if a game update changes the data structure, old saves don't work anymore and you have to start the game over. So even if our universe was a set of static physical states, which I argue it isn't, one needs an "agreed" data

[19] Mathematically, Information $I = Log_2(N)$, for N options in a choice.

structure to save and reload it. Else the reload would give nonsense, just as old WordPerfect files reload into Word as gibberish because Word doesn't recognize WordPerfect's data structures.

Does physical reality have a unique data structure? 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 is without a reader. To save and reload a universe one must not only know its data structure but also exist outside it!

Yet don't we store movies and replay them later? Yes we do given an agreed format like mp3, but what is stored is just a sequence of static images. To see the movie again requires a projector or laptop with the power to *dynamically* play them in sequence. Without a projector to play it, there is no movie. Equally we can store a *program* in static form but to run it requires a computer plugged into a power source. So even if one could save the universe as static data, what "projector" using what power source could rerun it?

Trans-humanists suggest that one could live forever by uploading their mind and downloading it to a new body, but this confuses the static and dynamic aspects of information. Even if we could perfectly copy a brain's physical state at a moment, which I argue we can't, that would be no more than taking a photo of a movie, which is not a basis to reload the movie. Even many photos taken and replayed in sequence would not "resurrect" the person, any more than playing a movie of a person who is dead resurrects them. One could record a physical scenario and replay it as a realistic *hologram* to *emulate* say a dead relative but that wouldn't *recreate* them. The viewing experience would be real but the "person" being viewed would not experience life as an observer. Even in a multi-player online game, the other people playing aren't "in" the game, so saving the game doesn't save them. Chapter 6 returns to this question in more detail.

Since genes are information, why not clone genes to create a biological copy of ourselves? We can, but nature already does it, as identical twins are clones from the same original cell. Yet they are two different people not the same person. A physical copy of a brain like mine doesn't make another me but another person.

One can't escape that dynamic events stored as static physical states need a dynamic system to "reload" into. In a nutshell, to save processing is another process, just as to reload it is. A physical copy of me isn't me because it is another life event. Even if that copy of "me" has experiences, it still isn't me if I don't experience them. Something is missing in the reloading reality idea and it is the quantum reality behind physical events.

2.1.4. The processing of processing

To truly copy physical reality, one must understand what it actually is in the first place. It is clear that a photo of me is not me, nor is a movie of me, nor is a biological replica of me. So if quantum processing creates physical events as quantum theory implies, why not copy that quantum processing?

Research into quantum processing reveals that it is more powerful than physical processing because it is based on qubits not bits. While a bit is a choice between two states, a qubit can also take any *superposition* of them, i.e. can be both zero and one *at the same time*. So quantum processing isn't just better than physical processing, it is *enormously* better, e.g. doubling the processing of my computer requires double the bits but doubling that of a quantum computer requires the addition of just one qubit. Quantum computers are a whole new processing level.

We don't "do" quantum computing in the way that we do physical computing but rather just set up a situation that lets us use what naturally occurs. We *tap into quantum processing* rather than cause it. It is not surprising to quantum realism that what processes physical reality performs beyond anything we can achieve by physical means.

Quantum processing can be seen as the creation of processing in the same way that processing is seen as the creation of information. While a bit is based on one process making one choice between two options, a qubit can be seen as two processes making two choices between two options. This lets a qubit include the outcome of a *superposition* of both options, if the two choices go different ways. Thus quantum processing is able to choose all possible options rather than just pick one.

This leads to a definition of quantum processing as the creation of processing, just as processing is the creation of information. Quantum processing is then dynamic in the sense of being a creative act, just as our processing is dynamic in the sense of being the act of creating information.

If quantum processing creates physical reality, to *really* duplicate a physical event one must copy the quantum processing behind it. Unfortunately, the *quantum no-cloning theorem* explicitly excludes this. It states that it is impossible to create an identical copy of a quantum state because it cannot be *known*, as to "know" a quantum state is to collapse and so destroy it. This fundamental premise of quantum theory implies that talk of uploading and downloading universes, minds or even ourselves to a virtual heaven or hell have no basis in quantum theory or information theory. It is all just wishful thinking.

Quantum theory describes *quantum waves* that expand at the speed of light until they are observed and collapse to a physical event. Quantum realism interprets these waves as *processing waves*, as the next chapter explains for light. Processing waves are *events* not *things*, and the only way to "save" an event is to run it again. One can save and reload states but not events since the act of storing an event is another event. It follows that a quantum network that generates processing has no capacity to store it. We can save and reload physical states but the quantum processing generating them can't be saved. While our cell-phone and Internet networks use caches and buffers to handle overloads, the quantum network proposed can't use static memory of any sort. While our processing devices like computers and cell-phones use storage, quantum nodes don't have that option.

The *quantum no-storage statement* results from the quantum no-cloning principle that in turn follows from what makes quantum processing so powerful – that it is *processing creating processing*. The benefit is that being inherently dynamic, quantum processing isn't based on physical states so McCabe's argument doesn't apply. From this point, the term "processing" often refers to quantum processing not the physical-based processing of our devices.

2.2. SPACE AS A NETWORK

This section considers how a quantum network could connect to simulate our space.

2.2.1. 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; OR
2. 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 field equations, e.g. an electron as a dimensionless point has infinite mass and charge density unless one assumes other dimensions as string theory does. The infinities of quantum field theory were resolved by the mathematical trick of *renormalization* that makes the infinities of field theory go away by requiring particles to interact via other particles in what are called Yang-Mills interactions. Dirac described it as follows:

> "*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."

Renormalization is the mathematical trick that pulls physical reality from the quantum hat but digitizing physical reality achieves the same effect in a simpler way. It is often forgotten that continuity is a mathematical convenience not a proven 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

In contrast, a digital reality can't be continuous because there are no "half pixels" or "half cycles". Quantum realism then answers Zeno's questions as follows:

> *There is indeed an instant when the arrow is in a fixed, unmoving position but there is still movement as another quantum cycle generates the next physical state. Equally the hare cannot get closer to the turtle forever as there is a minimum pixel distance that can't be divided further, so the hare catches the turtle*.

Denying the infinitely small avoids the infinitely large, so a digital world of irreducible pixels and indivisible ticks makes the infinities of continuity disappear, like ghosts in the day. Reality as a series of frames strung together, as in a movie, resolves the paradoxes that continuity cannot. Processing as a choice from a *finite* set by definition doesn't allow *infinite* values.

Our space is discontinuous because it breaks down at the order of Planck length. To study the very small needs short wavelength light that is high energy light but putting too much energy into a space gives a black hole that hides information from us. If you probe the black hole with more energy it expands its horizon to reveal no more, so what is below the Planck length cannot be known. In the same way one can never observe below Planck time. Planck length and time are the irreducible limits of our digital reality.

Quantum realism predicts what current physics does not, that repeatedly dividing our space gives a pixel that can't be split and that repeatedly dividing our time gives a cycle that can't be paused. Just as closely inspecting a TV screen reveals only irreducible pixel dots, closely inspecting our space reveals only irreducible Planck lengths. If physical reality is an image on a screen, the screen's resolution and refresh rate are defined by the Planck limits, where the pixel size is a Planck length of 10^{-33} meters and the refresh rate Planck time implies is 10^{43} times per second.

2.2.2. Is space nothing?

Does space itself exist? This question has concerned the greatest minds of physics. Simply put:

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

Newton saw space as the canvas upon which God painted, so it would still exist even without objects. In contrast Leibniz considered a substance without properties unthinkable, so to him space was just a concept based on object relations, just as a meter is defined as the distance between two marks on a platinum-iridium bar in Paris. If objects only move with respect to each other, he concluded that without matter there would be no space.

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 spin 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? He concluded that the skater *really is spinning* in space (Greene, 2004) p32.

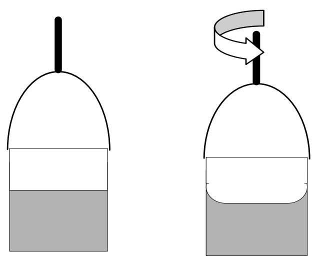

Figure 2.2 Newton's' bucket.

This seemed to settle the matter until Einstein showed that objects actually do 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. So in a truly empty universe, Newton's bucket would stay flat and a spinning skater's arms would not splay. This isn't testable as one can't empty the universe, but this resort to speculation 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 virtual space could handle object interactions in 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 has to be compared to every other point every quantum cycle, which task grows geometrically with the number of interactions. For a simulation the size of our universe, the processing is unimaginable.
2. *Distributed.* In this option, each point of space is a node with a fixed processing capacity pre-allocated. Now collisions aren't based on central calculations but on local overloads that occur if a node gets more processing than it can handle. This limits the processing required better and as space expands it also adds more processing. In this virtual reality, space isn't continuous and does exist apart from the objects in it.

Reverse engineering prefers the second option in which the processing is limited. It implies that our space is like a TV screen that can show "nothing" or perhaps static but is always there. A point of "empty" space is then a node of the quantum network that is null processing, just as a point on a TV screen can show nothing instead of a dot. So if every object in space disappeared space would still exist, just as a screen still exists even if no image is shown. And it is also the current verdict of many in physics that:

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

Space as a quantum processing network is neither the passive canvas of Newton nor the nothing of Leibniz because it is *null processing,* which is active despite having a null output.

2.2.3. A Cartesian space

That space is a "something" raises the question *What does it do?* It seems strange to talk of what space "does" but modern 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.

For the purposes of geometry, Euclid gave our space a structure many years ago as follows. First, he imagined a *point* with no dimensions. Then he extended that point continuously to create a *line,* that was again extended at right angles to give a *plane,* that was again extended to give a *cube.* This defined a *Cartesian space* with three orthogonal dimensions, where every point was represented by three real number coordinates (x, y, z).

Yet war-gamers don't use Euclid's space, as squares only give four directions to attack an enemy, so they divide their maps into hexagons instead to give more *interaction directions.* In general terms, a space requires:

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

Simulating space as a network isn't a new idea, e.g. in Wilson's networks a node is a volume of space and in Penrose's *spin networks* a node is a point event with two inputs and an output (Penrose, 1972). Yet all these models, including loop quantum gravity (Smolin, 2001), cellular automata (Wolfram, 2002) and lattice simulations (Case, Rajan, & Shende, 2001), *map nodes to a Cartesian space*. Hence as networks they all encounter the problem of *scalability*.

2.2.4.The scalability problem

Berners-Lee defined a *scalable* system as one whose performance doesn't degrade as it expands however big it gets (Berners-Lee, 2000). He designed the World Wide Web to this principle, that growth must increase demand and supply in tandem. The Internet also works this way, as every new ISP[20] demand also increases the processing to handle it, so it can grow forever. Such a network has to be distributed but when the decentralized Internet was first mooted, pundits predicted that lack of control would collapse it into chaos. It didn't, and that was *because* it had no central control. *Scalability requires any quantum network generating our universe to work by distributing control*.

As computer scientists discovered, an infinity anywhere in a centralized network can crash it but a distributed network 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 (Whitworth, 2008). The cortical hemispheres, the highest brain systems, are duplicated so if one fails the other carries on like a brain in itself. This logic applies when constructing a space but while Cartesian coordinates work for small spaces they aren't *scalable* because they require:

1. *A known size:* In order to define the coordinate memory allocation, e.g. a point in a 9-unit cube that is stored as (2,9,8) must be stored in a 999-unit cube as (002,009,008), which is more memory.
2. *A zero-point origin*: An absolute origin in the space, i.e. a central (0,0,0) point.

The bigger the space the more memory its coordinates take so a Cartesian space expanding like ours would need a maximum size defined *before the first event,* to avoid a Y2K problem. The Y2K problem arose because old computers stored years as two digits to save memory, e.g. 1949 was stored as "49". The problem was that the year after 1999 was "00"'- which was also used for 1900. A lot of money was spent fixing this problem.

A Cartesian space would also require an origin point from which to expand. Since Hubble's data showed every star and galaxy receding from us, a Cartesian space implies that Earth is that origin! But since the planet earth was only created recently, it can't be the zero-point origin. If our space is expanding *with no absolute center,* it can't be a Cartesian space.

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

That the performance of space hasn't changed much after expanding for billions of years suggests it is scalable. If space as a processing network expands like the Internet, then adding more nodes must increase supply and demand. Yet the network still has local limits:

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

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

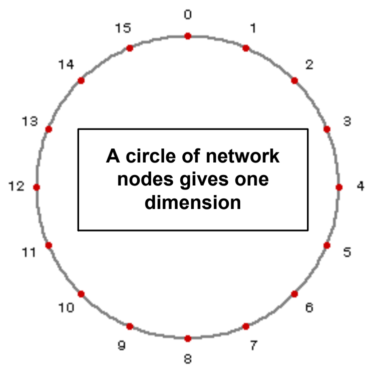

Figure 2.3. A circle emulates one dimension

2.2.5. A polar space

Euclidean space is so deeply ingrained in western thought that one might think it is the only way a space can be but one can derive *polar coordinates*[21] based on rotations rather than straight lines. Instead of beginning with a point that makes a line then a plane, etc., one can begin with a point that creates a circle and continue from there. In network terms, a circle defines one-dimension, as every node has two neighbors giving left and right *directions* and the *distance* between two points can be defined as the number link connections (Figure 2.3). A network defines distance and direction by its *architecture*, i.e. how the nodes connect, e.g. a node directly linked to another is "near" while one many links away is "far". Unlike a line dimension, a circular dimension is finite rather than potentially infinite and does not have its zero point on itself.

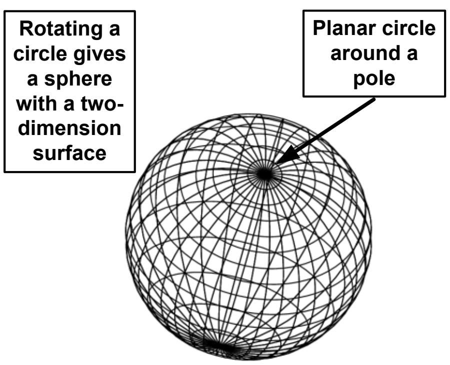

Figure 2.4. A sphere surface emulates two dimensions

Now just as Euclid did for a line, the circle in Figure 2.3 can be *rotated* 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 on the sphere surface is the center.
4. *Approximately flat.* If the sphere is large enough.
5. *Simply connected.* Any loop on it can shrink to a point.

In other words, this surface performs just like our space but with only two dimensions.

[21] 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.

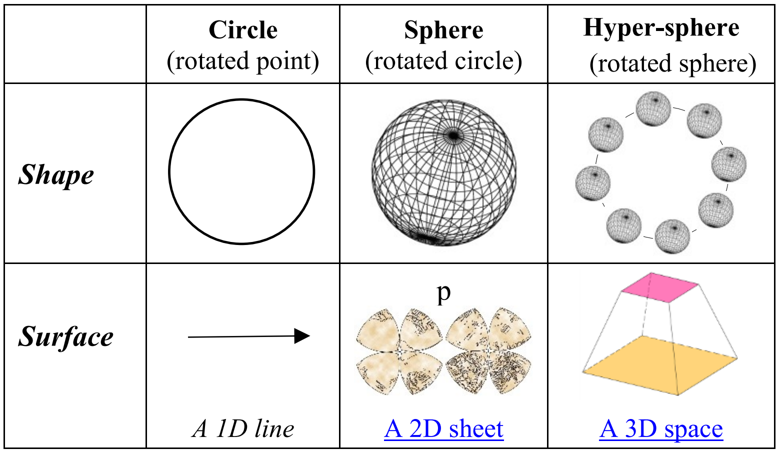

Figure 2.5. A hypersphere has a three-dimensional surface

Now just as rotating a 1D circle gives a sphere with a 2D surface, so rotating a sphere gives a *hypersphere* with a 3D surface (Figure 2.5). A hypersphere is what you get when one rotates a sphere just as a sphere is what you get when one rotates a circle. It is well defined mathematically but while a sphere surface has two dimensions, a hypersphere surface has three. Centuries earlier, the mathematician Riemann speculated that our space was a hypersphere *surface* because the facts fit: such a surface is unbounded, simply connected and three-dimensional just as our space is. The logic is even more convincing today, when Einstein says that space curves like a surface and cosmology says it expands everywhere at once like an expanding balloon surface. Logically, our 3D space could easily be a surface in a four dimensional bulk:

> "*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

Davies makes the case even more clearly:

> "*… the shape of space resembles a three-dimensional version of the surface of a sphere, which is called a hypersphere.*" (P. Davies, 2006) p45

Quantum realism concludes that our 3D space is a hypersphere *surface* within a four-dimensional quantum network that can transmit quantum waves. Why then does our space appear flat not curved? The simple answer is that the surface of a hypersphere bubble that has been expanding for over 14 billion years would seem flat to us.

2.2.6. Relative coordinates

Given the nature of our space, quantum realism concludes that polar coordinates simulate it better than Cartesian coordinates. Cartesian space expands from a zero-point within it but a polar space, like the surface of a balloon being blown up, doesn't expand from any point on that surface. A balloon surface expands everywhere at once on the surface. Current physics agrees that our space is expanding "*everywhere at once*" rather than from a fixed point within our space, so this favors a polar space rather than a Cartesian space.

Another feature of a circle is that any point can "begin" it. Equally the axis chosen to turn a circle into a sphere is arbitrary, so any node on a sphere surface could be a pole depending on the rotation axes used to create it. A sphere surface has as many different polar coordinates as there are axis poles but each set maps the same surface, which in network terms just changes how the nodes connect.

For a connected network to alter its links is easy, e.g. cell phone networks routinely change their connections to improve efficiency. So if each node *locally configures* its own connections as if it were the axis of every rotation, it can "paint" its own polar coordinates. This fits Einstein's idea that every object "*has its own space*". This approach doesn't allow an objective view of space but as will be seen, our world 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. Each gets a slightly different view but that doesn't matter if every view is equivalent. Quantum nodes decide themselves which nodes are neighbors just 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*".

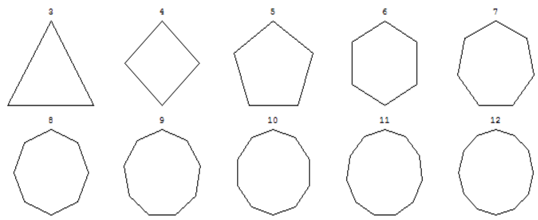

Figure 2.6. N-circle rotations, N = 3-12

2.2.7. The density of space

Space as a network must have a *density* based on the number of links 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 for a space but war-gamers avoid octagonal nodes because they don't "fill" a flat board, i.e. octagons placed side-by-side leave gaps. Yet while Euclidean squares fill the board they only give four interaction directions, so war-gamers prefer hexagons as they both fill the board and give more interaction directions.

If the quantum network emulating space is dense, each point will have many connection directions but a large N-circle can't fill a Euclidean space. So does this exclude it from emulating our space? For example, not all paths in such a space would be reversible, so following a route taken in reverse may not return to the same node, though it would 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 for space but objects in our world are better described by quantum clouds than 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 a polar space.* Even so, this model predicts that space as a polar network has a finite number of directions for any quantum event. Quantum realism predicts that direction, like length, is quantized, so there will be a minimum *Planck angle*[22].

2.2.8. Quantum space

Quantum realism concludes that our 3D space is a surface *contained* within a 4D quantum space. In 1919, Kaluza derived Maxwell's equations by expressing Einstein's relativity equations in four dimensions. The idea was rejected because a *real* extra dimension would make gravity vary as an inverse cube and the solar system would collapse. Kaluza's fourth-dimension contradicted physical realism but when mathematicians used *complex numbers* to explain electromagnetism as a rotation into a fourth dimension, they sensibly called it *imaginary* to avoid this.

Klein then suggested that Kaluza's dimension was *compactified,* curled up in a tiny circle so entering it returned you to the start, but this was also seen as unlikely - until years later string theorists needed to explain the six extra dimensions their mathematics required. So began the idea that space contains extra dimensions *within it*, but why would nature create extra dimensions that do nothing except make our equations work?

In quantum realism, a virtual reality must present on a screen surface that needs an extra dimension to contain it. If our space is a screen, its three *transfer dimensions* must be contained by another. Unlike string theory, this dimension *contains* our reality rather than *curls up* within it. This then is quantum space. *Quantum space is the space that contains our space as a surface within it.* It requires an extra dimension that we can no more enter than an avatar on a screen can enter our world. Today, some physicists see our

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

space as a *brane* in a higher-dimensional *bulk* because an extra dimension *sequestered* from our space can explain gravity (Randall & Sundrum, 1999):

> "*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

Quantum realism agrees, but sees our space as a polar surface rather than a Cartesian "slice".

2.2.9. Quantum waves

The advantage of space as a surface is that it allows waves upon it. In current physics, light is a transverse wave whose amplitude is said to be "imaginary" but quantum realism lets light vibrate into quantum space. A transverse wave needs a surface to vibrate upon and since light can travel in the vacuum of space, it must be a 3D surface. If a pool top is sealed in concrete, no waves can travel on it because the water can't move up and down. So if our 3D space is "sealed" how can light be a transverse wave? Light has to vibrate at right angles to its direction and is "sequestered" from that dimension because a wave 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 across the surface but the water moves up and down transversely hence a cork just bobs up and down as a wave passes. What moves horizontally is a *pattern of transverse displacements* not the water. Light then is a pattern of electromagnetic displacements into quantum space. Since light as a wave can't travel in the direction of its amplitude, the quantum dimension is indeed "imaginary" to us.

That we are sequestered from the quantum dimension doesn't mean it doesn't exist. We can *infer* that light waves arise from positive and negative electromagnetic displacements just as a water wave does. This requires a surface for light to vibrate upon and that surface is space. Current physics can't accept that this displacement is *real* but quantum realism can. It sees light as quantum processing passed on and deduces that the *fundamental quantum process* rotates circle of values at right angles to space, in what from now on is called a *transverse circle.*

To set a circle of values is efficient because the processing end begins another cycle. If quantum processing is like our processing, there are no half-cycles so a cycle must complete once begun. When this *fundamental process* runs in one node, equal positive and negative displacements in the same cycle cancel out to give space. The same processing distributed over more nodes gives the wave pattern of light (Figure 2.7) as the next chapter explains.

That light is based on a rotation into an unseen dimension seems strange but the complex numbers that explain electromagnetism assume just that. Schrödinger's equation describes an electron as a three-dimensional wave whose value at any point the mathematics *defines as imaginary*. Schrödinger 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 an entity exists there but a probability is just a number. One might expect the ultimate formula of reality to be something physical, but it isn't. We know that the quantum amplitude that predicts physical events isn't based on mass, momentum, velocity or any other physical property. *That the unreal creates the*

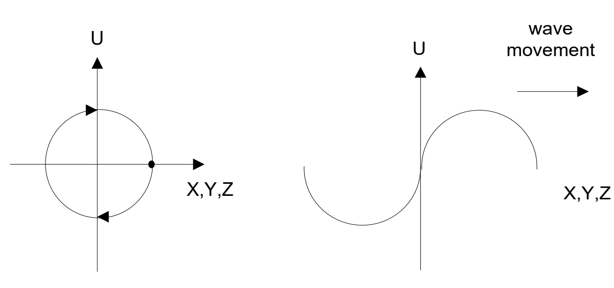

Figure 2.7. A quantum cycle as a. Space and b. Light

real makes no sense but physicists implicitly accept this when they use complex numbers[23]. Quantum realism concludes that light is a quantum processing wave setting displacements on the surface of space.

2.2.10. Creating Directions

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, the line that a moving object takes is the shortest path between two points. Objects were said to move in a straight line by an inertial direction until it was found that gravity curved their path. Einstein concluded that gravity somehow "curves" space to change the geodesic. While Newton saw the earth as attracting an apple, Einstein saw it as bending space-time so the apple naturally "falls" to earth. Objects still make their own direction but Einstein let gravity alter space to change that directional movement.

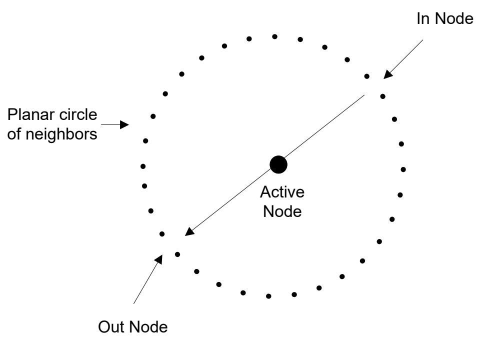

Figure 2.8. A planar circle transfer

Quantum realism approaches the issue of movement direction from a network perspective so photons move in a straight line by how the quantum network passes them on, not by themselves. In this view, each node is what current physics calls a point of space:

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

Imagine one node connected to neighbors on the quantum network that has to receive and pass on a photon. How it does so then defines the geodesics that Einstein says define gravity. Since every photon has a *polarization plane* at right angles to its transverse oscillation on space, let the set of neighbor connections for any given polarization plane be a *planar circle*. Planar circles reduce the direction problem for any node to an in-out planar circle problem (Figure 2.8). This simplifies direction just as two-dimensional *anyons* simplify the quantum Hall effect (Collins, 2006).

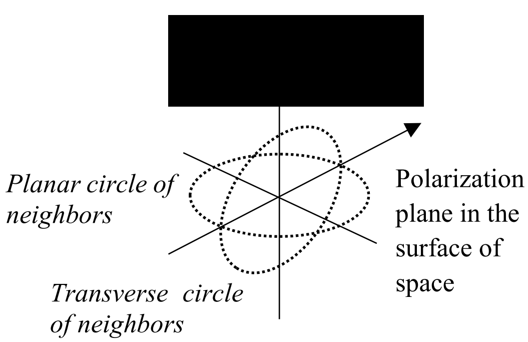

Figure 2.9. Planar and transverse circles

For a network, the shortest "distance" between two nodes is that which involves the least number of transfers. Even if a photon takes *every path*, as the next chapter suggests it does, the *fastest* path will always be a straight line in the simulated space. It is proposed that quantum objects move in a "straight" line because that is the fastest network route. In Chapter 5, a large mass like the earth redefines what straight is by changing the processing load differentially around it, i.e. it literally "curves space". In quantum realism, the geodesics of space depend on what network paths give the fastest transfers.

In summary, for *one node* receiving *one photon*, there is a *planar circle* that defines the processing transfer direction and a *transverse circle* that defines the

[23] They also accept that an electron is both a wave *and* a particle, that space is both finite *and* continuous, that the universe both began at a big bang *and* is all there is, and so on until they get inured to illogic.

processing amplitude (Figure 2.9). Quantum spin complicates this but for now, the planar circle gives the geodesics of space while the transverse circle allows the processing that defines time.

2.3. TIME AS QUANTUM CYCLES

In physical realism, time is a dimension into which substantial objects extend themselves as they do in space. In quantum realism, objects are only images and time is a by-product of the processing cycles that generate them. This section argues that time as quantum cycles better explains time in our world than time as a dimension.

2.3.1. The nature of virtual time

In an objective reality, time passes inevitably as matter exists by its own nature alone. In a virtual reality, time passes as processing cycles complete, e.g. in Conway's Life simulation (Figure 2.10). As pixel patterns are born, grow and die, their "lifetime" is how many processing cycles they "live" for. If Life pattern that repeats for twenty minutes of our time is run on a faster computer, it might only repeat for only a few seconds but its virtual life, defined as the number of cycles completed, is the same. *Virtual time depends only on the number of processing cycles that occur.* Since we measure time in our world by atomic clocks that count atomic cycles, it could also be virtual.

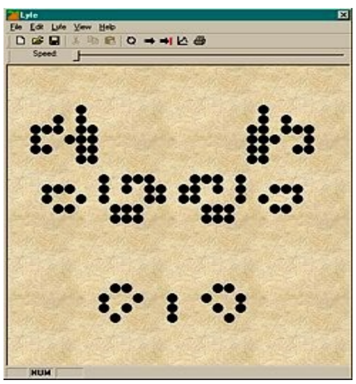

Figure 2.10. Conway's Life Simulation

Einstein's special relativity supports the idea that our time is virtual. In his twin paradox, after one twin travels the universe in a rocket at near the speed of light he returns a year later to find his brother an old man of eighty. Neither twin was aware their time ran differently but one twin's life is nearly over while the other's is still beginning. Yet the eighty-year-old twin wasn't cheated of time, as he still got eighty years of heart beats and grandchildren to boot. That time slowed down for the rocket brother only become apparent when he re-united with his twin. In relativity, time changes are undetectable by the parties affected, just as one expects for a virtual reality.

When people first hear that time dilates they suspect a trick, that only *perceived time* changes but it is *actual* time as measured by instruments that changes so it's no trick. And it's not just theory, as accelerating short-lived particles makes them live many times longer than they usually do. Physical realism struggles to explain this, as time in an objective reality shouldn't vary according to how fast one goes.

If we live in a virtual reality, time dilation is expected, as all gamers know that the screen slows down in a big battle when the computer has a lot to do. The screen frame-rate *lags* due to a processing load but what each avatar can do is unaffected. In other words, game time is not affected when the screen slows down.

Quantum realism therefore interprets Einstein's theory to mean that our virtual time slows down when the quantum network has a lot to do. In the twin paradox, the rocket twin's acceleration increased the quantum network load leaving less processing available for his life events, so he only aged a year. The twin on earth had no such load so eighty years of his life cycled by in the usual way. If our virtual time "ticks" with each quantum cycle, what slows those cycles down also slows down our time.

2.3.2. Is time travel possible?

Minkowski interpreted Einstein's theory of relativity using a four-dimensional space-time matrix. Instead of existing at a Cartesian (x, y, z) point in space, objects now exist at a Cartesian (x, y, z, **t**) point in space-time, where **t** refers to *time*. An object sitting at a point in space now has a *world line* that extends it in time. One can allocate "locations" in time as for space and talk of the "temporal parts" of an object as one does its left and right parts. This enhanced idea of how objects self-exist has been generally accepted.

The Minkowski interpretation presents a *block theory of time* where "time capsule" states can be browsed like the pages of a book, as all past, present and future states exist in a "timeless time" (Barbour, 1999) p31. That the future and past already exist in space-time implies that time travel is indeed possible. It also predicts *closed time-like curves,* where a material object follows a spacetime world line that loops back to its starting point, just as an object moving in space can curve back to where it began. Spacetime is the landscape that physicists assume objects endure within. The evidence is that the mathematics works but mathematical models are notoriously unreliable indicators of reality, e.g. assuming all the mass of a body exists at its center of gravity works to calculate trajectories but no-one believes it is so. When physicists say that time travel is *"based on General Relativity*" they really mean it is *based on Minkowski's interpretation* of relativity, i.e. a mathematical model.

Since no physical evidence whatsoever supports time travel, the idea that things exist in a spacetime seems to be just an upgrade of Newton's idea of space as a "canvas". It is a mathematical convenience not a reality description. After all, if we ever do achieve time travel, surely the first job would be to go back in time to stop the stupid things we are doing now! There are practical reasons why time travel isn't possible in our world:

a. *The grandfather paradox:* A man travels back in time to kill his grandfather, so he could not be borne and so he could not kill him. In the same way, closed time-like curves deny causality as they give an event that is "simultaneous" with its cause. It follows that one can have going back in time or causality but not both.

b. *The Marmite paradox:* I see forward in time to me having Marmite on toast for breakfast but next morning I decide not to, so I didn't see forward in time. If reality is a sequence of pre-existing states run forward, as block theory suggests, then *life is a movie already made* so there is no choice. It follows that one can have going forward in time or choice, but not both.

Quantum realism accepts that time dilates but denies that this prevents causality or free choice, i.e. it denies time travel. Like the multiverse myth, time travel is great science fiction but not great science.

2.3.3. Specifying time

To specify time in processing terms as was done for space, consider that our time has the following properties:

1. *Sequence*. Time defines a sequence of events.
2. *Causality*. Time lets one event cause another.
3. *Unpredictability.* Future time is not predictable.
4. *Irreversibility.* Time events cannot be reversed[24].

A virtual time that acts like ours must support sequence, causality, unpredictability and irreversibility.

1. Sequence

For a processing system, time based on storing 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 is unimaginable, so the storage needed is unbelievable.

[24] The special case of anti-matter generating anti-time is explained in Chapter 4.

b) *Inefficiency*. Why fill a database with *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? Or if only what is important is put on the record, how are those events selected[25]?

Why store every event of simulation when you can just run it again? Quantum processing doesn't allow storage but it does allow a sequence of events. Or perhaps it already has a "storage" system and *the physical world is it*. After all, a physical event is a *selection* from a multitude of quantum events. Each physical event is in essence a report - we query quantum world to get the status update we call the physical world. This report 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 but that which lives for itself alone passes away. The physical world is the quantum world's solution to its storage problem.

2. Causality

Given a sequence of events, causality is their lawful connection. The basis of this is that quantum states:

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

However rather than static states, it makes more sense to attribute this progression to dynamic processing:

"*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

Quantum realism argues the same except each unit generates processing rather than information. So instead of a single causal stream, it generates all possible causal paths at once. As each processing event defines the next, no intervening states are necessary, so quantum theory's evolution of *states* is the exploration of all possible *events*.

3. Unpredictability

A choice that creates information has by definition a known "before" and an unknown "after". Before there are many options but after there is only one, so the choice result isn't itself a choice as it is just one. In quantum theory, a photon approaches a screen as a quantum *wave* of probabilities that randomly collapses to the *point* where it hits. A physical event is a probability until it is *randomly* chosen, where random means that *nothing in physical history can predict it*. Even knowing every physically knowable thing, one can't predict when a radio-active atom will emit a photon. Quantum theory tells us that *every* physical event involves a random quantum collapse that no prior physical "story" can explain. If our world is a machine, then it is one with:

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

Quantum realism concludes that *quantum collapse is a server choice* made outside our virtual reality, so physical events *always* contain an element of unpredictability even though they *always* have a causal history.

4. Irreversibility

All the laws of physics are time reversible, so physics wonders "*Why doesn't time run backwards?*" If physical objects are just there and time is a dimension, going back in time doesn't break any laws of physics.

[25] 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.

But in quantum theory, an object is a quantum wave that spreads until it "collapses" at a physical event. Quantum realism adds that quantum waves are processing waves and *quantum collapse is a processing reboot* (see later). In these terms, the question becomes "*Why isn't a quantum reboot reversible?*" A reboot is when processing restarts from scratch, e.g. rebooting restarts a computer and loses any work in progress unless you saved it! One can't *undo* a reboot because when a processor restarts, the previous event sequence is lost. Whatever was happening before the reboot is gone forever and likewise what exists before a quantum reboot is irreversibly gone. If quantum collapse creates physical events, that it is a reboot makes them irreversible. *The quantum collapses that current physics calls imaginary create the arrow of time.*

Quantum processing taking every path, punctuated by an occasional reboot or collapse, gives a time that is sequential, causal, unpredictable and irreversible, just like ours.

2.3.4. Time is not a dimension

To Newton, time was a universal stream that carried all before it but if time itself changes that can't be so. A time that defines all change cannot be itself subject to change[26], so our time may not be as fundamental as Newton thought it was:

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

One might think that a four-dimensional quantum grid operating in time requires five dimensions but what creates our time has no need to exist within it. A fourth dimension allows the quantum cycles that create time, so quantum realism has only four dimensions not five. Hawking & Hartle argue that in the beginning there existed four equal dimensions until the first event broke that symmetry when *one of four equivalent dimensions became time and the rest became space* (Hawking & Hartle, 1983). Quantum realism agrees but sees the original symmetry as a quantum network that "separated" into the three dimensions of the surface we call space and another for the transverse quantum cycles that create time. Space and time, like everything else, then come from quantum reality.

Quantum realism has no time dimension, only quantum cycles with time as a byproduct. What exists are events not substances, giving a "*Physics of Now*" (Hartle, 2005) p101 that has no past, future or time travel. Yet this "now" is not a cosmic now as each locale has its own time rate based on its own cycle rate. When matter doesn't self-exist in time, it doesn't need a time dimension to self-exist in. Quantum realism only requires *an ever-present here and an eternal now.*

2.4. SOME IMPLICATIONS

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

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

2.4.1. Space is a surface

In 1929 the astronomer Hubble found that all the galaxies were expanding away from us, which implied a "big bang" about 14.5 billion years ago and finding its leftover radiation all around us today supports this. Physics concluded that this event began not only our universe but also our space and time, but if it all exploded "out", why is the radiation from long ago still all around us today? And if the universe is expanding, what is it expanding into?

The current reply is that the big bang wasn't really a bang - but what then was it? If *in the beginning* there was a singularity of all matter at a point, by current physics it should have collapsed into a black hole from which nothing can emerge. So why wasn't the universe stillborn? Something else was needed so according to inflation theory (Guth, 1998) an immense anti-gravity field then appeared from nowhere to expand the universe faster than light for 10^{-32} seconds. After solving the black hole problem, it then vanished to play no further part in the universe. So the modern *creation myth* is that nothing made everything at a point that magically expanded faster than light to avoid forming a black hole, until it stopped doing that for no reason and sedately evolved into the galaxies, stars and us. It isn't a very convincing story.

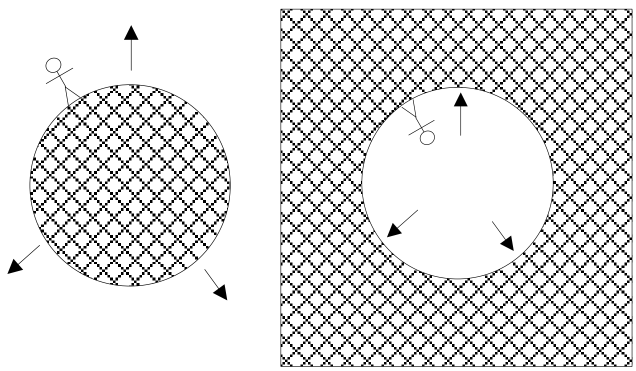


Figure 2.11. A big bang vs. a big bubble

In quantum realism, *in the beginning* there was a quantum reality we don't understand and it created physical reality from itself. It emulates 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 expands everywhere at once. The waves that move on its surface in any direction wrap around, so the early light went "out" then wrapped around to end up everywhere as cosmic background radiation. That our space is the *inner surface* of a big bubble not the outer surface of a big "bang" (Figure 2.11) answers questions like:

1. *What is space expanding into?* It is expanding into the surrounding *quantum 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.

2.4.2. The small rip

Based on what we know, it isn't possible for our universe to exist at a singular point. Extrapolating the equations of general relativity to when they no longer apply doesn't prove there was a singularity. Quantum realism concludes that our universe came from a quantum reality that existed before it began, not from nothing.

It postulates that the first event was when one node of the quantum network *became a server* by passing its processing to its neighbors, creating what we might call the *first photon* in the *first unit of space.* That the universe began small avoids the black hole problem, as what initially exists physically is just the tiny seed of the universe to come.

What then is a server? In computer science, a server is a processor that serves other nodes on a network, e.g. a network server that handles many client terminals. In a *client-server relation*, a server can handle many clients if it is faster than them. A simple example is a "dumb" terminal that is just a keyboard and screen connected to a network server. When I press a key, a request is sent to the server which then sends the right letter to the screen. The speed of the server means that even if I type as fast as I can, in-between each keystroke the server is able to handle hundreds of other people also typing.

The quantum network has no "dumb" nodes but it can still support a *quantum client-server relation,* where a quantum server generates processing the way a physical server generates information. This makes quantum processing dynamic, as described earlier.

The first event was then when one node "gave" its processing to the network to create a tiny but very intense electromagnetic wave. No black hole occurred because the first event only created one "photon" but its intensity triggered other nodes to do the same giving the *chain reaction* physics calls inflation. A tiny "injury" to the quantum fabric quickly became huge, just as a pinprick can quickly rip a taught fabric apart. Inflation then occurred faster than the speed of light because this "ripping" occurred at the *server rate* not the *client rate*. In this view, the initial plasma was:

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

Inflation then was the quantum network "breaking apart" into servers and clients, to create the free processing behind our universe as a virtual reality. What then stopped inflation from continuing forever? Inflation created space as well as photons, as each step of the chain reaction created not only a unit of light but also a unit of space. Since adding space into an electromagnetic wavelength dilutes its power, the creation of space acted to slow down the chain reaction. Hence the cosmic background radiation that was white hot at the dawn of time is now cold. The separation into server and client that made all the *free processing* behind our universe was a once only event that hasn't repeated (Davies, 1979). Galaxies have come and gone but since inflation, *the net free processing of the universe has remained constant*.

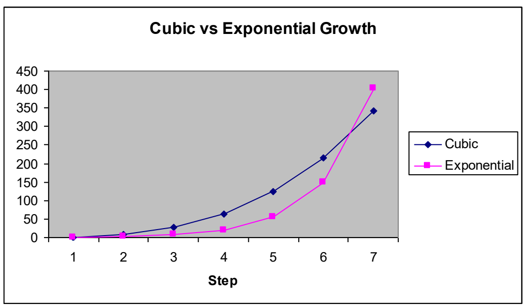


Figure 2.12. Cubic vs. exponential growth.

The photon chain reaction grew exponentially but a hypersphere surface grows as a cubic function and a cubic growth will overpower an exponential one if the resolution is quick (Figure 2.12), as the evidence suggests it was. In the first event *one* grid node *separated* to create one photon in one volume of space. This then cascaded in the faster-than-light expansion physicists call *inflation*[27] but each step also made a point of space that weakened the chain reaction until it stopped. The expansion of space "healed" the injury by stopping the chain reaction that created our universe almost as soon as it began but the bubble continued to expand, lowering the energy to levels suitable to life. The expansion of space isn't just an oddity of physics as without it, life could not have evolved at all.

It follows that the "big bang" wasn't big, at first anyway, nor was it a "bang" as we use the term. It was *a rip in the primal reality* that began as one photon in one volume of space. This denies the "miracle" that everything came from nothing to exist at a dimensionless point, that then magically expanded faster than light until it equally magically stopped. *Quantum realism sees the first event as a small rip rather than a big bang*.

2.4.3. The transfer problem

When two processors exchange data they work together to ensure that what is sent is received. If one processor sends two information packages and the receiver can only handle one, the second is lost. For a

[27] 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.

virtual reality, the "thing" the second package represents then disappears, *forever*. For a virtual reality like SimCity, this *transfer problem* might cause a building to suddenly disappear. Imagine if our world did that! Our universe has run for billions of years with no evidence that even a single photon has been lost. So if our universe is a virtual reality, the quantum network must have solved the transfer problem.

Our systems solve the *transfer problem* using protocols, basically rules that ensure no information is lost in transfers, e.g. *http* is the Internet transfer protocol. There are many protocols but they mainly involve:

1. *Locking*. Lock a file for exclusive access before writing to it.
2. *Clock rate*. Motherboards use a common clock rate.
3. *Buffers*. Network nodes have memory buffers to store overloads.

Locking. My computer stores this chapter as a file on disk. To edit it, I load the file into a word-processor, change the words, then save it back to the disk. While I am editing, the system "locks" the document exclusively, so if I try to open the same file for a second edit, it says it is "in use". This avoids the possibility that two people edit the same text and the last person to save overwrites the changes of the first. Locking is also inefficient as a change now requires two steps, which allows the *deadlock* case in Figure 2.13, where node A waits to confirm a lock from node B that is waiting for a lock from C that is waiting for a lock from A, so each of them waits *forever*. If a quantum network followed this protocol, we would encounter "dead" areas of space, which we do not. Something better is needed.

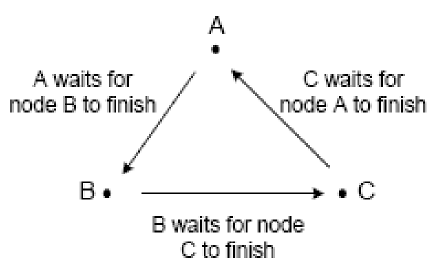


Figure 2.13. Transfer deadlock

Clock rate. Motherboards avoid the double-send of locking by using a common clock rate. When a *fast* central processing unit (CPU) issues a command to move data into a *slow* register it must wait for that to happen. Waiting too long wastes CPU cycles but trying to use the register too soon gives garbage from the last command. The CPU can't "look" to see if the data is there because that is another command that needs another register that would also need checking! Instead it uses a *clock rate* to define how many cycles to wait for any task to be done. The CPU gives its command then waits that many cycles before using the register. The clock rate is usually set at 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. This solution requires a system with a central clock but we know that our universe doesn't have a common time. A universe that ran to a central clock would cycle at the rate of its slowest node, say a black hole, which would be massively inefficient. Again something better is needed.

Buffers. Early networks solved the transfer problem using centralized protocols like *polling,* where every event went through a central processor but this was soon found to be inefficient. Protocols like Ethernet[28] improved efficiency tenfold by *distributing* control, to let nodes run at their own rate with buffers to handle any excess. So 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 sends to a *printer buffer* that feeds the printer. This lets 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. The Internet fits buffer size to load, with big buffers for backbone servers like New York and little buffers for backwaters like New Zealand. Yet this would not work to simulate a universe. Galaxies are the "big cities" of our universe but where they occur is not predictable and allocating even small buffers

[28] 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*.

to the vastness of space would waste memory. And since the quantum network by its nature has no static memory, it cannot use buffers.

2.4.4.The pass-it-on protocol

None of the above methods work for a quantum network so how can it not lose transfers, in order to conserve energy for example? Transfers can't be synchronized by a common clock rate as our universe has no common time, quantum processing can't be stored in static buffers by its dynamic nature, and locking transmissions would lead to deadlock situations that we don't observe.

One thing we know about our universe is that the speed of light is constant. If quantum nodes transferring quantum processing waited for destination nodes to finish their cycles, the speed of light would vary for the same route, which it doesn't. That light doesn't wait implies that nodes immediately receive any transfer as an *interrupt*. Won't this lose the processing they are currently doing? Not if each cycle every node *first* passes its processing to its neighbors, *then* processes what it receives. The *pass-it-on protocol* is that every cycle quantum processing is passed on. Note that each node has separate channels for each network neighbor connection and no "overtaking" is possible.

The problem with this solution for a network is that it could create an infinite loop, but there is one more thing to consider - that space is expanding. In quantum realism, space expanding isn't just mysteriously adding "nothing" but adding new quantum nodes. When a new node enters space, it has no free processing to pass on for its first cycle so it receives only. So any pass-it-on ripple will stop when it meets a new node of space, as it accepts the extra processing without passing anything on. As space is expanding everywhere not just at some "edge", any pass-it-on loop will eventually stop.

There is one more consequence. The ongoing spreading of light throughout the universe as an interrupt will act to make the asynchronous quantum network largely synchronous. The effect isn't perfect, but it is general.

In this protocol, nothing ever waits so there is no need for buffers. Any quantum processing activated on the quantum network will immediately spread out, as it is passed on at the speed of light. Every node of the quantum network is always ready to receive and each can run at its own rate which we know increases efficiency. Light moves on one node every cycle, every transfer is accepted and expanding space nullifies infinite pass-it-on loops.

2.4.5. Empty space is full

If empty space was really empty it would have no energy. This is not true so:

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

That *empty space isn't empty* (Cole, 2001) is illustrated by:

1. *The Casimir effect.* Two uncharged flat plates held close together in a vacuum register a force pushing them together. Current physics attributes this *vacuum pressure* to virtual particles that pop out of the "empty" space around the plates but how can emptiness create particles? Yet according to quantum theory, a point can't constantly have zero energy and this *energy of the vacuum* allows the Casimir effect. Again a space of truly nothing couldn't have this property.
2. *Light waves travel in empty space.* If light *waves* travel in a vacuum, space must be the *medium* in which those waves vibrate. It follows that the vacuum that mediates light waves can't be nothing.

Empty space isn't a *physical thing* 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.

In quantum realism, space presents as empty but is actually *full* of processing. This "fullness" generates the vacuum energy that gives the Casimir effect and also mediates light. It can show nothing or something just as a screen can be blank or show an image. The quantum network shows nothing because each node runs a null process, i.e. a positive-negative cycle that sums to zero. Yet since the network is *asynchronous*, each node runs its own cycle and many asynchronous null vibrations can't all be zero at once. So while points of space *average* zero at any instant they aren't all *simultaneously zero,* just as quantum theory predicts. A quantum "ether" isn't a physical ether but it is the non-physical medium that Einstein suspected had to exist.

Imagine a large window with a view, where one sees the view but 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. Now suppose that the "glass" that transmits physical reality has no imperfections so it can't be 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. The quantum network can be imagined as a *network of perfect diamonds* that flawlessly reflects the images of physical reality within itself.

2.5. REINVENTING PHYSICS

The era of finding simple equations like $E=mc^2$ is over. Today, the equations of physics fill books because the low hanging fruit have been picked. A better tool is needed for the higher fruit and that tool is computer simulation. Yet while one can guess equations that work from the data, developing a simulation requires an understanding of what is being simulated.

2.5.1. The trouble with physics

A century ago, physics left the safe haven of classical mechanics seeking the promised lands of relativity and quantum theory. It found equations based on quantum waves, time dilation, curved space and other wonders that worked brilliantly but did so in ways that couldn't be physical. Rather than consider a non-physical reality, physics settled down in the *semantic desert of physical realism* where it has remained ever since.

The Trouble with Physics (Smolin, 2006) today is that no new knowledge is being generated, so what puzzled Feynman fifty years ago still puzzles us today. Hawking calls this impasse "*The End of Physics*", recalling nineteenth century claims to know everything there is to be known about reality. How wrong that was, but the result this time is starvation not revolution, as physics finds ever more ephemeral "particles" and speculates on theories that can *never* be tested. Some produce books and TV shows to "explain" what they don't understand themselves while experts rally the troops with papers on strings, multiverses and supersymmetry that are *Not Even Wrong* (Woit, 2007). Even the weeds of error don't grow in this desert!

For decades now, physics "breakthroughs" have been *speculations* on possible advances that turned out to be mirages. We read stories of white holes, eleven dimensions, closed time loops, WIMPs, wormholes, heavy sterile neutrinos, super-particles and more all hinting at the next revolution in physics that never comes. Theoretical physics today is stagnating and given past performance, the next fifty years are likely to be as barren as the last. For example, after speculating that hypothetical axion particles from a hypothetical flavon field, or axiflavons, are the key to solving many physics problems, the authors write:

"*Its thrilling stuff, if for the moment it is only conjecture*" New Scientist cover story, August, 2018, p31

Instead of building castles in the air, why not grow theories from the data ground up?

The data suggests that the cosmos is mostly made of something we cannot see, and quantum realism says that something is quantum reality. So the trouble with physics is that it is looking in the wrong place, like the man who lost his keys and when asked why he was looking under a lamp post said "*I lost them in* *the forest but the light is better here*." Physics has turned its back on perhaps the greatest discovery of mankind, that the physical world is generated by something beyond itself, because it *assumes* that science can't look beyond the physical. In contrast, quantum realism suggests that one can scientifically investigate quantum reality using information theory. All one has to do is look at reality in a new way. It is time to develop a new vision of reality *from the ground-up*.

2.5.2. Grounded physics

When Europeans first discovered China, they came as conquerors to a culture that made no sense in bible, king and country terms. Anthropologists eventually realized that new ideas like "keeping face" only really made sense in an entirely new context. The scientific name for the method used to acquire a new context is called grounded theory. It aims to first observe with an open mind, *then* theorize. Anthropologists visit a new tribe, watch, listen and record, *then* form a theory to test next day, and do this iteratively until they understand their culture on its own terms. *Letting the data speak first* avoided colonial bias but seemed to reverse the usual predict-test method of science, until Kuhn suggested that science has *two* phases (Kuhn, 1970):

1. *Paradigm growth:* Theory predicts new data.
2. *Paradigm shift:* Data implies a new theory.

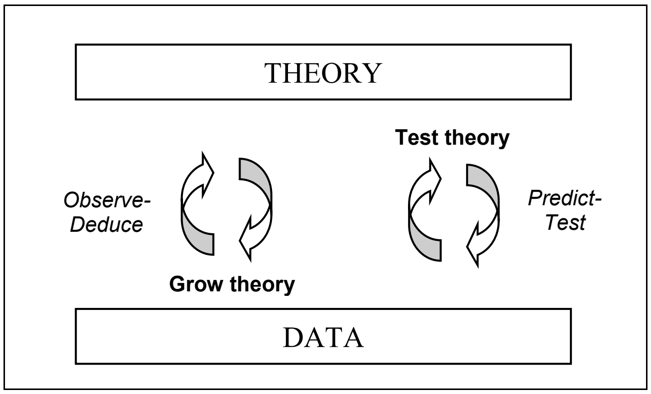


Figure 2.14 Paradigm shifts grow theories

In *paradigm growth,* theories grow based on data but in *paradigm shift* the data grows an entirely new theory. Paradigm growth is slow and steady, as water wears away rock over years, but a paradigm shift is often sudden, like an earth-quake that changes the landscape in a short time. In the history of science, established theories dominate until an intellectual earthquake raises a new theoretical landscape from the data ground. Science as a way of *connecting* data to theory doesn't always work from theory to data by a predict-test method but also works from data to theory by an observe-deduce method (Figure 2.14). *This then is what physics has to do with the new "culture" of quantum reality*.

The grounded theory of computing is called *reverse engineering.* It observes outputs to deduce processing causes that are tested by further interactions. So to reverse engineer physical reality to deduce quantum processing is an established method in science, well known in computer science. Physics has approached quantum theory like colonials in China, calling imaginary what doesn't conform to its traditional beliefs. The physical realism culture handed down from Aristotle is as embedded in physics as King and Country was in colonial Britain. Physics needs a paradigm shift to see reality in a new way.

2.5.3. Accepting quantum reality

Quantum realism aims to reverse engineer the physical world based on quantum theory and computer science. It accepts as true the quantum theory statement that quantum waves can't be seen directly because any attempt to do so gives a physical event, so quantum reality is literally unobservable not just by us but also by our measuring devices. But this doesn't stop us reverse engineering it, as that is how quantum theory was deduced in the first place!

Some scientists fear that assuming the quantum world is real will lead to a God theory, one that "explains" by an all-powerful referent but doesn't predict anything. In contrast, quantum processing is finite and the principles of processing are known. If reverse engineering leads to testable predictions, why not try it? For example, Chapter 4 predicts what current physics denies - *that light can collide*.

To reverse engineer physical reality one must accept that quantum theory is a *reality description*, so:

1. *Quantum randomness* really does come from outside physical reality.
2. *Complex numbers* work because electromagnetism really does rotate into another dimension.
3. *Planck limits* exist because our space and time really are digital.
4. *Feynman's sum over histories* works because quantum entities really do take every path.
5. *General relativity* lets our space curve because it really is a surface.

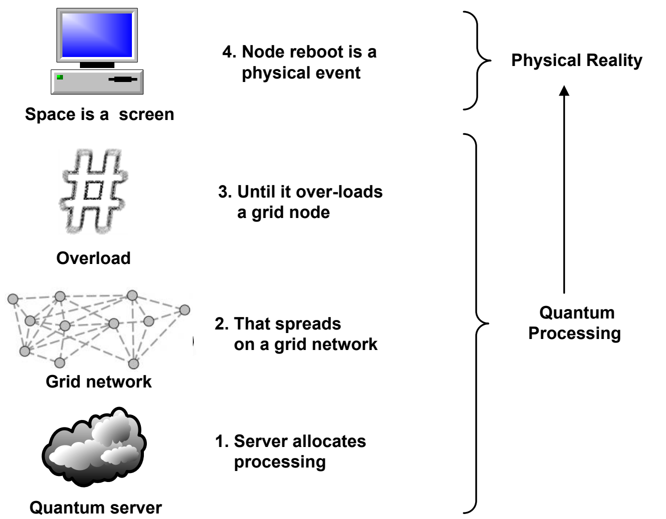


Figure 2.15. Quantum processing gives physical reality

In essence, quantum realism implies that the equations of physics aren't imaginary or fictional but literally true. If the equations of quantum and relativity theory are good enough to use, aren't they good enough to believe? The *calculus* used throughout physics is an illustrative example. It began as a thought experiment, like quantum theory, that infinitesimals "in the limit" predict physical reality. Again like quantum theory, it worked brilliantly but physical realism decreed that it had to be "*just theory*". Yet why not see calculus as a reality description? Why not conclude that reality *actually does change* in infinitesimal pixel steps and time progresses in indivisible cycles[29]! Zeno's paradoxes are resolved if we replace time in our equations with processing cycles. *Calculus was only rejected as a reality description because the continuity of physical reality is a canon of physics*.

2.5.4. A quantum processing model

Last century, physics invented an amazing theory, a tale of quantum waves spreading at light speed that collapsed instantly to a physical event when observed. It made no sense because no physical wave could do that but it worked brilliantly! So physics decided to *calculate* quantum waves that spread, superpose, collide, collapse and entangle in physically impossible ways while at the same time *denying* those waves existed at all! This began the current era of fake physics, of equations that work based on theories that don't. *No-one noticed that quantum theory was an excellent description of how processing waves spread and restart on a network*.

We now develop the view that quantum waves are processing waves. Processing waves that spread on a network can *superpose* when they overlap, *collide* when they overload, *collapse* when they reboot at a node, and *entangle* when the restart merges the processing. Quantum waves as processing waves can also explain relativity as described in Chapter 5. Quantum realism aims to use the equations of physics to define the quantum processing engine.

The assumption that quantum reality exists is no less valid than the *naïve* assumption that the physical reality we see exists of and by itself. Figure 2.15 summarizes the model now presented: a quantum server distributes processing on a quantum network until a node overloads and reboots to give a physical event.

[29] For any calculus involving time, replace *dt by dp*, a small number of processing cycles. Now *dp* can indeed "tend to zero" because there cannot be less that one processing cycle.

Table 2.1. Space and time as explained by physical realism and quantum realism

Physical Realism	Quantum Realism
Physical realism. Only the physical world exists so: a) Physical objects cause all physical events b) Randomness is not possible c) Replaying physical events is reloading reality d) One day we will upload and reload ourselves	**Quantum realism**. Only the quantum world exists so: a) Quantum processing causes all physical events b) Randomness is possible c) Replaying physical events is not reloading reality d) Quantum reality can never be saved or reloaded
Space. Is the "no-thing" between matter so it is: a) *Empty*. Yet it hosts virtual particles b) *Continuous*. Yet there is a Planck length c) *Containing*. Space contains all things in itself d) *Expanding*. But how can nothing expand into nothing? e) *Absolute*. A cartesian space has an absolute center f) *Doesn't mediate light*. So light is a wave of nothing g) *Unlimited*. So the universe can exist at a singularity h) *Always zero*. Which quantum theory denies	***Space***. Is the quantum network null processing so it is: a) *Full*. Null processing just looks empty b) *Discrete*. Hence there is a Planck length c) *Contained*. Space is merely a 3D surface d) *Expanding*. Into a larger quantum bulk that contains it e) *Relative*. Each quantum node "paints" its own links f) *Mediates light*. So light is a wave "on" space g) *Limited*. The bandwidth of space is a black hole h) *Averages zero*. As quantum nodes are asynchronous
Time. Objects exist inevitably in time, so it is: a. *Continuous*. Yet there is the Planck time limit b. *Real*. Yet it slows down with object speed c. *A dimension*. That real objects can time travel in d. *Reversible*. According to every law of physics	***Time***. Time is based on quantum cycles, so it is: a. *Discrete*. So Planck time is one quantum cycle b. *Virtual*. So it slows down with processing load c. *Not a dimension*. So time travel is impossible d. *Irreversible*. As a physical event is a quantum reboot
Directions. Moving objects are self-directed so: a. *A straight line* is a natural moving object property b. *Gravity* "bends space" to alter straight line paths c. *Angles*. Every angular direction is possible	***Directions***. Moving objects are self-directed so: a. *A straight line* is the fastest network transfer path b. *Gravity* alters the fastest network transfer path c. *Angles*. Are quantized for a quantum event
The big bang. The universe began entire all at once: a. *Cause*. Nothing at all, as the universe is all there is b. *Start*. Our physical universe started as an infinitely dense singularity at a dimensionless point c. *Inflation*. A huge anti-gravity field from nowhere then expanded the singularity faster than light d. *Inflation stopped*. After 10^{-32} of a second that field conveniently disappeared forever e. *Cosmic back-ground radiation* expanded "out" so it should be far away at the cosmic edge by now	***The small rip***. The universe began as a tiny "seed": a. *Cause*. The previously existing quantum network b. *Start*. Our physical universe started when quantum node created one photon in one unit of space c. *Inflation*. The extreme energy of the first photon caused others to follow suite in a chain reaction d. *Inflation stopped*. Inflation also generated space that diluted the first light to stop the chain reaction e. *Cosmic back-ground radiation* expanded inside a spherical surface so it is still all around us today

Quantum realism is the case that a quantum reality we don't see generates the physical world we do see as a virtual reality.

Table 2.1 given next compares quantum and physical realism for space and time so readers can decide for themselves which offers a better explanation of the facts.

DISCUSSION QUESTIONS

The following questions are addressed in this chapter. They are better discussed in a group to allow a variety of opinions to emerge. The relevant section link is given after each question:

1. Can information be defined in purely physical terms? Do so, or explain why it isn't possible. (2.1.2)
2. Does a hologram copy of physical events replay reality? What is missing? (2.1.3)
3. If the universe is a virtual reality, what would be necessary to save and reload it? (2.1.3)
4. How does quantum processing differ from the physical processing of our computers? (2.1.4)
5. Can one copy a physical state? What about a physical event? What about a quantum state? (2.1.4)
6. If the physical world is a virtual reality, what is the screen? What is its resolution and refresh rate? (2.2.1)
7. State Zeno's paradoxes. How does physics resolve them? How does quantum realism resolve them? (2.2.1)
8. Is space something or nothing? If nothing, what transmits light? If something, what is it? (2.2.2)
9. Would a network simulating the universe be centralized or distributed? Explain why. (2.2.4)
10. If a quantum network generates space, why doesn't it slow down as space expands? (2.2.4)
11. Why do polar dimensions explain our space better than Cartesian dimensions? (2.2.5)
12. How can space expand "everywhere at once", as physics says? (2.2.6)
13. What is the main problem of using a polar space? How is it resolved? (2.2.7)
14. Is an extra dimension more likely to be *curled up* in our space or to *contain* our space? (2.2.8)
15. If reality has a fourth dimension, why can't we enter it? (2.2.8)
16. If light is a transverse wave, like a wave on a lake, on what surface is it vibrating? (2.2.9)
17. Traveling at near light speed slows down your time. Why doesn't this let you live longer? (2.3.1)
18. Is there any evidence for time travel in physics? Why is time travel *in one location* unlikely? (2.3.2)
19. Why doesn't quantum realism allow a quantum entity to go back and forth in time? (2.3.3)
20. If three dimensions of the quantum network simulate space, what does the fourth represent? Is it time? (2.3.4)
21. Why is cosmic background radiation from the early universe still all around us? (2.4.1)
22. What caused inflation and what stopped it? (2.4.2)
23. What happens if a data transfer in a simulation fails? How do our systems avoid this? (2.4.3)
24. How might a quantum network avoid transfer failures? (2.4.4)
25. Is the vacuum of space empty or full? Explain. (2.4.5)
26. What is the "trouble with physics" today? (2.5.1)
27. If theoretical physics is making no progress, what scientific alternative is there? (2.5.2)
28. Do the current equations of physics describe what is imaginary or what really exists? Justify. (2.5.3)
29. If the equations of quantum theory describe nothing, why do quantum events that don't exist predict physical events that do? If something, how can science study what isn't physical? (2.5.3)

30. Is quantum realism a "God theory"? Why or why not? (2.5.3)
31. How do quantum waves as processing waves change our understanding of quantum theory? (2.5.4)

Chapter 3. The Light of Existence

"There is a theory which states that if anyone discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable. There is another theory which states that this has already happened." (Adams, 1995)

In the last chapter, our universe began when one node of a pre-existing quantum network created the first photon in the first unit of space, which then booted up the rest of the universe. If light and space began at the same time and since space is nothing to us, the electromagnetic vibration we call light was the first existence. It was the first step on a long road that led to matter and us.

3.1. WHAT IS LIGHT?

Light is all around us yet it has always been a mystery. As Einstein commented just before he died:

> "*All these fifty years of conscious brooding have brought me no nearer to the answer to the question 'What are light quanta?' Nowadays every Tom, Dick and Harry thinks he knows it, but he is mistaken*." (Walker, 2000) p89

Nothing has changed today, as physics remains quite unable to say what light actually *is*.

3.1.1. The mystery of light

The mystery of light is that it does what matter cannot. Even after centuries of detailed study, physics still can't explain *why* it:

1. *Doesn't slow down over time.* Why hasn't light slowed down even after billions of years?
2. *Has a constant speed.* Why is the speed of light constant in a vacuum?
3. *Comes in packets.* Why does light come in packets called photons?
4. *Is like a wave and a particle.* How can a photon spread like a wave but arrive like a point particle?
5. *Always takes the fastest path.* How does light always find the fastest path?
6. *Chooses its path after it arrives.* Can light reverse causation?
7. *Can reveal an object it doesn't physically touch.* How does light allow non-physical knowing?
8. *Spins the same on any axis.* Why do photons "spin" the same on any axis?

Quantum realism sees light as processing spreading on a quantum network that is the "*… primary world-stuff*" (Wilczek, 2008, p74) and whose nodes some call the "*atoms of space*" (Bojowald, 2008). So does this processing represent a wave or a particle?

3.1.2. Particle or wave?

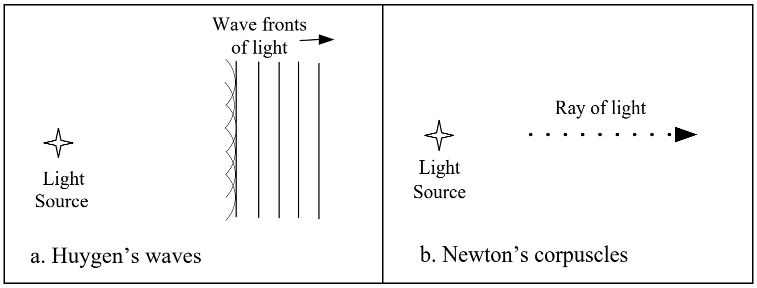


Figure 3.1. a. Huygen's wave front. b. Newton's corpuscles

In the seventeenth century, Huygens noticed that light beams at right angles pass through each other so they must be waves, as if they were objects like arrows they would collide. He concluded that light was an *expanding wave front* spreading out in all directions, with each strike point the center of a new little wavelet. He proposed that as the trough of one wave cancels the crest of another, the wavelets interfere as they spread. The result is a forward moving envelope that at a distance from the source acts like a ray of light (Figure 3.1a). *Huygen's principle*, that *each wave front point is a new wavelet source expanding in all directions,* explained reflection, refraction and diffraction. In contrast, Newton's idea of bullet-like corpuscles traveling in straight lines explained only reflection and refraction (Figure 3.1b) but his simpler view carried the day.

Two hundred years later Maxwell wrote down the equations of light as a complex wave but then Einstein equally convincingly concluded from the photo-electric effect that it comes in particle-like packets called photons. So the theory of light has swung from Huygens' waves to Newton's corpuscles to Maxwell's waves to Einstein's photon packets. Then physics finally gave up and concluded that light is wave *and* a particle, although no-one can clarify how such a *wavicle* is even possible. Three centuries after Huygens and Newton, we still don't know whether light is a wave or a particle.

3.1.3. Young's experiment

Over two hundred years ago Young did an experiment that still baffles physicists today. He shone light through two slits to get an interference pattern on a screen (Figure 3.2). Only waves diffract like this so light must be a wave but how then does a ray of light hit the screen at a point like a particle? Conversely, if photons are particles how do they interfere like waves?

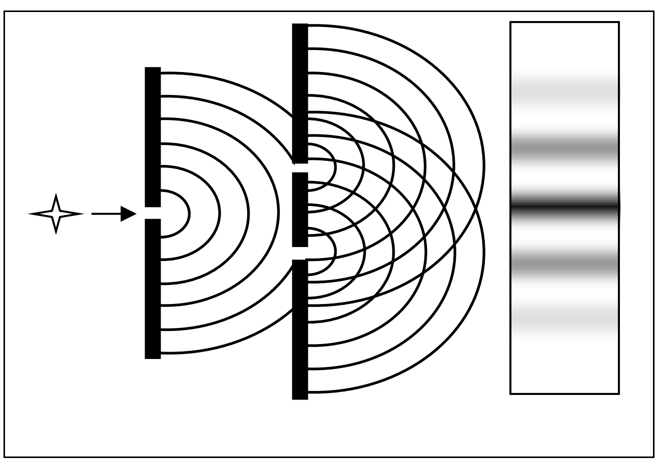
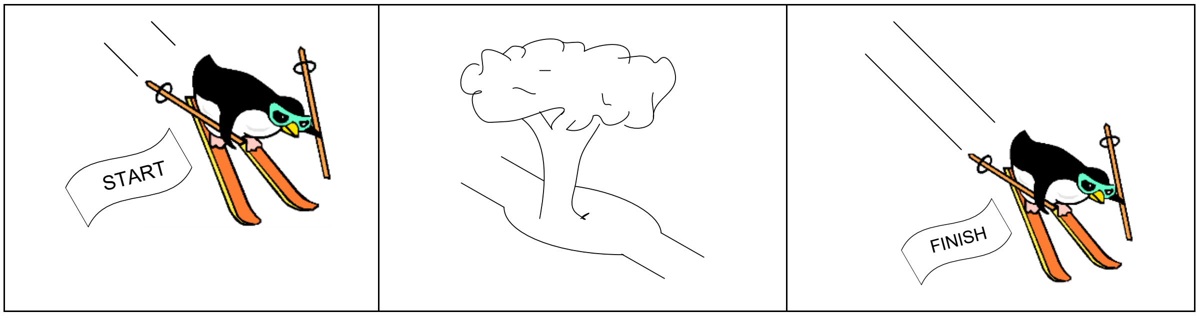


Figure 3.2. Young's double slit experiment

To find out, physicists sent *one photon at a time* through Young's slits. Each photon gave the expected dot but then the dots formed an interference pattern whose most likely impact was *behind* the slit barrier! The effect was independent of time, so shooting one photon through the slits each year gives the same pattern. Since each photon can't know where the previous one hit, how does the interference pattern occur?

In an objective world, one could just see the slit a photon went through before it hit but our world doesn't permit this. Detectors placed in the slits to see where the photon goes just fire half the time as expected. A photon *always* goes by one slit or another, *never* through both at once, so the interference pattern should not be possible. The evidence suggests that a photon is a particle when we look but a wave when we don't. This is like a single skier setting off, on the way sliding around *both* sides of a tree, then still crossing the finish line as one skier (Figure 3.3). The problems in a nutshell are:

1. *If a photon is a wave*, why doesn't it smear over the detector screen as a wave would?



a. *A particle starts* ***b.*** *A wave flows* ***c.*** *A particle finishes*

Figure 3.3. Wave-particle duality

2. *If a photon is a particle,* how can it give an interference pattern?

And the same applies to every quantum entity, as electrons, atoms and even molecules show Young's two-slit diffraction (M. Arndt, O. Nairz, J. Voss-Andreae, C. Keller, & Zeilinger, 1999).

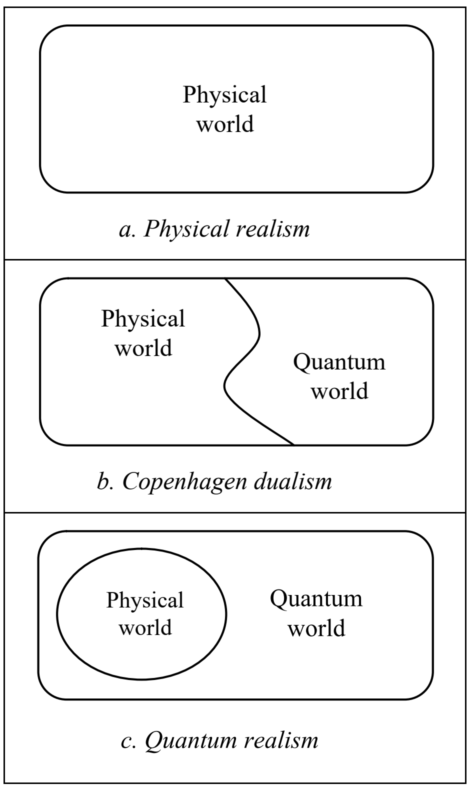


Figure 3.4. a. Physical realism, b. Bohr's dualism, c. Quantum realism

3.1.4. The Copenhagen compromise

After centuries of dispute over whether light is a wave or a particle, Bohr devised the *wave-particle* compromise that holds today. He suggested in Copenhagen in the 1920's that the two views are "complementary", i.e. both true, and nothing better has been found since:

"*…nobody has found anything else which is consistent yet, so when you refer to the Copenhagen interpretation of the mechanics what you really mean is quantum mechanics.*" (P. Davies & Brown, 1999) p71.

This *don't ask, don't tell* policy lets a photon be a wave when we don't look as long as it is a particle when we do. It conveniently lets physics use particle or wave equations as required. Yet in no physical pond do rippling waves ever turn into particles and on no billiard table do the balls ever turn into waves. *Convenience* let Bohr successfully sell the *big lie*[30] that light is a *wavicle.* As Gell-Mann said in his 1976 Nobel Prize speech:

"*Niels Bohr brainwashed a whole generation of physicists into believing that the problem (of the interpretation of quantum mechanics) had been solved fifty years ago.*"

Bohr's wave-particle dualism, like Descartes' mind-body dualism, is a mystical marriage of convenience between incompatible domains, accepted by those who want to believe.

Quantum theory contradicts physical realism so it is not possible for a quantum world to exist within an objective physical reality (Figure 3.4a). Bohr's Copenhagen statement that the quantum world could be assumed to exist alongside the physical world solely for the purpose of physics calculations was an admission of logical failure not a reality description (Figure 3.4b) (Audretsch, 2004) p14). Even as he publicly recognized that quantum equations require a quantum world

[30] A big lie is a statement so outrageous that people think it must be right or it wouldn't be said.

to exist in some way, in private he denied the quantum world existed at all. One cannot have "the best of both worlds" when those worlds are incompatible.

Quantum realism rejects both physical realism and the Copenhagen compromise, proposing instead that physical events are a subset of quantum events so classical mechanics is a subset of quantum mechanics (Figure 3.4c). We now explore this alternative.

3.1.5. How come the quantum?

As Feynman famously said:

> "… *all the mystery of quantum mechanics is contained in the double-slit experiment*."
> (Satinover, 2001) p127.

Quantum theory explains the two-slit results as follows:

> A photon *wave function* spreads in space by the equations of quantum theory. This ghostly wave goes through both slits to interfere with itself as it exits, but if observed immediately "collapses" to be a thing in one place, as if it had always been so. If we put detectors in the slits, it collapses to one or the other with equal probability. If we put a screen behind the slits, it interferes with itself then collapses on the screen according to the interference.

Yet the mathematics doesn't say what this wave is that goes through both slits nor why it shrinks to a point when observed, hence Wheeler's question: *How come the quantum*?

To see how strange this is, suppose the initial photon in a two-slit experiment hits a screen at some point to become the first dot of what will *always* turn into an interference pattern. Now suppose that in another experiment with a detector blocking the other slit, the initial photon goes through the same slit to hit the screen *at the same point* to become the first dot of what will *never* be an interference pattern. The difference between these outcomes *must* exist from the start but the physical events are identical – a photon goes through the same slit to hit the same screen point. The only difference is whether the slit the photon *didn't go through* was blocked or not. Indeed for every set of physical events that generate an interference pattern, one can conceive a physically identical set of events that don't produce an interference pattern because the slit the photon didn't go through was blocked.

Yet how can the slit a photon *could have gone through but didn't* decide if there is interference or not? How can a *counterfactual*, an event that didn't physically happen, change the physical outcome? In a purely physical world, such a thing is not possible. Quantum theory's unlikely tale of imaginary waves that collapse when viewed makes no physical sense yet it is the most fertile theory in the history of science. Even so, it leaves two key issues unresolved:

1. *What are quantum waves?* What exactly is it that spreads through space as a wave? The current answer, that the waves that predict physical events don't exist, is unsatisfactory.
2. *What is quantum collapse?* Why do quantum waves restart at a point when viewed? The current answer, that quantum waves collapse "because they do", is equally unsatisfactory.

Until it answers these questions, quantum mechanics is just a recipe without a rationale.

3.2. THE QUANTUM WAVE

Maxwell's equations describe light as a wave that vibrates nothing in a plane that doesn't exist because it is outside our space. In quantum realism, the complex plane really does exist and light is a quantum wave not a physical wave.

3.2.1. Light is a wave

Maxwell's equations describe light as a vibration in an electromagnetic field that sets *imaginary* potentials at right angles to its polarization. When this wave vibrates slowly the result is radio waves, faster vibrations are visible light and very fast vibrations give x-rays and gamma rays (Figure 3.5). The light we see is the part of this spectrum that vibrates about a million-billion times a second, gamma rays are a billion times faster, while radio waves vibrate only a few times a second. For simplicity, from now on the term "light" will refer to *any electromagnetic vibration* because the only difference is the frequency.

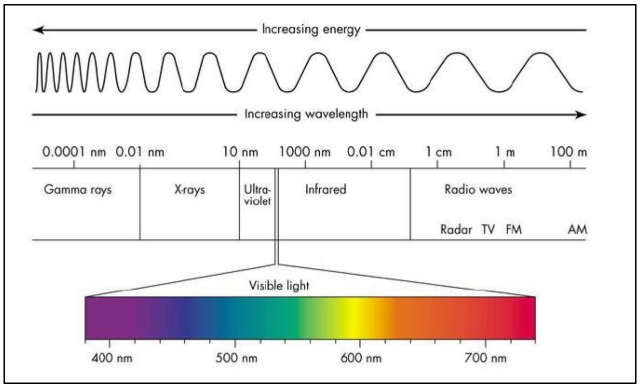


Figure 3.5. The electromagnetic spectrum

Newton's optics describe a *ray* of light as traveling on a single movement axis. We now know that such a ray includes photons *polarized* in many directions and can use filters to polarize a ray one way. Modern lasers can even produce a *pulse* of light of one frequency in one polarization plane that travels on one axis, i.e. one *photon.*

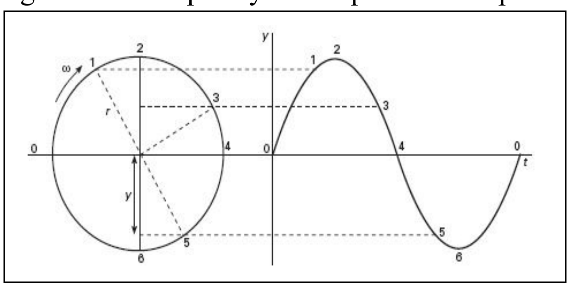


Figure 3.6. A circle maps to a sine wave

Using such techniques, we can produce rays of polarized light that are *out-of-phase,* so the crests of one occur at the troughs of the other. The result is two rays that are separately visible but in combination they give absolute darkness. The photons cancel each other out just as out-of-phase waves do. *This light + light = darkness is only possible for waves.* Note that flashlight beams can't do this because they aren't polarized. *This result proves that light really is a wave*.

We even know the type of wave. Light is a *sine wave,* which in mathematics maps to a circle extended (Figure 3.6). If a pointer turning like a clock hand in a circle moves on a surface the amplitude result is a sine wave (Figure 3.7).

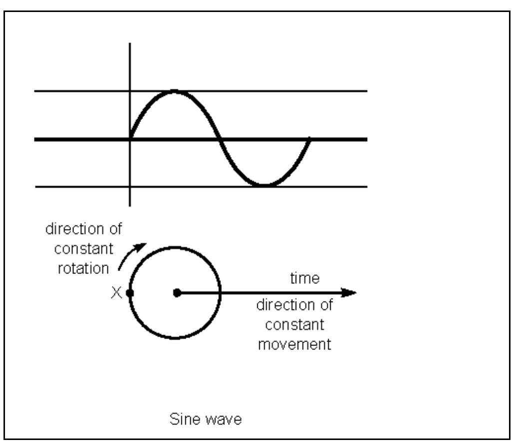


Figure 3.7. A sine wave is a moving rotation

Wave theory describes a water wave as a sine wave vibration caused by the forces of gravity and elasticity acting at right angles to the water surface. When a wave arrives, a surface water molecule is pushed say up until gravity pulls it back down, then the water elasticity pushes it back up, etc. The wave just moves water molecules up and down hence a cork just bobs up and down as the wave passes. What "travels" on the surface is a *transverse oscillation* not the water itself.

Using *imaginary wave mathematics*, we can describe a light wave in the same way except that no one has any idea what is going up and down. We say it is the electromagnetic field but to *name* a cause is not to *explain* it. In quantum realism, light is a vibration into a *quantum space* that contains our space as a *surface*.

3.2.2. We are flatlanders

Does light oscillate in a physical direction? To a physical realist, the answer seems obvious as how else could it do so? Physical realism explains sound because it is a *longitudinal wave* that vibrates air molecules in its travel direction. Hence there is no sound in the vacuum of empty space because there are no air molecules there. In contrast, light is a *transverse wave* that vibrates at right angles to its line of travel and it travels in the vacuum of space or we couldn't see the stars at night. This transverse vibration *can't* be in a physical direction because space is *isotropic,* i.e. "up" from one view is "down" from another. Simply put, physical space has no "free" directions for the positive-negative charges of electromagnetism to vibrate into. *Physical realism has no explanation at all for the vibration of light*.

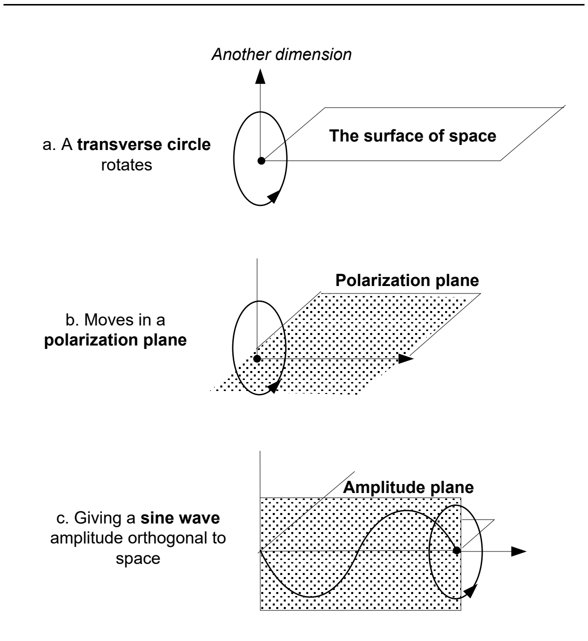


Figure 3.8. A transverse circle moving on space is a sine wave

Space as a *surface* however makes it possible for light to move *on* space as waves move *on* a lake, but in three dimensions not two. So light, as a transverse quantum wave, vibrates into a plane beyond our space just as complex number theory describes. But while physical realism calls the complex plane *unreal*, quantum realism calls it *real,* which makes us 3D "Flatlanders".

In Abbot's story, the *Flatlanders* were beings who lived their lives on a flat surface (Abbott, 1884). Everything they did happened in two dimensions not three, so they could see a circle say but could only *imagine* a sphere as expanding and contracting circles passing through their reality.

Now imagine a point moving on their flat land that sets values in a *transverse circle* at right angles to their space (Figure 3.8a). Flatlanders could only conceive of these values existing in a *complex plane* that didn't exist for them, as we do for light. As the point moves the complex plane defines a *polarization plane* in their space (Figure 3.8b), again as we have for light. The result is an "unreal" *sine wave* amplitude (Figure 3.8c) just as we describe electromagnetism.

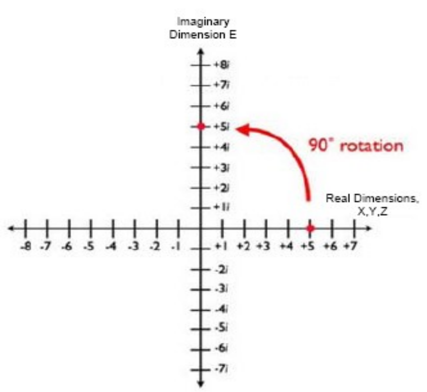


Figure 3.9. Complex rotations

Since light appears to us as a transverse rotation *outside* our space, quantum realism concludes that complex number theory explains electromagnetism because light *really is* a rotation outside our space:

"*In quantum mechanics there* ***really are*** *complex numbers, and the wave function* ***really is*** *a complex-valued function of space-time.*" (L. M. Lederman & Hill, 2004) p346

Complex numbers describe a rotation into an imaginary dimension outside our space[31] (Figure 3.9). We call the complex plane *imaginary* because it doesn't exist

[31] Complex number theory describes a *rotation* into an imaginary plane. In normal multiplication, multiplying a number by two doubles it, e.g. 5 x 2 = 10. Multiplying by 4 adds it four times, e.g. 5 x 4 = 20. In complex multiplication,

in our space, just as Flatlanders would call a plane that doesn't exist in their space imaginary. Quantum realism needs an extra dimension for light to vibrate on space, so the complex plane really exists. The ability to accept a photon that vibrates into at right angles to its polarization plane *outside space* will shortly be called a *node channel*. That we can't enter this plane doesn't mean it doesn't exist, it means that we are *three dimensional Flatlanders.*

3.2.3. What mediates light?

All waves vibrate a medium, so light as a wave needs a medium. *Something must move to make light waves* but with no physical ether, current physics simply declares that:

"*... we accept as nonexistent the medium that moves when waves of quantum mechanics propagate*." (Laughlin, 2005) p56.

In current electromagnetic field theory, electric changes cause magnetic changes that cause electric changes and so on, in a circular fashion. So light is said to be a:

"*... self-renewing field disturbance*." (Wilczek, 2008) p212.

This begs the question of what renews the fields that renew? That an electric field powers a magnetic field that powers the electric field is like Peter paying Paul's bill and Paul paying Peter's bill. With such logic, I could borrow a million dollars today and never pay it back. According to current physics, light is a cosmic Ponzi scheme!

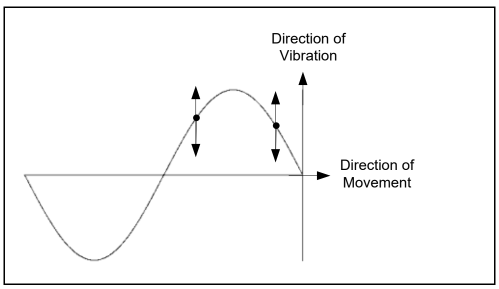


*Figure 3.10. Physical waves vibrate matter up and down **on** a surface*

Physical waves work by moving matter up and down (Figure 3.10). They inevitably involve friction and so by the second law of thermodynamics eventually diminish, with no exceptions[32]. Yet ancient light that has traveled the universe for billions of years to reach us still arrives at the speed of light with its *amplitude* undiminished. Light as a *frictionless wave of nothing* is physically impossible so it can't be based on any physical movement. A century of physics still hasn't answered the question:

How can vibrating nothing (space) create something (light)?

In quantum realism, empty space is no more empty than an "idle" computer is idle[33]. So the:

"*... vacuum state is actually full of energy...*" (P. Davies & Brown, 1999) p140.

The source of this activity is a network that never stops. Physical waves fade by friction but light is maintained by a quantum network that is always "on". This is the real power source behind our virtual reality. Electricity and magnetism correlate not because they mutually cause each other but because both reflect an ongoing quantum activity. Physical realism has never explained what powers light but *in quantum realism, what mediates light as a wave is the quantum network.*

Quantum theory describes a quantum field that Feynman called the *vector potential*, Born called the *probability amplitude* and Hiley called the *quantum potential* (Davies & Brown, 1999) p138. Physics today calls it the *quantum function (Ψ)* but cannot explain why a mythical field predicts physical reality. Quantum realism calls it the *quantum field* and argues that it predicts physical events because it generates them.

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i is a 90° *rotation* into an "imaginary" plane, so times *2i* is a 180° rotation that turns a number into its negative, e.g. 5 x *2i* = -5. Times *4i* is a 360° rotation that has no effect, so 5 x 4*i* = 5.

[32] Planets orbit forever but the gravity that maintains this derives from the same quantum source as light.

[33] Processing must continually run, so an "idle" computer still runs a null cycle, i.e. it doesn't do nothing.

3.2.4. The speed of space

Einstein deduced the speed of light from how our world behaves but why is it that speed and no other? Saying a photon goes at light speed because it has no mass doesn't explain why there is a maximum speed at all. Why not the speed of light plus one? What makes the speed of light a maximum for our universe? The current view of physics, after almost a century of consideration, is that:

> "*… the speed of light is a constant because it just is, and because light is not made of anything simpler*." (Laughlin, 2005) p15

Yet "*because it just is*" has never been a very satisfactory answer in science. In this model, light moves at a fixed speed because the quantum network refreshes at a finite rate, just as our computers do. But while a 5GHz computer runs 5,000,000,000 cycles per second the quantum network cycles nearly 10^{45} times a second. The processing we call light is passed from one node of space to the next each cycle, so its speed depends on the quantum network cycle rate not the photon itself. What we call the speed of light is really the *speed of space*[34].

Actually, the speed of light isn't constant as light slows down in water. When light moves in water we *say* the medium is water and when it moves in glass we *say* the medium is glass but when it moves in a vacuum we call it a wave of nothing! In quantum realism, whether it travels through glass, water or space, the medium is always the quantum network. Light slows down in water not because water is its medium but because the quantum network slows down when it has to process matter as well as transmit light. Light slows down in water for the same reason that a computer game slows down under load. Light also slows down in a gravitational field for that reason. The quantum network cycles at different rates depending on load but still keeps photons in a strict sequence one behind the other, like the baggage cars of a train driven by the same engine. Each node passes on the photon it has then accepts another in the line. If the engine slows down under load, say near a massive star, photons go slower *but still keep the same order,* e.g. in gravity lensing, photons from a cosmic event arrive on earth at different times by different paths but are still in lock-step order. This maintains causality, as if one photon could overtake another one might see an object arrive before it left! Causality requires photons to stay in sequence and the quantum grid rigorously maintains this.

3.3. THE QUANTUM PROCESS

In this section, the entire electromagnetic spectrum from radio-waves to gamma rays is generated by the same quantum process more or less spread out.

3.3.1. The basic network command

Just as a particle model requires fundamental particles so a processing model requires a basic network command. The set of operations a processor can do is its *command set,* e.g. a processor designed for simple arithmetic might have "add one", "subtract one" and "add zero" as basic commands. A computer has a bigger command set but the idea is the same. As computing began using databases and networks new commands were added, giving *complex instruction set computing* (CISC) until it was discovered that *reduced instruction set computing* (RISC) is more efficient.

The proposed command set for the quantum network is the ultimate RISC design of *one command*:

Set the next value in a transverse circle

A transverse circle *on* space permits positive-negative electromagnetic values and it always works because a circle's end is also its start. A full transverse circle completed in one cycle is a null process and

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[34] In quantum realism, the speed of light $c=L_P/T_P$, where L_P is a Planck length of 1.616×10^{-35}, and T_P is Planck time of 5.39×10^{-44} seconds. The result of 299,792,458 meters per second is the speed of light (see here).

the last chapter concluded that this was space, as a transverse circle sets equal positive and negative displacements that cancel to "nothing", where these displacements aren't physical but occur in quantum space just as complex number theory says. *It is now proposed that this quantum network command passed on is light.*

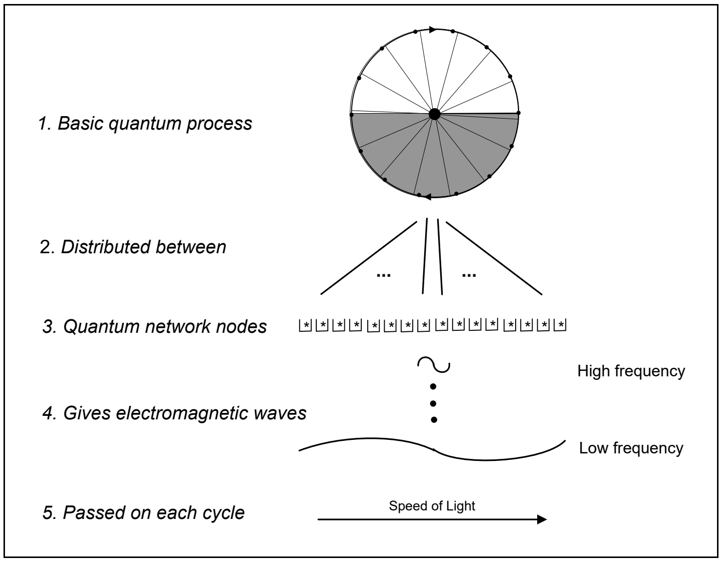

Figure 3.11. Light is a distributed quantum process

Figure 3.11 shows how a basic quantum process can be distributed more or less to give the entire electromagnetic spectrum. At the top is a *quantum process* (1) that is *distributed* (2) among some number of *quantum network nodes* (3) that run it at some *frequency* (4) as a sine wave that is passed on at the *speed of light* (5). Just as a circle rotation frequency can map to any sine wave frequency so a circular process distributed more or less can map to any sine wave frequency in the electromagnetic spectrum. The frequency of a photon of light depends on the degree to which the quantum process is distributed because *when processing is distributed more it runs slower not less*. A longer wavelength just means that each node runs the same process more slowly.

In our terms, the node processing rate is the frequency of light, so sharing the same process over different wavelengths gives the different frequencies of light. As the process is cloned each cycle by the pass-it-on protocol, the nodes behind continue to run it to completion. As new nodes begin, others complete the transverse circle, so the total server processing demand per photon remains the same. Since the basic quantum process is also the null processing of space, in this view *light is in effect space spread out*. Hence a photon has no rest mass because if it rested for its wave train to catch up, it would revert back to empty space. *Every photon in the electromagnetic spectrum is thus the same basic quantum process more or less distributed*.

3.3.2. The energy of light

Energy is a useful concept in physics. It is the *capacity to do work* defined as a force times the distance it acts. Work is thus the result of energy and *energy is stored work,* e.g. a falling object acquires *kinetic* energy as a gravity force acts on it over the distance it falls and that stored energy is released when it hits the ground. This concept applies to other things like heat and Einstein suggested that even mass is a form of energy. The idea that a measurable abstract quantity transforms into different forms but is conserved overall has been very successful.

What then is energy in quantum processing terms? We know that light energy depends on frequency so higher frequencies of light like x-rays have more energy. If short wavelength light distributes the same quantum process over a shorter wavelength, each node gets more processing per cycle. *Energy is then the quantum processing transfer rate at the node.* It follows that light with a short wavelength has more energy because fewer nodes in the wavelength means that each gets a bigger share of the quantum process and so completes it faster. A long wavelength photon in contrast shares the same process with more nodes so each runs at a slower rate which means less energy. Higher light frequencies have more energy because each node gets more processing "work".

At the beginning of last century, it was found that the energy of light varies *linearly* with frequency. This was unexpected since light was seen as a wave and the energy rate of a water wave varies as the *square* of its frequency. Physical wave theory predicted that a furnace that emitted light at many frequencies should increase at all frequencies as it got hotter, so a very hot furnace should in theory give a lethal dose of x-rays, but in practice it didn't. That light emitted from furnaces didn't obey the laws of physical waves was called at the time the *ultra-violet catastrophe.*

Planck solved the problem by making atoms emit energy in multiples of a basic quantum amount later called Planck's constant. Assuming the light emitted was *not* continuous gave Planck's relation:

Light Energy = Plank's constant x *Frequency*

Now the light energy emitted varied directly with frequency, not with its square, and this predicted the observed radiation correctly. Einstein then generalized this based on the photo-electric effect to conclude that it applied to all light. Yet why light waves were delivered in the "lumps" we call photons was a mystery that remains to this day. *Why don't light waves act like water waves?*

In quantum realism, light comes in lumps because a photon is the basic quantum command that no network effect can be less than. Quantum processing can't be less than one quantum cycle because this is the fundamental network operation. How much the quantum process is *shared* among the photon wavelength defines how many cycles each node takes to complete it, i.e. the light frequency. If the wavelength is longer, each node gets a smaller share and so takes longer to complete its cycle. It follows that *energy as the processing rate at the node* varies inversely with wavelength and thus directly with its frequency, as Planck deduced from the data. More exactly, if Planck's constant is the transfer of one quantum process per second, energy as the node processing rate will be Planck's constant times its frequency, i.e. Planck's relation[35]. Quantum realism thus *derives* Planck's relation from first principles.

Equally a photon's energy comes in discrete packets because its wavelength must change one node at a time. One less node running the same quantum process changes the per-node processing rate or energy by a fixed amount. *Light energy is quantized because the wavelength of a photon is digital* so it must reduce one Planck length at a time. Each node removed shortens the wavelength leaving the same processing to be shared by those remaining. As the wavelength reduces, higher frequencies are harder to come by, as removing one node from fewer nodes changes the energy more, hence the ultraviolet catastrophe didn't happen. This predicts that the highest frequency of light, here called *extreme light*, occurs when its wavelength is two Planck lengths, and it must double its energy to reach the next frequency which is empty space!

3.3.3. Planck's constant

In physics, Planck's constant is the *minimum energy transfer* possible and is the basic unit of energy. In quantum realism, the quantum process is the smallest change possible because it is the basic quantum network operation. It follows that Planck's constant represents the basic quantum network process. We see the energy of light changing across the electromagnetic spectrum but in this model every photon is based on the same quantum process. The smallest *act* the quantum network can do is its basic operation and that creates the simplest existence, namely a photon of light. Equally no physical *change* can be less than one Planck unit which in this model is the net processing of a photon. That this processing is *divided* over the nodes of a photon's wavelength is why its energy is frequency *multiplied by* Planck's constant.

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[35] Let one photon be a quantum process shared over the nodes of its wavelength. Let h represent that process as energy, E be the photon processing rate at the node per cycle and λ be the number of nodes in the photon wavelength. Since the processing is shared between λ nodes, so is the energy h, so the photon processing rate at the node $E = h/\lambda$. If f is the number of quantum cycles each node takes to complete a quantum process that can run in one node in one cycle, then $f = 1/\lambda$. The Planck relation $E = h.f$ then follows. Note that this describes quantum units. To get our energy $\mathbf{E}$ in per second terms one must multiply E by c, the speed of light that reflects the quantum grid cycle rate of 10^{43} cycles per second, so $\mathbf{E} = h.c/\lambda$. In this case our frequency $\mathbf{f} = c/\lambda$ giving the same result $\mathbf{E} = h.\mathbf{f}$ in our units.

Yet in the last chapter, Plank's constant defined the size of space, as if it were smaller atoms would be smaller and if it were larger quantum effects would be more evident. Yet why should the basic unit of energy also define the size of space? There is no reason in current physics for what defines the smallest unit of space to also define the smallest unit of energy.

In this model, Planck's constant is the basic energy unit because the basic network command is to set a *transverse circle* of values. In the last chapter, movement depended on a node's *planar circle* of neighbors, that by Pythagoras's theorem defines the "distance" between nodes. The number of nodes in a transverse circle defines the basic energy unit and the number of nodes in a planar circle defines the size of space. If *the quantum network is symmetric*, transverse and planar circles will be the same size, so if Planck's constant reflects the size of a transverse circle, it will also define the size of the planar circle that defines space. In network terms, this "size" reflects the quantum network density based on the number of connections each node has to others. Planck's constant defines both space and energy because it represents the *quantum network density* that creates both.

3.4. PROCESSING SPREADS

The no-cloning theorem (Wootters & Zurek, 1982) says *we* can't copy quantum states because reading a quantum state gives a physical event that destroys it. However *the quantum system* that made them in the first place can easily make more. Quantum processing can't be saved but it can be instantiated and it turns out that in this sense nature is the ultimate copy machine.

3.4.1. Light spreads

In quantum realism, any processing put on the grid immediately spreads out in all directions, like ripples on a pool but in three dimensions. Not only is a photon's processing shared among the nodes of its wavelength, it is also passed on in every direction at one node per cycle, i.e. the speed of light. *Huygen's principle*, that light is a wave spreading with each point a new wave source, then works because quantum processing spreads. A ray of light isn't just going forward on a linear path but spreading out in all directions at the same time, hence it goes through both Young's slits at once.

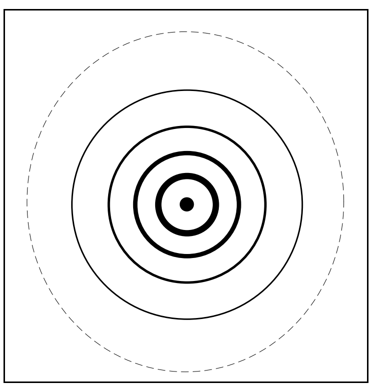

Figure 3.12. Pond ripples spread

Gauss noted that when a pebble drops in a pool, the initial energy spreads out in ripples of decreasing strength such that the *energy flux* per ripple is constant, but for friction. As shown in Figure 3.12, each ripple is the same energy just spread out over a larger circle. The same principle applied to the three-dimensional "ripple" of light is that the *processing flux* is constant and there is no friction. This quantum "flux" spreading on a sphere surface reduces power as an inverse square of distance, giving a basis for the inverse square laws of electrical, magnetic and gravitational fields. In addition, processing values cancel at the node as fields do at a point[36] and processing is passed on every cycle at the speed of light, just as fields propagate. The next chapter attributes all the fields of the standard model to one quantum field.

3.4.2. Instantiation

The proposed method by which processing spreads on a quantum network is instantiation, an object orientated design method that allows screen objects to inherit processing from a source class. For example, if many buttons on a screen look and work the same, there is no point repeating the same code for each. It is more efficient to define a general program *class* that every button calls. The buttons then all look the

[36] If charge 1 has electric field E_1 and charge 2 has electric field E_2, the electric field at any point $E = E_1 + E_2$

same because they *instantiate* the same code. We say they are *instances* of the same class process and this logic works for any on screen "object" like a drop-down menu or a mouse-over pop-up.

Quantum instantiation works the same way, except that what is instantiated is a dynamic process not static information, so a photon is seen as a *spreading cloud of quantum processing instances*. Each instance once started begins the "task" of completing a transverse circle at its given rate. The limiting factor is the photon server that divides its processing among the spreading instance. One can think of two people sharing a shovel where in the time one person can dig one hole, two people sharing a shovel can only dig half a hole each, and if the shovel is shared among more people, each goes even more slowly. In this analogy, the "shovel" shared by a photon is a server capable of one basic quantum process per quantum cycle.

Although a photon is envisaged as a cloud of instances spreading on the quantum network, the *rate* of each instance is limited by server capacity. While a physical wave reduces in amplitude as it spreads, a processing wave just slows down because *processing distributed runs slower not less.* As a quantum wave spreads, its frequency reduces not its amplitude. *A quantum wave is a processing wave spreading on the quantum network.*

3.4.3. What is a photon?

In quantum realism, a photon "exists" as processing running on the quantum network regardless of how that processing is distributed. Whether a photon is just starting at a point or spread out in space as a quantum wave that is larger than a galaxy doesn't matter. For processing, *where* it runs is irrelevant as long as *it does run*. What exists is neither quantum states nor physical states but processing that never stops and is in our terms "immortal". To say a photon *has* wave function is to maintain the stubborn illusion that it is a particle *thing* with a wave function *property*. Quantum realism says that *the photon is the quantum wave* and the "particle" we see is just a *view* created on demand when a physical event occurs. The particle is just the view we get while the quantum wave is the photon in itself. If "*all the world's a stage*", then classical mechanics describes the stage but quantum mechanics describes what is really going on backstage.

A physical realist might ask "*If a photon is a wave of instances that can go through both Young's slits at once, which one is the photon?*" The question again betrays the assumption that a photon is a "thing". The world of matter we see supports this view but the world that quantum theory describes doesn't. We see a photon hit a screen at a point like a particle but that it traveled in the same way is just an assumption tacked onto the facts. Knowing how a photon arrives isn't the same as knowing how it travels. Quantum theory tells us that photons *travel* as quantum waves but *interact* as point particles. Its critics couldn't fault this logic because there is no fault. What can travel like a wave but arrive like a point particle? The next section suggests that quantum processing can.

3.5. PROCESSING RESTARTS

Quantum theory says that quantum waves spread until they collapse in a physical event, so what does *quantum collapse* represent in this model? How can a quantum wave that might be spread over a galaxy *instantly* "collapse" to a point? All we know is that nothing physical can do this.

3.5.1. Hidden variables?

Einstein, like Newton, believed that a photon *particle* traveled a fixed *path* from its start point to hit a screen at a point. So when quantum theory declared that where the photon hit the screen was *random* and the data supported this, physical realism had two options: either quantum theory was *incomplete* as "*God does not play dice with the universe*" or there was a *hidden* physical cause:

"This is the fundamental problem: either quantum mechanics is incomplete and needs to be completed by a theory of hidden quantities, or it is complete and then the collapse of the wave function must be made physically plausible. This dilemma has not been solved until today, but on the contrary has become more and more critical." (Audretsch, 2004) p73

Einstein raised this problem and Bohr chose to ignore it, but it still haunts physics today. On the one hand, quantum theory always works for quantum entities so how can it be incomplete? On the other hand, every attempt to "reify" quantum states (make them physical) has failed, so there seems no way to make the collapse of quantum waves "*physically plausible*". Einstein's search for "hidden variables" to explain quantum theory is in essence an attempt to make quantum theory physically plausible. It hasn't succeeded because what quantum theory describes is not physical, as it is what creates the physical. So physics will never solve this dilemma until it accepts that quantum theory is real. Quantum realism however resolves the dilemma by recognizing that quantum waves are processing waves.

3.5.2. Quantum waves restart

If a photon is a spread-out wave as quantum theory says, how can it arrive at a point? A wave should hit a barrier as a smear but a photon hitting a screen gives a dot instead. Radio waves are many meters long and so should take time to arrive, even at light speed, but they don't. If they did, in the delay between the wave front's first hit and the rest arriving, the tail could hit something else. One photon could hit twice, which it never does! A physical wave delivers its energy over its entire wavelength so how does a quantum wave deliver *all* its energy *instantly* at a point:

> "*How can electromagnetic energy spread out like a wave … still be deposited all in one neat package when the light is absorbed?*" (Walker, 2000) p43

Physics doesn't know how a quantum wave collapses to a point in a physical event:

> "*After more than seven decades, no one understands how or even whether the collapse of a probability wave really happens*." (Greene, 2004), p119

Einstein didn't like quantum collapse because it implied faster than light travel. He argued this as follows, given that a photon is a wave that spreads as quantum theory says:

> *Before* the photon hits a screen its wave function exists at points A or B with some probability but *after* it is entirely at point A say not at B. The moment A "knows" it is the photon then B "knows" it isn't. Now as the screen moves further away, eventually A and B could be in different galaxies but if the collapse is *immediate,* how can nature do this? How can two events *anywhere* in the universe be *instantly coordinated faster than light*? This contradicts special relativity.

In quantum theory, quantum waves are three-dimensional waves that spread to any size then collapse to a point when observed. Nothing physical can do this, but processing spreading on a network can overload a node, giving reboot that:

a. *Is irreversible*. A reboot can't be reversed.

b. *Conserves processing*. The processing before and after a reboot is the same.

c. *Allows change*. A reboot can re-allocate processing in potentially new ways.

When a photon quantum wave arrives at a screen, the extra processing will overload nodes that are already maximally occupied with the screen matter. If many nodes reboot, the first one to access the photon server will succeed. It then restarts the photon server that is supporting the expanding quantum wave. Now if a *parent server* maintaining many *child instances* restarts for one node, it must immediately stop supporting all other instances. *The collapse of the quantum wave function is then just the inevitable disbanding of child instances when the server process restarts*. A quantum wave, no matter how large, can instantly disappear, as if it never was, because it is a wave of processing instances not a "thing".

When a photon hits a detector screen, what *actually* arrives isn't a lonely particle looking for a point to hit but a cloud of instances requesting processing from nodes already busy with screen matter. When a screen node overloads, it requests the server to restart the process and as one photon has only one server, only one such client request can succeed. The *first* node to successfully request a server reboot restarts the *entire* photon and this is where the photon "hits" the screen.

Can a quantum wave that has spread to the size of a galaxy *instantly* collapse to any point in it? When our computers change a screen point, the program doesn't "go to" the screen pixel to change it. It can change any screen point directly and likewise a quantum server is directly linked quantum nodes anywhere on the screen of space. The *node-to-node transfer rate* that defines the speed of light is irrelevant to the *server-client* link that governs quantum collapse. So what troubled Einstein, that a quantum wave can collapse *instantly*, is not a problem for quantum realism

Seeing quantum entities as processing, not a matter substance, changes everything, e.g. when two electrons collide and bounce apart, we assume the same matter leaves as entered the collision, but if the "collision" is a network overload and server restart, the "particles" that leave are actually brand-new creations, just off the quantum press. In this view, *physical events annihilate and create quantum entities,* just as quantum theory says. It is the conservation of processing in the reboot that maintains the illusion that a matter "substance" continues to exist.

3.5.3. The quantum lottery

What then affects *where* a photon hits a screen when it arrives? According to quantum theory, the power of the quantum wave defines the *probability* it will hit at any point but where it *actually* hits is a random choice based on those probabilities. So while the probabilities are *exact*, the actual hit point *varies* based on no known physical cause.

Quantum theory calculates the *probability* a photon will hit a screen point as follows:

a. Its wave equation describes how the photon cloud spreads through both slits.

b. Given two paths to a screen point, positive and negative wave values add to a net result.

c. The net amplitude *squared* is the *probability* the photon physically exists at that point.

So quantum theory explains Young's experiment as follows:

> *The photon quantum wave spreads through both slits, then its positive and negative values add or cancel at the screen to give interference that affects the probability of where it hits.*

All this "quantum activity" is seen as entirely imaginary so it doesn't really happen but in quantum realism, there really is a quantum wave that really does generate physical events. If a quantum wave is a processing wave and a physical event is a node overload that restarts the server, what decides that? Servers have many clients so a quantum server response to a client node reboot request could be:

1. *Access*. The server restarts that node's processing which denies all other nodes access for that cycle, i.e. collapses the quantum wave. This then is a physical event.
2. *No access*. The server doesn't respond as it is busy elsewhere, so the node just drops the process and carries on. This then was a potential physical event that didn't happen.

Quantum collapse is random to us because it is a winner takes all lottery run by a quantum server we can't observe. When many nodes reboot, the first to initiate a server restart locks out the others and wins the prize of *being the photon*, leaving other instances to wither on the grid. *It follows that screen nodes with more server access are more likely to reboot successfully.*

Why then does quantum theory define its probabilities based on the *square* of the quantum wave amplitude? The quantum wave is a sine wave and the *power* of a sine wave is its amplitude squared. This power defines the processing *demand* that determines *access* to the photon server. That positive and negative quantum amplitudes cancel locally is an expected efficiency. *Nodes that access the server more often have a greater probability to successfully reboot and host a physical event*.

When many screen nodes overload at once, where a photon actually hits depends on server activity that is, to us, *random,* just as quantum theory says. But quantum theory can deduce the *probability* of where a photon hits from the square of the quantum wave amplitude at each point because *the power of the quantum* *wave at a node defines its server access*. Thus quantum realism *derives* what quantum theory simply *declares,* based on the known data.

Quantum realism then describes Young's experiment in terms of *server access* as follows:

a. The photon processing wave spreads instances through both slits.
b. If they reach the same node by different paths, positive/negative values add to a net result.
c. When many screen nodes overload and reboot, the net quantum amplitude *squared* defines the probability of *server access* that results in a physical event.

In Young's experiment, the photon server supports client instances that pass through both slits then interfere as they leave, *even for a single photon*. This interference alters the server access that decides the probability a node overload will succeed. The first screen node to overload and restart the server is where the photon "hits". If detectors are in both slits, both fire equally because both have equal server access. If a detector is in one slit, it only fires half the time because the server is attending to instances going through the other slit half the time. Table 3.1 interprets Feynman's summary of quantum mechanics (Feynman, Leighton, & Sands, 1977) p37-10 as a calculation of *server access*.

Quantum realism now answers questions like:

a. *Does the photon go through both slits at once?* Yes, photon instances go through both slits.
b. *Does it arrive at one screen point?* Yes, photon processing restarts at one screen node (point).
c. *Did it take a particular path?* Yes, the instance that caused the reboot took a specific path.
d. *Did it also take all other possible paths?* Yes, other instances, now disbanded, took every path.

Table 3.1. Quantum theory as server access

Quantum theory	*Server access*
1. Existence. The probability a quantum entity *exists* is the absolute square of its complex quantum amplitude value at a point in space [37]	*1. Restart.* The probability a quantum entity restarts a server in a physical event depends on node access, which is the absolute quantum amplitude squared
2. Interference. If a quantum event can occur in two alternate ways, the positive and negative amplitudes combine, i.e. they interfere[38]	*2. Combination.* If quantum processing can arrive at a node by alternate network paths, the positive and negative values combine, i.e. they interfere
3. Observation. Observing one path lets the other occur without interference, so the outcome probability is the simple sum of the alternatives, i.e. the interference is lost[39]	*3. Interaction.* Interacting with a quantum wave on one path lets the other occur without interference, so the probability of either path occurring is the simple sum of the alternatives, i.e. the interference is lost

If quantum theory is literally true, a photon really is a "wave" that goes through both Young's slits, but it arrives at a screen *point* because a physical event is a server restart triggered by *one node*. A photon as server processing never dies because it can be born again from any of its legion of instances.

---

[37] If Q is the quantum wave amplitude and P its probability, then $P = |Q|^2$ for one channel.

[38] If Q_1 and Q_2 are the probability amplitudes of two ways that arrive at one point then the total amplitude $Q = Q_1 + Q_2$. If $P = |Q_1 + Q_2|^2$, then $P = P_1 + P_2 + 2\sqrt{P_1 P_2}\, \text{Cos}(\theta)$, where θ is the interference phase difference.

[39] Now $P = P_1 + P_2$ with no interference term.

3.6. LIGHT TAKES EVERY PATH

That light can spread like a wave but arrive at a point like a particle explains the longstanding mystery of how light always finds the fastest path to any destination.

3.6.1. A wave moves

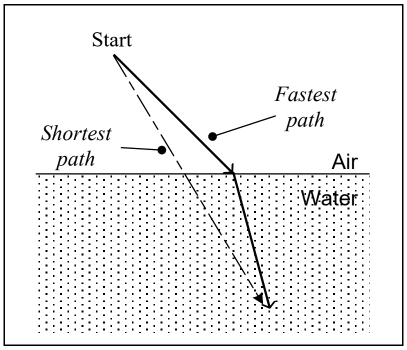

Figure 3.15. Light refracts

Newton explained why he rejected Huygens's wave view of light as follows:

"*For it seems impossible that any of those motions … can be propagated in straight lines without the like spreading every way into the shadowed medium on which they border*." (Bolles, 1999) p192

If light moves as a wave, it should bend round corners as sound waves do when we hear people talking in the next room and indeed it does. In 1660 Grimaldi found that light does bend but by less due to its shorter wavelength. How then can a wave move in a straight line? Figure 3.13 shows how the photon wave power varies along its directional axis so it is more likely to exist at the thicker sections. The result of detecting photons by screens at different distances confirm this as they aren't in a perfect straight line but randomly spread about (Figure 3.14). A physical particle would have to travel in a zigzag path to explain this! Only the *average* measurements are a straight line.

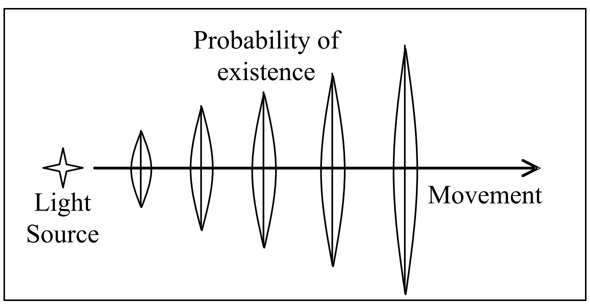

Figure 3.13. A *photon probability of existence*

If light only travels in a straight line *on average,* why doesn't it sometimes "*bend into the shadows*", to show us a torch beam from the side? On the other hand, if light is photon particles traveling in a straight-line path, as optics suggests, how does it find its way?

3.6.2. The physical law of least action

That light always finds the best path to any destination has puzzled thinkers for centuries. As Hero of Alexandria noted, light always takes the shortest path, so how does it find that path? It might seem obvious that it is a straight line but how, at each step, does a photon know what *straight* is?[40]

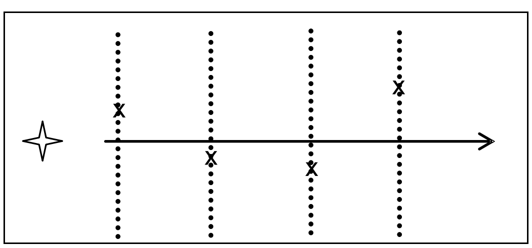

Figure 3.14. Detection of a photon of light

In 1662 Fermat amended Hero's law to be the path of least time as when light enters a medium like water where it travels slower, it *refracts* to take the fastest not the shortest path (Figure 3.15). Imagine the photon as a life guard trying to save a drowning swimmer as quickly as possible. Is the dotted straight line shown the quickest path to the swimmer? If the lifeguard runs faster than he or she swims, it is faster to run further down the beach then swim a shorter distance as shown by the solid line in Figure 3.15. The dotted line is the shortest path but the solid line is the fastest and that is the path light takes. Again, how does a photon of light know *in advance* to take this faster path?

In 1752, Maupertuis generalized further that:

[40] By relativity, light doesn't always travel in a straight line, so "straightness" is not self-evident.

> "*The quantity of action necessary to cause any change in Nature always is the smallest possible*".

This *law of least action,* that nature always does the least work, was developed mathematically by Euler, Leibnitz, Lagrange, Hamilton and others, sparking a furious philosophical debate on whether we live in "*the best of all possible worlds*". Despite Voltaire's ridicule, how light always finds the fastest path remains a mystery today, e.g. light bouncing off the mirror in Figure 3.16 *could* take any of the dotted paths shown but the principles of optics are that it always takes the solid line fastest path. As the photon moves forward in time to trace out a complex path, how does it at each stage pick out the fastest route? As Feynman says:

> "*Does it 'smell' the neighboring paths to find out if they have more action*?" (Feynman et al., 1977) p19-9

To say that a photon chooses a path *so that* the final action is less is to get causality backwards. That a photon, the simplest of all things, with no known internal mechanisms, always takes the fastest route to any destination, for any media combination, any path complexity, any number of alternate paths and inclusive of relativity, is nothing short of miraculous.

3.6.3. The quantum law of all action

Super-computers running a million-million cycles a second take millions of seconds (months) to simulate not just what a photon does in a million-millionth of a second, but in a million-millionth of that (Wilczek, 2008) (p113). How can these tiniest bits of the universe with no known structures make such complex choices? The answer proposed is that "a photon" is a vast set of processing instances.

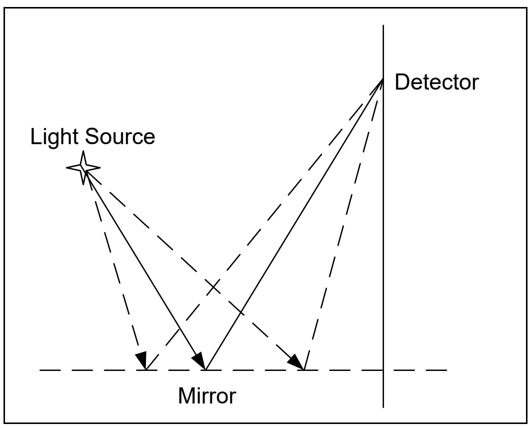

Figure 3.16. Principle of least action in optics

Feynman's *sum over histories* method predicts how light goes from A to B by calculating all the paths, then choosing the one with the least action integral (Feynman et al., 1977) p26-7. It was accepted as a *method* because it works but not as a *theory* because no physical particle can do that. Like the rest of quantum theory, it was a physical impossibility that just happened to predict perfectly.

In quantum realism, Feynman's method works because it describes what the photon actually does. Photon instances do take *all available paths* and physical reality is decided down the line by the first photon restart. The instance that happens to take the fastest path to a detector reincarnates as the photon in a physical event making its path the path the photon took. The server restart makes all other instances disappear, like a clever magician removing the evidence of how a trick is done. Indeed, how else could a law of least action arise? A photon can't know in advance the best way to an unknown destination *before* it leaves, so it takes them all and *picks the fastest later.* In a virtual reality, calculating and taking a path are the same thing. Knowing nothing in advance, the photon simply spreads instances down every path and the first to cause an overload at a detector becomes "the photon". What reaches a detector by the fastest route isn't a solitary particle magically knowing the best path in advance but a quantum ensemble that explores every path and disbands when the job is done.

In quantum realism, every physical event derives from a myriad of quantum events. The quantum world tries every option and the physical world takes the best and drops the rest, so if this isn't the best of all possible worlds, it isn't for lack of trying. The physical law of least action comes from a *quantum law of all action,* that:

Everything that can happen in physical reality does happen in quantum reality.

Feynman's "*Whatever isn't explicitly forbidden must happen*" is the same as Gellman's quantum *totalitarian principle*. Both imply the *evolutionary physics* introduced in the next chapter.

3.7. QUANTUM SPIN

In physical realism, quantum spin is a mathematical construct rather than what physically occurs but in quantum realism, *quantum spin really happens*.

3.7.1. The curious case of quantum spin

Quantum spin is so strange that when Pauli first proposed it he was not believed:

> "*... the spin of a fundamental particle has the curious feature that its* ***magnitude*** *always has the* ***same*** *value, although the direction of its spin axis can vary…*" (Penrose, 1994) p270

A classical object like the earth spins in a *rotation plane* around an *axis of rotation* (Figure 3.17), so its spin on any other axis is a fraction of its total spin. If the spin is unknown, measuring spin on any three orthogonal axes is needed to give the total spin. So that one can measure quantum spin on *any axis* to get the total spin makes no sense in classical terms.

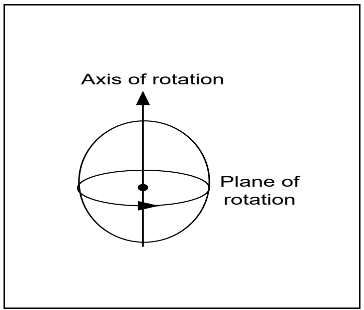

Figure 3.17. Classical spin

Quantum realism explains why spin measured on any axis always gives the full spin. A photon gives all its spin to any axis measurement for the same reason that measuring a photon in either of Young's slits always gives the full photon. A physical event is an all or nothing restart, so if it happens the result is the entire photon including all its spin. The spin result for a photon is, as expected, one quantum process which is Planck's constant in radians[41].

Imagine a coin spun on a table too fast to see its spin direction except that a quantum coin is also spinning at every point on the table. The only way to find out the spin is to stop it and that can't be repeated unless the coin is re-spun in a new case that could be either direction again.

3.7.2. Quantum directions

In current physics, a photon vibrates into a complex dimension that doesn't exist but in quantum realism it oscillates *on* space into a real quantum direction at right angles to its *polarization plane*. Recall that the quantum amplitude of a photon was defined to be at right angles to its polarization plane. Since our space has three dimensions, three orthogonal polarization planes allow three orthogonal quantum directions. The mathematics agrees that adding a fourth dimension to our space gives three new *quantum directions* not one[42], all at right angles to each other (Figure 3.18). This lets light at a point vibrate in three ways at right angles to the three polarization planes through it.

[41] Spin is expressed in Plank's reduced constant of $\hbar = h/2\pi$ (in angular radians).

[42] If physical space has dimensions (X, Y, Z), quantum space has dimensions (X,Y,Z,Q), with Q a fourth quantum dimension. Physical space has three planes XY, XZ and YZ but quantum space adds three more planes XQ, YQ and ZQ, so a photon vibrating into quantum space can do so in three orthogonal planes.

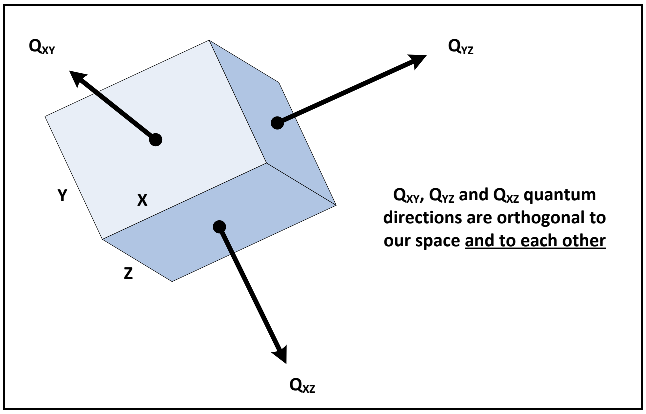

Figure 3.18. Quantum directions

Light moving on an axis can polarize in two ways called vertical and horizontal, where a filter that blocks vertically polarized light doesn't block horizontal polarized light and vice-versa. This is because light traveling in a direction has two entirely different quantum directions to vibrate into. These are at right angles *to each other* hence what blocks one quantum vibration doesn't block the other.

3.7.3. Spin in four dimensions

The above also explains what happens when light meets a filter on an angle. A filter at an angle to the polarization plane of light reduces the light that gets through but still lets some photons through entirely. A filter at bigger angle to the light polarization lets fewer photons through, e.g. a filter at 81° to the polarization plane lets only 10% of the photons through but again some still get through entirely. How can a photon pass *entirely* through a filter that mostly blocks it? The answer proposed now is spin.

To recap, spin involves a:

a. *Rotation axis.* Around which the spin occurs that doesn't change with the spin.

b. *Rotation plane.* In which the spin occurs whose dimensions swap values as the structure spins.

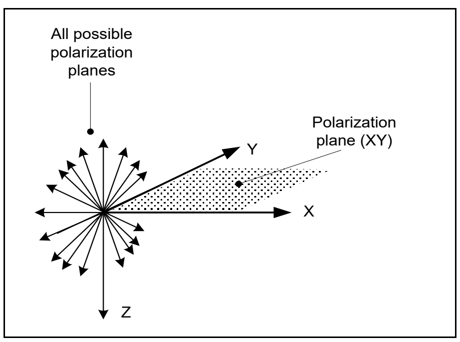

Figure 3.19. Polarization planes

Imagine a spinning propeller that rotates round an axis into the rotation plane that we see from the front. From the front the blades swap vertical and horizontal extents but the axis is just a point. From the side we see the axis but one propeller blade "disappears" as it spins into an unseen horizontal dimension.

Now spin in four dimensions works like spin in three but with more options. If a photon *spins on its movement axis,* as a bullet from a gun does, it spins into all the planes that cut its movement axis (Figure 3.19). This allows it to pass through a filter on an angle to its polarization plane. But as it spins, its quantum amplitude direction doesn't change because it isn't on the rotation plane[43] so when a vertically polarized photon spins into the horizontal plane it disappears entirely, like a piece of paper on edge that can't be seen. As a photon spins on its movement axis, its amplitude varies according to angle. The quantum amplitude of a spinning photon appears and disappears like a propeller seen from the side. That this amplitude projects into the planes that cut its movement axis according to angle[44] explains the percentage of light that gets through a filter on an angle.

How then do photons get *entirely* through a filter on an angle? Again it is because quantum measurement is an all-or-nothing affair. The filter reduces the probability that instances get through a filter but if one

[43] The Planck transverse circle already turns around the X axis into the YQ plane, but the photon can still spin in the YZ plane. This swaps its Y and Z values while leaving Q and X unchanged. Q remains perpendicular to XY, so as Y and Z swap it becomes invisible, as it has no extension orthogonal to the XZ plane.

[44] If Q is the quantum amplitude it reduces as Q.Cos(θ°) as it spins, where θ° is the angle from in the polarization plane. So at a 90° angle it has no value as Cos (90°) = 0.

does and is detected, the entire photon restarts at the point. The entire photon gets through a filter for the same reason that a screen registers an entire photon. A physical event always delivers "the photon".

3.8. PHYSICS REVISITED

That a photon is quantum processing spreading on a network until an overload restarts it suggests how light can do what is physically impossible. It's time to revisit some well-known physics findings.

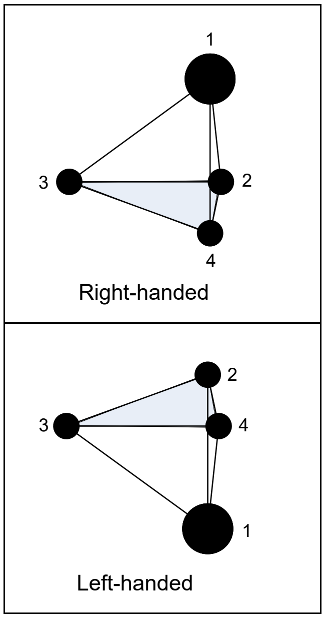

Figure 3.20. Ammonia molecule states

3.8.1. Superposition

Quantum theory says that in Young's experiment *every* photon goes through both slits at once in a *superposition*. While solving a normal equation gives one solution that satisfies its conditions, solving the quantum wave equation gives a *set* of solutions, each a physical event state with an associated probability. These *orthogonal solutions* evolve over time but at each moment only one of them can actually occur. The mathematics has the unusual feature that if any two states are solutions so is their linear combination[45]. While single states match familiar physical events, *these combination states never physically occur,* yet they underlie the mysterious efficacy of quantum theory. It is in just such a combination that one photon goes through both Young's slits at once.

Not only photons can superpose, e.g. ammonia molecules have a pyramid shape (Figure 3.20) with a nitrogen atom apex (1) and a base of hydrogen atoms (2, 3, 4) that can manifest in either right or left-handed forms. To turn a right-handed molecule into a left-handed one, a nitrogen atom must pass through the pyramid base which is physically impossible (Feynman et al., 1977) III, p9-1 but in quantum theory, if each state is valid then so are both at once. So an ammonia molecule can be left-handed one moment and right handed the next, *even though it can't physically change between these states*. To call superposition ignorance of a hidden physical state is to misunderstand it, as superposed quantum currents can flow both ways round a superconducting ring at once even though physical currents would cancel (Cho, 2000).

In quantum realism, a superposition is when the processing of a quantum entity simultaneously distributes to two or more outcomes. So when a photon wave spreads through two slits in Young's experiment, it literally *half-exists* in both. When the photon is later observed in a physical event, that is the photon restarting based on a specific instance. Superposition is *physically* impossible but that quantum processing tries every option is just is business as usual in the quantum world.

3.8.2. Schrödinger's cat

Schrödinger found superposition so odd he tried to illustrate its absurdity by a thought experiment. He imagined his cat in a box with a radioactive source that could randomly emit a photon to trigger a deadly poison gas. In quantum theory, a photon plus detector is a quantum system that both detects and doesn't detect the photon until observed. If the box is also a quantum system it also superposes and the poison is both released and not, so the cat is in an alive-dead superposition until Schrödinger opens the box. But how can a cat be alive and dead? Or if cats can't be alive and dead, how can photons exist and not exist? Or if photons can do this but cats can't, when does the superposition stop?

In quantum realism, a photon spreads on the network until an overload restarts it in what we call an "observation". So observing the world *formally causes* what we see but this isn't a *sufficient cause* as every

[45] If Ψ_1 and Ψ_2 are state solutions of Schrödinger's equation then $(\Psi_1 + \Psi_2)$ is also a valid solution

observation is an interaction between two parties. Quantum realism isn't that we alone are dreaming the physical world but that our *interaction* with the quantum world generates a physical view.

If quantum collapse is the result of a quantum network overload, then *any* overload will cause it, not just those that involve us. So the quantum superposition collapses immediately the detector records a photon. It then releases the poison regardless of whether Schrödinger sees it or not. Likewise, the cat interacts with the poison whether Schrödinger sees it or not. Before opening the box, *Schrödinger* doesn't know whether the gas was released but *the cat does* (or did). Quantum superposition stops the moment *any observation* occurs. It is not delayed until **we** interact with the system. In quantum realism, *quantum collapse occurs with any observation, not just those that involve human eyes*.

This approach requires that we are not the only observers of physical reality. In quantum realism, every physical event is an observation, so when we observe a photon, it is also "observing" us. The universe isn't a virtual reality just for us, as a dream would be, so quantum events were generating physical events long before our species came along. *Quantum realism implies that everything is "observing" everything else in a fundamental sense*.

3.8.3. Delayed choice experiment

That photons travel about a foot per nanosecond allows a *delayed choice* two slit experiment. Two detection options are used, either the usual screen or two telescopes that focus on one slit or the other (Figure 3.21). The trick is that the choice of which to use is made *after* a photon passes the slits, when the screen is either quickly removed or not. If the screen is used, the result is the usual interference so the photon passed though both slits but if the telescopes are used only one fires so the photon took one path or the other. One must conclude that detectors turned on *after* the photon passed the slits decide the path the photon took *before* that:

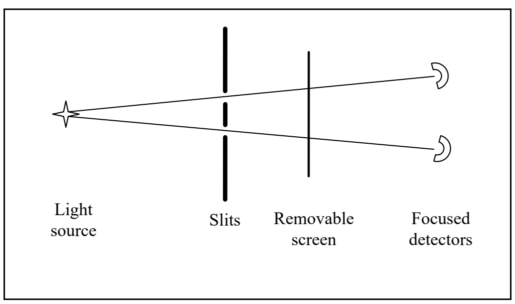

Figure 3.21. Delayed choice experiment

"*It's as if a consistent and definite history becomes manifest only after the future to which it leads has been settled.*" (Greene, 2004) p189

If an observation made *after* a photon travels a path decides the path it took *before* that, physical realism must conclude that the future can affect the past! The distances involved are irrelevant, so a photon could travel from a star for a billion years then decide *when it arrives at earth* if it physically arrived via galaxy A or B. As Wheeler says:

"*To the extent that it {a photon} forms part of what we call reality… we have to say that we ourselves have an undeniable part in shaping what we have always called the past.*" (P. Davies & Brown, 1999) p67

That time flows backwards puts all physics in doubt but this does not happen in quantum realism. It just sees photon processing taking every path and leaving physical events until later. In computing, this *just-in-time* processing is the basis of efficient app design. So photon instances go through both slits and if a screen is there they give interference but if it is not there they just carry on spreading until an instance registers a telescope to restart there. Since that instance went through one slit, we call that the photon's "path". On the other hand, if the screen is left there, physical realism concludes that the photon went through both slits. However for the quantum reality, swapping the screen in and out after the light goes through the slits doesn't matter because *the physical event that defines the path occurs on arrival.*

Every photon observation is based on an instance whose path history becomes that of "the photon". Photon instances take every path until an observation restarts the photon making its path the photon's *physical path*. According to physical realism, the *delayed choice* two slit experiment implies backwards causality but quantum realism has no time reversal and causality remains intact.

3.8.4. Non-physical detection

Quantum theory allows experimenters to use light to detect an object on a path it didn't travel. In Figure 3.22, a light source shines on a beam splitter which sends half the light down *path 1* and half down *path 2.* At first, since path 1 goes to detector 1 by a mirror and path 2 goes to detector 2 by another mirror, the light travels both paths equally so each detector fires half the time. Then the experiment adds a second splitter where the paths cross and now detector 1 registers but detector 2 stays silent. Quantum theory explains this as follows:

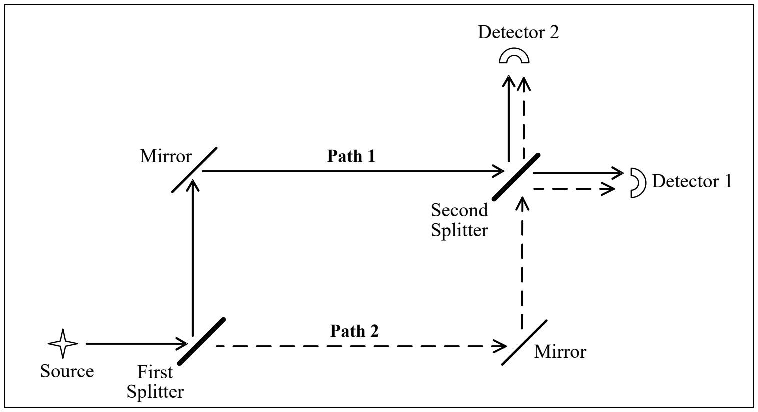

Figure 3.22. The Mach-Zehnder interferometer

As photon quantum waves evolve down the paths, each mirror or splitter delays the phase by half. The two paths to detector 1 have two turns so they are in phase but path 1 to detector 2 has three turns and path 2 has only one so they cancel at detector 2. Detector 2 never fires because quantum waves from the two paths to it always cancel out.

Now if a receptor sensitive to *any* light is put on path 2, the previously silent detector 2 sometimes fires *without triggering the receptor*. This never happens if path 2 is clear, so it *proves* that something is blocking path 2. This experiment (Kwiat et al, 1995) verifies that:

1. With two clear paths, only detector 1 fires.
2. With an object blocking path 2, detector 2 sometimes fires,
3. Yet the path 2 receptor registers nothing.

Table 3.2. Non-physical detection

Path	Probability	Result	
		No Obstacle	**Path 2 Obstacle**
Path 1 to Detector 1	25%	Detector 1 fires	Detector 1 fires
Path 2 to Detector 1	25%	Detector 1 fires	Path 2 registers light
Path 1 to Detector 2	25%	Detector 2 doesn't fire	*Detector 2 fires but path2 doesn't register any light*
Path 2 to Detector 2	25%	Detector 2 never fires	Path 2 registers light

Using this setup, one can *register an object without physically touching it* (Audretsch, 2004) p29. theory explains this odd result as follows (see Table 3.2):

> *As photon quantum waves evolve down the paths those on path 2 are now blocked by a receptor that registers light half the time. Since the path 1 waves to detector 2 no longer cancel out, it fires a quarter of the time even though no light is registered on path 2. The other quarter of the time the path 1 light registers on detector 1. Detector 2 firing proves there is an obstacle on path 2.*

To show how strange this is, suppose path 2 contains a bomb so sensitive that even one photon will set it off but the experimenters don't know this. Now suppose they set up the system to send one photon and get lucky – detector 2 fires proving something is there. They have detected the bomb without physically touching it in any way! This is a bad bomb detection technique as half the time it sets the bomb off, but even so *it is possible*.

This *non-physical detection* supports quantum theory but again physical realism can't explain it and never will. If the physical world is all there is, it isn't possible to register a thing with no physical contact whatsoever. How can a photon detect a bomb on a path that it didn't take?

This result confirms that quantum waves really exist but physical realism has no explanation for it at all.

3.8.5. Quantum entanglement

Quantum entanglement is one of the great mysteries of quantum theory. When a Cesium atom releases two photons in opposite directions, quantum theory says they evolve as an entangled system with net zero spin yet each photon still randomly spins up or down. However far apart they get, if one photon is spin up the other *must* be spin down but if both spin *randomly,* how does each *instantly* know to be the opposite of the other? Einstein called this "*spooky action at a distance*".

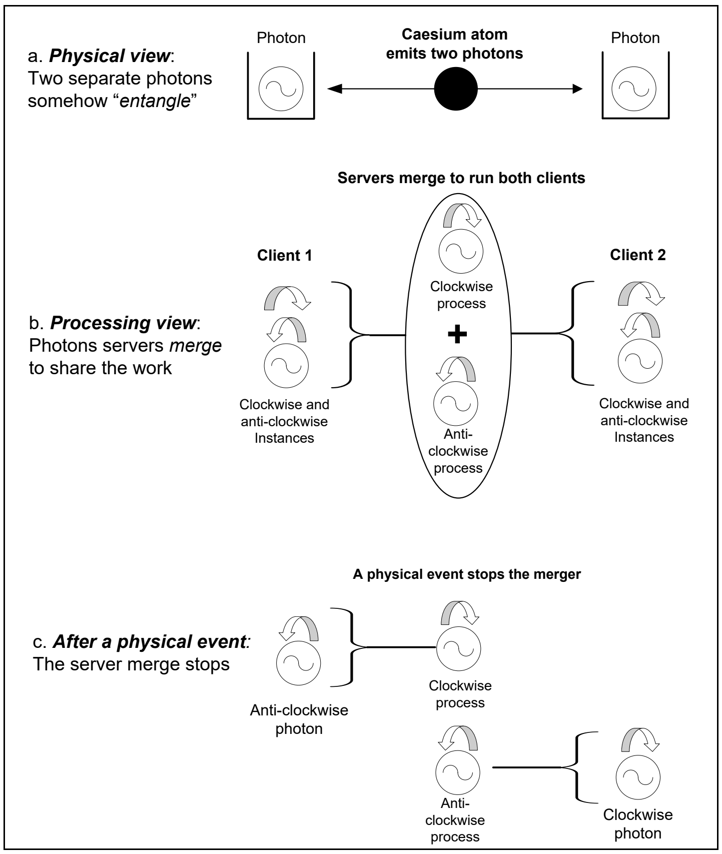

Figure 3.23. Entanglement as merged processing

Experiment confirms this is true even when the photons are too far apart to exchange a signal at the speed of light (Aspect et al., 1982). Based on Bell's inequality, a prediction based on an Einstein thought experiment (Einstein, Podolsky, & Rosen, 1935) carried out the definitive test that entanglement occurs. It was one of the most careful experiments ever done, as befits the ultimate test of quantum theory, which was proved right yet again. And yet again no physical basis for the result is possible!

Two photons heading in opposite ways are physically apart so if each spins randomly as quantum theory says, *why can't both be up or both be down*? What connects them if not physicality? Quantum theory says that the initial spin of zero must be conserved but gives no clue as to how. Nature *could* conserve spin by making one photon spin up and the other down from the start but apparently this is too much trouble. It lets both photons have either spin until one spin is registered then *instantly* adjusts the other to be the opposite *regardless of where the photons are in the universe*. Entangled states that defy physical realism are now common in physics (Salart, Baas, Branciard, Gisin, & Zbinden, 2008).

Quantum realism *explains* what quantum theory *describes* as follows. The two photons emitted by a Cesium atom begin in a reboot that reloads two photon processes at once, i.e. *entangles them*. Being dynamic, both processes then spread out in both directions but as they entangled in one node, if one photon spins one way the other has to spin the other, so the initial net spin is zero. To us, two photons leave the Cesium atom (Figure 3.23a) but the processing result is more complex: half of each photon process heads off in *both* directions because each is a processing *sequence*. What appears to us as two physical photons are at the quantum level *both* supported by two photon servers that in effect share both "jobs" (Figure 3.23b).

What initially "entangles" is the processing that creates physical events. What leaves to the left is a "photon" run by two servers and what leaves to the right is served in the same way. The two entangled photons are each served by two photon servers. When one of the hybrid photons is measured for spin, the instance that generates that physical event is random as per quantum theory, and it restarts one of the photon servers. That leaves the other opposite spin server to run the other photon (Figure 3.23c).

To recap, when photons entangle their processing merges. From that point, two servers service both "photons" jointly until another physical event starts things anew. The entangled photons look like photons and act like photons but actually each is two "photon halves" in server terms. Spin is conserved because the start and end processing is the same, just as the rules of quantum mechanics require.

The effect of entanglement is non-local for the same reason quantum collapse is, that client-server effects ignore the node-to-node transfer limit of the speed of light. If one imagines pixels being produced on a screen, the processing doesn't have to "go to" a point to cause a change. It can change any point on the screen directly and likewise photon servers act directly no matter how far apart the entangled photons are on the "screen" of our space.

Entanglement also underlies super-conductivity where many electrons entangle. Again the server processing is merged so every electron is a processing hybrid of all the electrons. Hence electrons can "move" without resistance in a superconductive state because each electron in effect exists everywhere in the metal. In Bose-Einstein condensates any number of quantum processes can merge in this way.

3.8.6. The holographic principle

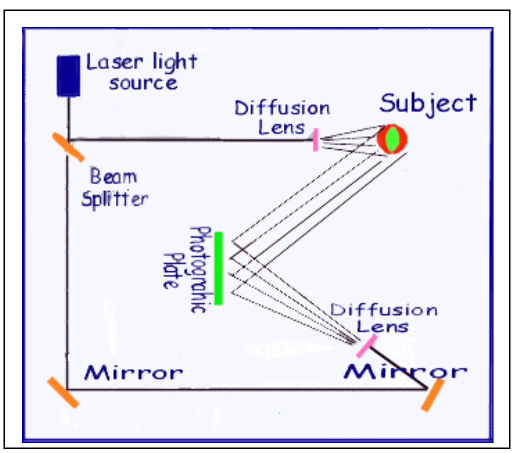

Figure 3.24. Producing a hologram

Our eyes see depth because light from different distances arrives slightly out of phase. Flat photos that only store light intensity don't show depth but holograms show depth because they store the phase differences that encode it, so holograms can show 3D images. A hologram is made by splitting laser light and letting the half that shines on the object interfere with a matched reference half to give an interference pattern (Figure 3.24). Light later shone on that flat pattern recreates the original 3D image as a holograph.

The *holographic principle* is that everything we know about the universe is essentially a hologram, or more precisely:

Everything physically knowable about a volume of space can be encoded on a surface surrounding it (Bekenstein, 2003).

This principle, which is widely accepted in physics, is that all the information we receive about the world can be encoded on a flat surface just like a hologram. The information in a space seems to depend on its volume but if one were to pack smaller and smaller memory chips into a space to get more information in it, the end result would be a black hole whose entropy depends on its surface area not its volume. Since black holes have more entropy than anything else for the same volume it follows that the information about *any* physical object can be encoded on a two-dimensional surface. The holographic principle is maintained by the behavior of black holes (Bekenstein, 2003).

Quantum realism interprets the holographic principle as follows. A virtual world must be observed from some angle so the act of observing uses up one of the three dimensions of space. If an observation is an information transfer, as proposed here, that leaves only two dimensions to carry out the transfer. So the physical world registered at a point can always be painted on the surface of a sphere around it because that is the structure that delivers it. Quantum realism thus *requires* the holographic principle and equally that it applies to our world supports quantum realism.

So is our 3D universe really two-dimensional? The holographic principle is a consequence of how physical reality *presents* not how it *operates*. A 3D world that *presents* as an image must be delivered across two dimensions but space still has three degrees of freedom. The holographic principle implies that physical reality is virtual not that it is two dimensional. Equally to say that the physical world is "like a hologram" is misleading, as this is no Star Trek hologram we can enter and leave at will because our bodies *are* its images. If this "hologram" was ever switched off, the continuity of physical reality would immediately stop and the only way to recover it would be to start it all again from scratch.

3.8.7. The uncertainty principle

Heisenberg's uncertainty principle is that one can't know a quantum entity's exact position and momentum at once. This *complementarity,* that position and momentum are separately knowable but together unknowable, is part of quantum mechanics but why does the one deny another?

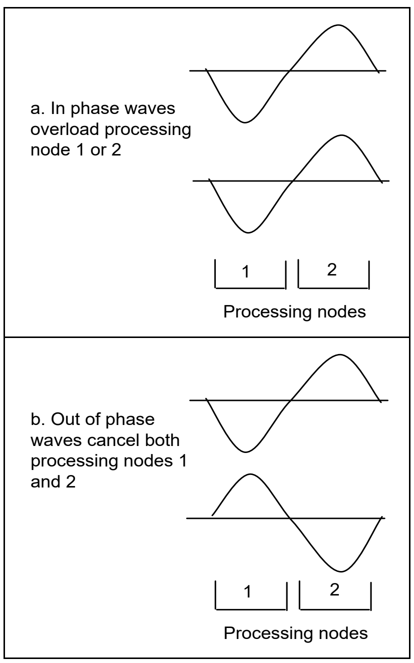

Figure 3.25. Waves interacting

In quantum realism, measurement is an information transfer:

"*... a measuring instrument is nothing else but a special system whose state contains information about the "object of measurement" after interacting with it:*" (Audretsch, 2004) p212

And it occurs when a quantum wave interaction causes a node of the quantum network to overload. Figure 3.25 shows a simple case of two waves interacting in two nodes. If they are *in phase,* one node overloads to give a position exactly but the wavelength is unknown. If they are *out of phase,* both nodes cancel to define the wavelength exactly but there is no position information. Waves interacting reveal position or wavelength but not both, with no repeats. If the result gives position there is no wavelength data and if it gives wavelength there is no position data. In both cases, the observed wave has given all the information it has to the interaction. One wave "observing" another can give position or wavelength information but not both.

The quantum uncertainty principle comes from the nature of wave interactions based on De Broglie's equation of momentum and wavelength[46]. The information change in any photon interaction can't be less than a quantum process so position plus momentum can't be less than Planck's constant[47].

3.9. REDEFINING REALITY

Time and again quantum theory predicts what is physically impossible and experiment proves it is right - yet physics still clings to physical realism! The "logic" seems to be "*The physical world must be real because what else could it be?*" The answer now proposed is that the "*what else*" is quantum reality. Either a real physical world is doing impossible things or it's time to redefine reality to be quantum.

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[46] If p is momentum, λ is wavelength and h is Planck's constant, then $p = h/\lambda$

[47] Mathematically $\delta x.\delta p \geq \hbar/2$ where x is position, p is momentum and $\hbar$ is Plank's constant in radians.

3.9.1. A fairy tale for physicists

Quantum theory states that quantum collapse is *random* and the evidence agrees, e.g. a radioactive atom really does emit a photon when it wants to, in a way that we can't physically predict. Quantum randomness means that choices are being made *for no known physical cause*. Since in quantum theory *every* physical event arises from a quantum collapse, this threatens the primacy of physical causality. That *every* physical act is partly random contradicts the physical realism claim that *only* physical events cause physical events.

In 1957, Everett devised *many-worlds theory* to meet this threat by proposing that every quantum choice spawns *an entire new universe*. So when an electron anywhere in the universe chooses to be say spin up, another universe is magically created in which it chose to be spin down, so quantum randomness isn't random at all. Everett's idea was first seen as absurd, as it is, but today physicists prefer it 3:1 over the Copenhagen view because it supports physical realism (Tegmark & Wheeler, 2001, p6). A majority of physicists now believe that for fourteen billion years every photon that exists has been creating new universes with its every act! With up to 10^{43} universes being created per photon per second, it isn't hard to see that the:

> "… *universe of universes would be piling up at rates that transcend all concepts of infinitude.*" (Walker, 2000) p107.

From a scientific perspective, this doesn't just offend Occam's razor, it outrages it. Do you believe that in the time it took to read this sentence, a billion, billion *universes* arose just from the photons that hit your eyes? Current physics does because it is the only way to dispel the ghost of quantum randomness. So many now talk of the *multiverse* as a fact despite no evidence at all, based only on the belief that *"It has to be so"*. The multiverse idea is truly a *fairy tale for physicists* (Baggot, 2013).

Historically, the *multiverse* is a reincarnation of the *clockwork universe* idea that quantum theory demolished last century. It just replaces a clockwork universe with a clockwork multiverse. Deutsch attempts to rescue this zombie theory[48] by letting a finite number of universes repartition after each choice (Deutsch, 1997) but this only recovers the original problem, as what chooses which worlds are dropped? Why would the universe, like a doting parent with a quantum camera, want to store everything we *might* do? The ex-post-facto multiverse fairy tale shows how far some will go to support a belief in physical realism.

3.9.2. The measurement problem

The quantum measurement problem is that:

> "*The full quantum wave function of an electron itself is not directly observable…*" (L. M. Lederman & Hill, 2004) p240

Nature's *firewall* separates us from quantum reality because any attempt to observe a quantum wave collapses it to a physical event, which raises the problem that quantum science is based on what cannot be directly observed. This issue was raised last century and this century is no different:

> "*The history of the quantum measurement paradox is fascinating. There is still no general agreement on the matter even after eighty years of heated debate*." (Laughlin, 2005) p49.

Can a theory about what can't be observed be science? On the one hand is the view that only "*…what impinges on us directly is real*." (Mermin, 2009) p9, so quantum theory describes the unreal. On the other hand, is the fact that this description of "unreal" quantum states is the most successful theory in the history of physics. One might argue that:

1. Quantum theory is supposed to be part of science,

[48] Zombie theories make no new predictions and can't be falsified. Like zombies, they have no progeny nor can they be killed by falsification, as they are already scientifically "dead".

2. Science is only about what we can physically observe,
3. We can't physically observe quantum waves, so quantum theory isn't science!

If science was entirely about what we observe physically then quantum theory wouldn't be a science, but actually assumption#2 above is *logical positivism masquerading as an axiom of science*, which it is not. Logical positivism is actually the naive nineteenth century fallacy that science describes only physical things. Actually, science is based on Locke and Hume's *empiricism*, that scientific theories be tested by physical feedback, so quantum theory is a science because it *predicts* physical events, regardless of what it *describes*. There is no requirement in science that the constructs of theories must represent physical things, e.g. there is no evidence that gravity is physical but Einstein's theory of gravity is science.

History supports this conclusion, as logical positivism has failed every discipline that has tried it, e.g. behaviorism tried to reduce psychology to physical acts until Chomsky showed this was impossible for language. In computing, positivism would reduce everything to hardware and ignore software, human-computer-interaction and the social causes behind systems like Twitter. In many ways, physics is the last bastion of positivism, the idea that only physical events "really" exist, but this is not sustainable.

The problem with positivism is that it tries to ignore the observer, when the evidence is that our reality is always an *observer-observed interaction*, so to ignore the observer is to ignore half of reality. In this view, the *observer* is fundamental to our reality and can be defined as the final destination of the information delivered in any physical event. Even physics requires an observer, as quantum collapse needs an observer and relativity demands an observer frame of reference. Attempts to "ban" the observer from science just don't work because the observer is always part of our reality.

In quantum realism, the measurement problem is a basic property of reality rather than a problem, as the quantum world *observes itself* to create the physical world as a set of views. Physical reality arises when quantum reality is interrogated, just as a click in a game produces a view. *The long-sought boundary between the classical and quantum worlds is the "click" of observation*.

As Kant said, we only ever see a *phenomenon* not the *noumenon* or "thing in itself" (Kant, 2002, p392). Taking physical phenomena as real and quantum noumena as unreal was the wrong turn that led physics into the scientific desert of physical realism.

3.9.3. The Quantum Paradox

The tradition of objective reality began with Aristotle's view that:

> "*... the world consists of a multitude of single things (substances), each of them characterized by intrinsic properties ...*" (Audretsch, 2004) p274

Two thousand years later, this vision of a world of substantial things that cause all effects still dominates thought. So why doesn't physics apply this doctrine to quantum theory?

"*... why not simply accept the reality of the wave function?* (Zeh, 2004) p8

The problem is that quantum theory:

> "*… paints a picture of the world that is less objectively real than we usually believe it to be*." (Walker, 2000) p72.

And if one accepts one thing that isn't "objectively real", where will it end?

> "*... if we are to take ψ [the quantum field] as providing a picture of reality, then we must take these jumps as physically real occurrences too…*" (Penrose, 1994) p331

Schrödinger tried to explain quantum theory in physical terms but failed, as have all who have tried since. Quantum theory describes what isn't physically possible as quantum states that disappear at will ignore physical permanence; entangled effects that occur instantly over any distance ignore the speed of light limit; and superposed states that co-exist in physically opposite ways ignore physical incompatibility.

The world that quantum theory describes can't possibly be physical. A quantum wave can spread across a galaxy then instantly collapse to a point but:

"*How can something real disappear instantaneously?*" (Barbour, 1999) p200

When Pauli and Born defined the quantum amplitude as the *probability* of physical existence, physics ceased to be about anything physical at all:

> "*For the first time in physics, we have an equation that allows us to describe the behavior of objects in the universe with astounding accuracy, but for which one of the mathematical objects of the theory, the quantum field* ψ*, apparently does not correspond to any known physical quantity.*" (Oerter, 2006) p89

Physical realism can't support a theory that what is unreal can generate what is real. The *quantum paradox* is that if quantum unreality causes physical reality, then:

"*Can something that affects real events … itself be unreal?*" (Zeh, 2004) p4.

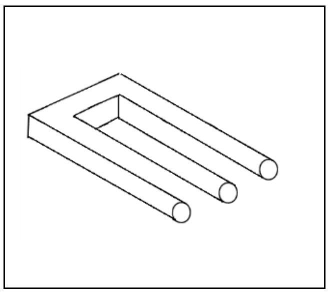


Figure 3.26. A paradox

For over a century, physics has faced the quantum paradox like a deer in headlights, attracted by the quantum brilliance but afraid to abandon its traditional stance of physical realism.

Paradoxes only go away when false assumptions are exposed, e.g. Figure 3.26 has two square *and* three round prongs depending on where you look, which is impossible. The answer isn't some mystical "*square-round duality*" but to see that one line can't bound both a square prong and a round one at the same time. Likewise, the quantum paradox arises from the false assumption of physical realism. When Penrose asks:

"*How, indeed, can real objects be constituted from unreal components?*" (Penrose, 1994) p313

the honest answer is that they can't. One might equally ask "*How can a purely physical world have random events?*" or "*How can a complete physical universe begin?*" A physics based on illogic builds paradox into its foundations and to do this is to institutionalize illogic. This is not science. The logical way forward is to accept that quantum reality creates physical unreality based on the facts of physics.

3.9.4. Resolving the quantum paradox

Bell's experiment tested the following *axioms* of current physics (D'Espagnat, 1979):

1. *Physical realism*. That "*there is some physical reality whose existence is independent of human observers.*" (D'Espagnat, 1979) p158
2. *Locality*. That no influence of any kind can travel faster than the speed of light.
3. *Induction*. That logical induction is a valid mode of reasoning.

The result showed that one or more of these assumptions *must be wrong.* If physical realism and induction are true, then locality must be wrong. If locality and induction are true, there can't be a real physical world out there. If physical realism and locality are true, then logical induction must be false. To this day, physics has not resolved this issue:

> "*According to quantum theory, quantum correlations violating Bell's inequalities merely happen, somehow from outside space-time, in the sense that there is no story in space-time that can describe their occurrence*:" (Salart et al., 2008) p1

Quantum realism resolves the quantum paradox by changing the first two axioms as follows:

1. Remove the word "physical" from the first axiom so it becomes:

That there is a ~~physical~~ reality whose existence is independent of human observers

This permits a quantum reality to exist independent of human observers.

2. Add the world "physical" to the second axiom so it becomes:

That no physical influence of any kind can propagate faster than the speed of light.

This permits quantum collapse to occur instantly as server-client effects aren't physical influences, so Bell's results no longer contradict locality.

The result is that a statement of scientific realism such as:

"*If one adopts a realistic view of science, then one holds that there is a true and unique structure to the physical universe which scientists discover rather than invent.*" (Barrow, 2007) p124

now becomes instead:

"*If one adopts a realistic view of science, then one holds that there is a true and unique structure to the universe which scientists discover rather than invent.*"

Quantum realism agrees there is a true and unique structure to the universe that scientists discover rather than invent but the physical world we see just reflects it. Physical realism was the mother of physics but every child leaves its mother at some point, and quantum realism is that point.

3.9.5. The unmeasured reality

To think physical events are real is like thinking a TV soap opera is real. When people meet actors from their favorite TV show for the first time, they often treat them like their onscreen persona, so it is no surprise that most people think the physical world real. It is natural to assume that what presents is reality, but no case has ever been made for physical realism because it is assumed to be *self-evident.* Yet this is just our bias:

> "*Observers have to be made of matter…Our description of nature is thus severely biased: we describe it from the standpoint of matter.*" (Schiller, 2009) p834

The physical world as a substantive reality is a meta-physical idea held without proof, since that we *register* the physical world doesn't *prove* that it is real. Yet we accept:

> "*… the dogma that the concept of reality must be confined to objects in space and time…*" (Zeh, 2004) p18

Science advances by questioning assumptions not sanctifying them. Quantum theory claims that behind physical reality there is quantum reality of which Bohr said *we must not speak*. Yet if physics is science, since when was science about protecting a dogma? Quantum theory tells us that quantum collapse takes only an instant, so entities are mostly in-between measurements:

> "*Little has been said about the character of the unmeasured state. Since most of reality most of the time dwells in this unmeasured condition …the lack of such a description leaves the majority of the universe … shrouded in mystery*." (Herbert, 1985) p194

If entities exist mostly in unobserved, uncollapsed quantum states, by what logic are their brief moments of collapse considered reality? *Surely reality is what is there most of the time?*

And if quantum waves cause physical reality, isn't saying that the unreal causes the real backwards logic? By what rationale is the cause of physical reality unreal? If one thing causes another, *surely the cause is real not the effect?*

The current denial of quantum reality is doctrinal not logical, based on faith not facts. When atoms were first proposed, physical realists like Mach denied they existed because they couldn't see them but today we accept unseen electrons, protons, neutrons and quarks. Now, when quantum theory says the physical world is based on probabilities, we cry "*Enough!*" and turn away. That the answer to life, the universe and everything is just a number is a step too far. After two thousand years of scientific struggle, do we now walk away from our own final conclusion?

3.9.6. The great smoky dragon

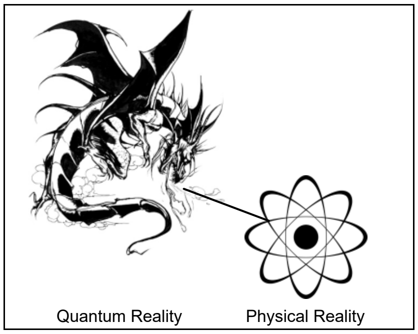


Figure 3.27. The quantum dragon

We see ourselves in the sunlight of rationality standing before the dark cave of quantum paradox, but as in Plato's cave analogy, maybe it is the other way around. Perhaps we are sitting in the cave of physicality with our backs to the quantum sunlight, calling the shadows it casts on the wall of space real. Quantum theory and relativity have loosed the chains that bind us but who will turn and look? Einstein did, but the quantum brilliance blinded him. Bohr did but wearing his impenetrable Copenhagen suit, he saw only his own reflection. The quantum light is currently quarantined behind a wall of arcane equations and the acolytes who harvest it must first *deny that it even exists.* The first rule of the quantum world is that there is no quantum world, but calling its own best theory a theory of nothing is leading physics nowhere.

Quantum realism says that light is indeed a quantum wave that instantly restarts when observed, just as quantum theory says, because a processing wave can do that. Table 3.3 contrasts how quantum realism and physical realism explain the behavior of light so the reader can decide. Quantum theory today makes no more sense now than when it was invented last century and the next hundred years will be the same until it becomes a *reality description.* If the quantum world is *a great smoky dragon* (John A. Wheeler, 1983) then the physical world is its smoke (Figure 3.27). *The quantum world is no shadow world existing alongside physical reality but the real world whose shadow is the physical world we see*.

Table 3.3. Physical vs. quantum realism explanations of light

Physical Realism	Quantum Realism
A photon is a "wavicle" that: a) Sets imaginary positive/negative values b) Moves as a sine wave, for an unknown reason c) Has the fastest speed possible, for an unknown reason d) Doesn't fade by friction, as a physical wave would e) Collides to give *all* its energy at a point, like a particle	*A photon is a quantum process* that: a) Rotates values at right angles to space b) A moving rotation projects a sine wave c) One transfer per cycle is the maximum network rate d) Never fades because the quantum network sustains it e) Restarts *all* its processing in a physical event
Energy. A photon's energy: d. Decreases as its wavelength increases e. Increases as its frequency increases f. The increase is quantized for some reason	*Energy.* A photon's *processing rate per node*: a) Decreases as more nodes share one process b) Increases as each node runs the process faster c) Adding a node to a wavelength is a quantum increase
Planck's constant. Defines both: a) The minimum unit of energy, and b) The minimum length of space c) For some unknown reason	*Network density.* Defines both: a) The basic processing action is a *transverse circle*, and b) The basic unit of length is a *planar circle* c) Both circles are the same size by network symmetry,
Quantum waves. In theory, a photon quantum wave: a) Spreads outwards as a sphere b) Passes through two slits to interfere with itself c) Can collapse to any point regardless of its spread d) Becomes a physical event with a probability that depends on the net power of the wave at each point	*Processing waves*. A photon processing wave: a) Transmits instances outwards as a sphere b) Instances pass through two slits and interfere on exit c) Can restart at any node regardless of its spread d) The physical event probability depends on server access given by the net quantum wave power at each point
The law of least action. Light always takes the path of least action to a detector, for some unknown reason	*The law of all action.* Light takes every path to a detector and the first to arrive restarts the photon program
Retrospective action. A photon decides the path it took to a detector after it arrives, which is backwards causality	*Just in time action.* Photon instances take every path and the one it re-spawns from defines the photon's "path"
Non-physical detection. One can detect an obstacle on a path not physically taken, which is physically impossible	*Quantum detection.* Blocking an alternate path prevents quantum interference and alters the physical results
Quantum spin. A photon polarized in one plane spins: a) With the same spin for any axis, for some reason b) In both directions at once, somehow c) Into other planes, according to angle	*Quantum spin.* Quantum processing in four dimensions a) Restarts give the total spin for any axis b) Can spread two ways at once c) Projects onto other planes according to angle as it spins
Superposition. Quantum waves superpose or combine in physically impossible ways so they can't exist	*Processing overlays.* Processing can superpose in all possible ways as long as there is no overload
Entanglement. The random spin of an entangled photon instantly defines the other's spin anywhere in the universe	*Merging.* Entangled photons merge their processing, so two servers run both photons until the next restart
Holographic principle. All the information about a point of space receives can be encoded on a surface around it	*Transmission principle.* All the information a node receives is transmitted by its sphere of neighbors
Quantum paradox. Unreal quantum waves generate real physical events	*Quantum reality.* Real quantum waves generate virtual physical events

DISCUSSION QUESTIONS

The following questions are addressed in this chapter. They are better discussed in a group to allow a variety of opinions to emerge. The relevant section link is given after each question:

1. What is the mystery of light? (3.1.1)
2. According to current physics, is light made of waves, particles or both? (3.1.2)
3. In Young's experiment, does a photon go through both slits or just one? Give reasons. (3.1.3)
4. Bohr's Copenhagen dualism lets quantum waves exist for calculations but nothing else. What is the problem with this? (3.1.4)
5. Can counterfactual events that didn't happen define physical outcomes? Give reasons (3.1.5)
6. What proves for sure that light is a wave? (3.2.1)
7. What does it mean to say that we are three-dimensional "Flatlanders"? (3.2.2)
8. Can light waves vibrate in a physical direction? If not, in what direction then? (3.2.2)
9. Why hasn't light slowed down, even after traveling for billions of years in space? (3.2.3)
10. If space is nothing and light travels in empty space, what mediates light waves? (3.2.3)
11. Why can nothing travel faster than light does in any medium? (3.2.4)
12. What does every photon in the electromagnetic spectrum have in common? (3.3.1)
13. What is energy in processing terms? (3.3.2)
14. Why does all energy come in Planck units? (3.3.3)
15. If a quantum wave is a processing wave, how does it spread? (3.4.2)
16. Why is it wrong to say that a photon "has" a quantum wave? (3.4.3)
17. Will hidden variables ever explain why photons hit a screen at a random points? (3.5.1)
18. Is a photon a wave, a particle, or both? If both, how can that be? (3.5.2)
19. How can a quantum wave collapse instantly to a point, regardless of its spatial extent? (3.5.2)
20. Why does a photon wave always deliver all its energy instantly at a point? (3.5.2)
21. How can a photon go through both Young's slits but still hit the screen at a point? (3.5.3)
22. Why does a photon's *probability* to hit a point depend on its quantum wave *power* at the point? (3.5.3)
23. What causes quantum randomness? (3.5.3)
24. Why can't physics explain how a photon particle always finds the shortest path? (3.6.2)
25. How does a photon always find the shortest path to any destination? (3.6.3)
26. Why is a photon's spin on any axis always the same? (3.7.1)
27. Why does a filter that blocks horizontally polarized light not block vertically polarized light? (3.7.2)
28. How can a photon of polarized light pass *entirely* though a filter nearly at right angles to it? (3.7.3)
29. How can physically incompatible quantum waves overlap, i.e. superpose? (3.8.1)
30. Can Schrödinger's cat be both alive and dead? Explain. (3.8.2)
31. According to quantum theory, observation creates physical reality, so is life just a dream? (3.8.2)
32. Does a delayed choice two-slit experiment prove that time can flow backwards? (3.8.3)
33. How can a photon choose the physical path it took to reach a detector *after* it arrives? (3.8.3)
34. Can light detect an object on a path it didn't travel? Is this physically possible? (3.8.4)
35. How do entangled photons *instantly* affect each other faster than the speed of light? (3.8.5)
36. Is the physical world distinguishable from a hologram? Why does quantum realism require this to be so? (3.8.6)
37. Is there any evidence for the multiverse? Why then do many physicists believe in it? (3.9.1)
38. What is the long-sought boundary between the quantum world and the physical world? (3.9.2)
39. What is the quantum paradox? How has physics handled it? (3.9.3)

40. How does quantum realism resolve the quantum paradox? (3.9.4)
41. If quantum entities exist mostly in an unmeasured state, what makes this state “unreal”? (3.9.5)
42. Does quantum theory describe unreality or reality? Give reasons. (3.9.6)

Chapter 4. The Matter Glitch:
An alternative to the standard model

"Scientists who don't question their theories are priests" Brian Whitworth

A *world view* is a way of looking at the world that includes a statement of what is real. *Physical realism* is the world view that there is one reality out there apart from us and the physical world is it. Its claim to truth is based on evidence from the physical world. *Dualism* is the equally common religious world view that behind the real physical world is a spiritual reality that created it and to which one can return at death, implying a higher purpose to physical life. Its claim to truth is divine revelation from the spiritual world.

Quantum realism as a world view sits in between these two dominant ideologies. It agrees with physical realism that there is one reality out there apart from us but disagrees that the physical world is it. It agrees with orthodox religion that there is a reality beyond the physical world but disagrees that there are two realities. Its claim to truth is that as a statement about the physical world, it is subject to science. This chapter develops a testable *prediction* to separate quantum realism from physical realism.

4.1. WHAT IS MATTER?

Quantum realism explains space, time and light as follows:

- *Space*. Space as null processing is both something and nothing.
- *Time.* Time as processing cycles completed can "dilate", as Einstein says it does.
- *Light*. Light as one process distributed more or less explains the unity of the electromagnetic spectrum.

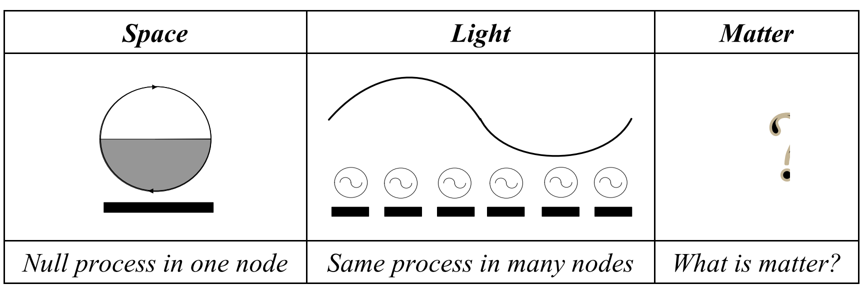


Figure 4.1. If a photon is space stretched out, what is matter?

The challenge now is *to explain matter using the same quantum processes used for space, time and light* (Figure 4.1). If the model can't explain matter it fails, making the results so far mere curiosities. Current physics explains matter using the particles of the *standard model.* Quantum realism must explain everything it does and more to succeed.

4.2. THE STANDARD MODEL

The standard model of physics took over a century to build and summarizes:

> "*... in a remarkably compact form, almost everything we know about the fundamental laws of physics.*" (Wilczek, 2008) (p164)

It is currently considered by physicists to be:

> "*...truly the crowning scientific accomplishment of the twentieth century.*" (Oerter, 2006) p75.

Table 4.1. The standard model of particles

PARTICLES	***MATTER PARTICLES***				
	Leptons		***Quarks***		***Anti-Matter***
	Electron like	*Neutrino like*	*Up-like*	*Down-like*	
Generation *1*	Electron (**e**)	Neutrino (**ν**)	Up quark (**u**)	Down quark (**d**)	Same mass, opposite charge
Mass (Charge)	0.511 (-1)	< 3 x 10^{-6} (0)	1.5 - 4.5 (+2/3)	5 – 8.5 (-1/3)	
Generation *2*	Muon (**μ**)	Muon neutrino (ν_μ)	Charm quark (**c**)	Strange quark (**s**)	As above
Mass (Charge)	105.7 (-1)	< 0.19 (0)	1,000 – 1,400 (+2/3)	80-155 (-1/3)	
Generation *3*	Tau (**τ**)	Tau neutrino (ν_τ)	Top quark (**t**)	Bottom quark (**b**)	As above
Mass (Charge)	1,777 (-1)	< 18 (0)	174,000 (+2/3)	4,000 – 4,500 (-1/3)	
	FORCE PARTICLES				
Field:	***Electromagnetic***	***Strong***	***Weak***	***Gravity***	***Higgs***
Name Mass (GeV)	Photon (γ) (0)	Gluon (**g**) (0)	W^+, W^-, W^0 (80.4; 80.4; 91.2)	Graviton (0)	Higgs (125)
Charge	-1 to +1	Eight "colors"	Isospin (+½, -½)	0	0

The standard model considers all reality to consist of *particles,* which it divides into matter particles called *fermions* and force particles called *bosons* (Table 4.1). The difference essentially is that fermions collide with each other and bosons don't. Physics currently attributes all forces to force particles and attributes all matter to matter particles.

Matter particles are divided into electron and neutrino *leptons* and up and down *quarks,* both of which have unstable *higher generation* variants for some unknown reason. Up and down quarks then combine into the protons and neutrons of atomic nuclei that electrons orbit around, giving all the atoms of ordinary matter. Apart from neutrinos that whizz around for no reason and anti-matter that was expected but is nowhere to be found, it all seems fairly tidy. Yet as Woit notes:

> "*By 1973, physicists had in place what was to become a fantastically successful theory … that was soon to acquire the name of the 'standard model'. Since that time, the overwhelming triumph of the standard model has been matched by a similarly overwhelming failure to find any way to make further progress on fundamental questions.*" (Woit, 2007) p1

Some fundamental questions the standard model *doesn't* answer include:

a. Why don't protons decay as neutrons do?
b. Why is our universe matter not anti-matter?
c. Why do neutrinos have a tiny but variable mass?
a. Why do leptons and quarks have three particle "generations" then no more?
b. Why do electrons "half spin"?
c. Why do particle masses vary enormously but charges don't?
d. Why do neutrinos always have left-handed spin?
e. Why do quarks have one-third charges?
f. Why does the force binding quarks *increase* as they move apart?
g. What is the dark matter and dark energy that constitute most of the universe?

The issue isn't that these questions are unanswered but that over fifty years has seen no progress in answering them. As the great hopes of string theory and super-symmetry led nowhere, the next fifty years look like being the same. This chapter answers these questions based on quantum processing not physical particles.

4.3. ELECTRONS AND NEUTRINOS

In quantum realism, the universe began as a plasma of *massless* high energy photons, so how did matter arise from this energy cauldron? Since electrons and neutrinos are the smallest matter entities, they are the most likely candidates for the first matter.

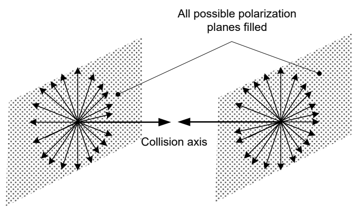


Figure 4.2. Extreme light beams meet head-on on an axis

4.3.1. Electrons

In current physics, an electron has a small mass and a negative charge. It is a zero-dimensional *point particle* that doesn't occupy any space. Its "size" then is exactly zero but how an entity with no spatial *extent* has mass *substance* is never really explained. The standard model does not answer the question of what an electron actually **is**.

In quantum realism, an electron is processing that occupies one node of the quantum network, so it has a "size" just as a screen pixel has a size. A photon is a distributed quantum process being passed on, so:

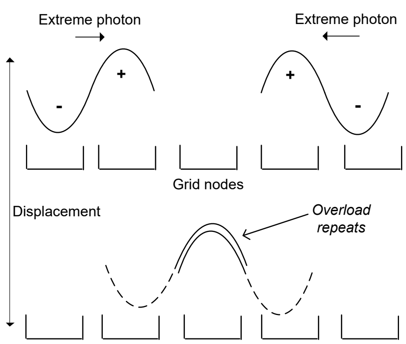


Figure 4.3. An electron channel reboot

1. One photon is accepted at a node by one *channel* that vibrates at right angles to its polarization plane.
2. The bandwidth of one channel is one quantum process per quantum cycle.
3. Channels transmit photon streams in lockstep order so they can't overtake.
4. If two photons meet head-on in a channel, it accepts both.

Normal photons meeting head-on don't overload a channel it as its bandwidth exceeds their processing total but *extreme light* is different. An *extreme photon* has a two-node wavelength so it has half a quantum process in each node. If two such photons meet head-on, each requesting a half quantum process, the channel bandwidth overloads, i.e. they "collide".

Since photons *spin* on their axis of movement, a photon that collides can restart in another axis channel to disentangle but this can't happen if the overload occurs in every channel. An *extreme light beam* has extreme photons filling every channel of its movement axis so if two such beams meet head-on, *every* channel on one axis overloads at once (Figure 4.2), so now there are no free channels for photons to restart in. That extreme light beams meet head-on is obviously unlikely but it must have occurred in the early plasma by the law of all action, that everything possible eventually happens (3.6.3).

Figure 4.3 shows the result for one channel, with every channel the same. In this and other pictures, a "head" is the leading half of an extreme photon and a "tail" is the following half. When two heads of half a quantum process meet, they overload the channel bandwidth so both photons restart the next cycle. Two new photons then set off in different directions but that gives another overload that restarts them again and the overload/restart repeats every quantum cycle from then on. *The network that once hosted only waves now has a permanent processing bump - an electron*. It is stable because any entity arriving *on that axis* finds all the channels taken while anything at right angles just passes right through.

In his PhD, Feynman partitioned the electron wave equation into opposing advanced and retarded waves but didn't pursue it, perhaps thinking that electron *particles* can't be *waves.* Since then, Wolff has argued that electrons are in and out spherical waves (Wolff, M., 2001), Cramer's transactional theory uses retarded and advanced waves (Cramer, 1986), and Wheeler–Feynman's absorber theory does the same (J. A. Wheeler & Feynman, 1945). Experiments show that electromagnetic waves can repeatedly interact to form static states (Audretsch, 2004, p23) and repeated *observations* can maintain a quantum state if the time delay is short (Itano, Heinzen, Bollinger, & Wineand, 1990). It follows that electromagnetic waves can collides to form static standing waves just as other waves do (Figure 4.4). Quantum realism concludes that *an electron is a quantum standing wave created when extreme photons collide.*

This contradicts the standard model in several ways. Instead of a point particle made of nothing else, an electron is made of photons in a single quantum node. Instead of having no structure, those photons fill the channels of one axis. If matter is light trapped in a never-ending loop, *it isn't inert at all*. Matter is light "frozen" in place but still pulsing at the speed of light, like a stuck record endlessly repeating. Matter as a standing wave is both stationary and moving. But since this only applies on one axis, an electron is only *one-dimensional matter*.

When a computing processor gets in an infinite loop, it "hangs" and doesn't respond to input. When our devices hang, we just restart them but this doesn't work for the infinite loop of restarts described above. If a network node "locked" in an infinite loop that even a restart can't fix, it would be a major *glitch*. But for the quantum network, the *matter glitch* was an evolution not an error.

4.3.2. The charge byproduct

Current physics defines charge as what causes electrical effects and electrical effects as caused by charge. This circular definition, that charge is what charged particles have, means we don't really understand it. In the standard model, charge is a *self-evident property*, like mass, and the two are considered unrelated.

In contrast, quantum realism aims to *derive* physics not just *describe* it, so if mass is a processing overload that repeats, what is charge? An electron as positive quantum processing that repeats endlessly must leave negative processing that never runs, shown as the dotted lines in Figure 4.3. That a quantum network must keep its processing books in order suggests that the *charge of an electron is its permanent processing deficit.* So instead of an unrelated property, quantum realism suggests that *charge is the direct byproduct of matter*.

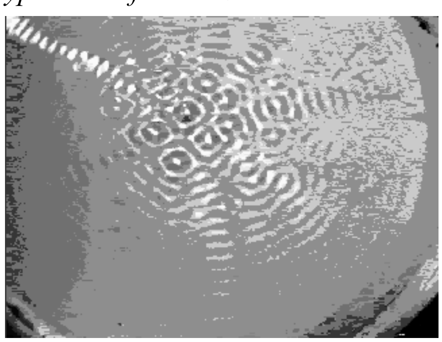


Figure 4.4. A standing wave on water

This conception fits the properties of charge. Charge as a processing remainder can be positive or negative as charge is, and opposite processing cancels just as opposite charges do. And since the electron repeatedly restarts, the processing remainder is constant, again as an electron's charge is. Quantum realism connects mass and charge, with mass the net *processing done* and charge the net *processing undone* per cycle. The next chapter covers how charge spreads on the quantum network to cause effects.

4.3.3. The neutrino option

Electrons are critical to our world as without them there would be no chemistry and no life, but our universe also contains a "little nothing" that until recently we didn't even know existed – the *neutrino*. The sun floods the earth with vast numbers of them each day that mostly pass through us like ghosts. The neutrino seems quite pointless, so why did nature make so many of them?

The standard model expects neutrinos to have no mass at all as they have no charge but their tiny mass was how we detected them in the first place. When asked why neutrinos have a *non-zero* mass but *exactly zero* charge, the standard model is silent.

In this model, the same photons that collide *in-phase* to give an electron in Figure 4.3 can collide *out-of-phase* as in Figure 4.5. Both "collisions" overload all the channels of an axis but while *photon heads* meeting gives an electron, *heads and tails* meeting mostly cancel to give the smudge on space we call a neutrino. So rather than a "building block" that seems to have no use, a neutrino is an alternative option required by the creation of electrons. Note that a tail-tail meet isn't possible because it implies a prior head-head meet.

But if a neutrino is an electron-type collision in a different phase, why doesn't its mass processing cancel entirely as its charge does? Perfectly synchronized head and tail processes would cancel but the quantum network, like the Internet, has no central control to synchronize it. The universal flow of light synchronizes adjacent nodes (2.4.4) but it isn't perfect, so the photons in a neutrino don't exactly cancel. Over many channels, these asynchronies give the small processing excess we call its mass, although the processing left over still exactly cancels. *The neutrino's tiny mass but zero charge reflect the asynchrony of the quantum network.*

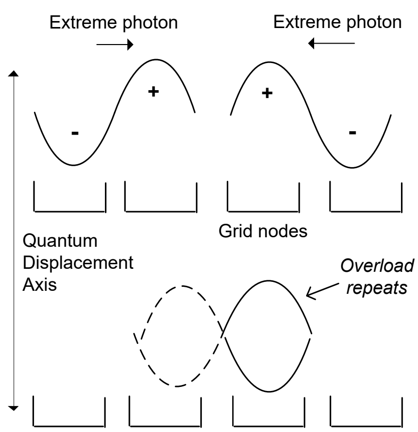


Figure 4.5. A neutrino channel reboot

To recap, a point of space *node* offers many *quantum channels* for every axis through it. The full set of channels for any transfer axis are a *channel set,* and it has a finite bandwidth just as each channel does. Table 4.2 describes electrons and neutrinos in terms of *channel set bandwidth,* where:

1. *Total processing.* Is the total processing, regardless of sign, that the local node must handle. If this "fills" the channel set bandwidth, the channels repeatedly overload in a *stable* result.
2. *Net processing.* Is the net processing after opposite displacements cancel out. It defines the *mass* as the ongoing server processing calls needed.
3. *Remainder.* The net processing left undone is *charge*.

Table 4.2. Lepton processing

Lepton	Photons "collide" in a node	Channel sets
a. Electron	*Photon heads* from one side	+1/2
	Photon heads from the other side	+1/2
	Total processing (stability)	**1 (full)**
	Net processing (mass)	**+1**
	Remainder (charge)	**-1**
b. Neutrino	*Photon heads* from one side	+1/2
	Photon tails from one side	-1/2
	Total processing (stability)	**1 (full)**
	Net processing (mass)	**~ 0**
	Remainder (charge)	**0**

Electrons and neutrinos are then brother leptons by their common one-axis photon structure, even though one is something and the other almost nothing. *Quantum processing repeatedly overloading all the channels of a node axis gave electrons and neutrinos as the first matter.*

4.3.4. Anti-matter

Dirac's equations predicted anti-matter before it was found but they didn't say *why* nature had given every matter particle an "evil twin" of the same mass but opposite charge. The standard model just added an anti-matter column to fit the facts but that the matter we see has an inverse remains one of the most baffling discoveries of physics. Why does nature even allow anti-electrons that can instantly annihilate electrons?

In quantum realism, anti-matter is to matter as neutrinos are to electrons – a necessary alternative. If our universe began with *one photon,* then it had to first vibrate *up* or *down* with respect to the surface of space. A clockwise rotation *in* space is anti-clockwise from the other side (Figure 4.6a) but a first-up rotation *on* a surface stays that way however it is viewed (Figure 4.6b). The first photon had to choose between *first-up* or *first-down* processing and all its offspring followed suit. So all the photons in an electron process the same way, say first-up.

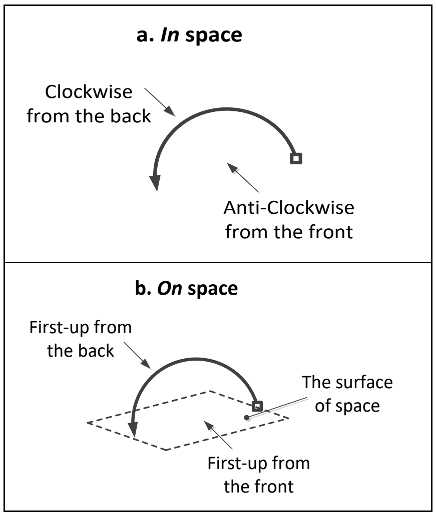


Figure 4.6. Rotation in and on space

All processing has the property that it can *run in reverse* so *processing implies anti-processing*, e.g. a quantum process that sets a circle of values from a start point can set the same values in reverse. So if an electron is photons processing one way, the same processing in reverse is an anti-electron. And if reversing an electron's processing gives an anti-electron, the same logic applies to every matter particle.

If *mass* is the net processing and *charge* is processing left-over, an anti-electron will have the same mass as an electron but opposite charge. A processing model of matter predicts the existence of anti-matter and its properties, including that an anti-electron will "annihilate" an electron, as both turn back into photons.

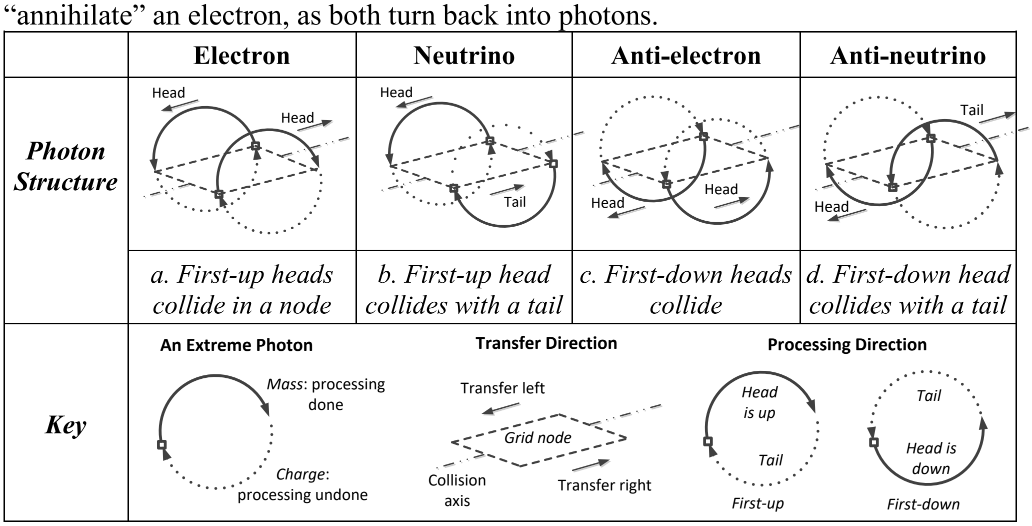


Figure 4.7. Lepton photon structures

Figure 4.7 defines the basic leptons by their photon components as follows:

1. *Matter. First-up* photons collide to give either an:
   i. *Electron (4.7a)*. "Up" *heads* collide to give mass and the negative remainders give negative charge.
   ii. *Neutrino (4.7b)*. "Up" *heads* mostly cancel "down" *tails* to give a tiny mass but the remainders cancel fully giving no charge.

2. *Anti-matter. First-down* photons collide to give either an:
   i. *Anti-electron (4.7c)*. “Down” *heads* collide to give mass and the processing remainder gives a positive charge.
   ii. *Anti-neutrino* (4.7d). “Down” *heads* mostly cancel “up” *tails* to give a tiny mass but the remainders cancel entirely to give no charge.

In sum, *quantum realism derives the “fundamental” leptons of the standard model from photons*.

4.3.5. Where did the anti-matter go?

The standard model treats matter and anti-matter as equivalent opposites, so while in our universe atoms have negative electrons there could be an anti-universe with positive electrons. In that world, everything would seem the same to its inhabitants *because the laws of physics would be exactly the same*. The problem then is, why do we only see matter all around us? Did the big bang produce:

1) No anti-matter, for some unknown reason?

2) Matter and antimatter equally but the antimatter in the universe is hidden?

3) Matter and antimatter equally but matter somehow “overcame” antimatter?

Physics dismisses the first option by the standard model and the second because no anti-meteors, anti-planets or anti-stars have been seen. The current view is that the big bang made equal amounts of matter and anti-matter, as per the standard model, then “somehow” matter overcame anti-matter. That no evidence supports this belief is called a “mystery” of physics:

> “*The lack of anti-matter is a deep mystery that cannot be explained using the Standard Model.*” (Oerter, 2006) p101

The standard model requires the first event to make equal amounts of matter and anti-matter because it treats them as equivalent but in quantum realism, our universe began with a single photon that had to choose whether to vibrate first-up or first-down on the surface of space. When our first photon chose processing over anti-processing, our universe became matter not anti-matter. The first light then evolved into matter only, not matter and anti-matter equally as the standard model says. *It follows that the anti-matter the standard model is trying to explain away never was*. The first photon chose to oscillate one way and from then on anti-matter was a path not taken. Physical realism can’t explain why our universe is matter not anti-matter because that choice occurred before the physical universe began.

4.3.6. Anti-time

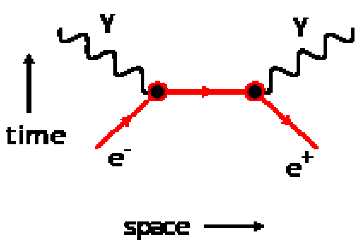


Figure 4.8. A Feynman diagram

The assumption that time always works the same way doesn’t apply to anti-matter (Ambjorn et al., 2008). For example, in the Feynman diagram of an electron hitting an anti-electron, the latter *enters* the collision going *backwards in time* (Figure 4.8). The logic is symmetric, so to the anti-electron the electron is going back in time. Yet both the electron and anti-electron are *entering* the interaction not leaving it.

Minkowski interpreted Einstein’s theory to mean that objects can move faster or slower along the time dimension in a *block theory of time,* where every event that ever was or will be can be paged like a book (Barbour, 1999). Minkowski’s model has *one* time dimension so a particle going “*backwards in time”* is reversing causality but the anti-matter particle in Figure 4.8 isn’t doing that. The anti-electron is *entering* the collision just as the electron does with no causal reversal, so Minkowski’s interpretation struggles to explain how time runs backwards for anti-matter. If time is an independent dimension, to reverse time is to travel back in time and deny the causality behind all physics.

In quantum realism, time is a construct that passes as processing cycles complete, not part of a spacetime "canvas" upon which matter exists. This fits Einstein's conclusion that every particle in the universe in effect has its own "clock", because in a distributed quantum network, every node runs at a rate that varies with the local load.

If time passes as processing cycles finish, matter has a tick of time for every forward processing cycle and anti-matter has a tick of time for every backward cycle. Anti-matter exists in *anti-time* as matter exists in *time* because for matter a forward cycle is a tick of time and for anti-matter a reverse cycle is a tick of time. *To a matter being,* anti-matter runs time in reverse but *to an anti-matter being* we are the ones running time in reverse. Matter exists by processing while anti-matter exists by anti-processing, but in both cases there is "forward" processing that defines their time.

That anti-matter runs time in reverse is possible because our time is virtual. This doesn't mean that anti-matter time can reverse causality but that *Feynman diagrams need dual time axes, one for matter time and one for anti-matter anti-time*. Anti-time is an alternate virtual time that exists because anti-matter processing is the reverse of matter processing. That processing creates time means that not only does every particle in the universe have its own clock, *it also decides its own clock direction*.

One might suppose that if reality is virtual, then time can rewind just as an Internet browser has a "Back" button. But a browser back button only undoes *your* last act, it doesn't undo interactions like online registrations as this must reverse both parties. With six degrees of separation, rolling back just six events for one person could affect the entire web! To undo *interactions* one must roll-back the entire network and this is also true for the quantum network.

In quantum realism, anti-time doesn't imply time reversal because a physical event is a processing reboot that can't be undone. Anti-matter exists in anti-time *between* physical events but it can no more undo its physical interactions than matter can. In our universe, physical events cannot be reversed, rewound or fast-forwarded, whether by matter or anti-matter, so there is no time travel. If the past is gone and the future is not yet defined, there is only an eternal now.

4.4. QUARKS

Quarks constitute the atomic nuclei that make up nearly all the matter we see. If neutrinos are strange then quarks are stranger, as their charges come in unexpected *thirds* and their nuclear binding *increases* with distance. Yet they obey the equations of matter, so can the processing that explains electrons and neutrinos be extended to account for quarks? Quarks must somehow be more than the *one-dimensional matter* of electrons and neutrinos.

4.4.1 A triple collision Standard model quarks are fundamental particles not related to electrons and neutrinos. and they come in two types called "up" and "down", with different masses and charges. An up quark has a plus ⅔rds charge and a down quark has a minus ⅓rd charge for no known reason, except this conveniently lets two down quarks combine with an up quark to give a proton that is the nucleus of Hydrogen, the first periodic table element.

For quark mass to arise like that of an electron, it must also be based on an extreme photon collision. So if leptons are a two-way collision, quarks must be a three-way collision, where three beams of extreme light meet in one node (Figure 4.9). Again, this unlikely event must have occurred in the first plasma by the quantum law of all action. The collision is in a plane, so if one axis line needs two beams to fill its channels, it needs four beams to fill the dimensions of a plane. Two beams colliding fill the channel set of one axis but three beams colliding fill only 1.5 channel sets, not the two that a plane has.

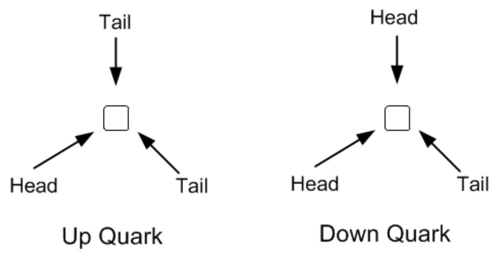


Figure 4.10. Up/down quark structure

Hence the result can't be stable alone and indeed quarks are never observed alone. Had this not been so, the model would fail, leaving few other options for consistent reverse engineering at this point.

A three-axis collision has an interesting symmetry, as photons on any of the three axes half exist on the other two by the cosine rule[49] so any quark axis is one beam vs. two others at half strength, i.e. a lepton type collision. That a quark is a semi-stable symmetry that can combine with other quarks to give a stable planar structure is now explored.

4.4.2 The phase options

One day, how three beams of extreme light at equal angles meeting at a point interact may be resolved by simulation or experiment but for now it must be envisaged. In the lepton case, two beams meeting head-on can complete the one channel set bandwidth of one node axis, as each contributes half a channel set. This gives the repeating overload we call *matter* and the *charge* remainders correctly for leptons and anti-leptons.

In the quark case, *three* beams meet in a node where again each provides half a channel set. To give stable matter by the same logic, the result must fill the channels of a *plane* not just a *line*. A node plane has two dimensions so its bandwidth is two channel sets. Dividing the two channel sets of a plane by three-axes of colliding photons means *each collision axis fills at two-thirds of a channel set*.

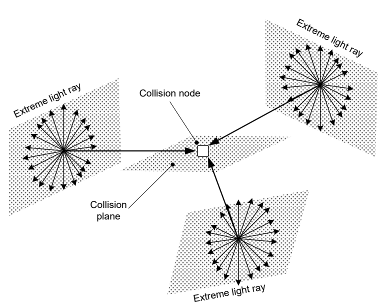


Figure 4.9. Three extreme light beams meet

A tail-tail-tail meet isn't possible as it implies a prior head-head-head event so the phase options are:

1. *Head-head-head.* Three sets of photon heads meeting at equal angles in a node will allocate processing equally. Every axis is only partly filled so it has free channels that let other entities in so the result isn't stable.
2. *Head-tail-tail.* Now two photon beams leave a node as another arrives, as shown in Figure 4.10a. For the reasons given next, this is proposed to be an *up quark.*
3. *Head-head-tail.* In this case one beam has passed through the node as the other two arrive, as shown in Figure 4.10b. For the reasons given next, this is proposed to be a *down quark.*

[49] A photon moving on axis X has a quantum amplitude on axis Y cutting X that decreases as Cos(θ), where θ is the angular difference between X and Y. For a quark with three axes, each one has two others cutting it at 60^0, where Cos (60^0) is one half.

Of these options, the last two are proposed to be up and down quarks (Figure 4.10).

4.4.3 A three-way structure

A three-way meeting raises the issue of *interaction order* as photons compete for channels on a first-come-first-served basis. If a photon head entering a node meets a photon tail leaving it, the tail must start before the head or it would be a head, giving the rule that *tails fill channels first.* Following this logic, Table 4.3 gives the expected processing result in channel sets as before, except now there are three collision axes not just one. Again, mass is the net processing and charge is the net remainder but now the axis bandwidth is only two-thirds of a channel set. The details are:

1. *Up quark.* If two extreme photon beams leave a node as another arrives, the tail sets first fill a *charge axis* with a plus two-thirds charge left over. The remaining tails and the later arriving heads then fill a *neutral axis* where the remainders cancel. This leaves a *free axis* with a sixth of a channel set of entangled photons. The result has two-thirds charge and is stable on two axes but has extra photons in the third axis.
2. *Down quark.* If one beam has passed through a node as the other two arrive, the tails first cancel opposing heads to fill a *neutral axis* as the remainders cancel. Then the heads and the remaining tails fill a *charge axis* with a minus third charge left over. This again leaves a third *free axis* with a sixth of a channel set of entangled photons. The result has a minus third charge and is again stable on two axes with again extra photons in the third axis.

Table 4.3. Quark processing details by axis

QUARKS	*Photons meet in a node*	*Processing channel sets by axis*		
		Charge	*Neutral*	*Free*
Up quark	*Tail* exits charge axis	-1/3	-1/6	
	Tail exits neutral axis	-1/3	-1/6	
	Head enters free axis	0	+1/3	+1/6
	Total processing	**2/3 (full)**	**2/3 (full)**	**1/6**
	Net processing	**-2/3**	**~0**	**±1/6**
	Remainder	**+2/3**	**0**	**0**
Down quark	*Tail* exits neutral axis	-1/6	-1/3	
	Head enters charge axis	vs +1/3	vs +1/6	
	Head enters free axis	+1/6	+1/6	+1/6
	Total Processing	**2/3 (full)**	**2/3 (full)**	**1/6**
	Net Processing	**+1/3**	**~ 0**	**±1/6**
	Remainder	**-1/3**	**0**	**0**

This result is interesting because it gives the correct third charges for quarks which no other model does[50]. While the standard model *allocates* one-third charges to quarks after the fact, quantum realism *derives* them. It predicts that quarks occupy one node like leptons but only fill two of the three collision axes.

To sum up, the proposed quark structure is:

1. *Charge axis*. Holds the quark charge, of up quark +⅔ and down quark -⅓.
2. *Neutral axis*. Heads and tails cancel with no remainder.
3. *Free axis*. The remaining one sixth channel set of photons is “extra”.

[50] Table 4.3 partitions three half channel sets colliding as ⅔rds + ⅔rds + ⅙th = 1.5 where each axis fills at ⅔rds of a channel set. The result is a half short of the two needed but gives two stable axes with an excess of free photons in the third axis.

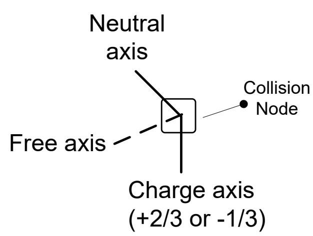


Figure 4.11. Three quark axes

Figure 4.11 summarizes the proposed structure where the axes are at 60° even though the photons meet at 120° because quarks are head-tail mixes, so one beam is always *leaving* as the others *arrive*.

That quarks aren't stable individually fits the fact that they never exist alone. Their *symmetric* structure might let a group of them maintain an exterior of stable axes but as quarks are stable in a nucleus, they must somehow connect to fill all the channels of a plane, or again the model fails. Physics calls that connection the *strong force*.

4.4.4 The strong force

The forces that bind protons and neutrons in an atomic nucleus are so strong that when they break there is a nuclear explosion. The bond has to be that strong to overcome the huge electric repulsion between same charge protons. Since protons and neutrons consist of quarks, particle physics needs a *strong force* to bind them in the nucleus. This force has the peculiar property that it has no effect at very short range but gets *stronger* as quarks get further apart. It exchanges no energy so it isn't electro-magnetic and it increases with distance so it isn't gravity. The standard model required a new field that generated new particles, as described by *quantum chromodynamics*.

Quantum chromodynamics was a field theory derived by analogy to *quantum electrodynamics*, the field that generated electromagnetism. It described a new *strong field* that emitted new particles called *gluons* with a new *color charge*. In essence, the strong field acted via massless gluons just as the electromagnetic field acted via photons. These gluons are said to carry red, blue and green charges that bind quarks in a proton just as photons bind electrons in atoms, but with three values not two. These red, blue and green charges cancel to "white" just as positive and negative charges cancel to neutral. But three colors need anti-colors so to turn a red quark blue needs an anti-red gluon as well as a blue gluon. Yet the calculations worked, so when in 1978 the PLUTO project managed to interpret a three-jet Upsilon event in gluon terms, gluons joined the standard model pantheon. No-one spoiled the party by asking why a *universal* field through *all space* was needed for a *quark-only* effect.

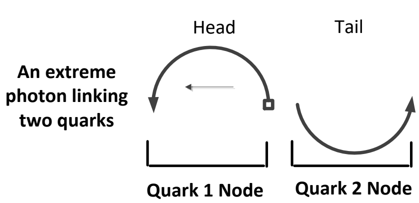


Figure 4.12. One photon in two quarks

Quantum realism interprets the same facts quite differently, as it attributes the strong force to quarks *sharing photons.* As shown in Figure 4.12, an extreme photon with its head in one node and tail in another can exist across two quarks that are side-by-side. It is proposed that the extra photons in the quark free axis essentially act as "hooks" that can insert themselves into other nearby quarks. In this view, quarks bind to other quarks by sharing photons rather than being "pushed" together.

Photon sharing gives a bond that is initially zero but increases with distance, for as linked quarks separate the shared photon wavelength increases to release the energy needed to pull them back together. In the next chapter, matter moves by a probabilistic reboot so stretching a photon increases the processing in the gap making the quarks more likely to restart there. The more the quarks separate, the stronger the effect, hence quarks side-by-side experience no force when close but are pulled together as they separate. In effect, shared extreme photons are the "elastic bands" that hold quarks together.

Does photon sharing let quarks fill all the channels of a node plane to achieve stability? Unless this is possible, the quantum processing model again fails.

4.4.5 Protons and neutrons

The atomic nucleus that was once thought indivisible is now known to consist of protons and neutrons that in turn are made up of quarks. A proton is two up quarks and a down quark and a neutron is two down quarks and an up, so the odd quark charges add nicely to give a positive proton and a neutral neutron (Table 4.4). How do quarks achieve this?

Table 4.4. Quarks give protons and neutrons

	Quark 1	Quark 2	Quark 3	Charge
Proton	Up $+\frac{2}{3}$	Up $+\frac{2}{3}$	Down $-\frac{1}{3}$	+1
Neutron	Up $+\frac{2}{3}$	Down $-\frac{1}{3}$	Down $-\frac{1}{3}$	0

If the free photon "hooks" of one quark insert themselves into the neutral axis of another quark, this gives a sixth of a channel set of processing in *both* quarks (Table 4.5A). Note that one photon in two adjacent quarks uses all its processing with no remainder. Now let photons from the second quark neutral axis return the favor until the first quark axis is full (Table 4.5B). Both axes are now complete and the positive and negative processing remaining in the neutral axis still cancels to neutral (Table 4.5C). Quark charge is unaffected because the charge axes aren't involved so free-neutral photon sharing completes the free axis and leaves the neutral axis the same. Photon sharing not only binds quarks but also creates the extra processing needed to stabilize the free axis of the first quark.

Table 4.5. The strong link completes quark 1

	Quark 1 Free Axis	*Quark 2 Neutral Axis*
A. The free photons of quark1 insert their tails into quark2	$[+\frac{1}{6}^{th}]$ ----	---> $(-\frac{1}{6}^{th})$
B. Quark 2 photons reciprocate until the quark 1 axis is full	$(-\frac{1}{4})$ <---- $(+\frac{1}{4})$ <----	---- $[+\frac{1}{4}]$ ---- $[-\frac{1}{4}]$
Total Processing	$\frac{2}{3}^{rds}$ (full)	$\frac{2}{3}^{rds}$ (full)
C. The quark 2 remainders cancel		$+\frac{1}{12}$, $-\frac{1}{12}$

This link only completes one quark but the second quark can also complete its free axis by linking to a third quark that can also complete by linking back to the first. Figure 4.13 shows how the triangular structure of quarks lets them share photons in a triangle so that all become stable. The result is a proton or neutron depending on the quark mix, just as current physics asserts, but now what binds the quarks isn't magical particles from nowhere but photon sharing between quarks.

What then are the gluon "color charges"? That each quark needs a different axis status to link in a triangle suggests that the standard model's red, blue and green "charges" are *quark orientations.* A quark as an inert particle might need an agent to change its axis orientation but quarks as dynamic processing swap axes *naturally,* as every cycle is a new event. Every cycle, photons compete for channels by each trying to occupy any channel they can. If it fails because another got there first, it just tries elsewhere. There is no predefined plan, just a free-for-all that gives different axis outcomes each time, so all that is needed to change a quark axis orientation is another quantum cycle

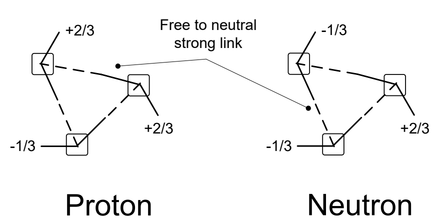


Figure 4.13. Proton and neutron quark structures

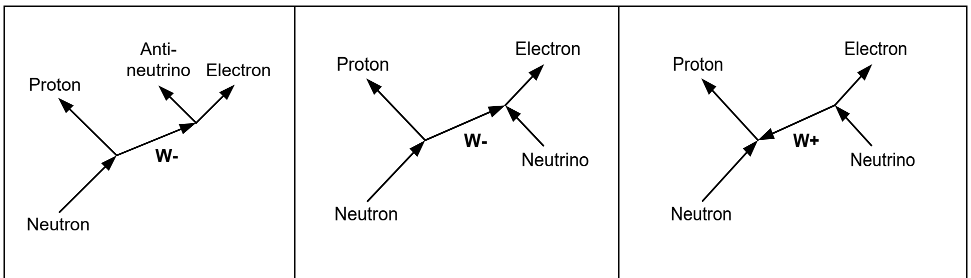
An analogy might illustrate how quantum processing fills channels. Imagine a stack of wine glasses upon which water is falling. When the water fills one wine glass, the remaining water just flows from it to the next, until every glass is full. *Hence there is no need for any central control to "manage" the allocation of water to glasses.* Now suppose there is exactly enough water to fill all the glasses, and when this happens the system restarts, i.e. all the glasses empty and another water pouring cycle begins. In the same way, the quantum processing of a quark fills all the channels of a node plane to trigger a restart that repeats the cycle.

This approach reflects the earlier conclusion that the quantum world tries every option until a *stable* result occurs, which here means that all the channels of an axis *complete*. To see matter as an inert thing that must be pushed to change is like thinking a running video has to be "pushed" when actually the processing does that. Likewise, what "pushes" the world to change is quantum processing not invisible particles.

In quantum realism, an electron becomes stable by completing the channels of one axis and three quarks do the same for two axes by sharing photons in a triangle. Protons and neutrons *evolved* because they filled the channels of two dimensions not because invisible agents forced them together. The strong force arises because quarks have a processing *excess* while electromagnetism arises because electrons have a processing *deficit.*

4.4.6 The weak force

Physics then discovered that while a neutron is stable in a nucleus, after about fifteen minutes in empty space it turns into a proton. One of its down quarks "flips" to become an up quark, turning the whole into a proton. Again the standard model needed *some agent* to cause neutron decay and as gluons couldn't do it, it postulated a new *weak* force that:



a. A neutron emits a W- to decay into a proton: $N \rightarrow P^+ + e^- + \underline{\nu}$	b. A neutron emits a W- as it interacts with a neutrino: $N + \nu \rightarrow P^+ + e^-$	c. A neutron absorbs a W+ as it interacts with a neutrino: $N + \nu \rightarrow P^+ + e^-$

Figure 4.14. Standard model neutron decay routes

1. *Affects all matter*. Electromagnetism affects charge and gluons affect quarks but the weak force affects all matter.
2. *Violates parity-symmetry*. Weak interactions are left-right different.
3. *Has no bound state*. Electromagnetism binds atoms in molecules, the strong force binds nucleons in the nuclei and gravity binds stars in galaxies but the weak force binds nothing.
4. *Was asymmetric*. Neutrons decay into protons but protons are stable in space.

Since neither strong nor electromagnetic forces act like this, the standard model followed the by now standard practice of inventing a new *field* with new *bosons* and *charges*. The new charge, called *isospin* (+½,-½),was retro-fitted to allow charm quarks to interact with down quarks but not up quarks, etc., as observed. But this time the boson agents needed had to be heavier than protons and a field that *absorbed and emitted mass* was unheard of.

Yet by now, virtual agents were the norm and given the equations worked, it was accepted practice to "prove" they existed by finding matching accelerator collision resonances. So when in 1983 CERN found million, million, million, millionth of a second values in the expected range, *weak bosons* immediately joined gluons in the standard model pantheon. On this flimsiest of evidence physicists today claim that:

> "*Experiments have observed three bosons that carry the weak force*" (Marburger, 2011) p221.

Now suppose a murder case witness said "*I have observed the knife that killed the victim*" but on cross-examination revealed that he made a knife of the same size in his knife shop! No court in the land would accept that evidence so why does physics call the same thing "proof"? *CERN observed the energy spikes that it created not bosons carrying any force!* Since no evidence whatsoever links the CERN signal to the weak effect, *it isn't proven at all*. If finding a matching energy spike proves a virtual agent exists, does not finding one for gravitons mean they don't exist? One can't have it both ways. Even so, physics now accepts that neutrons decay when a 4.8 MEv down quark "emits" a W boson of mass 80,400 MEv! No-one questions how such a *tiny* particle could ever emit such a *massive* particle.

Even worse, the equations testify that a neutron can decay in any of three ways, as it could:

1. Emit a W^- that decays into an electron and anti-neutrino (Figure 4.14a), OR
2. Emit a W^- boson that is hit by a neutrino to give an electron (Figure 4.14b), OR
3. Interact with a neutrino and a W^+ boson to give an electron (Figure 4.14c). Three different causes might seem better than one but are three different alibis for a murder better than one? That a quark *could* emit a W- into a field or *could* absorb a W+ from one is the sort of after-the-fact reasoning that science is supposed to protect us from.

The equations were also reversible, leading to a fruitless thirty-year search for proton decay. Currently, the massive Kamioka experiment estimates the free proton half-life is over a billion, billion, billion years, so *protons definitely don't decay as the standard model predicts*.

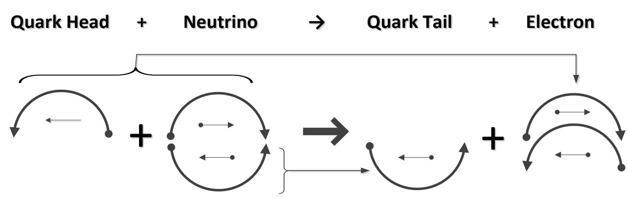


Figure 4.15. A neutrino converts a quark head into a tail

The reverse engineered quark structure given earlier suggests a simpler alternative. If a down quark is a *head-head-tail* photon mix and an up quark is *head-tail-tail* set, a neutron becomes a proton when *a set of photon heads become tails*. As Figure 4.15 shows for one channel, if a neutrino hits a quark head directly the processing can rearrange to turn quark heads into tails. A neutrino hitting a neutron just right can turn it into a proton as the beta decay equation implies[51]. Conversely a proton needs an *electron* hit to turn its tails into heads but to get an electron right next to a quark takes a lot of energy hence proton decay occurs only in the hearts of stars. The effect described doesn't alter the net remainder so it isn't electromagnetic, no photons are shared so it isn't strong and it affects any head/tail photon mix, i.e. all matter.

Quantum realism concludes that the weak effect is due to neutrinos that are all around us. It predicts that a neutron in a neutrino-free space won't decay. Hence weak bosons, like fairies at the bottom of the garden, are made-up agents.

4.4.7 The God particle

That massive particles pop out of empty space created a problem for the standard model. The W boson mass had to come from somewhere so the answer was of course *another field!* The Higgs particle proposed was needed to sustain the particle business, so the search for the Higgs became the holy grail of physics, attracting over 30 billion dollars in funding. Then in 2012, after a fifty-year search, CERN found a resonance in the right *range*[52] and physicists all over the world breathed a sigh of relief, calling it the "God particle", perhaps because it answered their prayers. Finding a million, million, million, millionth of a second 125GeV signal meant the standard model lived on! Yet the Higgs particle:

1. *Doesn't explain mass.* The Higgs flash adds no value to general relativity, our best theory of mass to date, nor does it explain the dark energy and dark matter that is most of the universe. Its only role is to rescue the standard model:

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[51] In beta decay, a neutrino hitting a neutron can turn it into a proton by the equation $N + \nu \rightarrow P^+ + e^-$. Equally an electron can turn a proton into a neutron by inverse beta decay $P^+ + e^- \rightarrow N + \nu$. Why insert fictional boson particles into these equations?

[52] The researchers note: "*The theory does not predict a specific mass for the Higgs boson.*" (CMS collaboration, 2012) so *any* high mass particle would have done the job.

> "*… the Higgs field allows us to reconcile … how … weak interactions work, that's a far cry from explaining the origin of mass or why the different masses have the values they do.*" (Wilczek, 2008) p202

So the Higgs isn't about mass creation at all but about sustaining the standard model of particles.

2. *Is medieval circular logic.* If a massive Higgs particle creates mass, what gives it mass? If another Higgs, what gives it mass and so on? A Higgs particle that begets itself is indeed a God particle! Some say *the field itself* creates the mass but what then does the Higgs boson do? Weren't bosons invented to avoid invisible fields causing visible effects in the first place? That *like creates like* harks back to the medieval fallacy that only water can cause wetness. Science debunked this by showing that water comes from hydrogen and oxygen *gases* that aren't watery at all. Instead of the circular logic that mass creates mass, in quantum realism mass comes from the energy of photons.
3. *Is impossible by quantum theory.* In a carefully crafted press release, CERN claimed that zero-spin would confirm the Higgs then found it so but quantum theory clearly states that a spin-zero point particle with mass is impossible (Comay, 2009). All known point particles with mass are spin-half particles and only matter-antimatter mixes like mesons have spin zero. Since not-yet-found higher order mesons have zero-spin, are in that mass range and have the same photon decay and detection frequency, "The Higgs" is more likely a top or anti-top meson.

In essence, the Higgs is a medieval circular logic that explains at best 4% of the mass of the universe in a way that is impossible according to quantum theory. That what at best explains at best a tiny fraction of the mass of the universe is now called the "origin of mass" is a tribute to the power of marketing not science.

The Higgs is the culmination of the belief that *inert particles* can only be pushed around by other particles. To sustain this vision, physics had to invent *virtual particles* that don't exist in any normal sense. *The grand irony of it all is that physical realism today is now justified by a multitude of unreal virtual agents!* For example, consider what it implies about the matter around us:

> "*The Higgs mechanism is often said to account for the origins of mass in the visible universe. This statement, however, is incorrect. The mass of quarks accounts for only 2 percent of the mass of the proton and the neutron, respectively. The other 98 percent, we think, arises largely from the actions of gluons. But how gluons help to generate proton and neutron mass is not evident, because they themselves are massless*." (Ent, Ulrich, & Venugopalan, 2015)

It is true that nearly all an atom's mass comes from the protons and neutrons in its nucleus and most of their mass comes not from quarks but the virtual gluons binding them. *It follows that, according to current physics, nearly all the mass we see around us comes from massless virtual particles!*

Actually, the Higgs is an imaginary agent created to explain another imaginary agent created to explain an observed effect, namely neutron decay. When a theory uses one invisible thing to explain another it becomes a theoretical house of cards. It is telling that years after apparently finding the "god particle", it hasn't led to a single other discovery or benefit.

4.4.8 Mass and energy

It originally seemed that light had the property of energy but no rest mass and matter had the property of mass but no rest energy, until Einstein concluded that light had a relativistic mass and matter had a resting energy that could be released in nuclear bombs. It became apparent that mass and energy were somehow related.

Mass was originally defined as *weight* but this was later changed to be called *gravitational mass*. Newton's discovery that a mass needed a force to accelerate it led to the different definition of *inertial mass*. They are different because a weightless object in space still needs a force to move it, i.e. it has inertial mass even though it has no gravitational mass. If *momentum* is defined as mass times velocity, a massless photon should have no momentum but solar sails move when the sun shines on them and photons are bent by the gravity of the sun. This led to another definition upgrade as a photon with no *rest mass* was said to gain *relativistic mass* as it moves to give it momentum[53].

Light was originally seen as pure energy, where *Planck's relation* $E = hf$ defined the energy E of a photon as its frequency f multiplied by Planck's constant h. The last chapter interpreted this relation in processing terms. If a photon is one quantum process spread out, its energy was the *processing transfer rate* at the node. Since the throughput per node reduces as more nodes share the process, a photon's energy decreases as wavelength increases. Conversely as wavelength decreases, fewer nodes running the same process each get a bigger share so photon energy increases with frequency. If matter is made of photons running at the highest possible frequency, it follows that the inherent energy of matter relates to the energy of those photons.

Einstein's equation $E=mc^2$ does for matter what Planck did for light, define its energy. In 1905 he deduced that the energy of matter is its mass times the speed of light squared and atom bombs confirmed this but it has never been clear why mass relates to light at all. *If mass is an inherent substance, why does its energy refer to the speed of light?*

In quantum realism, an electron is many photons repeatedly colliding in many node channels. Each channel contains the equivalent of *a photon with a one node wavelength,* whose energy by Planck's relation is Planck's constant times the speed of light divided by one Planck length. If Planck's constant is one quantum process transferred over a Planck length squared per Planck time, substituting for Planck's constant in Planck's relation gives Einstein's equation for mass and energy[54]. Quantum realism thus *derives* Einstein's equation from the conclusion that matter is light condensed.

[53] Relativistic mass is defined by special relativity. Rest mass is mass with no relativistic effects.

[54] In this model, the speed of light $c=L_P/T_P$, for L_P Planck length and T_P Planck time. A photon's energy $E_P=h_P.c/\lambda$, for h_P the energy of one quantum process transfer, c the speed of light and λ the wavelength. In an electron λ is one node, so $E_P=h_P.c/L_P$. If mass m_p is the program that repeats, h_p transfers m_p over a Planck length square every cycle, i.e. $h_P=m_p.L_P.L_P/T_P$. Substituting gives $E_P= m_p.L_P.c/T_P$, or $E_P=m_p.c^2$. This derivation doesn't prove $E=mc^2$. Einstein did that based on how our physical world behaves. It just finds this model consistent with Einstein's equation.

4.4.9 A summary

In current physics, the fundamental entities of the standard model are described in terms of mass, charge and energy, where energy relates directly to mass.

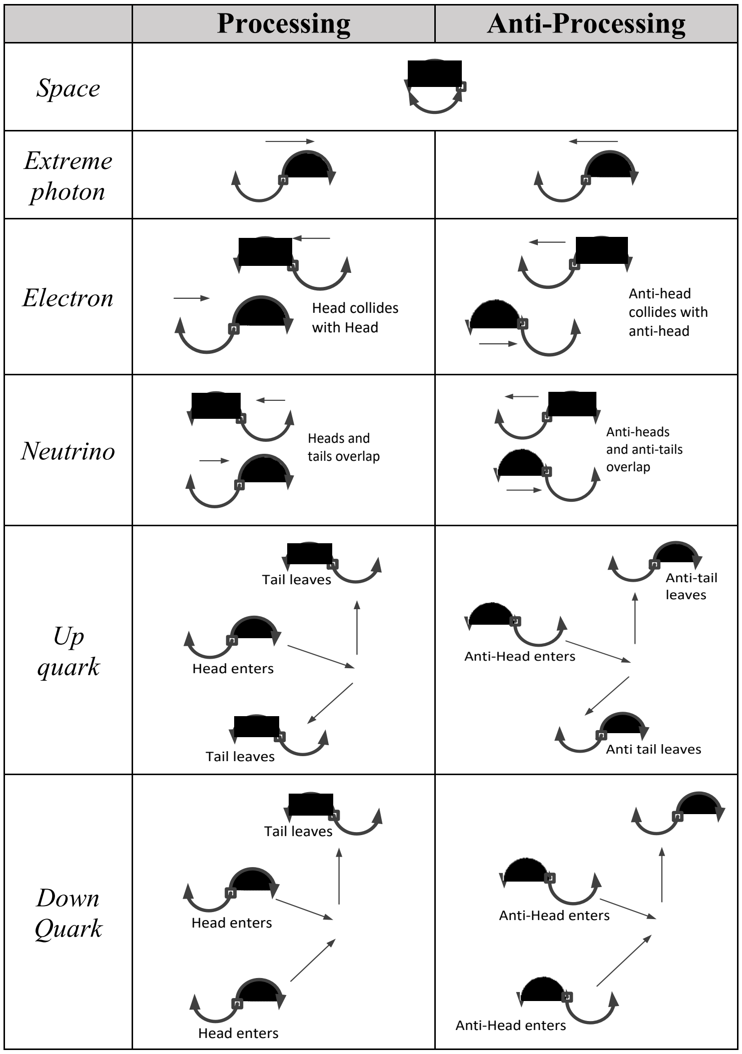

Figure 4.16. The basic processing combinations

Quantum realism describes the basic entities of physics in terms of quantum processing. Quantum realism describes the basic entities of physics in terms of quantum processing. Mass is the net processing that repeats endlessly when a node "hangs" the quantum network, charge is the net processing left-over that never runs, and energy is the processing transfer rate per cycle. Figure 4.16 summarizes this model based on mass, charge and energy:

1. *Space.* A point of empty space is a node that runs one quantum process in every channel. The net processing is zero so it has no mass, the transfer rate averages zero so it has no net energy transfer and a zero remainder gives no charge.
2. *Photon.* A photon can't stop to be weighed but its net processing at each node gives it mass, its processing transfer rate defines its energy, and no processing left over means it has no charge.
3. *Electron.* An electron fills the channels of a node axis with positive processing to give mass and the processing remainder gives it a negative charge.
4. *Neutrino.* A neutrino's axis channels are filled with positive and negative instructions that nearly cancel to give a tiny mass while the remainders cancel to zero charge.
5. *Quark.* A quark is a three-way photon collision that doesn't quite fill the channels of a plane but its net processing repeats so it has mass and the remainder gives one-third charges according to phase (up or down).
6. *Anti-matter*. Anti-matter versions of electrons, neutrinos and quarks are derived by reversing the processing. The net processing demand is the same giving the same mass but an opposite remainder gives an opposite charge.

Quantum realism represents the mass, charge and energy of the basic entities of physics in processing terms.

4.5. FIELDS UPON FIELDS

Following Newton's idea that only *particles* affect other particles, physics spent most of last century trying to prove that *particles* cause all the forces in nature. The aim was to explain forces like magnetism and charge that act at a distance with no actual particles in sight. They succeeded in inventing a world where unseen virtual particles vastly outnumber real particles.

4.5.1 The many fields problem

Currently, light is seen as a vibration of the electromagnetic field, where according to Feynman:

> "*A real field is a mathematical function we use for avoiding the idea of action at a distance*." (Feynman et al., 1977) Vol. II, p15-7

Fields are common in physics today, e.g. the earth holds the moon in orbit by a gravitational field that exerts a force at every point in space, an electric field sets values at every point in space, and so on for other fields. Emboldened by the success of Faraday's fields, physics began to invent fields that added what mathematics calls *degrees of freedom* to space.

Adding a degree of freedom to each point of space in effect adds a dimension to it, so *adding many fields is like adding many dimensions to space*. Gravity required one-dimension, electromagnetism two, the strong force three and the weak force two. These eight extra dimensions plus the three of space are why *string theory needs eleven dimensions to work*.

Yet the mathematics soon gets out of control because all these dimensions interact. Indeed, the main "discovery" of string theory's attempt to explain the fields of physics mathematically was that it gives an almost unlimited number of possible architectures, over 10^{500} at least. This is why string theory doesn't predict anything, so few scientists today see it as a fruitful approach. That a universe of eleven dimensions somehow collapsed into ours is a far-fetched idea akin to the multiverse story.

The alternative is some sort of *field unification* that reduces all the fields of physics to one. This is said to be a primary goal of physics today but the standard model only offers more fields not less, as its only answer to an unexplained effect is a new field. Quantum realism proposes that one field, the *quantum field,* generates all the effects we see.

4.5.2 The frog in the pan

In an apocryphal story, a frog dropped in a pan of boiling water jumps out immediately but if put in tepid water that is *slowly* brought to the boil, by the time it realizes the danger it is too weak to jump out and perishes. The standard model seems to have done something similar last century. It began when Faraday proposed that an invisible field around an electric charge caused it to attract and repel other charges at a distance. This was considered fanciful until equations defined the electromagnetic field but today, fields explain every force in physics. Yet a field is a *disembodied force* that acts at a distance and Newton, centuries earlier, had issues with this:

> "*That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance thro' a vacuum, without the mediation of anything else … is to me so great an absurdity, that I believe no man … can ever fall into it. Gravity must be caused by an agent…*" (Oerter, 2006) p17

Maxwell derived his equations by imagining ball-bearings twisting in vortex tubes but attempts to develop his physical model failed. Driven by the belief that something physical had to make iron filings move in a magnetic field, *field theory* came up with the idea that the field created *force-carrier particles* to do its bidding. Since electromagnetism acted in photon units and Einstein had shown that photons were particles, this worked nicely.

The standard model was born when Maxwell's equations were interpreted as virtual photon effects made by Faraday's invisible field. Yet these *virtual photons,* unlike real photons, couldn't be independently verified because they come into existence, cause an effect and then are instantly consumed by the act. Agents that can't be verified contradict science but physicists could *see them in the equations.* This scientific flaw seemed a small price to pay to carry on calculating, but the pseudo-science temperature had just gone up a notch.

Since a photon is a boson, field theory generalized that all fields act via *boson agents.* Hence gravitational fields had to work via virtual particles called *gravitons* that to this day have no real-world equivalent. There is no evidence at all that any such particle has ever existed yet they are accepted by the fallacy that to name a cause is to offer an explanation. To suppose a thing exists just because a theory says so contradicts science, so again the pseudoscience temperature rose as scientific rigor fell.

Then field theory turned to the strong force that binds protons and neutrons in the nucleus. In this next step, massless, charge-less virtual photons were joined by virtual gluons with color charge, so fields could now create *charge*. Soon after the weak force was attributed to a weak field that generated weak bosons with both charge and *mass*. Things were heating up so it was essential to show that this virtual particle at least existed. When a match was found among billions of particle accelerator events it was declared "proven", ignoring established scientific methods for establishing causality.

Finally, to allow virtual particles with mass it was necessary to invent another field with a virtual particle so massive it needed a billion-dollar accelerator to find it. All this, to support the physical realism canon that:

"…the forces of Nature are deeply entwined with the elementary particles of Nature." (Barrow, 2007) p97

Physics has pasted field upon field to prove this belief until now virtual particles pop in and out of space to cause every effect. They are said to be everywhere making everything happen despite *no scientific evidence they cause anything all*. Despite being lawful, they are *magical*, because an invisible field creates them and their effect absorbs them, so by definition they can *never* be verified. Virtual particles are the scientific version of a blank check and once physics accepted unverifiable causes it couldn't go back. *Each new field invention has weakened physics scientifically until, like the frog in the pan of water heating up, it is now in danger of dying as a science*.

4.5.3 Virtual particles aren't necessary

Suppose one could see a computer output but had no access the hardware and software that created it. If one saw that every change occurred in bit amounts, would one assume that virtual "bit particles" created them? A better conclusion is that the bit is the basic unit of processing. When physics *deduced* virtual photons, all it really knew was that photons exist and electromagnetism changes in photon amounts. Following Newton, it concluded that virtual photons were the cause.

Quantum realism sees the same facts differently. Electromagnetic effects occur in photon units because the photon is the basic network operation, so all changes inevitably *look like photon effects*. The quantum network changes in photon units for the same reason that computer outputs change in bit units. The link between photons and electromagnetism is *correlation not causation*, and confusing the two is the oldest error in science[55]. Quantum processing that tries every option doesn't need agents to push it, e.g. an electron can fall to a lower energy orbit without an "orbit boson" to make it so. The forces that physics attributes to particles are the natural results of quantum processing as follows:

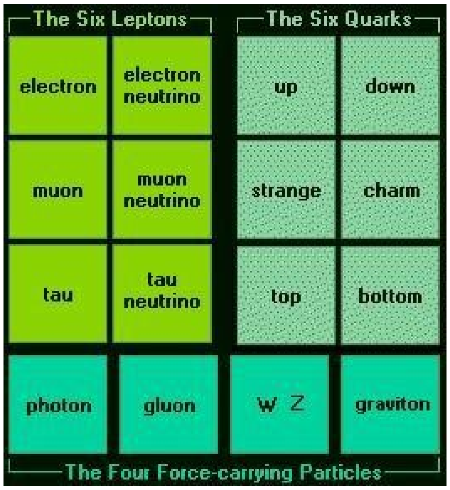

Figure 4.17. The CERN standard model

1. *Electromagnetism.* Where the standard model sees virtual photons quantum realism sees a network re-allocating its basic operation. No virtual photons are needed to explain electromagnetism.

2. *The strong effect*. The standard model needed a new field, three new charges and eight gluons to bind quarks in a nucleus but in quantum realism quarks share photons to achieve stability, and the color charge is the axis orientation needed for a stable result. Again, no magical gluon agents are needed.

3. *The weak effect*. The standard model needed another field, three more bosons and two new charges to explain neutron decay but still couldn't explain why protons don't decay. In quantum realism, neutron decay is a neutrino effect and the reverse is an electron effect that only occurs in stars so protons are stable in empty space. Weak bosons are again unnecessary and thus imaginary agents.

4. *The Higgs.* If weak bosons don't exist, the Higgs boson isn't needed at all. CERN just added yet another species to its already overflowing menagerie of pointless "particles" that played no role whatsoever in the evolution of matter.

5. *Gravity.* Gravity was the first field and every attempt to find gravitons has failed but standard model iconographies still display it as if it were proven (Figure 4.17). In quantum realism, particles will never explain gravity as what is **in** a space-time canvas can't alter space and time as gravity does. Chapter 5 attributes gravity to the *grid processing gradient*.

What rules apply in this brave new world of virtual particles? The standard model lets the Higgs interact with weak bosons to give them mass but how do the other bosons interact? A quark is subject to electromagnetic, strong, weak, Higgs and gravity forces, so if a virtual photon, gluon, weak boson, Higgs and graviton appear *at the same time,* what happens? To say that virtual bosons only interact to make our equations work is quite unsatisfactory. And as matter bosons need anti-matter versions, what happens when a Higgs meets an anti-Higgs?

The standard model invents virtual particles for effects that quantum realism derives from a core quantum process. Why invent a multitude of virtual particles to explain what a single quantum process can? *Quantum realism concludes that virtual particles are unnecessary because quantum processing can explain their effects*.

[55] The number of ice-creams sold in America correlates with deaths by drowning, so do ice-creams kill? In Europe, number of stork nests correlates with human babies born, so do storks bring babies? In both cases, X and Y correlate because both are caused by a third agent Z, namely the weather, not because they cause each other. Correlation is not causation.

4.5.4 The standard model grows

Occam's razor, *not to multiply causes unnecessarily*, is the pruning hook of science but the standard model ignores it. Last century physical realism was a simple theory of mass, charge and spin but today it needs isospin, hypercharge, color, chirality, flavor and other esoteric features to work. The standard model needs sixty-two core particles[56], five invisible fields, sixteen charges and fourteen bosons to work (Table 4.6). It has so many ad-hoc parameters that if it were a machine, one would have to *hand-set* over two dozen knobs just right for it to light up. If physical realism is preferred today, it isn't because of its simplicity.

For this complexity one might expect completeness but the standard model doesn't explain gravity, proton stability, the absence of anti-matter, quark charges, neutrino mass, neutrino spin, family generations, quantum randomness or why inflation occurred. Nor does it explain dark energy or dark matter, i.e. *most of the universe.* And with each new discovery *it grows*, so inflation needs a hypothetical *symmetron field* and neutrino mass needs another 7-8 arbitrary constants:

Table 4.6. Fields, charges and bosons of the standard model

Field	Charges	Bosons
Electromagnetism	+1, 0, -1	Photon (1)
Strong	Red, Green, Blue, White, Cyan, Magenta, Yellow, Clear	Gluon (8)
Weak	+½, 0, -½	W^+, W^- & W^0 (3)
Gravity	1?	Graviton (1?)
Higgs	1?	Higgs particle (1?)
Total = 5	**Total = 16**	**Total = 14**

"*To accommodate nonzero neutrino masses we must add new particles, with exotic properties, for which there's no other motivation or evidence.*" (Wilczek, 2008) p168.

The standard model *grows* on the data around it, as when it meets new facts it expands itself.

4.5.5 A particle toolbox

The standard model is less a theory than *a particle toolbox that can be tailored to accommodate results after the fact.* When anti-matter was discovered it just added new columns and when family generations came along it added new rows. When mesons were found someone said "*Who ordered that?"* then the standard model made them bosons that carried no force! When new facts arrive, the standard model accommodates them in an existing structure or builds a new wing.

It is hard to fault a model that absorbs knowledge rather than generates it, e.g. it includes gravitons that a long search hasn't found so was that a fail? It predicted proton decay but twenty years of study have pushed their lifetime to that of the universe so was that a fail? It sees matter and anti-matter as symmetric so does that our universe is only matter constitute a fail? It expected massless neutrinos until experiments gave them mass and penta-quarks and strange quarks until a two-decade search found neither, *and the list goes on*. Today it predicts that weakly interacting particles (WIMPs) will explain dark matter but again a long search has found nothing. The standard model is like a hydra in that when the facts cut off one "head" it just grows another. Indeed it is unclear what exactly it would take to falsify a model whose failures are called "unsolved problems in physics". All this is in the name of mere equations.

The standard model's claim to fame is that it *accurately* calculates results to many decimal places but in science, *accuracy doesn't define a theory's validity*. An equation that accurately *interpolates* between a

[56] Two leptons with three generations plus anti-matter variants is 12. Two quarks with three generations plus anti-matter variants and three colours is 36. Plus one photon, eight gluons, three weak bosons, one graviton and the Higgs is another 14. The total is 62.

known set of data points is not a theory that can *extrapolate* to new points. This is why an equation is not a theory but today, generations of physicists fed on equations not science (Kuhn, 1970) think that equations are theory. Yet as Georgi says:

> "*Students should learn the difference between physics and mathematics from the start*" (Woit, 2007) p85.

Theories are expected to *predict* new situations not just accurately calculate known situations. If a theory construct isn't valid, i.e. represent what it is supposed to, it doesn't matter how *reliable* it is. The virtual particles of the standard model aren't valid because ultimately, they don't represent anything that can be verified to exist at all.

When it comes to prediction, the standard model's validity is dubious, e.g. it claims it predicted top and charm quarks before they were found but after finding three generations of leptons and two of quarks, "predicting" a third quark generation is like predicting the last move in a tic-tac-toe game. It also claims to have predicted gluons, W bosons and the Higgs but inventing magical agents based on data-fitted equations isn't prediction. Fitting equations to data then matching their terms to ephemeral resonances in billions of accelerator collisions is the research version of tea-leaf reading – look hard enough and you'll find something. The standard model illustrates Wyszkowski's Second Law, that *anything can be made to work if you fiddle with it long enough*.

The standard model reflects the data we know, it doesn't generate knowledge. Hence its answer to why a top quark is 300,000 times heavier than an electron is "*because it is*". What baffled physics fifty years ago still baffles it today because equations can't go beyond the data set that created them, only valid theories can. The last time such a barren and invalid model dominated thought so completely was before Newton.

4.5.6 The last "standard model"

In the second century, Ptolemy's Almagest let people predict the movements of the stars for the first time based on the idea that heavenly bodies, being heavenly, moved around the earth in perfect circles, or circles within circles (*epicycles*). *It wasn't true but it worked*, and Ptolemy's followers *made it work* for centuries. As new stars were found they *altered the model* to make it more complex and themselves more expert. This ancient standard model only fell when Copernicus, Kepler, Galileo and Newton developed a *causal model* to replace it. The standard model of physics and the Ptolemaic standard model have a lot in common as both are:

1. *Descriptive*. Descriptive models describe what is by identifying *patterns*, ideally in the form of equations, but this is the first step of science not the last. Only causal models truly predict.
2. *Parameterized*. Ptolemy's model let experts choose the free parameters of epicycle, eccentric and equant to fit the facts just as the standard model of today lets experts choose the free parameters of *field, bosons and charge*.
3. *Retrospective*. Ptolemy's model defined its epicycles *after* each new star was found just as today's standard model bolts on a new field *after* each new force is found.
4. *Barren*. Descriptive models only interpolate so the Ptolemaic model would *never* have deduced Kepler's laws and likewise today's standard model will *never* deduce that matter is made of light.
5. *Complex*. Medieval astronomers tweaked Ptolemy's model until it became absurdly complex just as the equations of today's standard model fill pages and those of its string theory offspring fill books.
6. *Normative*. The Ptolemaic model was the norm of its day so any critique of it was seen as an attack on the establishment and likewise today any standard model critique is seen as an attack on physics itself (Smolin, 2006).
7. *Wrong*. Ptolemy's model *mostly worked* even though planets don't move in circles around the earth and likewise the standard model calculations *mostly work* even though virtual particles don't exist.

When the medieval church pressured Galileo to recant they didn't ask him to *deny* the earth went around the sun but to just call it a *mathematical fiction,* rather than a reality description. Today, physicists *volunteer* the same about quantum theory but what quantum theory describes *really does* happen, just as the earth *really does* go around the sun.

In research methodology, after *describing* patterns comes finding *correlations* and finally attributing *causes* (Rosenthal & Rosnow, 1991), so the standard model is a *descriptive model* that should have evolved into a *causal theory* but didn't. The reason it didn't is that physics denies the existence of what quantum theory describes, for as Bohr said:

"*There is no quantum world. There is only an abstract quantum mechanical description*." Newton, p244

This view led him to deny the need for meaning at Copenhagen, led Everett fantasize about many worlds (Everett, 1957) and led Witten to try to go it alone with mathematics in string theory, none of which led anywhere. This one choice, to deny meaning and just calculate equations, arrested the scientific growth of physics, which abandoned science when it abandoned meaningful causes. The only option left was to invent magical particles that pop out of empty space to cause what the equations describe, and this is the standard model. The standard model is a naive descriptive paradigm ruled by acausal equations that are leading nowhere. *In the history of physics, it is essentially a scientific dead end.*

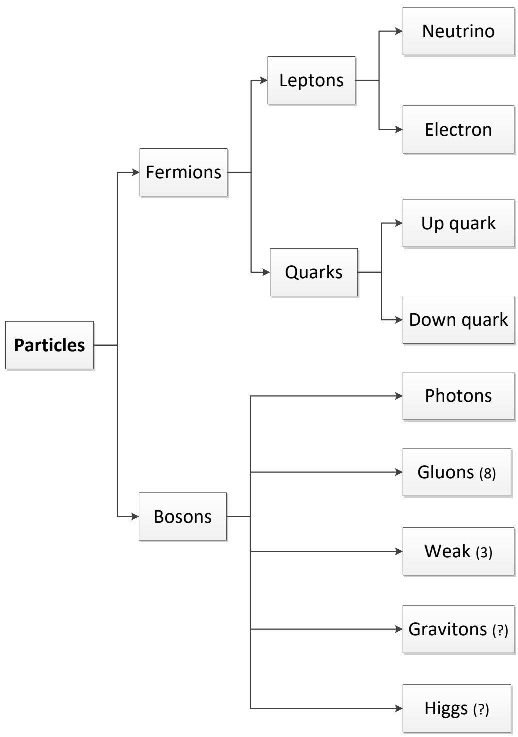

Figure 4.18. The current particle model

4.5.7 The current particle model

Matter as a substance implies that it can be broken down into *fundamental particles* and battering matter into bits seemed the best way to do that. So physics spent most of last century and billions of dollars smashing matter apart to find what it called fundamental particles, defined as those that can't be broken down further.

But when pressed on *what a particle actually is,* physicists retreat to wave equations that don't describe particles at all. This bait-and-switch, displaying a particle but giving a wave equation, is now routine in physics. If one points out that *the equations describe waves not particles*, they reply it doesn't matter because the equations are fictional! Feynman explains how this double-speak began:

"*In fact, both objects (electrons and photons) behave somewhat like waves and somewhat like particles. In order to save ourselves from inventing new words such as wavicles, we have chosen to call these objects particles*." (Richard Feynman, 1985) p85

It seems that physicists with particle accelerators see everything as a particle, just as a boy with a hammer sees everything as a nail. But the "fundamental particles" that physics found turned out to be:

1. *Ephemeral*. A lightning bolt is long-lived compared to most of the particles in physics today, e.g. a tau is a million, million, millionth of a second energy spike. Since we don't call a lightning bolt a particle, why does physics call a tau a particle?
2. *Classifiable*. The standard model classifies a tiny electron, a massive tau and a positron as leptons but what can be classified can't be fundamental because classifying requires common properties that imply

that something else is more fundamental. "Fundamental" in physics just means a point entity that can't be further smashed apart.

3. *Massive*. A top quark has the mass of a gold nucleus of 79 protons and 118 neutrons. It is 75,000 times heavier than an up quark so why does the cosmic Lego-set have one "building block" 75,000 times bigger than another? Not surprisingly, this "fundamental block" plays no part whatsoever in the function of the universe we see.

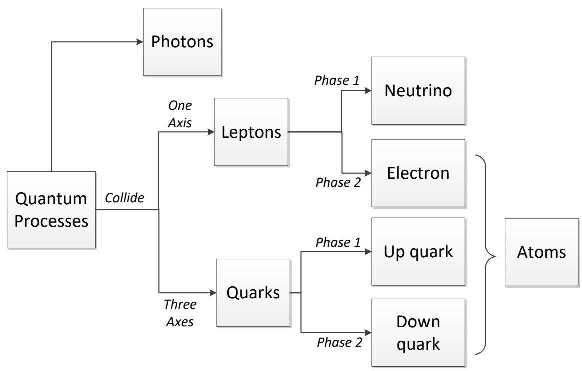

Figure 4.19. A quantum processing model

4. *Unstable*. If a top quark is "fundamental", why does it immediately decay into other particles? Equally, when a neutron emits an electron to become a proton, three fundamental particles become four! This is a strange use of the word "fundamental".

Entities that decay and transform into each other aren't fundamental because what is fundamental isn't subject to decay or transformation, and energy events that last less than a millionth of a second aren't particles because substantive particles should last longer than that. A brief eddy in a stream isn't called a particle, so why does physics call a brief quantum eddy a particle? *Quantum realism concludes that the fundamental particles of the standard model are neither fundamental nor particles.* In this view, what current physics calls particles are actually quantum reboot events.

Figure 4.18 summarizes the current particle model. It shows a set of "fundamental" matter particles that are classified plus virtual bosons that come from nowhere to make things happen. Light is clearly a wave but a photon with no mass is still called a particle for convenience. This, we are told, is the end of the story simply because particle accelerators can't break things down any further.

Meanwhile, the fundamental particles of matter are said to have no size at all despite their "substance". The conundrum that matter takes up space, and particles with no extent can't add up to do that, is said to be resolved because virtual particles from invisible fields keep them apart. It is a wonderfully circular argument.

This model is accepted because physicists are conditioned not to look behind the curtain of physical reality. One is reminded of the wizard of Oz telling Dorothy: "*Pay no attention to that man behind the curtain*", to distract her from what is really orchestrating events. The wizards we call physicists ask us to pay no attention to the quantum waves that quantum theory tells us are creating physical reality. *Quantum realism is an attempt to look behind the curtain*.

1.6.5. 4.5.8 A quantum wave model

Figure 4.19 is the quantum wave alternative proposed here. It is simpler because it doesn't need bosons to push particles around since quantum waves act like an ever-flowing river that actively finds a stable state. Quantum waves spread at the speed of light to act at a distance, so virtual particles aren't necessary. While the lines in Figure 4.18 are *similarities* between supposed fundamentals, the lines in Figure 4.19 signify a *dynamic evolution*.

Quantum realism begins with a basic quantum process that generates the first entity, a photon, as a quantum wave. Light then goes on to form the leptons and quarks that go on to form the atoms that in time formed us. In this physical evolution, the entire physical universe "booted-up" from a single photon rather

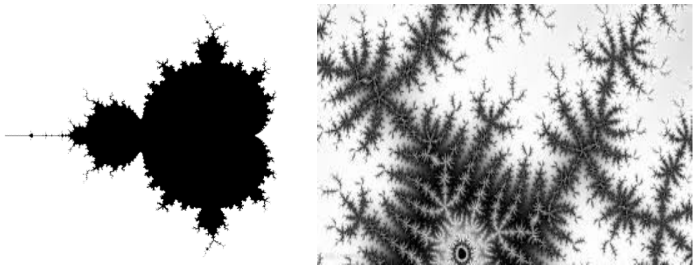

Figure 4.20. Mandelbrot's set, a. Main, b. Detail

than being "made" from a matter Lego-set. It is a vision of something alive that grows rather than inert particles pushed around by magical forces.

The quantum network *defines* the smallest unit of space, so there is no need for virtual particles to keep dimensionless points of matter apart. It also explains *why* the speed of light is a maximum, as the maximum transfer rate of a network is one node per cycle. If matter is a standing quantum wave, electrons and neutrinos are brother leptons because they are phase versions of the same quantum collision, as are up and down quarks. Matter is now an evolution not a given.

The standard model tries to *reduce complexity* to a matter Lego-set but ultimately it fails. A quantum wave model *evolves complexity* from quantum simplicity. The Mandelbrot set illustrates how dynamic simplicity gives complexity, as one line of complex code repeated gives rise to endless forms (Figure 4.20). The Mandelbrot set is endlessly complex not because was "built" from many components but because it is an endlessly dynamic interaction.

Quantum realism derives the complexity of the physical world from quantum simplicity.

4.5.9 Testing quantum realism

According to the standard model, matter collides by a basic substantiality that light does not have, so:

> "*Two photons cannot ever collide. In fact light is quantized only when interacting with matter.*" Wikipedia

In contrast, quantum realism predicts that *extreme light in empty space will collide to form matter.* Lest this seem fanciful note that:

1. *Photons confined have mass*. A free photon is massless but if confined in a hypothetical 100% reflecting mirror box it has a rest mass because as the box accelerates unequal photon pressure on its reflecting walls creates inertia (van der Mark & t'Hooft, 2011). By the same logic, photons entangled in a node will have mass.
2. *Einstein's formula.* That matter is energy works both ways so if nuclear bombs can turn mass into energy, photon energy can create mass. The Breit-Wheeler process describes how high energy photons can create matter.
3. *Particle accelerator collisions routinely create new matter*. Protons that collide and stay intact give new matter that didn't exist before. If this matter comes from the collision energy, why can't high energy photons do the same?
4. *Pair production.* High-frequency light near a nucleus gives electrons and positrons that annihilate back into space.
5. *Light collides.* When high-energy photons at the Stanford Linear Accelerator hit an electron beam to accelerate it at almost the speed of light, some electrons knocked a photon back with enough energy to hit the photon behind it, giving matter pairs that a magnetic field pulled apart to detect (Burke & et al, 1997). That light alone can collide in a vacuum to give matter is a testable prediction but no experiment has yet unequivocally confirmed it. When beams of pure light collide in pure space to create matter, the boson-fermion distinction will fall and with it the standard model. Quantum realism predicts that matter evolved from light, so the future of physics lies in colliding

light not matter. The standard model expects the short-lived energy flashes of its accelerators to unlock the secrets of the universe but it isn't happening, and quantum realism says that it never will. If *matter evolved*, billion-dollar accelerators are just discovering evolutionary dead-ends, as in evolution, what doesn't survive doesn't matter. Particle models assume that matter came first but in quantum realism, light was the first existence.

4.6. THE EVOLUTION OF MATTER

People once thought we were created as we are now by God, until science discovered that we evolved from other life forms over millions of years. Particle models implicitly assume that matter always was but cosmology suggests that the atoms of the periodic table also evolved in a process called *nucleosynthesis*. This building-up of complex atoms from simple ones occurs in stars and supernovae and is ongoing today. Without this *grand evolution* of matter, the periodic table of elements (Figure 4.21) would not exist and neither would we. This section suggests that the evolution of matter is the *evolution of stability*.

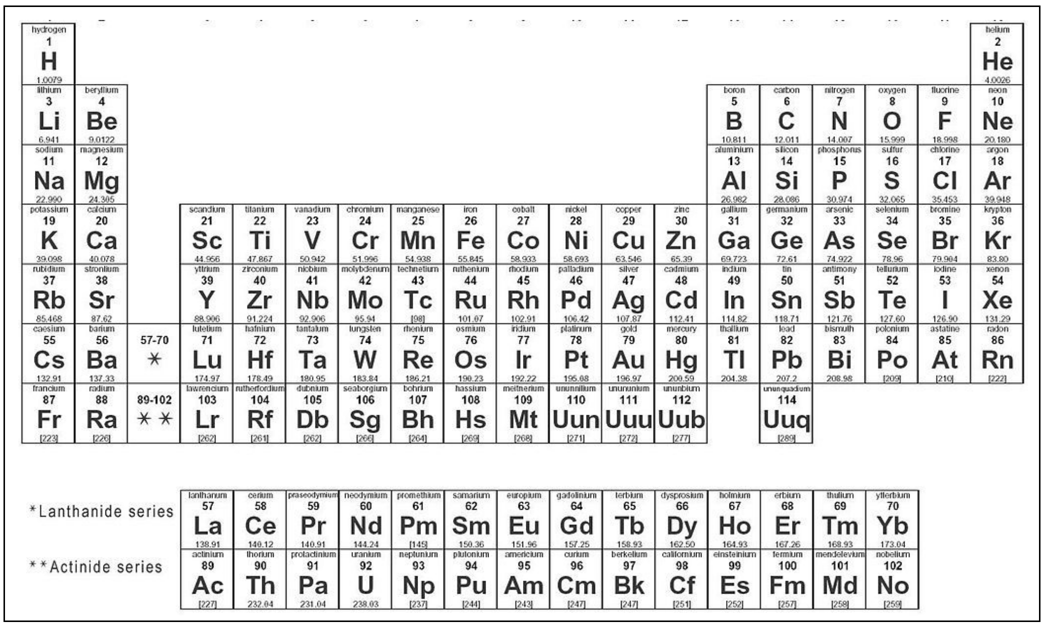

Figure 4.21. The Periodic Table

4.6.1 Nuclear evolution

In the periodic table, a Hydrogen nucleus has one proton and a Helium nucleus has two protons but in addition, it also has two neutrons and no-one knows why. Higher elements have even more neutrons but what they do is a mystery: *"... all the stable nuclei have more neutrons than protons (or equal numbers), and the heavier nuclei are increasingly neutron-rich.*" (Marburger, 2011) p254

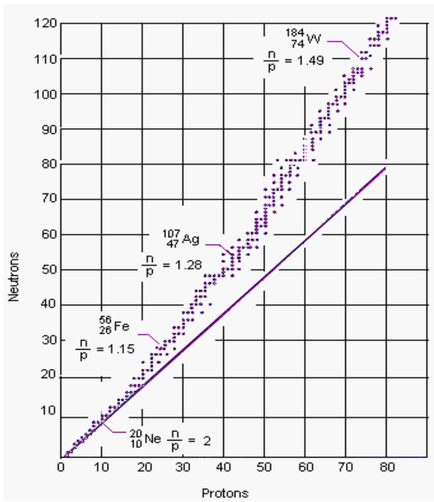

Figure 4.22 Nuclear neutrons by protons

For some reason, heavier nuclei need more neutrons to be stable (Figure 4.22) until in Uranium, proton repulsion breaks apart the nucleus in nuclear radiation. There is currently no theory that explains the neutron's role in keeping the nucleus stable. The shell model used to explain electrons doesn't work because some nuclei aren't spherical. The standard model doesn't help because if gluons are holding the protons together, why have neutrons? And how do the gluons know how many neutrons are needed to stabilize a heavy nucleus?

The quark structure described earlier sheds light on the issue as it describes protons and neutrons as quarks linking in a closed triangle. It follows that such triangles can open up and recombine in longer quark strings if the same rules are satisfied: namely a *closed* shape with the *internal angles* of an equilateral triangle.

In this view, a Helium nucleus is not two protons and two neutrons sitting separately together, like fruit in a bowl. It is the quarks of two protons and two neutrons linking by photon sharing to form *a single string that closes back on itself*.

So it is quite incorrect to envisage a Helium nucleus as separate proton and neutron *particles* sitting side-by-side with gluons somehow forcing the protons together. Instead, the Helium nucleus is *a single quark string* held together by photon sharing, just as protons and neutrons are. Higher nuclei are then bound just as protons are, *by photon sharing*. The only restriction is that each link must bend the string 60º which requires quarks to rotate to make a connection.

That this configuration arises dynamically then explains why neutrons are needed. Since photon sharing needs direct proximity, a proton is unlikely to come that close to another proton because they repel so neutrons are needed to link to the protons. When forming a quark string, neutrons act as *string buffers* in between same-charge protons that repel when side-by-side. This requires at least as many neutrons as protons, as observed. Hence Helium with a two-proton string ideally needs *two* neutrons to act as buffers between the two protons in a string.

Folded quark strings will be compact and nearly spheres, as observed, but larger nuclei may need more neutrons to avoid fold-back loci that happen to make protons adjacent. In this *nuclear evolution* certain shapes will be more stable:

> "*Nuclei with either protons or neutron equal to certain "magic" numbers (2, 8, 20, 28, 50, 82, 126) are particularly stable*." (Marburger, 2011) p253

If atomic nuclei are folded quark strings, those with a "magic" number of nucleons will be more stable because they form the symmetric shapes that gave rise to magic numbers in the first place. A quark string model explains the properties of atomic nuclei and the role neutrons play in their creation. In quantum realism, nuclei are *single* 3D shapes that fold in space as proteins do.

4.6.2 Particles can't "orbit" an atom

In current physics, an electron is a particle in space but a wave in an atom, by the miracle of wave-particle duality. Everyone knows that a particle isn't a wave nor is a wave a particle but this "miracle" exists because it lets physics choose one set of equations for electrons in orbit and another for electrons in space. No-one asks "*How does the electron know to be a particle in one place and a wave in another?*"

Apparently, electrons know *Pauli's exclusion rule,* that they can overlap like waves when they have different *quantum numbers*. The shell model lets electrons co-exist in "orbits" by quantum numbers that aren't based on or even compatible with any other physical laws. Since quantum numbers were made up after the fact, it is a classic case of "backward logic".

If electron particles really did *orbit* atomic nuclei as planets orbit the sun they would occasionally collide, but they *never do*. An atom of lead has 82 electrons whizzing around in close proximity but is stable for billions of years. How do all those particles never meet? And a particle in orbit is accelerating, so it should lose energy and spiral inwards but again electrons never do this. Are the laws of physics different for matter in an atom? Current theory handles this by inventing a cloud of virtual photons to shield electrons from the nuclear attraction and other electrons.

In quantum realism, an electron is *one-dimensional matter,* that is matter-like on one dimension but light-like on the other two. In three-dimensional space, the matter dimension makes the electron slower than light on average but on a *two-dimensional surface* around an atom it can be entirely light, i.e. entirely wave. A particle circling a center needs an agent to stop it falling in but wave can pulse forever if the circumference matches its wavelength. It can't spiral in because its wavelength sets a minimum orbit circumference and waves of different harmonics can accommodate many waves that never "collide" (see next section). Electrons as *matter-light hybrids* lets an electron be a particle in space and a wave in an atom. It predicts that while electrons move slower than light in three-dimensional space they *pulsate* in atoms at the speed of light.

4.6.3 The evolution of electron shells

Every element in the periodic table has different number of electrons organized in *shells*. Each shell can hold a certain number of electrons and when the outer shell *fills* the result is an *inert* element like Neon. Each periodic table row ends in an inert element that doesn't chemically react because it doesn't exchange electrons. In contrast, other elements do exchange electrons in chemical reactions. Every chemical reaction, from acidity to oxidation, is atoms exchanging electrons to complete their outer shells in the now familiar search for stability. Atoms form stable *molecules* when those with extra electrons donate them to those with deficits giving chemical bonds that complete the shells of both parties.

Table 4.7. Particle shell and sub-shell predictions

Shell	Sub-shell						No
n	*s*	*p*	*d*	*f*	*g*	*h*	
1	1s=2						*2*
2	2s=2	2p=6					*8*
3	3s=2	3p=6	3d=10				*18*
4	4s=2	4p=6	4d=10	4f=14			*32*
5	5s=2	5p=6	5d=10	5f=14	5g=18		*50*
6	6s=2	6p=6	6d=10	6f=14	6g=18	6h=22	*72*

The current electron shell description is based on two quantum numbers:

1. *Shell **n*** (1, 2, 3 …). Was initially the orbit radius.
2. *Sub-shell **l*** (*s, p, d* …). Has no clear meaning.

The *s, p* and *d* sub-shells were deduced from spectroscopic data analysis to contain 2, 6 and 10 electrons. Electrons then fill shells and sub-shells according to quantum numbers. In the initial model, inner orbits with fewer electrons filled before outer orbits and so the periodic table grew. Doubling the first orbit of two electrons quadrupled the orbit area to allow eight electrons, tripling allowed eighteen, quadrupling it thirty-two and so on. Hence the first row of the periodic table has two elements, Hydrogen and Helium and the second row has the eight elements Lithium-Neon.

This worked nicely but the third row is still only eight elements, including the carbon and oxygen we need to live, and the expected eighteen elements only occur in the next row. As Table 4.7 shows, the initial model predicted periodic table rows of 2, 8, 18, 32, 50 and 72 but instead the rows were 2, 8, 8, 18, 18, 32 and 32. So in the by now well-established practice, theory was fitted to fact by tweaking the quantum numbers so the *sub-shells* occur in this odd order:

Row 1: 1s Hydrogen-Helium (two elements)

Row 2: 2s, 2p Lithium-Neon (eight elements)

Row 3: 3s, 3p Sodium-Argon (eight elements)

Row 4: 4s, 3d, 4p Potassium-Krypton (eighteen elements)

Row 5: 5s, 4d, 5p Rubidium-Xenon (eighteen elements)

Row 6: 6s, 4f, 5d, 6p Cesium-Radon (thirty-two elements)

Row 7: 7s, 5f, 6d, 7p Francium-? (thirty-two elements)

The "logic" here is that it works. The third shell "fills" with one of its sub-shells empty, so generations of chemistry students have had to learn that Argon completes its third shell without the *3d* sub-shell, even though that denies what a sub-shell *means.* If they asked why, the answer was *because it does!*

Instead of describing electrons by quantum numbers we invent, electrons as quantum waves expects these properties:

1. *Shell*. A sphere circumference around the atom nucleus that fits the electron as a quantum wave.
2. *Sub-shell.* A higher wave frequency that the shell circumference allows.
3. *Direction.* The electron wave direction, where quantum waves at right angles don't interfere.

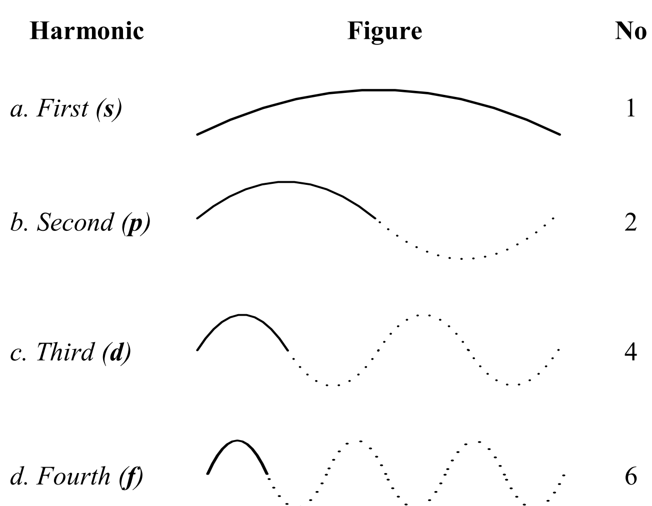

Figure 4.23. Wave harmonics for a length

If an electron is extreme photons entangled in a collision on one axis, its other axes will also have entangled photons. If these are also extreme photons, they will be up one cycle and down the next so the minimum shell circumference is half this wavelength. This *fundamental harmonic* is currently called the *s* subshell.

The next shell will have a circumference double that of the first shell. This allows not only another fundamental but also a second harmonic that is twice the frequency. This *second harmonic* is currently called the *d* sub-shell. Figure 4.23 shows how a given shell circumference can accommodate different harmonics to represent different sub-shells. The number of waves that can concurrently occupy each harmonic is given on the right-hand column.

The periodic table can now be explained in terms of electron waves as follows:

1. The first shell has a half wavelength circumference so a bipolar wave can go up and down on alternate cycles (Figure 4.23a) as the *first harmonic* of the *first shell* or *1s sub-shell*. This shell can accommodate two waves at right angle *directions* so the first shell completes with two electrons. This gives the first row of the periodic as Hydrogen plus the inert gas Helium.

2. The second shell has a one wavelength circumference compared to the first and the *first harmonic* again alternates up and down at this length giving a *2s* sub-shell with two electrons. The *second harmonic* (Figure 4.23b) can accommodate two electron waves at the same time which for two *directions* is four electrons. The extra harmonics of two-dimensional waves such as appear on a drum surface allow two more electrons, giving six in total for the *2p* sub-shell. The second shell total is thus eight electrons, giving the second row of the periodic table Lithium to Neon.

3. The third shell has a one and a half wavelength compared to the first as it triples the first circumference. This again gives *3s* and *3p* sub-shells *but the next harmonic can't occur*. A bipolar (up-down) wave can vibrate once on a string half its wavelength and twice on a string of the same wavelength but it can't do more on a string one and a half times that as the result self-destructs. Adding another half-wavelength adds no new harmonics so the third shell, like the second, allows only eight electrons giving eight elements in the periodic table third row. *A harmonic wave model has no 3d sub-shell.*

4. The fourth shell has a two-wavelength circumference compared to the first. Four times the first radius *allows a new harmonic* that accommodates four electrons per circumference which for two directions is eight (Figure 4.23c), plus two complex harmonics is ten. This *4d* sub-shell plus the *4s* and *4p* sub-shells gives the eighteen elements of the periodic table fourth row.

5. The fifth shell, like the third, allows no new harmonic, so its *5s, 5p* and *5d* sub-shells repeat the previous total of eighteen, giving the periodic table fifth row.

6. The sixth shell allows a new harmonic with six electrons per axis (Figure 4.23d), which doubled again is twelve, plus two complex harmonics is fourteen. This plus eighteen from the *s, p* and *d* harmonics gives the thirty-two elements of the sixth periodic table row[57] and the seventh orbit also has 32 elements.

An electron wave model fills the periodic table as follows:

1. 1s — Hydrogen-Helium (2 elements)
2. 2s, 2p — Lithium-Neon (8 elements)
3. 3s, 3p — Sodium-Argon (8 elements)
4. 4s, 4p, 4d — Potassium-Krypton (18 elements)
5. 5s, 5p, 5d — Rubidium-Xenon (18 elements)
6. 6s, 6p, 6d, 6f — Cesium-Radon (32 elements)
7. 7s, 7p, 7d, 7f — Francium-? (32 elements)

Electrons now fill shells and sub-shells in strict order, with no strange jumping between them, based on:

1. *Shell.* The first shell circumference is half the wavelength of the highest frequency of light, i.e. a Planck length. The following shells are multiples of this (1, 2, 3, 4, …).
2. *Sub-shell harmonic.* Where *s* is the first harmonic, *p* is the second harmonic, and so on.
3. *Direction.* The great circle axis orientation , where opposite waves don't interact.

Electrons fill in the order they do based on:

[57] If *the first shell has circumference C*, the sixth shell has circumference 6C, with subshell harmonic wavelengths: 6s (λ=12C), 6*p* (λ=6C), 6*d* (λ=3C) and 6f (λ=1C).

1. *Shell order*. Each shell is a greater circumference. If an electron were pure light a longer wavelength would be less energy but it has mass so larger orbits require more processing, i.e. more energy. Shells fill in the order 1, 2, 3 etc. because smaller orbits need less processing.
2. *Harmonic order*. Each sub-shell harmonic is a shorter wavelength for the same orbit circumference, so it involves more energy. Sub-shells fill in the order *s, p, d etc.* because lower harmonics need less processing

An *electron wave model* explains the rows of the periodic table as *caused by* the harmonics that a shell circumference can accommodate, so electrons fill the shells with no tweaks needed.

In quantum realism, electrons in atoms are quantum waves whose behavior is better described by wave harmonics than abstract quantum numbers.

4.7. OTHER MATTERS

Looking around the earth, Aristotle saw a world of mainly matter, but looking around the cosmos today, scientists see mainly space and light, and the matter we see is about 4% of the universe. In quantum realism, matter is a distant third in the scheme of things hence this book addressed space, light and matter in that order. This approach suggests answers to questions about matter that have puzzled physics for some time.

4.7.1 Why do electrons "half spin"?

In current physics, an electron is a dimensionless point. Since a point of no extent can't physically spin, physics has given up trying to understand quantum spin in general, let alone how matter *half-spins*:

> "*We simply have to give up the idea that we can model an electron's structure at all. How can something with no size have mass? How can something with no structure have spin?*" *(Oerter, 2006) p95*

In quantum realism, a photon is a quantum wave that vibrates into a quantum dimension orthogonal to its polarization plane, so it has a structure that *really does spin*[58]. As earlier concluded, quantum space adds *three new quantum directions* to every point, all at right angles to each other[59] as well as our space (see 3.7.2).

A photon is a *two-dimensional structure* in quantum space that, like a paper sheet, is invisible when viewed edge-on. So horizontal filters stop horizontal but not vertically polarized light because photons polarized at right angles occupy different spaces that don't exist to each other.

An electron is photons filling the channels of one axis so for any line of view, only half of their quantum amplitudes are visible. If one photon is 100% visible another at right angles will be 0%, for one that projects 99% there is another that projects only 1%, and so on. If only half an electron's photons register with us, we can only measure half its spin and so say it *half spins.*

This also explains another interesting property of electrons. Turning an object 360 degrees in our space returns its original state but turning an electron 360 degrees only *half-turns* it — it takes 720 degrees of turning to return an electron to its original state. This is impossible in three dimensions but an electron in four dimensions has two planes to turn into not one. A 360 turn in one dimension only turns half its photons and so another turn is needed to turn the other half. It must always be remembered that *we are 3D Flatlanders in a four-dimensional quantum reality* (Abbott, 1884).

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[58] For a photon moving in direction X, its quantum amplitude Q vibrates in plane QX. The structure QX can then spin.

[59] The orthogonal directions X, Y, Z of space give three orthogonal planes XY, YZ and XZ. A fourth dimension Q adds three more orthogonal planes Q_1X, Q_2Y, Q_2Z, where Q_1, Q_2 and Q_3 are at right angles.

4.7.2 Neutrino asymmetry

If the laws of physics varied with position, each new location would need new rules. That in our world, view direction changes the values but not the equations gives a *spatial symmetry* that is basic to physics itself. Yet neutrinos violate this principle because they *always spin left-handed*, an asymmetry that is reflected neither in the world we see nor the laws that describe it. As Pauli said:

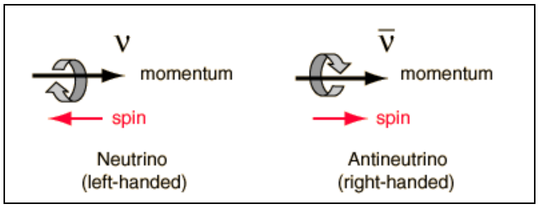

Figure 4.24. *Left and right-handed spin*

"*I cannot believe God is a weak left hander*" (L. Lederman & Teresi, 2012) (p. 256)

What is spin-handedness? If you point your left thumb forward, the fingers of your hand curl in a left-handed spin direction and if you point your right thumb forward, the fingers curl in a right-handed spin direction. If your hands only move *forward* the spin stays the same but move one hand *backwards* and they both have the same spin, as reversing direction reverses the spin. Reversing an electron's direction should create a mirror image of it that spins the other way by spatial symmetry and electrons do indeed spin both ways. In contrast *all* neutrinos are left-handed and *all* anti-neutrinos are right-handed (Figure 4.24). So while electrons spin either way, a neutrino reversing direction still spins left and an anti-neutrino still spins right when it reverses.

The standard model can't explain how a fundamental particle can spin the same way when it reverses direction, as when a neutrino changes spin it becomes an anti-neutrino that it isn't the same as its mirror image, contradicting spatial symmetry.

The photon structures of quantum realism suggest an answer. When the first photon chose to move up or down on space to make matter or anti-matter, it also had to choose left or right spin and apparently it went left. The electron's entangled photon sets *both* spin left, so their opposite directions let it have both left and right spin at once. In a physical event, an electron can spin either way and changing direction reverses both spins so it still spins either way, randomly.

One might expect the same for neutrinos but while the electron's mass comes from *both* photon sets colliding, neutrino mass comes from only *one* of the photon sets. A neutrino reversing direction changes phase *so what create its mass is now the other set of photons, which also spin left*. When electrons reverse direction their mass origin doesn't change but when neutrinos change direction the *other* set of left spinning photons create the mass. Neutrinos always spin left because when they reverse direction the source of their tiny mass changes.

Since a neutrino processing in reverse is an anti-neutrino, they always have right-handed spin for the same reason that neutrinos always spin left. The mirror image of a particle should be the same particle but the mirror image of a neutrino's processing is not the same by the asymmetry that created our universe of matter. A processing model explains why neutrinos *always* spin left and anti-neutrinos *always* spin right.

4.7.3 The mass problem

A proton's charge is one, the simple sum of its constituent quark charges, but its mass is a hundred times that of three quark masses. When quarks combine, their charges just add but for some reason their masses don't:

> *"… though the actual value of the basic electric charge … remains a theoretical mystery … all other charges found in the universe are … multiples of this value. Nothing like this appears to be the case for rest-mass, and the underlying reason for the particular values of the rest-masses of … particle types is completely unknown.*" (Penrose, 2010) p153.

Current physics attributes the extra mass to the virtual particles binding quarks but how do *massless gluons* make mass? And why don't they multiply charge as well? The standard model has no answer because it just describes what is.

In quantum realism, charge as left-over processing is limited to one quantum process per channel so charges simply add and can never be more than plus one or less than minus one. Why then isn't the net processing done, or mass, limited in the same way? The answer now suggested is that *the dynamic action of processing interferes*.

Interference occurs in networks when two processes seek the same resource at the same time. They *interfere,* just as two cars coming to an intersection at the same time can't both enter the same space. Studies show that traffic flow slows down when traffic merges, as at motorway on-ramps, because the cars have to negotiate who goes first. And such slow-downs can have run-on effects to cause traffic jams that extend for miles so *the effect of interference is not linear*.

The same thing happens on a computer network, as when processing "collides" it must stop and try again, just as cars do at an uncontrolled intersection. This wastes time, so interference slows down computer networks just as it slows down traffic networks and again the effect is not linear but can cumulate. Computer networks initially tried central controls like the traffic lights we have on road networks but this was found to be inefficient. A better solution was distributed protocols like Ethernet that let any process access a network resource when it wants to but if a collision is detected both stop and retry after a random time interval (to avoid a repeat collision). A computer network under load slows down for the same reason that a traffic network slows down at rush hour, *because many entities are seeking access to the same resources*.

In quantum realism, the quantum network is essentially a first-come-first-served system with no central control. So interference will occur when photons compete for the same channels and some have to try again elsewhere. This wastes processing and in this model, *processing is mass*.

The mass increase expected can be estimated by the number of *channel overlaps*, where photons compete for channels. For example, an electron has two photon streams intersecting but a quark has three photon streams intersecting. Since this gives more overlapping channels, interference causes a quark to have more than 50% of an electron's mass. Each quantum cycle, every entangled photon has to find a channel and every case of interference uses up processing, so quarks end up with about ten times the mass of an electron. Quarks in a proton have even more overlap and thus more interference and so more mass. *Mass as processing explains the "creation of mass" without recourse to magical gluons*.

Interference also suggests why down quarks are heavier than up quarks. If an up quark is two photon tail sets colliding with one set of photon heads (Table 4.3), the tails access channels first leaving one set of heads to fill the remaining channels. In a down quark, one tail set gets first access, leaving two sets of photon heads to fight over the rest, giving more interference and more mass. The masses the standard model *allocates* could *be derived* from simulations that model the quantum processing that creates them.

4.7.4 Charge neutrality

The standard model seems to assume that matter began like Venus from the sea, complete and perfect, with charge just an *accessory*. Our galaxy is largely charge neutral so physics supposes the universe as a whole is the same, but how did that happen? If charge is an inherent property arbitrarily allotted, why did the big bang dole out equal amounts of it? The current answer, that the universe is charge neutral because it was made "just so" is unsatisfactory.

In quantum realism, matter evolved just as life on earth did. Quantum events repeat at a fantastic rate, so anything not 100% stable reconfigures sooner or later. *Every* option is tried until one "sticks", i.e. doesn't change. This is how electrons, neutrinos and quarks survived the initial chaos and the first atom occurred because a proton plus an electron survive better together than apart. Every periodic table atom has the same number of protons and electrons for the same reason, that they survive better together than apart. Hence the universe is charge neutral because atoms are a stable evolution of matter and they are charge-neutral. *The universe is charge neutral by evolution, not because some designer allocated charge that way*.

4.7.5 Family generations

Electrons, quarks and neutrinos have *family generations* each like the last but heavier, e.g. an electron has a *muon* elder brother of the same charge but two hundred times heavier and a *tau* eldest brother that is three and a half thousand times heavier! Up and down quarks have heavier *charm* and *strange* quark older brothers and *top* and *bottom* eldest brothers but again after three generations, no more. The standard model *describes* family generations but doesn't explain:

1. Why do family generations occur?
2. Why three generations then no more?
3. Why are higher generations *so heavy*?

In this model, the three family generations reflect the three dimensions of space. If an electron fills the channels of *one* axis, a muon could do the same on *two* axes and a taon on *three* (Figure 4.25). All are still point entities and no more generations can occur in a space of three dimensions. Each is heavier than before because overlapping channels *interfere* to increase the processing that is mass. Taons are *so* heavy because interference cumulates, just as one traffic delay can cause another.

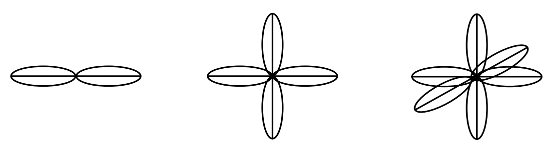

Figure 4.25. Electron generations as dimension repeats

If a muon is an electron collision doubled, why doesn't it have a minus two charge? It does but we can only measure charge one axis at a time and after each measurement the system resets. On *any one axis*, a muon's charge is minus one because the other remainders occupy orthogonal quantum dimensions.

One can't dimensionally repeat a quark structure three times, so quark generations aren't simple duplicates but the tail-tail-head planar *triangle* of an up quark can form a charm quark *pyramid* whose every side presents an up-quark's charge but with more mass by interference. A tail-head-head down quark could likewise form a strange quark pyramid. Top and bottom quarks then fill a node with two up and down quark planes at right angles, with more mass again by interference. *The mysterious generations of matter arise from the dimensions of space, and their large masses from quantum processing interference*.

4.7.6 Dark matter

Dark matter was discovered in the 1950s after astronomers found that our galaxy rotated as if it had more matter than its visible stars, five times more in fact. They concluded that most of the galaxy was "dark matter", dark because it can't be seen and matter because it caused gravity. Studying the rotation curves of other galaxies extended this conclusion to them and dark matter is now thought to be about 85% of the matter of the universe and quarter of its total energy. From its effects, scientists infer that dark matter exists as a halo around the supermassive black holes at the center of almost every galaxy, including ours.

Dark matter allows a galaxy to hold its stars together more tightly than their gravity allows. It isn't the matter we see because no light can detect it, it isn't anti-matter because it has no gamma ray signature and it isn't a black hole because there is no gravitational lensing, but without it the stars of our galaxy would fly apart. Dark matter is the "glue" that binds galaxies together but no one knows what it is. Without it, the matter-producing factories we call stars would not have the stability needed to create the elements of the periodic table.

The existence of dark matter, deduced from its effects, created a problem for the standard model which sees all matter as particles. It had to propose weakly interacting massive particles, or WIMPs, initiating another costly wild-goose chase despite talk of super-WIMPs (Feng, Rajaraman, & Takayama, 2003). WIMPs have now joined gravitons, proton decay and squarks as fruitless predictions of the standard model. *That no particle exists to explain 85% of our galaxy's mass is a significant standard model failure.*

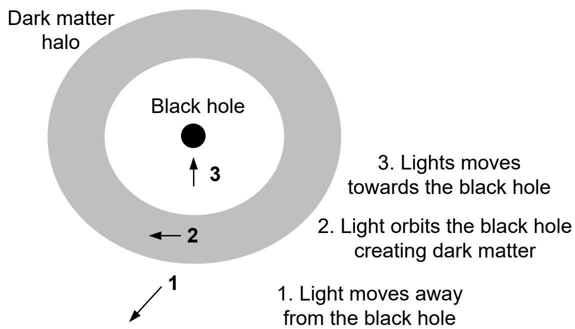

Figure 4.26. Dark matter is light in orbit

In a processing model, mass arises when net processing sustains over time. Any particle mass would have been seen by now so how else could net processing be sustained in a halo? One option is light trapped in "orbit" around the black hole at the center of most galaxies. This halo is possible, for if light is too close to a black hole it is pulled in and if light is too far away it escapes, but at a certain radius light will repeatedly circle in a very large loop (Figure 4.26).

Some light then rotates in vast but finite loop from which it can't escape. Over time this would build-up to a stream of circling light as more photons are added than leave. This stream would not be visible as light cannot be seen from the side.

Recall that in the pass-it-on protocol, nodes are *interrupt driven* so each cycle they *first* pass on current processing *then* receive any input to process, so if any node gets more processing than it can handle, it immediately passes it on. This allows the possibility of an infinite pass-it-on repeat but as argued earlier, any such repeat would be sooner or later absorbed by a node of new space. However, if the halo of rotating light around a black hole is massive enough, new space may not add fast enough to do this. The result would be a permanent net processing excess, which in this model is *matter*.

A dense enough stream of light constantly circling around a black hole will generate overloads. If they build up to be more than new space can absorb, they will pass-on permanent interrupts of excess processing. It follows that dark matter is created by light like ordinary matter, but it isn't a "particle" confined to a node but rather spread out through a vast stream of light. Light trapped in an orbit around a black hole gives rise to dark matter just as light trapped in a node gives rise to particle matter.

Ordinary and dark matter are both net processing that repeats but while ordinary matter is a stand-alone repeat, dark matter is a repeat that builds up due to a massive black hole. It isn't seen because photons don't collide with it but either pass through at right angles or join the stream. Matter generated in this way doesn't collide with itself because it doesn't have a particle structure. Particles as excess processing confined to a node collide with each other but dark matter as processing interrupts passed on in a loop halo don't collide. Hence when galaxies collide, the dark matter stays with the black hole that creates it when they separate, rather than colliding. This model allows small galaxies to exist with no black holes and even galaxies that have lost their stars to consist of 99.99% dark matter. *Dark matter confirms that mass can arise in a way other than as a "particle".*

4.7.7 Dark energy

After confirming dark matter, in 1998 astronomers discovered that the expansion of universe, previously thought to be slowing down under the force of gravity, was actually *accelerating*. Some sort of *negative gravity* had to be pushing the universe apart against the gravity that pulls it together. The force stopping gravity from collapsing the universe was called *dark energy*. Cosmologists estimate that dark energy is 68% of the energy of the universe, dark matter is 27% and the standard model particle matter is at best only 5%. Since the standard model's particles only account for a tiny fraction of the energy of the universe, it isn't even close to being a theory of everything.

Dark energy is a weak effect, spread evenly through space that doesn't seem to have changed much over time. In equations, it makes space flat so some call it a property of space itself but if so, it should increase as space expands. If it is caused by particles in space, as the standard model assumes every force is, it should weaken over time as space expands but it doesn't. Particles of any sort should clump together not remain evenly spread and what particle could cancel gravity to push the universe apart? The standard model doesn't have any explanation at all for dark energy because no particle can have a negative energy.

In quantum realism, our space is the inner surface of a bubble expanding into a quantum bulk that *adds nodes* as it expands. It follows that an expanding universe must lose energy, just as expanding a box cools the gas within it. New points of space are adding all the time evenly throughout space. Since they are new, for their first cycle they receive but don't transmit energy. This negative energy effect spread over all space is then dark energy. It does not diminish as space expands because more of it continually pops into existence to keep pace with the expanding universe, and indeed it may even be gradually increasing. *That dark energy comes from new space means that no particle cause will ever explain it.*

4.8. COSMIC EVOLUTION

The alternative to the *clockwork universe* of current physics is a *cosmic evolution* driven by natural selection at the quantum level. Quantum realism envisages a *living universe* constantly giving birth to itself rather than a *dead universe* winding down while being pushed around by lawful but magical forces.

4.8.1 Is the universe dead or alive?

According to current physics, dead matter made galaxies, stars, planets, life and us *by accident*. Even if something made the universe, it long ago abandoned it to matter interactions based on the laws of physics. In this view, the laws that control matter also control people, so consciousness is considered to be just an illusion - an epiphenomenon of matter complexity (Zizzi, 2003). Physicists assert that the laws of thermodynamics doom everything to run down, whether it is our bodies, the sun or the universe, so everything will end in an eternal emptiness or "big freeze". It follows that the universe, and its life, is ultimately *pointless,* so it doesn't matter what we do.

This *cosmic nihilism* calls itself the voice of reason but actual reason suggests a different direction. That the physical universe began implies that it came from something else, so we are not alone. That quantum randomness has no physical source implies there are non-physical causes, so matter is not all there is. That the universe always decays implies that it began ordered, which the primal chaos wasn't, so decay is not the only principle operating. That the laws of physics are based on probability not certainty means that this is no machine, so the future is not written. When examined closely, the story of a *mechanistic world going nowhere that accidentally made us* makes no more sense than that of a world *built just for us by a supreme being*.

One concludes that physical realism is *just a theory,* and scientists who don't question their theories are priests. Last century, it was the only game in the town but today quantum realism is a rational alternative. It proposes that space is a processing *network*, time is processing *cycles,* light is the basic *process* and matter is entangled light *rebooting.* This theory, based on the method of reverse engineering, is testable, so if it is wrong, let the facts decide not preconceived beliefs.

The standard model assumes that its bits of matter began at the big bang as they are now, but in quantum realism the universe had to *evolve*, as it booted up from one photon in one unit of space. This boot-up began small, just as Windows boots from a tiny CMOS that loads a *kernel* that loads a bigger *BIOS* that loads the full *operating system*. Booting up a computer isn't booting up a universe but if one photon spawned the first light that made matter, life and eventually us, it is the same on a vast scale. This means there were no divine shortcuts, as every element had to evolve in the matter factories we call stars or in a supernova sacrifice. *The evidence suggests that rather than being in a dead universe running down, we are part of a living universe evolving up.*

4.8.2 Our fine-tuned universe

Why is our universe suited for stars, galaxies and life to evolve? For stars to create atoms needs the stability of galaxies that would fly apart without dark matter. We make energy by *nuclear fission* that breaks higher nuclei apart but stars make energy by *nuclear fusion* that merges nuclei, as when two Hydrogen atoms form Helium. This process requires neutrons that the weak force just so happens to let stars create from protons. The laws of physics did not allow nuclear fusion to create the carbon atoms needed for life until a "just right" energy resonance was found:

> "*The energy at which the carbon resonance occurs is determined by the interplay between the strong nuclear force and the electromagnetic force. If the strong force were slightly stronger or slightly weaker … the universe might very well be devoid of life and go unobserved.*" (P. Davies, 2006)

The *Goldilocks Effect* is that our universe has an unreasonable number of parameters set "just right" for life, without which we couldn't exist. Were these values set "just so" by a kind creator or did an impartial system spawn many universes and we just happen to be on the life-supporting one? Ananthaswamy (2012) gives one example in detail:

> "*Take, for instance, the neutron. It is 1.00137841870 times heavier than the proton, which is what allows it to decay into a proton, electron and neutrino—a process that determined the relative abundances of hydrogen and helium after the big bang and gave us a universe dominated by hydrogen. If the neutron-to-proton mass ratio were even slightly different, we would be living in a very different universe: one, perhaps, with far too much helium, in which stars would have burned out too quickly for life to evolve, or one in which protons decayed into neutrons rather than the other way around, leaving the universe without atoms. So, in fact, we wouldn't be living here at all—we wouldn't exist.*"

The conclusion isn't that the universe is *designed* for life, as if so, it would be a poor design because most of the universe is inhospitable to life. Yet it is true that the parameters of our universe are balanced on a "knife edge", for as Susskind says:

> *"The great mystery is not why there is dark energy. The great mystery is why there is so little of it [10^{-122}]… The fact that we are just on the knife edge of existence, [that] if dark energy were very much bigger we wouldn't be here, that's the mystery."*

Other "cosmic coincidences" are (from Barnes, 2012):

1. *Strong force*. If the strong force were slightly stronger or weaker by just 1% there would be no carbon or heavier elements anywhere in the universe.
2. *Weak force*. If the weak force was any weaker the hydrogen in the universe would be greatly decreased, starving stars of nuclear fuel and leaving the universe a cold and lifeless place.
3. *Neutrons.* If neutrons were slightly less massive the universe would be entirely protons and if lower by 1%, then all protons would decay into neutrons, and no atoms other than hydrogen, helium, lithium and beryllium could form.
4. *Cosmic microwave background.* This radiation has a slight anisotropy, roughly one part in 100,000, just enough to allow stars and galaxies to form. Any smaller and the early universe would have been too smooth for stars and galaxies to form and any larger and stable stars with planetary systems would have been extremely rare.
5. *Cosmological constant*. The positive and negative contributions to the vacuum energy density cancel to 120-digit accuracy, but the 121st digit makes our universe possible.

Since *all* the above and more apply, our "luck" is hard to explain. And it is the *entire universe* that is fine-tuned to evolve, not just some part of it, so one can't conclude it is a "lucky accident" based on a sample of one. Unless of course there are many universes, hence the popularity of multiverse theory despite it being a scientifically worthless idea. But to conclude that there *had to be* many universes *in order* to make our universe an accident is not science. To be clear, the fine-tuning of our universe is based on evidence but the multiverse is based on no evidence at all. As O'Leary notes:

> *"The multiverse has only ever existed, so far as we know, in the mind of man. Its most promising research programs, string theory and early rapid cosmic inflation theory, have bounced along on enthusiasm alone, prompting ever more arcane speculations for which there may never be any possibility of evidence.*" (O'Leary, 2017)

A recent variant is Smolin's speculation that black holes spawn universes, based on an old idea suggested by Hawking in 1987, again with no evidence. Just because a black hole is a *mathematical infinity* doesn't mean it can create a universe.

In quantum realism, the physical universe came from a *pre-existing* quantum reality, so every universal parameter was defined from the start by the nature of that reality. A processing model expects the many parameters of the standard model to reduce to the core properties of a processing network, such as the network refresh rate (the speed of light), the network density (Planck's constant) and the rate the network is expanding (the cosmological constant). From these, simulations based on quantum reverse engineering could derive the other parameters.

In this view, if other "bubble universes" arose in the quantum bulk as ours did, they would have *exactly the same laws of physics* except the initial symmetry might break the anti-matter way. Each universe would then undergo a *quantum evolution,* just as ours has. In this view, our universe is as it is based on the quantum reality that preceded it and there is no benefit to speculate why. Its parameters were neither accidental nor chosen, so the universe is neither designed for life nor not designed so. It just did what it could given the original quantum reality. That a river is finely-tuned for crocodiles to live in doesn't mean it was designed for them but that crocodiles evolved to live in rivers. In the same way our universe is finely-tuned for life because life evolved to fit what it was given. *In quantum realism, the conditions for the evolution of the universe were established when it began*.

4.8.3 Quantum evolution

Darwin's "great idea" was that the human species was *naturally selected* by the evolution of life over millions of years rather than created by a divine intelligence. The conditions necessary for a *species* to evolve are identified as:

1. *Reproduction*. Species produce offspring that carry on their traits.
2. *Variation*. The offspring's traits vary, e.g. by mutation.
3. *Selection*. Those offspring better fitted to survive reproduce more to pass on their traits.

Evolution is essentially an *iterative method* that lets biological *patterns* suited to survive arise naturally based on trial-and-error rather than a preconceived plan. a view that was taken to contradict the orthodox religious view of a divine creator.

In quantum realism, the physical world *evolves* because the quantum world explores every option. To apply Darwin's theory to the quantum world, replace "species" by "quantum entity", defined as a quantum server process. A photon as a quantum entity is then subject to evolutionary conditions as follows:

1. *Reproduction*. The photon quantum wave generates "offspring" by instantiation.
2. *Variation*. The "clone" instances in the photon cloud vary in properties like location and direction.
3. *Selection*. Quantum collapse then selects one instance to restart the photon in a physical event.

When a photon cloud passes through Young's slits to hit the screen at a point, one instance is *selected* from many *variants* to trigger a server restart that *reproduces* the photon. Likewise, light finds the shortest path to any destination by a *quantum evolution,* where the instance that accidentally finds the shortest path to restart the server first is "more fit". Yet while the "success" of that photon instance is accidental, that some instance will find the fastest possible way is not.

Young's experiment doesn't change the photon but many photons merging into an electron do constitute a new "species" as an electron has different properties from light. An electron can be said to occupy an "niche" of quantum space just as a species occupies a niche in nature. And just as an organism has competitors that seek to displace it, so an electron is constantly bombarded with competitors for its channels. The photon pattern we call an electron is *stable* only because it can keep other quantum entities out of its niche and *survive*. The biological concept of *survival* is thus replaced by the concept of *stability* in quantum evolution.

The evolution of matter did not stop at the electron but went on to give neutrinos, quarks, protons, neutrons and all the atoms of the periodic table, and this *physical evolution* was in play long before Darwin's *biological evolution* began. If this were not so, how else could dead physical particles that in themselves have no life at all give rise to self-directed life? In contrast if processing cycles create *change* and quantum randomness gives *variety* then stable matter end-states are *naturally selected* in a physical evolution. Now it is expected that physical evolution will lead to biological evolution.

Quantum randomness illustrates the conundrum. In a clockwork universe randomness is pointless as it just introduces errors in the clock. Randomness is equally unhelpful in a god-designed universe as it just interferes with the divine plan. Hence neither mechanists nor theists welcome the randomness of quantum theory, but in quantum realism it is as necessary for physical evolution as genetic variety is for biological evolution. *One concludes that what drives the universe is not dead matter following fixed laws nor a divine plan prepared by a super being but a dynamic quantum evolution discovering its future.*

4.8.4 Our universe was borne not made

Is our universe following a plan? If it is following a pre-set route to a pre-defined end-state then we are pointless cogs in a big machine, powerless to change the divine plan. Conversely, that there is no plan and all it is just accident leads to the nihilism that *nothing really matters at all,* which denies the accountability that societies need to work, so society would collapse and we wouldn't be here (Whitworth & Ahmad, 2013). Yet plan vs. no-plan aren't the only options.

An air-conditioning system with a thermostat has no plan to turn on or off at certain times, just a temperature setting it is programmed to maintain and it follows that "law" and acts accordingly, given an electrical power source. It is not random but equally its acts aren't planned in advance. A computer simulation is more complex but again there is no plan for what it does moment-to-moment as what evolves may surprise even its designer, but it also follows built-in laws and again needs an ongoing source, in this case a computer processor. It isn't planned but neither is it acting by accident. Even more complex is a baby, where again one cannot say it has a plan but nor is what it does just accident. Psychology tells us that the brain is pre-set to learn a language, identify faces and form relationships but it can be any language, any face or any relationship. In all these cases, a system driven by some source of its activity is *predisposed* a certain way but has no preconceived plan of action nor is anything external directing it to follow a plan.

If evolution was built-in to our universe at the beginning, it was predisposed to evolve, subject to pre-set limits or laws, and supported by the power of ongoing quantum activity. This evolution was a trial-and-error process with no master plan nor any blueprints of what will happen, just as science says, but to call the evolution itself an accident is a step too far. If we do not even know how our universe began, how can we seriously conclude that it was an accident? That a universe *structured to evolve* doesn't have a central director to tell it what to do doesn't make it accidental. Evolution works by accidental means but evolution itself is not accidental because it tries every option to eventually find what works.

Our universe wasn't *built* as a watchmaker builds a watch to a pre-set design but was *borne,* like a baby not knowing where it is going or why but containing the essence of its parentage. Hence it was predisposed to evolve just as a baby is predisposed to learn. The birth of a particular baby may be accidental but that babies are borne isn't an accident because that is how species survive. Nor can the baby itself be considered an accident because its nature directly derives from its ancestry.

In quantum realism, the "parent" of physical reality is a quantum reality that is "alive" in the sense that it acts from its own nature rather than having to be "pushed". Instead of fundamental particles that always existed following fixed laws set by some distant deity or accident, quantum realism sees a *fecund universe* where quantum reality continually "gives birth" to physical reality. In this view, the physical world is constantly being created by something beyond itself.

The next chapter extends quantum realism to include the fields of gravity, charge and magnetism.

Table 4.8 compares how quantum realism and physical realism explain matter so the reader can decide.

Table 4.8. Physical realism vs. quantum realism for matter

Physical realism	**Quantum realism**
Matter. If matter is made of *fundamental particles* then particles cause everything, so: f) *Space*. Space is nothing as there is no null particle g) *Light*. Is a wave-particle without mass or charge! h) *Mass*. Measures the *particle substance* i) *Charge*. A property of matter unrelated to mass j) *Anti-matter*. Negative matter that for some reason has the same mass but opposite charge k) *Our universe* was *built* from the standard model Lego-set of 62 fundamental particles	*Matter*. Is generated by *quantum processing* that is the cause of everything, so: a) *Space*. Space is a null process not nothing b) *Light.* Is the same process shared by many nodes c) *Mass.* Measures the *net processing* repeating in a node d) *Charge.* The net remainder of the repeat processing e) *Anti-matter.* Matter processing in reverse that gives the same mass but opposite charge f) *Our universe* was *borne* from vibrations on the inner surface of a bubble expanding in a quantum bulk
Electron. A fundamental matter particle created from nothing that: a) Is a structureless point with no dimensions, even though that implies no mass, charge or spin b) Has mass even though no extent implies no substance c) Has negative charge just because it does and charge is not related to its mass d) Has *imaginary spin* which is half of its total spin for some reason e) Always moves for some reason but is slower than light f) Never collides in an atomic shell even though it is a particle with mass for some unknown reason	*Electron.* An ongoing *head-head* extreme photon collision that: a) Is the repeating overload of all the channels of *one axis through one node* b) Has mass as net quantum processing that repeats c) Has negative charge because negative processing is left-over for a head-head photon overload d) *Really spins* in quantum space but only half its photons amplitudes are seen from any angle e) Always moves like light but only on two dimensions f) Never collides because it is entirely light-like in a two-dimensional atomic shell
Neutrino. A fundamental matter particle that: a) Is a structureless point with no dimensions b) Has a tiny mass that varies unpredictably despite its predicted zero mass c) Has zero charge despite not having zero mass d) Always has left-handed spin for no known reason even though this contradicts spatial symmetry e) Is a lepton like an electron just "because it is" for no structural reason	*Neutrino*. An ongoing *head-tail* version of an electron that: a) Fills the channels of *one axis through one node* b) Has a tiny mass since its heads and tails don't quite cancel due to *quantum asynchrony* c) Has zero charge because process remainders cancel d) Always has left-handed spin because reversing direction changes phase to swap its mass photons e) Is a lepton like an electron because it is the alternate *phase* of one-axis quantum wave collision
Quark. A fundamental matter particle that: a) Is a structureless point with no dimensions	*Quark.* A repeating *three-axis* extreme photon collision that: a) Has a three-axis node structure

b) Comes in two types, up and down, with different masses and charges, for a reason that is never given c) Exists in groups but is never observed alone, for some unknown reason d) Has unexpected one-third charges for some reason	b) A three-axis photon collision has two viable phases: *head-tail-tail* (up) and *head-head-tail* (down) c) Three photon sets don't fill the channels of a plane so it isn't stable alone d) A three-axis collision predicts one-third remainders
Many fields. All the forces of nature are from invisible fields that invoke virtual particles from space to do their work: a) *Gravity.* Acts at a distance by creating virtual gravitons despite no evidence whatsoever that they exist b) *Electromagnetism.* Acts at a distance by an invisible field that creates virtual photons to cause effects c) *Strong force.* Acts when a strong field creates virtual *gluons* that let quarks with a red, green and blue *color charge* form a proton as the colors cancel to clear, and massless gluons create the proton's mass d) *Weak force.* Acts when a weak field creates massive virtual particles called W bosons that turn a neutron into a proton but *never* turn protons into neutrons for some unknown reason, except in stars e) *The Higgs.* Is the virtual particle needed to create the mass of the W bosons that cause the weak force f) *Virtual particles*. Virtual particles cause all effects and create almost all the mass we see around us	*One field.* All the forces of nature are from quantum processes spreading and interacting on a quantum network: a) *Gravity.* The spreading processing of matter creates a processing gradient that has effects (next chapter) b) *Electromagnetism.* Acts in photon units because the photon is the basic process of the quantum network c) *Strong force.* Acts because quarks *share photons* when their three axes *orientate* to form a proton, in a triangle structure where increased *interference* creates the proton's mass d) *Weak force.* Occurs when a neutrino turns a set of photon heads into tails to convert a neutron into a proton but to turn a proton into a neutron requires an electron to get close which only occurs in stars e) *The Higgs.* Is the imaginary cause invoked to explain another imaginary cause that explains an effect f) *Virtual particles*. Virtual particles are imaginary agents that don't exist at all
The universe of matter was *built* from basic particles as an engineer builds a building from bricks and wood a) *Atoms.* Electron particles with mass that "orbit" a nucleus should collapse or collide but they never do b) *Electron shells*. Electrons as particles fill shells in periodic table atoms based on data-fitted quantum numbers that represent nothing c) *Atomic nuclei*. Proton and neutron particles cram into the atomic nucleus like raisins in a plum pudding mix, giving no reason for more neutrons in higher nuclei d) *Family generations.* Two higher variants of the basic particles exist then no more, for no known reason e) *Dark matter.* A "halo" that is over 85% of the matter of our galaxy for which no particle cause has been found f) *Dark energy.* Is over two-thirds of the energy of the universe for which no particle cause is even conceived	*The universe* of matter *evolved* from quantum processing as life evolves by trying all the options to find out what works a) *Atoms*. Electron waves find different harmonics and distances to constantly vibrate so they never interfere b) *Electron shells*. Electrons as waves fill atomic shell circumferences based on wavelength, wave harmonics and great circle orientation c) *Atomic nuclei*. The proton and neutron quark triangles in an atomic nucleus open up to re-link in a single closed string that needs neutron buffers to fold corectly d) *Family generations.* Higher basic matter variants repeat on the two extra dimensions of space only e) *Dark matter.* Is a constant net processing created by light orbiting the galaxy black hole f) *Dark energy.* Is generated by the ongoing creation of new space that absorbs energy for its first cycle
The dead physical world is decaying, accidental and inert	*The living quantum world is changing, choosing and active*

DISCUSSION QUESTIONS

The following questions are addressed in this chapter. They are better discussed in a group to allow a variety of opinions to emerge. The relevant section link is given after each question:

1. How do mass and charge relate? (4.3.2)
2. Why are electrons and neutrinos both classified as leptons? (4.3.3)
3. Why do neutrinos have a tiny mass but no charge? (4.3.3)

4. Why is our universe made of matter instead of anti-matter? (4.3.5)
5. If anti-particles run time in reverse, can they go backwards in time? (4.3.6)
6. Why do quarks have strange one-third charges? (4.4.3)
7. What causes the strong force that binds quarks in the nucleus of an atom? (4.4.4)
8. Why does this quark binding get stronger with distance? (4.4.4)
9. Why are three quarks needed to form a proton or neutron? (4.4.5)
10. What do the quark "colors" of the standard model represent? (4.4.5)
11. What turns neutrons in space into protons? Why don't protons in space decay? (4.4.6)
12. Does the Higgs cause any of the mass around us? Why is it said to "cause mass"? (4.4.7)
13. Why does the energy inherent in all matter depend on the speed of light? (4.4.8)
14. Why does string theory need *eleven* dimensions to work? (4.5.1)
15. What did Newton think caused gravity? Does current physics agree? What does the evidence suggest? (4.5.2)
16. Why are forces due to virtual particles called "magical" despite being lawful? (4.5.2)
17. What rules does current physics apply to decide when virtual particles interact? (4.5.3)
18. Has the standard model ever explained any new evidence without expanding itself? (4.5.4)
19. What is the key difference between an equation and a theory? How do you assess each? (4.5.5)
20. How is the standard model of physics similar to the standard model of medieval astronomy? (4.5.6)
21. Are the standard model's fundamental particles actually particles? Are they fundamental? Explain. (4.5.7)
22. How does a processing model classify the basic entities of physics? (4.5.8)
23. Why does quantum realism's claim that matter is made of photons contradict the standard model? (4.5.9)
24. What came first, matter or light? Give a reason for your answer (4.5.9)
25. Why do all higher atomic nuclei need neutrons? (4.6.1)
26. An atom of lead has 82 electrons in a small space. Why don't they collide with each other? (4.6.2)
27. How do electrons "fill" the shells and subshells of an atom? (4.6.3)
28. Can electrons as point-particles spin? What can spin? Why do electrons "half-spin"? (4.7.1)
29. Why are neutrinos always left-handed? (4.7.2)
30. Why are protons much heavier than the quarks from which they are made? (4.7.3)
31. Why is the universe charge neutral? (4.7.4)
32. Why do leptons and quarks have three family generations, then no more? (4.7.5)
33. Why are the higher generations of leptons and quarks increasingly heavy? (4.7.5)
34. What is dark matter? Why can't we see it? How does it differ from ordinary matter? (4.7.6)
35. What is dark energy? Why can't a particle model explain it? (4.7.7)
36. Is our universe dead or alive? Give reasons. (4.8.1)
37. Why is our universe "finely tuned" for life? (4.8.2)
38. What are the quantum evolution equivalents of biology's reproduction, variation and selection? (4.8.3)
39. Was our universe "built" as a watchmaker builds a watch? If not, how did we arise? (4.8.4)

Chapter 5. The Quantum Field

"In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual."

Galileo Galilei

A long-standing goal of physics is the unification of its many fields. The last chapter attributed the effects of the standard model's strong and weak fields to quantum processing, and so has no need for them or the Higgs field. In this chapter gravity, electricity and magnetism also arise from a single quantum field that thus causes all physical effects.

5.1. GRAVITY RULES

Everyone knows that gravity attracts but how exactly does it do that? How does a lump of dead matter like the moon create tides on the earth from hundreds of thousands of miles away? Gravity rules the universe at large but how simple matter exercises this power remains a mystery.

5.1.1. The great divide

About a hundred years ago, relativity and quantum theory replaced the previous 200-year-old Newtonian model with a world of malleable time, curved space and matter probability waves. A century of research has confirmed both theories in their respective cosmic and sub-atomic domains yet *they contradict each other,* as relativity creates infinities at quantum lengths and quantum field tricks fail for gravity. As one physicist states:

> "*Mankind has uncovered two extremely efficient theories: one that describes our universe's structure (Einstein's gravity: the theory of general relativity), and one that describes everything our universe contains (quantum field theory), and these two theories won't talk to each other.*" (Galfard, 2016)

This schism existed at the heart of physics last century and essentially nothing has changed since. It is as if the universe has two different rule books, one for the very small and one for the very large with nothing in common, as the very large rules don't work for the very small and the very small rules don't work for the very large.

Two theories that contradict each other can't both be right but both quantum theory and relativity have been proved to be right innumerable times. The conclusion isn't that they are wrong but that both are incomplete. If both are right, then each is only half the picture and something more fundamental is at play.

Quantum realism concludes that these two theories can't talk to each other because *each exposes the other's theoretical errors but ignores its own*:

1. *Quantum theory:* Assumes that quantum states evolve on a static *spacetime background* (Smolin, 2006) that relativity assures us doesn't exist.
2. *Relativity theory:* Assumes that *foreground objects* follow fixed trajectories that quantum theory assures us isn't so.

The reconciliation now explored is that both foreground objects and their background context are created by a *quantum field,* defined as quantum processing on a quantum network.

5.1.2. How do space and time change?

Space and time in physics aren't just mental concepts but reality properties measured by rulers and atomic clocks. When objects try to occupy the same space at the same time they collide and the particle model assures us that this is the *only* way that matter interacts. The problem is that gravity ignores this restriction. It lets the sun hold the earth in orbit around it even though they are millions of miles apart and with nothing between them but space.

Einstein's solution was that matter changes the reality context, by altering time and space. *Special relativity* asserts that a moving matter object alters its own time and space and *general relativity* asserts that large objects change time and space for other objects around them. The equations work but they don't say how matter manages to change time and space. *How can mere matter change the time and space it exists within*?

This problem is why quantum theory can't replace relativity. The standard model works by particles but what particle can alter space and time? That would be like a painting making the frame it presents within larger or smaller! The nub of the quantum-relativity theory clash is that no graviton particle has ever been found and probably never will be. This leaves physics with two grand theories, one about particles and the other about their spacetime context, with no common ground at all.

5.2. SPECIAL RELATIVITY

If quantum theory is strange, relativity is stranger because it alters the time and space we take for granted. Special relativity suggests there is a mystery behind the movement of ordinary matter.

5.2.1. Our reality bubble

Maxwell's equations describe light as a wave so in the nineteenth century a superfine *ether* was assumed to propagate it in space. But if the earth orbiting the sun gave the seasons and its spin gave night and day, the *ether wind* couldn't always be stationary (Figure 5.1). The speed of light should vary: light going against the wind should go slower and light going with the wind should go faster. But in 1887, Michelson and Morley found to everyone's surprise that the speed of light was the same in every direction. There could be no ether wind! This was deeply counter intuitive - how could the movement of the earth not affect the movement of light?

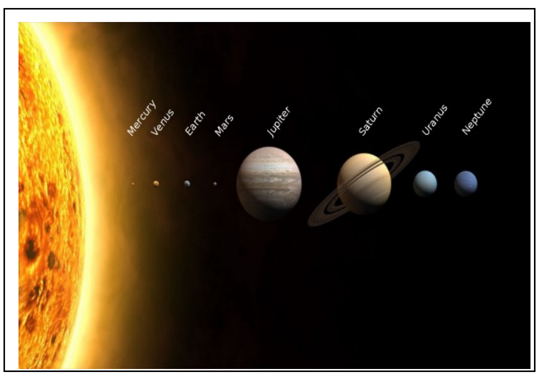

Figure 5.1. *How fast are we moving?*

In 1904 Lorentz showed that the equations of light stayed the same if space and time changed as objects moved. In 1905 Poincare deduced the *relativity principle,* that the laws of physics were the same in every reference frame*,* so a ball thrown up in a moving car acts the same as in a stationary car. In our world, constant speed observers get the same laws of physics, so throwing a ball, swinging a pendulum or shining a flashlight is the same on a constantly moving platform as on earth.

This is fortunate, as the earth **is** a planetary platform, carrying us through the cosmos. Its spin whirls us around at about 1000mph, it carries us around the sun at about 66,000mph and we go around the galaxy at an amazing 483,000mph. Some estimate that our speed relative to the cosmic background radiation is about 1,300,000 mph, yet science works on earth as it does in the rest of the universe. *We live on a moving planet, so how is our reality bubble maintained?*

5.2.2. Maintaining normality

Einstein discovered how our normality is maintained as follows. He imagined a moving train where a floor light reflects from a mirror up on the ceiling. A train passenger sees the light go straight up and down but a platform observer sees it travel a longer path in the same time (Figure 5.2). If time and space are the same for both, they get a different speed of light and different physics. Einstein's conclusion was that space had to shrink and time dilate to keep the speed of light constant, otherwise flashlights might not always shine and mirrors might not always reflect! Lorentz saw his transformations as mathematical curiosities but Einstein saw them as what made Poincare's relativity principle work. *Einstein recognized that for the universe to be as Poincare described, space and time had to change as Lorentz described*. Time and space had to change to make physics *invariant*[60].

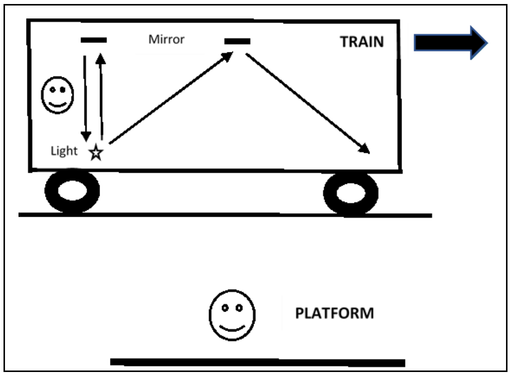

Figure 5.2. Einstein's moving train

The implications of this conclusion are strange indeed. Imagine a rocket flying past a space station in orbit (Figure 5.3). It doesn't seem possible that people on the rocket and on the space station both get the same speed of light, but in fact they do! If they didn't, our physics wouldn't work on Mars. Einstein's conclusion, that time and space change when one moves, has been verified by experiment.

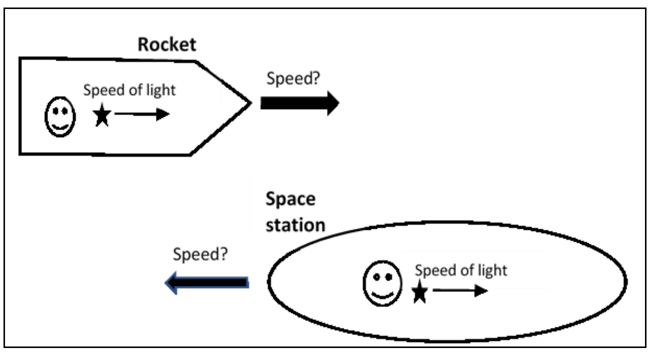

Figure 5.3. A rocket passing a space station

Yet who is really moving – is the rocket going past the space station or is the orbiting space station passing the rocket? It turns out that it doesn't matter. If the rocket moves, its space and time contract and dilate, or if the space station moves the same applies. Regardless of how the rocket and station move *relative* to each other, *distance* and *time* change just enough to keep the speed of light the same for both. For any particle model, this extraordinary finding makes no sense at all

It seems weird that time and space change to maintain normality when we move but as Einstein said, *this is why the universe* ***isn't*** *weird*. That the speed of light stays the same no matter how fast we are moving is why we live in a "normal" universe.

5.2.3. Maintaining causality

Why is the speed of light constant not say the speed of lead? Why is light the *gold standard of movement?* The answer is causality. Imagine a rocket going at nearly the speed of light to a planet and then returning to earth. If the rocket's speed affected the speed of light, a message sent on the journey **to** the planet might arrive after one sent on the way **back**. If the rocket exploded after rounding the planet, one might *first* see the blast *then* get a message from the crew that all is well, like getting a cheery Facebook message from a person after attending their funeral.

Relativity even tells us that a rocket that left the earth could use faster than light travel to go *back in time and return before it left*. As Buckley points out, given the options of faster than light travel, relativity and

[60] Einstein preferred the term invariance for his theory but relativity stuck.

causality, the universe can support two but not all three at once. Faster than light travel would allow the natural causality of events in our world to be breached. But it doesn't happen because light, as the constant messenger of reality, never gets causality backwards.

One must also conclude that *matter moves differently from light*. If matter and light moved in the same way, then some particle would be needed to push light to go faster again after it slowed down when it moved through water say. Needless to say, this is not so, and in general, it takes work to *move* matter but it takes work to *stop* light moving. If I drive at 100mph and throw a brick forward at 10mph, it goes at about 110mph but if I shine a torch, light goes at *exactly* the same speed! *How does light, and only light, do this?*

5.2.4. Time dilates

According to Einstein, the speed of light stays the same because time slows and distance shortens as matter moves faster. In the equations, *time stops at the speed of light* so a matter clock carried by a photon would not tick at all. A photon from the Andromeda galaxy takes 2.5 million years to get here but according to relativity, no time at all passes for the photon itself! It also says that light starts and ends its journey at the same location by length contraction. Needless to say, this makes no sense, as if time stops for light, how does it move at all? Clearly something is not right here, unless *matter time doesn't apply to light*.

In his classic thought experiment, Einstein imagined a twin leaving on a rocket that returns after five years of high-speed travel in space to find his twin brother is an old man of eighty! This could happen, because a muon traveling at 99.5% of the speed of light travels 3000 meters in its millionth of a second life when it should travel only 300 meters, i.e. speed extends its life tenfold. Relativity lets a traveler in a rocket accelerating at one *g* to get to our nearest galaxy and back in their 60year life but they would return to find the earth four million years older (Harrison, 1986, p157). The evidence is clear that *matter time really does slow down as matter moves faster.*

5.2.5. The universal speed limit

Light goes at the fantastic speed of 670 million miles per hour, about the distance to the moon in a second. Can we achieve this speed? What about a leap-frog method, like a rocket going at half the speed of light that shot a bullet forward at half the speed of light? Unfortunately, doing this changes time and space so the bullet only goes at four-fifths the speed of light!

How about gradually accelerating a rocket to reach the speed of light? Nature again intervenes by increasing the rocket's *mass,* until at near the speed of light it's near *infinite mass* needs a near *infinite force* to move it. This seems to contradict the conservation of mass and the law of thermodynamics, that energy in a closed system can't be lost. Einstein's answer was that energy and mass convert, by $E=mc^2$, so nothing is really lost. He didn't say whether mass was a form of energy, energy a form of mass, or both were aspects of something else.

In theory, in a rocket going 5mph slower than the speed of light one could throw a ball at 5mph per hour to reach the speed of light but in practice one can't produce the force needed to throw the ball. One might expect light in the rocket to move at almost twice the speed of light but Nature plays with space and time to keep every reference frame the same.

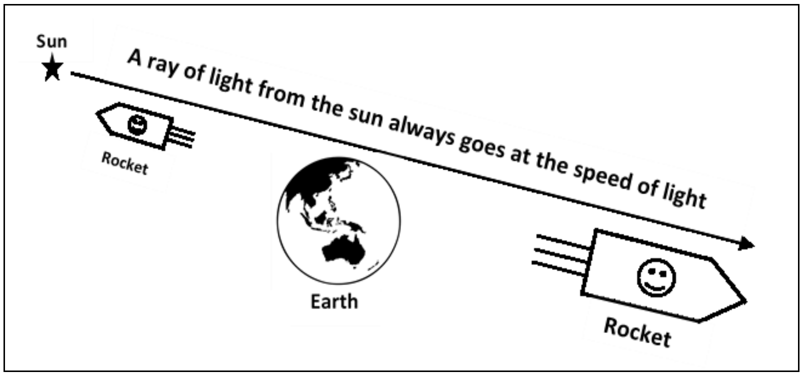

Figure 5.4. Light always travels at the speed of light![61]

Again, the implications are quite counter intuitive. For example, if the earth sent off two rockets at half the speed of light, one to the sun and one to Pluto (Figure 5.4), relativity says that light from the sun passes both rockets and the earth at the same speed! One might ask how can *the same photon* pass both rockets, one going to the sun and the other away from it, at the same speed? This makes no sense in classical or indeed any other terms.

The problem with relativity, as with quantum theory, is that the equations work but they don't make any sense. *How can the space that is the measure of movement itself move? How can time that is the measure of change itself change?* Einstein *deduced* that space-time had to change for our world to be as it is, but he didn't *explain* how it is so. Perhaps he expected us to unravel the mystery later but 100 years on, we are no wiser. *The next section suggests why our world behaves the way Einstein describes.*

5.3. MATTER TREMBLES

Einstein's special relativity *describes* what happens to our space and time when matter moves but doesn't say *why* it is so. According to quantum realism, light is quantum wave repeatedly spreading and matter is a quantum standing wave repeatedly restarting. Hence matter is inherently stationary while light is inherently moving. Since a standing wave doesn't "move" as a spreading wave does, quantum realism faces the odd question "*How does matter, as an inherently stationary wave, move at all?*"

5.3.1. A quantum standing wave restarts

Light as a quantum wave spreading on a quantum network explains its behavior better than photon particles, as it lets a two-slit experiment photon go through both slits as a wave and still restart at a screen point. So Feynman's integral over histories method works because it calculates what light actually does. Light can *act like a wave* then *look like a particle* because a processing wave can restart at the point overload where it "hits" the screen. Light then moves "forward" for two reasons. First, quantum processing always spreads on the quantum network. Second, the front of a photon wave runs its cycle before the back, so its backward spread largely cancels while the forward spread does not, so the end result is a forward moving wave, just as Huygens said.

In contrast, matter as standing wave with no "front" or "back" doesn't naturally move in any direction. It is inherently stationary but as its nature is still quantum, its quantum processing still spreads on the quantum network, just as light does. A *quantum standing wave* doesn't move but it still has a distribution on the quantum network. If a photon is like a moving boat whose quantum engine spreads ripples in all directions, matter is like a stationary boat whose quantum engine still spreads waves in all directions. And while a photon only restarts when it hits the screen, matter restarts every cycle.

Quantum theory implies that a quantum matter entity doesn't just sit passively at a fixed point but rather "trembles" about, based on its quantum distribution. This zitterbewegung reflects the "fuzziness" of quantum matter existence. It was deduced by Schrödinger from the Dirac equation for electrons but the logic applies to all matter. Light and matter then act alike in that while a physical measurement locates a point particle, at the quantum level they "exist" throughout their quantum distribution. But while a photon

[61] Earth picture from https://pixabay.com/en/earth-map-globe-world-australia-145504/

only restarts when it arrives at a screen, quantum matter restarts every cycle and where it does so depends on its quantum field strength, just as for light. One can imagine a screen dot that isn't redrawn at the same point each cycle but sometimes redrawn nearby depending on a probability distribution.

That matter randomly trembles at the quantum level based on its quantum distribution is implied by quantum theory. If the distribution is symmetric, this quivering *on average* has no effect on the macroscopic level. But if it is asymmetric for any reason, the entity will restart one way more than another. Since quantum events occur at a fantastic rate, the changes add up to cause movement in our time. If the quantum distribution is symmetric, the trembles cancel but if not, any probability bias adds up to give visible movement.

Quantum trembling explains why matter doesn't "move" as light does, by node-to-node transfer. It moves by restarting at a new point which is in essence a *teleport*. This type of movement is illustrated by quantum tunneling, when an electron within an impenetrable Gaussian field suddenly appears outside it, like a marble suddenly popping out of a sealed bottle. It didn't *travel a path* out as light might, as it can't exist in the intervening field. *It just teleported*. Matter can "tunnel" to any point in its quantum distribution by restarting there. *Quantum realism concludes that all matter moves this way.*

Quantum matter trembles because it isn't inert but made of light that is still active. That light moves by *path transmission* but matter moves by *direct teleport* suggests answers to the mysteries of special relativity.

5.3.2. Restarts change space and time

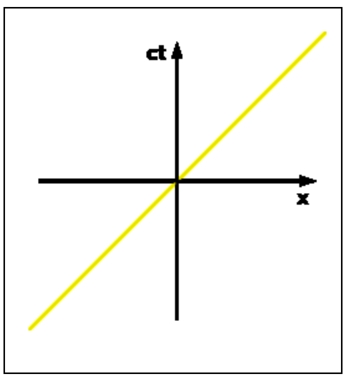

Figure 5.5. *Spacetime figure of a photon passing a point*

According to relativity, time and space adjust *exactly* to keep the speed of light constant however matter moves, but Einstein didn't say *how* this happens. *Quantum realism attributes the changes in space and time to matter teleporting*. If an entity restarts one node to the right say, any measure *it makes* in that direction is a pixel less, i.e. distance shortens in that direction. And if the restart interrupts a life cycle, that cycle of its life didn't get a chance to occur, i.e. time dilates. If matter spends a quantum cycle "in transit", that cycle isn't part of its life. For matter, life events and movement teleports share a limited resource - quantum cycles - that can give one or the other but not both at once. If distance is measured from where one is, a teleport one way shortens distance that way and if time is measured in life cycles every teleport steals a life cycle. Together, these two effects keep the speed of light constant as matter moves.

Figure 5.5 shows the space-time diagram of a photon of light passing stationary matter. The photon moves a point of distance per point of time to give a 45º line, i.e. the speed of light. When matter teleports, it loses a point of distance and a cycle of time which in effect slides the time axis down and the length axis right by one point. Since the photon still passes through the zero-point, shifting both axes by one means the photon line is still 45º, i.e. the speed of light is the same. *Special relativity arises because the movement of matter is based on origin changes not pointer changes*.

In Figure 5.4 earlier, *the same photon* from the sun passed both rockets and the earth at the speed of light because matter alters its time and space as it moves. The photon doesn't change what it does but rather the movement of each rocket alters how it measures distance and time, as each restart loses distance and time. Quantum realism *explains* why the movement of matter changes its space and time.

Einstein's theory implies that every matter body has *its own space and time,* so one can't talk of space and time without specifying for what? Time passes slower for objects that move faster because movement consumes quantum cycles. *Matter time* is measured by quantum cycles in the same node not interrupted by teleport cycles. Applying matter time to light creates contradictions because light moves to a new node every cycle. Einstein's equations imply that "time" stops for light but *matter time* doesn't apply to light.

Light moves in *quantum time,* which is the completion of any quantum cycle, as light could not move at all if no time passed for it.

5.3.3. Kinetic energy and photons

Radiant energy was earlier defined as the quantum processing transfer rate. Increasing a photon's wavelength divides the same process more to reduce the transfer rate, so the radiant energy of light reduces as its wavelength increases.

Kinetic energy as the energy of matter movement seems unrelated to radiant energy but when photons hit a solar sail it moves, so the two energies must relate. The reason is now proposed to be photons that don't disappear when they hit a solar sail but entangle with the sail matter. The family generations of leptons and quarks show that basic matter has spare channels by the nature of quantum space that photons can occupy. A matter entity can thus acquire more photons.

Added photons that have a direction will bias the quantum field in that direction. When a solar sail acquires photons, they bias its processing distribution to give macroscopic movement in their direction over time. When a moving body hits another, the extra photons are passed on so at the quantum level, kinetic energy is based on photons. If kinetic energy arises when matter acquires photons, it has the same basis as radiant energy.

That matter moves by acquiring photons suggests that mass increases as objects move faster, as relativity says, for the same reason that higher lepton and quark generations increase mass, namely interference. The increase isn't linear because interference doesn't increase linearly as information networks like the Internet illustrate. As matter goes faster, added photons compete more for the same channels giving the interference that in this model is mass. The mass increase tends to infinity because this is how interference increases with load.

Kinetic energy based on photon acquisition isn't quantized because a mass of any size can acquire one photon, dividing the change to any degree. The effect of adding a photon is shared so a large mass has more inertia, i.e. "resists" movement more as it requires more photons to make it move. *It also follows that to accelerate, a matter body must continually acquire photons*.

5.3.4. Bit-shifting reality

An objective world has only one type of movement but virtual worlds always have two. In Figure 5.6, one can move the avatars to the left by moving their pixels left or by moving the forest pixels behind them right. A program can create *relative movement* by moving the object or its background, as the avatars move *relative* to the forest in both cases. Programs move images by *bit-shifting* the foreground or background equally easily. In one case, avatar pixels move across the screen and in the other they keep a center-screen *frame of reference* as the background pixels scroll behind them.

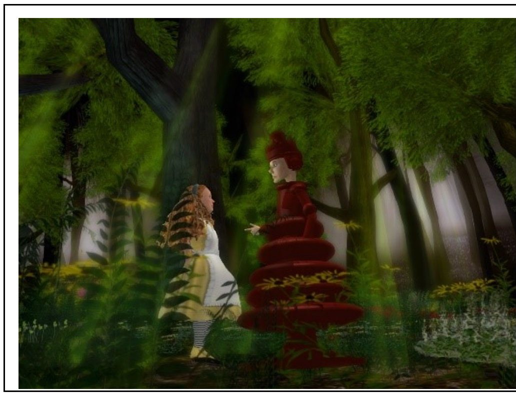

Figure 5.6. *Pixel avatars in a pixel forest*

Our reality also has two movement types, of light that is absolute and of matter that is relative to a frame of reference. Light and matter move differently in our reality just as in a virtual reality. Light moves like a pixel crossing a screen while matter moves like a center-screen image whose background scrolls. Bit-shifting space is the equivalent of moving the zero-point described earlier. The particle model assumes particles are moving on a stationary background but quantum realism adds the option of moving by bit-shifting the background. In a fast car, it isn't hard to imagine one is still and the world is scrolling by, perhaps because it is actually so.

5.4. GENERAL RELATIVITY

According to special relativity, being inside a plane going at a constant speed is equivalent to being stationary because planes going at different speeds adjust time and space to keep it so. General relativity extends special relativity to cover *acceleration*, when speed is increasing or decreasing.

5.4.1. Free-fall is acceleration

When a plane accelerates, the seat back pushes passengers to keep up with the plane but a parachutist in the initial free-fall accelerates without feeling any force at all. A parachutist who jumps from a plane feels no force in a *free-fall* even though gravity is accelerating them to the earth. As Douglas Adams said:

"*It's not the fall that kills you; it's the sudden stop at the end.*"

Einstein's insight was to equate the force of acceleration to the force of gravity. He called realizing that accelerating while falling from a building is like being at rest "*the happiest thought of my life*"! He concluded that *the force of gravity is equivalent to an acceleration*, so people in a rocket accelerating at 1**g** will feel a force pulling them down exactly like gravity on earth. Inside the rocket, they can sit down and have a cup of tea just as gravity lets them do on earth. Gravity is indistinguishable from an acceleration *except that no matter is being "pushed" to make it happen*.

Instead of concluding that a particle caused the acceleration, Einstein deduced that the earth warped the time and space around it. He replaced Newton's inexplicable force-at-a-distance gravity by general relativity gravity, that lets the earth distort space and time. For Newton, space was the fixed stage on which objects acted in a common time but for Einstein, *matter changed the space and time that define movement*. The earth distorts space and time so particles following straight paths now curve as if under the influence of a force. Einstein's *gravity works by redefining what it means to move in a straight line*.

Centuries earlier, Galileo showed that but for friction, all masses fall at the same speed since gravity and inertia both increase equally with mass. Einstein added that this is so because gravity is a constant acceleration that varies with mass just as inertia does. It was a brilliant solution, but it *left the standard model with a force that none of its particles could explain*.

5.4.2. The gravity gradient

Newton discovered gravity but found it *inconceivable* that inanimate matter caused it:

> "*It is inconceivable, that inanimate brute matter should, without the mediation of something else, which is not material, operate upon, and affect other matter without mutual contact;…*" (Wilczek, 2008) p77

Einstein attributed gravity to spacetime distortions but that Newton's *inanimate brute matter* distorts space and time is equally inconceivable! Physics today still cleaves to Newton's view that *only particles cause forces,* so when electromagnetism was found to act in photon units, it was attributed to virtual photons from space. But this trick didn't work for gravity, which still works with no particles in sight because no evidence for gravitons has ever been found. *Gravity lets objects accelerate without being hit by other objects*.

In quantum realism, matter isn't an inert substance but active processing that spreads on the quantum network. Just as one photon spreads a cloud of instances that travel all paths, so matter has a cloud of processing copies around itself. This *quantum field* allows electrons to teleport. The earth is too big to do that but it still generates a quantum field around it, just as an electron does.

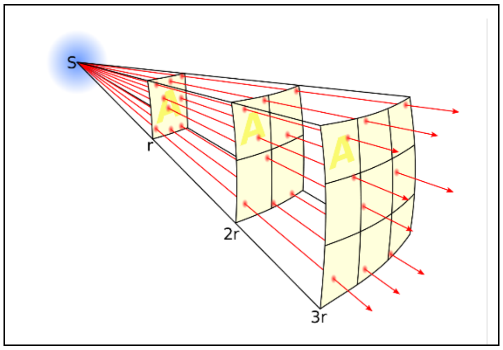

Figure 5.7 *Gauss's flux law*

The quantum field around matter should reduce as an inverse square of distance based on Gauss's theorem, that any flux spreading over a sphere surface diminishes as the inverse square of its radius[62] (Figure 5.7). This gives a *quantum field gradient* that is now proposed to cause gravity.

The gravity of small object is tiny but the earth's matter generates a huge quantum field around it. The effect increases closer to earth, so a small object in this field has more processing on the side nearer earth than further away, which increases the probability that it will overload and restart on the nearer side. The earth then moves matter not by pushing it, but by biasing the quantum field around it.

In classical theory, objects must be pushed to move but quantum theory lets electrons just appear in places based on their quantum distribution. In our terms, quantum entities *spread their existence around*. If matter has a natural "tremble" on the quantum level, it is only necessary to tilt the quantum field probability table one way to give what we call movement.

The earth spreads a quantum field asymmetry that makes nearby bodies more likely to restart one way, giving movement in our terms. A body moves when it is pushed but it also moves when the quantum load around it is asymmetric. If the local quantum network is busier one way, the ongoing matter "tremble" as an overload-restart occurs more often that way. *The gravity gradient moves nearby bodies by biasing the quantum load around them towards itself.*

5.4.3. Gravity swaps photons

As earlier concluded, matter moves when directional photons bias its quantum field one way. When an object hits another, photons are exchanged as movement. In this view, movement as a matter property is due to photons. This quantum basis for matter movement is now extended to include movement due to gravity.

In quantum theory, an electron can teleport through an impenetrable barrier because it exists throughout its quantum field and can restart anywhere in it. Likewise, the earth as a quantum aggregate also spreads it existence out around itself to cause its gravity. Particle theory sees the earth as inert matter localized in space but in quantum theory it *superposes* its existence on the space around.

Gravity can't be blocked so no "shield" can deny gravity. If gravity was caused by gravitons, anti-gravitons could create an anti-gravity area but no evidence anywhere supports this. Likewise, if gluons kept the nucleus together one could break it apart by a stream of anti-gluons but again no evidence supports this, although anti-gluons are said to exist. And since a photon of the right phase can cancel another photon, one could cancel the virtual photons of electromagnetism with the appropriate light but again no evidence supports this. Quantum realism concludes not only that these virtual particles don't exist but also that *it isn't possible to block a spreading quantum field by any physical means at all.*

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[62] The flux transferred across a sphere surface reduces as the inverse square of its radius $1/r^2$. Newton's law of gravity $F = g.m_1.m_2/r^2$ with m_1 and m_2 masses and g constant is an inverse square flux law, as is Coulomb's law $F = k.q_1.q_2/r^2$ with charges q_1 and q_2 and k constant. Both laws come from Gauss's flux law.

A matter body as a quantum aggregate moves when all its quantum parts move. If those parts constantly jiggle, the whole moves when they all take a quantum step one way. This is unlikely but quantum events occur at such a fantastic rate that it will occur and the gravity bias makes it happen more often one way. Hence matter moves incredibly slowly compared to light.

When an object falls to earth, the earth's quantum field participates in its quantum restarts so photons from the earth may restart in the object. As the body moves towards the earth, the smaller mass will acquire photons in the earth's direction that in this model cause acceleration. Matter then accelerates by constantly adding photons which come from the earth superposed around it. Photon exchange is the basis of the acceleration of gravity that acts at a distance because the quantum field cannot be contained. *Gravity then is equivalent to acceleration because both have the same quantum cause, namely the acquisition of photons*.

5.4.4. Gravity bends light

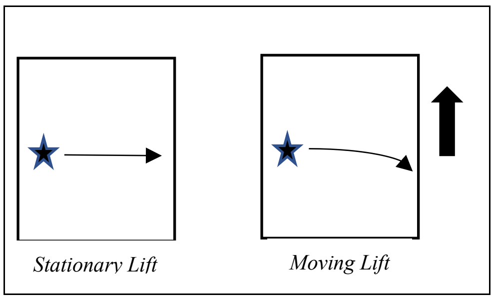

Figure 5.8. *Light bends when lift moves up*

Einstein deduced that gravity bends light by imagining a flashlight shining horizontally in a lift accelerating upwards (Figure 5.8). As the lift accelerates up, the light curves relative to it, so if gravity is equivalent to acceleration then it should bend light. Light should "fall" by gravity just as matter does, and light passing the sun is indeed bent. The analogy worked but how does inert matter reach out to move massless light?

In quantum realism, the sun bends light passing it by the same quantum field that keeps the planets in a gravitational orbit. In these terms, the sun is so massive that its existence permeates the entire solar system as quantum processing spreading. Since a photon is also processing that spreads in every direction, as it passes the sun, the greater load nearer to the sun slows down the spread in that direction. The photon wave front is thus bent by gravity just as in *refraction* (3.6.2) light is bent by water that also slows it down. If one side of a light wave has a higher load, those slower transfers skew the light that way. *Light has no mass but it has quantum processing, so the gravity gradient affects it*.

5.4.5. Gravity slows time

The special theory of relativity states that every mass in the universe *has its own clock.* I have one, you have one and our nearest star has one, so matter only has the same time if it has the same speed. General relativity lets gravity change matter time as well as speed. Time slows down near a large mass like the earth so a lot of computing is needed to make satellite navigation work because the internal clocks of GPS satellites far from earth tick at a different rate from the receivers on the ground. If one day people lived on the moon, time would pass faster for them, so they would age a tiny bit more because the gravity is less.

All this weirdness occurs because *matter time passes when it completes quantum cycles*. When large matter bodies like the earth spread their quantum processing around, they slow down the network which slows down time. Gravity slows time when the quantum field around matter makes quantum cycles take longer. The earth as a quantum aggregate *superposes its existence on the quantum network around itself* which alters how time passes around it. Gravity slows down time, as Einstein concluded, but does so by acting on the quantum network not on time itself. In quantum realism, time is a measurable property of our reality but it doesn't exist in its own right.

Would one live longer on a larger planet that has more gravity? It might seem so to others but the quantum cycles one *experienced* would be the same. Living on a heavier planet stretches time relative to earth but it doesn't change the amount of time one would experience.

5.4.6. Black holes

The equations of general relativity predict that when a large enough mass collapses under its own gravity, nothing can stop it. The result is a *black hole*, a region of space with gravity so strong that not even light can escape from it. It is now believed that nearly every supermassive galaxy, including our own, has a huge black hole at its center.

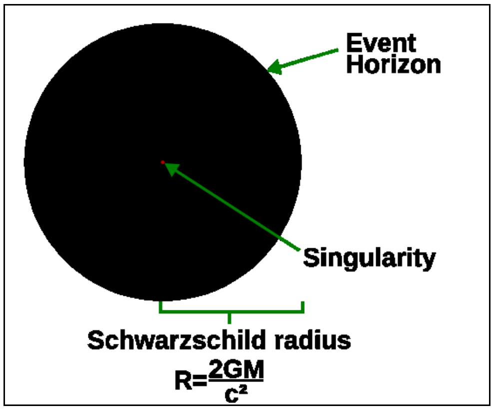

Figure 5.9. *A black hole*

Since nothing can stop it, the matter that forms as black hole collapses to a point of infinite density called a *singularity*. The *event horizon* of a black hole is the region from which nothing, not even light, can escape the pull of its gravity (Figure 5.9).

In quantum realism, black holes represent the *bandwidth of space*, when all the channels of space are filled. So despite what the equations "predict", a black hole isn't a point singularity of infinite density within its event horizon. What stops the matter collapse that produces a black hole is the finite bandwidth of space itself.

If a black hole is space processing at its maximum, adding to it must expand its volume, which is the case. Adding quantum processing requires more nodes of space, as each node in the black hole is already processing at maximum capacity. Recent arguments suggest that black "holes" are in effect black stars, i.e. sources of energy absorption (Barcelo, Liberati, Sonego, & Visser, 2009).

5.5. ELECTRICITY AND MAGNETISM

If the gravitational field of the earth is the reducing strength of the quantum field around it, what are the electric and magnetic fields of matter? How can one quantum field have three different aspects?

5.5.1. Electromagnetism

Magnetism was once thought to be distinct from electricity until the same equations were found to describe both. Today light is said to be an electric vibration sustained by the magnetic vibration it creates, even though it is impossible for two forces to mutually cause each other!

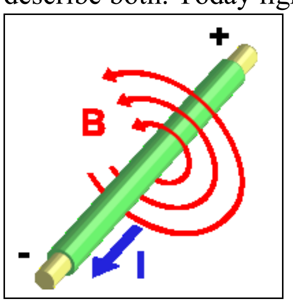

Figure 5.10. *Current I creates magnetism B*

A static charge isn't magnetic but when it moves, a magnetic field appears around it (Figure 5.10). So if you wrap a wire around a nail and pass a current through it, the nail becomes a magnet. The magnetism stops when the current stops, suggesting that electricity causes magnetism. Yet if you wrap a wire round a magnet and spin it, a current is induced in the wire so by the same logic, magnetism causes electricity. That electricity causes magnetism that in turn causes electricity is just another paradox that current physics has learned to live with because physical realism can go no further.

If magnetism is charge in another guise[63], why don't magnets affect static charges? Why does magnetism act at right angles to the electric field? Why does it reduce more as an inverse *cubic* function not an inverse *square* like electricity? Also, dividing a charged body gives positive and negative parts but dividing a magnet gives two magnets each with north and south poles, not a north

[63] Some suggest that a moving electron's length is foreshortened by special relativity giving more negative electrons than positive protons in a given length of wire, hence parallel wires with opposite currents attract. In quantum realism, this is correlation not causation.

pole and a south pole. These differences suggest that magnetism is somehow different from charge, even though both are somehow connected.

In current physics, when charges repel, virtual photons are said to batter them apart and when they attract, virtual photons are said to push them together. Magnetism is also attributed to the same virtual photons, even though it works quite differently. As long as the equations work, physics it seems would be happy to attribute electromagnetism to fairies with photon wands.

We understand electricity and magnetism separately but that doesn't explain electromagnetism any more than understanding horses and birds would explain a winged horse. That a field can be electric or magnetic depending on reference frame doesn't explain how *one* field has *two different* effects (electric and magnetic) that work in different directions and weaken differently. *Physics has no answer because it has never addressed what electromagnetism actually is.*

Yet Maxwell's equations connect magnetism to electricity, so:

> *"We will see that magnetism and electricity are not independent things – that they should always be taken as one complete electromagnetic field."* (Feynman et al., 1977)

Quantum realism now suggests that electric and magnetic effects both come from the quantum field.

5.5.2. Electric fields are the quantum field

In current physics, mass and charge are inherent properties of matter with no connection but in quantum realism, mass and charge are two sides of the same quantum processing coin:

1. *Mass:* The net processing that repeatedly overloads a node.
2. *Charge:* The processing remaining to do after the overload.

If the quantum processing that is mass spreads as gravity, what spreads due to charge? In this model, *all processing spreads on the quantum network*, not just the net processing done that causes gravity. As this processing spreads, the same processing limits apply so the remainders play no part in gravity, but how might they affect the network? If a node of the quantum network first passes its processing on, a quantum cycle has two phases:

1. ***Share phase***: Pass on current processing to neighbor nodes:
    a. *Cancel*: First cancel any positive/negative processing.
    b. *Share*: Share all processing among neighbors.
2. ***Execute phase***: Run the processing received from neighbors.
    a. *IF an overload*: Request a restart from the server(s) involved.
        i. *If ignored*: If no server response, drop the job.
        ii. *If accepted:* Reload processing from the server(s) as a *physical event*.

As concluded, gravity affects the *execute phase* because a massive body makes nearby matter restart more often towards itself. Charge in contrast, as the processing left over, has no effect on this phase but it would affect the *share phase* because more remainder takes longer to pass on. So a charged body should slow down quantum cycles closer to it by an inverse square effect like gravity, but there are no charged bodies as massive as the sun or earth for us to know. When charge builds up, it usually soon cancels with opposite charges, as lightning illustrates. The slowing effect of a small charged body will be minuscule, just as is its gravitational effect.

However, between opposite charged bodies close together the case is different. Now the remainders *interact* to cancel out and let the quantum network cycle faster. Each charge then *biases* the quantum network around the other to make it cycle faster the closer it is. Since both charged bodies are matter that restarts every cycle, the faster nodes are more likely to get server access, causing the bodies to move together. So opposite charges attract by biasing quantum restarts in one direction but in a different way from gravity. In contrast, between opposite charges the charges interact to slow down the quantum network between them, causing movement apart. Unlike gravity, this effect is only significant when charges *interact* to combine their effects on the quantum field.

To sum up, two factors alter where a matter body restarts:

- *Whether* the quantum network overloads (gravity).
- *Where* the quantum network overloads first (charge).

Gravity differentially loads the network so nodes closer to its source overload first while charge differentially speeds up or slows down the network, depending on whether the other charge is opposite or the same, so that faster nodes get server access first. Both effects arise because the quantum processing of matter spreads on the quantum network so both decrease as an inverse square by Gauss's law of flux. We call the effect of increasing overloads one way a gravitational field and the effect of increasing or decreasing the cycle rate an electric field. Matter spreads both its net processing *mass* and its processing remainder *charge* to bias the quantum network to cause movement. The difference is that while gravity has no opposite, charge only spreads until it is cancelled by an opposite charge.

In quantum realism, that mass and charge are complimentary matter properties makes gravitational and electric fields the complimentary effects of quantum processing. Both work by biasing the quantum trembling of matter rather than magically creating virtual particles to push it about, as the gravity gradient biases the processing load while charges interact to bias the cycle rate between them. *It follows that the electric field comes from the quantum field just as gravity does*.

5.5.3. Magnetic fields are the quantum field

The analysis so far gives no basis for magnetism and unless it can, the model again fails. We know that dividing a magnet gives two small magnets and joining two small magnets gives a big one. If big magnets come from smaller ones, all magnetism traces back to the smallest possible magnet, an electron, which is like a tiny magnet because it *spins.* In essence, every electron is essentially a little magnet whose north pole is its spin direction so *magnetism relates to quantum spin*.

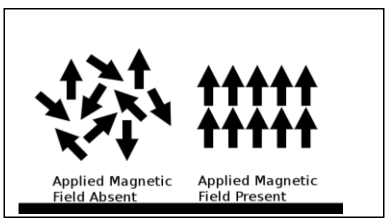

Figure 5.11. *Magnets combine*

We also know that metals become magnetic when their electrons, which are tiny magnets, are free to align the same way. If the electrons in a material spin randomly the net effect is zero but if they align the result is a magnet (Figure 5.11). Metals become magnets when their electron spins align but plastics can't become magnetic because their electrons aren't free to align. When electron spins align there is magnetism so *all magnetism occurs when electrons align their spins*.

Spin is a basic property of quantum matter, like mass and charge. In current physics, an electron as a point particle can't spin but in quantum realism an electron has a structure that really does spin. *All quantum entities spin when their quantum structures rotate*. So just as matter spreads mass and charge on the quantum network, it also spreads spin as an inherent property of the quantum field.

The Pauli exclusion principle states that opposite-spin electrons can occupy the same point but same-spin electrons can't. In quantum realism, this is because opposite spin electrons turn into different parts of quantum space, so if one electron spins clockwise and another anti-clockwise at the same point *they don't overlap*. In contrast same-spin electrons at the same point compete for the same quantum space that only one can fill. If quantum matter is processing that spreads, the same thing will happen to the quantum field around it to a diminished degree.

If matter spreads the spin of its electrons on the quantum network, electron instances between opposite magnets will fill different parts of quantum space, while between two same magnetic poles they will occupy the same quantum space. In effect, between two opposite magnets the quantum fields "fit together" better than between two same pole magnets. This will affect the load but the effect will be minimal because electrons have a tiny mass. But as with charge, the interaction will alter the cycle rate between magnets. One magnetic pole will cause the quantum field of an opposite pole to cycle faster closer to itself, again causing attraction by biasing its matter restarts. In contrast, between two same poles, the effect will be to make cycles take longer giving repulsion. *Magnetism then is quantum spin interacting positively and negatively on the quantum network.*

This logic also suggests how electricity causes magnetism. What we call *electricity* occurs when electrons move. Since electrons are one-dimensional matter, their *matter axes* must align in the movement direction for this to happen. When electrons align their matter axes to move as electricity, this also aligns their spins to give magnetism. A current creates a magnetic field because electrons align their spins when they move. Conversely, when a magnet moves, the magnetic field changes at right angles to a line from the magnet causing electrons to move that way as a current.

Attributing magnetism to the spread of quantum spin also explains its other properties. Charge can divide into positive and negative parts because a processing remainder is absolute but spin that is clockwise from one side is anti-clockwise from the other, so magnets divided give more magnets. Magnetism also disperses faster than charge because while charge spreads in two dimensions spin has an extra dimension to spread into. More could be added, but this is sufficient *to attribute magnetic fields to the spin direction property of the quantum field.*

5.5.4. There is only one field

Current physics has many quantum fields, like strong, weak and electromagnetic, and sees gravity as yet another different field. In contrast, quantum realism has only one field, the quantum field. It accepts the equations of gravity, electricity and magnetism but sees them as the mass, charge and spin properties of a single quantum field. Current physics calls electricity and magnetism aspects of the same field but that they "self-sustain" defies logic. It makes more sense that both are aspects of a single quantum field that is always inherently active.

Quantum realism relates electromagnetism to gravity, which no other theory does. It proposes that matter spreads a single quantum field that projects net processing (*mass*), processing remainder (*charge*) and processing spin direction (*spin*), to cause:

1. *Gravity*. A net processing gradient that affects other matter.
2. *Electricity*. A processing remainder gradient that interacts with other remainders.
3. *Magnetism*. A quantum spin gradient that interacts with other spins.

All the above fields are based on a single *quantum field* spread by matter on the quantum network. Matter can have these effects because it is active processing not an inert substance.

Gravity, electricity and magnetism move matter by *biasing* its natural quantum tremble not by creating virtual particles from nowhere to "make" it move. A *gravitational field* is a bias caused by the quantum field processing strength. An *electrical field* is a bias caused by the quantum field processing remainders. And a *magnetic field* is a bias caused by the quantum field processing spin alignment. All these fields act at a distance because matter as processing spreads on the quantum network and is not confined to a location. One could call what creates gravity, electricity and magnetism the *gravito-electro-magnetic* field but it is simpler to call it the *quantum field*.

5.6. CREATING ORDER

The *order* of a physical system measures its degrees of freedom, where high order implies fewer internal choices. In physics, a system's *disorder* is called *entropy*. The second law of thermodynamics states that entropy always increases over time for a closed system, so if the physical universe is all there is, it's expected *end-state* is one of maximal *disorder*. In this dismal vision, the end of all things is a thermal equilibrium where everything disperses to maybe one atom per cubic light year *in a big freeze*. After this, it is expected that nothing will change, *forever*! This section suggests that *the universe is evolving up to create order even as it is winding down to a big freeze*.

5.6.1. What is potential energy?

In current physics, *potential energy* is energy based on *position* in a gravitational field, so raising an object stores potential energy that is returned later when it falls. This balances the ledger, so energy isn't lost or made, but what stores and releases potential energy?

It is easy to forget that potential energy is a concept not a thing observed, so if a rocket is shot into earth orbit, where the liftoff energy goes isn't seen. If the rocket leaves the earth and travels in space forever, presumably its potential energy is stored forever. If it later crashes on a bigger planet like Jupiter to release more energy than leaving earth took, where does the extra energy come from? Energy is conserved if objects stay in the same place but they never do, so is potential energy just a fudge to make up any differences?

Those who explain physics say that energy is conserved because if the Jupiter rocket was re-assembled and returned to earth the energy would be restored. But how can future options explain the present? Imagine applying that logic to entropy, saying a cup broken on the floor has "potential entropy" because it can be reassembled again! One would ask, where is this potential entropy stored? So is potential energy stored in space, matter or gravity itself? *Current physics can't say*.

Normal energy conservation has a *means* so when a car's kinetic energy is lost to friction its tires become hot and radiate thermal energy. We can observe the kinetic energy turning into energy in the form of heat. In contrast, a ball thrown up loses its kinetic energy to where? With no means of energy exchange, one could argue that potential energy just a way to pretend that energy is conserved when it isn't. *So is energy really always conserved?*

5.6.2. The universal conservation

Energy as force applied over distance is the capacity to do *work*. The law of conservation of energy states that the energy of a closed system should be constant, so if our universe is a closed system it should conserve energy overall.

Yet physics also tells us that our universe is expanding. This means that the wavelength of every photon in it is now a bit longer than it was a moment ago, so it now has a bit less energy than it did before. The cosmic background radiation that was once white hot is now freezing cold because expanding space took its energy and *didn't give it back*. That the universe is expanding suggests that it is not closed and that all light loses energy as the universe expands suggests that energy isn't universally conserved.

The coldness of cosmic background radiation challenges the naïve view that we are in a closed system. A system that constantly expands can't be closed nor can it have a constant energy because to expand requires energy. The expansion of space is the exception that breaks the rule that energy is universally conserved. Energy is conserved *locally*, as solar panels, dams and windmills convert radiant, wind and gravitational energy into electricity, but it isn't *universal*. Just as the number of bank notes in a country might stay the same while inflation still decreases their value, so the expansion of space devalues energy globally.

Yet the number of free photons is always conserved. When a solar sail turns *radiant energy* into *kinetic energy,* the photons go into the matter and so are conserved. When a rocket crashes on Jupiter with more energy than it took to leave the earth, energy isn't conserved but photons are because the rocket acquires photons from the mass of Jupiter via its gravity. *Energy is conserved when photons are conserved, and when energy isn't conserved, photons are still conserved*.

When our universe began, *inflation* made a finite number of photons that since then have remained constant and the expansion of space didn't change this. Our universe is made of photons in various forms, whether in light, matter or gravity exchanges, and they are always conserved. In current physics, energy is an abstract that is conserved but in quantum realism actual photons are conserved.

In quantum realism, every physical event is a processing reboot where the processing before and after is the same. Current physics conserves matter, charge, energy, momentum, isospin, quark flavor and color but each "law" is partial, as matter isn't conserved in nuclear reactions and quark flavor isn't conserved in weak interactions. Quantum realism suggests that the conservation energy is an aspect of a more fundamental *universal conservation,* namely the conservation of photons. *Physical events come and go but* photons are *always conserved*.

5.6.3. Disorder is probable

All the laws of physics are reversible, so reversing a video of earth orbiting the sun breaks no laws of physics. Yet reversing a video of an egg breaking evokes laughter, even though at the atomic level every event in the egg breaking is just as reversible as the earth's orbit. In our world, things break apart far more easily than they come together, so an egg that took much time and effort to produce can break in just a second. The formal reason why eggs don't "unbreak" as easily as they break is the *second law of thermodynamics*, which states that *disorder always increases for a closed system*. The informal statement of this principle is *Murphy's law*, that if anything can go wrong it probably will. It extends the second law of thermodynamics to society, where its opposite is *Adam's law*, that from bad things good can come.

For example, suppose that injects some colored gas into the corner of a sealed box. The second law predicts that it will disperse throughout the box because that is the most disordered state. This happens because gas molecules constantly move to adopt different combinations and the number of combinations where the colored gas is spread out are far more numerous than those where the gas is just in a corner. The colored gas molecules *could* all move back to the corner, but it is extremely unlikely that they ever will.

The second law is thus a *statistical law* based on the laws of probability not a causal law. It doesn't state that objects *must* become more disordered, just that they are more likely to. In a world where disorder is more probable than order, in a constantly changing world, it sooner or later prevails. So when a combination works to give a result, whether it be a car, a human body or a marriage, there are always more ways for it to go wrong than there are for it to go right. Unfortunately, this principle also predicts that *the low-entropy states we call life shouldn't exist*.

5.6.4. Order happens

The opposite of entropy is *order* - the maintaining an unlikely state like an unbroken egg. Indeed, the entire earth is a complex web of order that somehow maintains itself despite changes like weather and errant asteroids. At first, physics argued that the earth is as a *local anomaly*, a random accident that bucks the universal trend, because:

> "… . *eventually all these over densities will be ironed out and the Universe will be left featureless and lifeless forever, it seems"* (Barrow, 2007) (p191).

Yet *the cosmos is also ordered*, as planets orbit stars that orbit galaxies that orbit super-clusters, where each order depends on the one above. Life on earth is only possible because the sun keeps its planets in order and the solar system is only possible because the galaxy keeps its stars in order. It isn't just the earth that presents a "local anomaly" and thanks to this cosmic order, life evolved on earth.

A better answer was needed so some physicists now suggest that the big bang was *very ordered*:

> *"The ultimate source of order, of low entropy, must be the big bang itself. ... The egg splatters rather than unsplatters because it is … the drive toward higher entropy … initiated by the extraordinarily low entropy state with which the universe began."* (Greene, 2004) p173-174

This is physics speak that the universe began very ordered and we are only half-way through its "grand devolution", so life is still possible. In this reverse logic, the initial chaos *had to be* very ordered *because* the second law is true, but that the current cosmic order devolved from a very ordered *initial chaos* makes no sense at all.

And life isn't just any old order but a *self-replicating order,* and the discovery that it might spread between planets radically changes the probabilities. Panspermia is the theory that bacteria can hitch a ride on an asteroid, meteoroid or comet to travel the space between planets, based on the discovery that bacteria can survive space, as bacteria in boxes outside the International Space Station were revived after over a year in space. Under harsh conditions, some bacteria form *spores* that are metabolically dead but can return to life under the right conditions, even after millions of years. That life can evolve on a planet that is temporarily suited then spread to another where it is permanently so significantly increases its probability, e.g. perhaps bacteria evolved on Mars then colonized Earth. The jury is still out, but evidence suggests that thanks to bacterial "colonists", millions of planets in our galaxy may have some form of primitive life. Clearly a galaxy that might be teeming with life isn't what the second law predicts after 14 billion years of constantly increasing disorder.

So the question remains*, if the universe is constantly devolving, how did life evolve?* We see order all around us, in our lives, in nature and in the cosmos, so we now consider the alternative *that the second law isn't the only universal principle at play.*

5.6.5. The law of evolution

The second law, that disorder always increases, applies because the physical world is constantly changing. As Heraclitus put it, reality is a *flux* where "*everything flows*". He pointed out that it isn't possible to step twice into the same reality stream because from one moment to the next it is never the same. For things to always move to disorder they must first be always moving, so the Heraclitean flux underlies the second law of thermodynamics as a necessary condition. The view that reality is a constant flux matches the quantum realism statement that *we live in a world of events not things*, because every physical event is a quantum creation. *Quantum realism also asserts the fundamental principle that quantum reality is unstoppable.*

The formal statement of this position is the *quantum law of all action*, that whatever is physically possible actually happens at the quantum level, so quantum randomness ensures that whatever can happen eventually does. In quantum realism, the physical world always changes because quantum processing renews each cycle, *so every moment is a new creation*. Hence the quantum law of all action underlies the second law of thermodynamics.

The quantum law of all action behind the second law also has another effect, that unlikely events must sooner or later occur and will persist if they are stable. It is very unlikely that two light rays with extreme photons in every channel will meet exactly head-on, but by this law it must have happened and when it did the *matter glitch* hung the system in an endless reboot. It is equally unlikely that 82 protons, 125 neutrons and 82 electrons should combine into an atom but somehow they did, and so we have lead. Lead atoms with a half-life of many millions of years exist not because they are *probable* but because they are *possible* and *stable*.

This means that what underlies the second law also gives the *evolutionary law* that *what can possibly survive will emerge to do so and influence what follows*. By this "first" law, matter *had to happen* despite being based on *improbable* events. And while the second law decreases order, *the law of evolution increases order*, e.g. combining an electron and a proton in a hydrogen atom reduces the choices of both because while an electron and a proton on their own can go in any direction, in an atom they must move in the same direction. In general, *when two or more entities combine to act as one, order increases*. It follows that the law of evolution opposes the second law of thermodynamics by increasing order in the universe. Evolution is then a universal anti-entropy principle and always has been.

If evolution was limited to biology, the second law might be the supreme determinant of order in the universe, but it is not, as the rules for evolution were in place long before biological evolution began. Matter evolved just as life did, so evolution is a universal principle just as the second law is. And two laws operating explains what we actually see better than one.

The order of our universe involves two laws with opposite effects, both caused by the quantum law of all action so one can't have one without the other. Each works in a different way, as the second law focuses on what is *probable* while evolution focuses on what is *possible.* Consider a salt shaker that is constantly shaken upside-down. It is *probable* that every grain will fall out, leaving it empty, but it is also *possible* that an unlikely combination of grains will permanently block the hole giving a different end-state. If the universe is being constantly shaken by an unstoppable quantum reality, whether one sees it as probably emptying out or possibly new combinations is a matter of opinion. The Goldilocks effect suggests that our universe is also taking the latter path.

It predicts that even as the universe as a whole is devolving into disorder, it is also generating highly ordered combinations, such as:

1. *Galaxies*. In galaxies, nearly all stars orbit in the same direction. Any star orbiting the other way eventually hits other stars and either gets thrown out of the galaxy or is turned around. This common orbit direction is an *order* created by evolution.
2. *Solar systems*. The planets in a solar system eventually adopt orbits that don't interact. Any exceptions again result in catastrophic events until the system stabilizes into an *order* created by evolution.
3. *Atoms*. Hydrogen atoms evolved because electrons and protons together are more stable than either alone and are also more *ordered*.
4. *Elements*. The elements of the periodic table evolved because their unlikely combinations of electrons, protons and neutrons are more stable. A lead atom is a highly *ordered* quantum combination engineered by evolution.
5. *Molecules*. Atoms combine into *ordered* molecules that evolve because they are more stable.

Evolution as the synthesis of order is all around for all to see, except for those blinkered by a mechanistic nineteenth ideology. All these evolutions *require* energy so by the second law they shouldn't be common but they are. And the evolution of matter was just the beginning, as molecules combined into self-replicating proteins, primitive archaea and bacteria combined into modern cells (Lane, 2015), cells combined into plants, animals and us, and we combined into ordered societies. The common thread is the discovery of combinations that survive.

In quantum realism, the first light collided to form both electrons and the quarks that merged into protons and neutrons. A proton and an electron then merged into the first hydrogen atom, and hydrogen fused into higher elements as stars formed. The evolution of matter that is ongoing today then led to the biological evolution that created us. In this view, *evolution* as a universal law was built into the universe from the beginning. The universe that physics sees as only dying is also evolving and we are one of its products. *The law of evolution explains what the second law cannot, that life evolved.*

5.6.6. How will the universe end?

Will the universe expand forever? For physicists, this depends on how space overall is curved. General relativity lets space curve locally but doesn't say how is space curved in general. The mathematics suggests that a positively curved universe will eventually stop expanding and shrink back in a big crunch, but a negatively curved universe will expand faster and faster forever, as there isn't enough mass to stop it. A positive curvature was expected but cosmology measures suggest that the expansion of space is accelerating not slowing down (Cowen, 2013), so space is negatively curved.

Quantum realism expects our space, as the inner surface of an expanding hyper-bubble, to have the slight negative curve that cosmology found. But that it will therefore expand forever is not implied. If our universe is a bubble expanding in a quantum bulk, there are probably others so they will eventually meet. What then happens when one bubble universe meets another?

The answer depends on whether the universes took the matter or anti-matter path. If our matter universe meets another matter universe, they will simply merge into an even bigger bubble. If this has already happened to our universe, it will be bigger than it could be by its own expansion. But there is also the Armageddon option, that it meets an anti-matter universe.

Gravity is all powerful in our universe because it only *adds,* so nothing can oppose it. One can block an electric field with an opposite field but nothing opposes gravity, so it reigns supreme. This is because our universe took the matter path. Yet matter has an anti-matter opposite that could not only shield gravity but would also *fall up* on earth[64]. Our universe has no anti-matter because it took the matter path but if it meets an anti-matter universe, both will annihilate back into the quantum bulk. In quantum realism, sooner or later, our universe will return from whence it came, and will do so *with a bang not a whimper.*

Yet even if Armageddon has already begun, we wouldn't know right away, as the wave of destruction will travel at light speed. Cosmology estimates our galaxy is at least 100,000 light years across and the observable Universe is over 90 billion light years across so the shut-down could take a while. Will our telescopes see it coming? There could be no warning, as we only see galaxies as they were millions of years ago. *When our physical universe is packed away, to return from whence it came, it will happen at the speed of light with no possible warning at all.*

5.7. WHAT NEXT?

This concludes the reverse engineering of physical reality at the physics level. This section briefly recaps the model so far and considers what it implies.

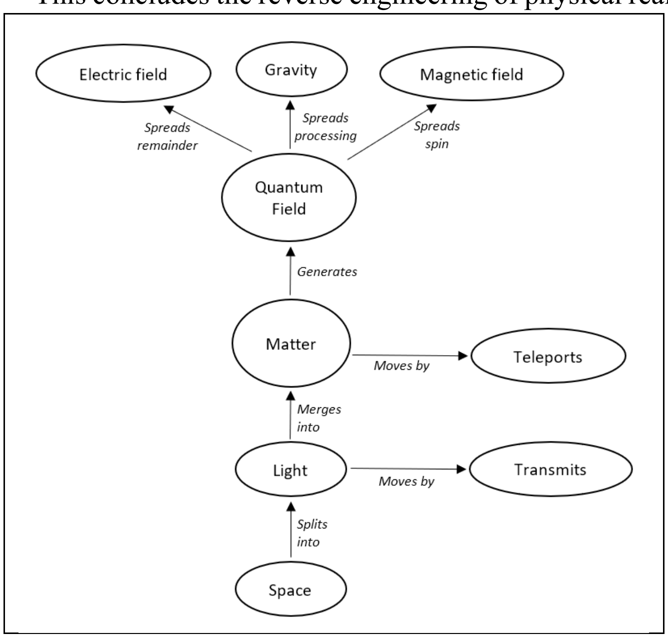

Figure 5.12 A brief recap of quantum realism

5.7.1. A brief recap

Figure 5.12 recaps the quantum reality model so far. It begins with space as null processing that sets a circle of values that outputs "nothing". *In quantum realism, space is null processing.*

Distributing this circle gives the sine wave of light, so the entire electromagnetic spectrum is one process more or less distributed. *In quantum realism, light is space distributed.*

Light as a digital wave has a highest frequency that can collide to give a quantum standing wave, which in the initial chaos gave electrons and neutrinos as one-way collision options and up/down quarks as three-way collision options. *In quantum realism, matter is light colliding in a quantum standing wave.*

[64] If sustained, to avoid the anti-matter first annihilating with the matter around it.

Matter as a repeating overload leaves charge as the processing left-over. The electron's negative charge, the neutrino's lack of charge and the curious one-third charges of quarks follow as processing remainders. *In quantum realism, charge is a byproduct of matter creation*.

Light waves transmit at light speed. Matter as a standing wave can't do that but it can restart anywhere in the quantum field it spreads around itself, giving it a natural "tremble". Its ability to "teleport" makes matter move in our time when a bias in the quantum field around it favors one direction, but each jump loses a cycle of time and a pixel of space. *In quantum realism, special relativity arises because matter teleports*.

A large body like the earth creates a quantum field gradient that makes smaller bodies around it overload and restart more often its way. *In quantum realism, gravity is a quantum field gradient that biases the natural tremble of other matter*.

The quantum field around charged matter objects spreads remainders that cancel between opposite charges to speed up the network and bias them to restart closer. Same charge objects spread remainders that add to slow down the network for the opposite effect. *In quantum realism, an electric field is quantum field remainders adding or subtracting.*

Matter is magnetic when its electrons align their quantum spin, so electrons moving in a wire as electricity align their spins to cause magnetism. Opposite magnets spread quantum field spins that use different quantum spaces while same spin fields occupy the same space. So opposite magnets speed up the network between them to bias them to restart closer while opposite magnetic poles slow down the network between them causing them to repel. *In quantum realism, a magnetic field is quantum field spins adding or subtracting*.

The reality that quantum realism describes is in essence simple, so the complexity we see didn't begin so. It *evolved*, as space became light, light became matter and matter became us. In effect, nothing became everything. Douglas Adams sums up this miracle as follows:

> "***The world is a thing of utter inordinate complexity and richness and strangeness that is absolutely awesome.*** *I mean the idea that such complexity can arise not only out of such simplicity, but probably absolutely out of nothing, is the most fabulous extraordinary idea. And once you get some kind of inkling of how that might have happened, it's just wonderful."* Douglas Adams, quoted by Dawkins in his eulogy for Adams (17 September 2001)

Indeed the best argument against physical realism is the ridiculous complexity of the models needed to describe it.

5.7.2. The virtual reality hypothesis

Quantum realism hypothesizes that the physical world is a *virtual reality* generated by quantum reality. It differs from the commonly proposed *simulation hypothesis* but it has the same premise - *that the physical world is not as it seems*.

A simulation can be defined as a representation of something that is not actually that thing, e.g. a small-scale model of the Empire State building is a simulation of it. A physical model is static but information simulations let participants interact with dynamic virtual environments to learn skills useful elsewhere, e.g. flight simulators let pilots learn to avoid mistakes that might crash an actual plane. Simulations like SimCity let people experience the challenge of building a city and computer games offer many other simulated experiences.

The simulation hypothesis proposes that our physical reality is a representation so realistic that its participants are unaware that they are living in a simulation. The best-known example is the film The Matrix, where Morpheus says:

> "*What is real? How do you define 'real'? If you're talking about what you can feel, what you can smell, what you can taste and see, then 'real' is simply electrical signals interpreted by your brain*."

In this film, machines in the future simulate New York in 1999 to humans in vats by feeding the appropriate electrical impulses to their brains, so one physical world is in effect simulating another. Since physical processing requires effort, the assumed prime directive is to limit the processing cost, so the simulation hypothesis implies a virtual world with a:

a. *Fake history.* Why bother simulating the fourteen billion years before humans arrived?

b. *Fake cosmos.* Why bother simulating a vast universe of space, planets and stars?

c. *Fake quantum theory.* Why bother simulating a quantum world beyond any physical computing?

This view implies godlike designers who "fit" the simulation to match what our brains will accept as real, much as a movie director might. Since in this view the world we see is a *trick*, supporters of the simulation hypothesis rest their case on finding flaws in the simulation, including what quantum theory predicts (Campbell, Owhadi, Sauvageau, & Watkinson, 2017). Unfortunately finding a "flaw" in quantum theory wouldn't in itself prove the simulation hypothesis. It would merely require a revision of quantum theory, and given the depth of previous research, this is unlikely.

A simulation of New York represents a city that physically exists elsewhere but the virtual reality proposed by quantum realism doesn't reflect any substantive physical reality elsewhere. It generates observer experiences based solely on its own event history. Thus quantum realism proposes a virtual reality hypothesis not a simulation hypothesis.

Quantum realism implies that the "rabbit hole" of physical reality runs far deeper than the simulation hypothesis followers suppose. It sees a quantum world generating all physical events, even those we don't see, so this virtual reality has no "holes". In quantum realism, every second of the past fourteen billion years happened, every far-away galaxy seen in a telescope exists, and everything quantum theory describes is literally true. All this comes from a quantum reality that quantum theory assures us is not, and can never be, physical. If the universe is real not fake, and if what quantum theory describes can't be physically computed, it follows that we aren't living in The Matrix so attempts to show this are doomed to fail.

Quantum realism concludes that whatever "other" is generating physical events, it can't be physical. Hence theories of machines, aliens, super-beings or our future-selves programming our reality from another physical world aren't possible. Nor can that "other" be anything that derives from physical reality, including *programs* derived from physical hardware, *information* derived from such programs, or *dreams* that derive from a brain. So the only way to prove the physical world is virtual is the scientific method, to reverse engineer physical reality to generate a testable prediction.

Quantum realism concludes that everything we know comes from a quantum reality that is *unstoppable* and *unavoidable*. The prime directive of this virtual reality isn't *efficiency*, because quantum reality always "runs" anyway, but *evolution*. The evidence suggests that we live in an *evolving virtual reality*.

5.7.3. A virtual evolution

It is hard to review the order that has evolved in our universe since it began, including galaxies, star systems, planetary systems, life and us, without wondering if there is a purpose? If the physical universe is a virtual reality, the ongoing quantum commitment required to support its existence supports this view. *So is the physical evolution we see all around us going somewhere*?

Science currently understands evolution as a means whereby biological life forms create more complex ones over time, like an algorithm that explores the space of possible design forms to discover those fit to survive. *Evolutionary algorithms* are programs that generate a solution set, evaluate their “fitness”, then randomly tweak the best until a solution *emerges*. In computing, this iterative trial-and-error method can solve multi-dimensional problems not possible by direct calculation.

The current biology view is that evolution isn't "going anywhere", so it has no top or bottom. Gould makes a good case that to place humanity at the pinnacle of evolution is just ego. In this view, bacteria are just as "evolved" as people, indeed more so as they have been evolving far longer than us. Gould argues that if one reversed time to replay evolution, it would produce entirely different life, as all the chance factors would make the same history unlikely to recur (Gould, 1990).

Evolutionary algorithms contradict this view, as they tend to find the same solution if the design space is limited. Morris and others argue that evolution can repeatedly find the same solutions despite random events (Morris, 2003), e.g. birds, bats and even fish evolved flight using wings despite following different paths. Studies of evolutionary potential suggest that evolution does repeat. If the physical world is an evolutionary algorithm, then if possibilities exist, re-running the program will always find them. Hence quantum realism concludes that *matter had to evolve, despite being a random event*.

Yet it is indeed egotistical, as Gould says, to think that a system that has run for billions of years across billions of light years is running for our sake. The physical universe isn't just a show just for us if it was running long before we arrived and will no doubt continue long after we are gone. So was our evolution inevitable? Life involves permutations and combinations so vast that one can't conclude that a hairless ape had to become sentient. Maybe homo-sapiens was the lucky ape that won the evolution lottery but some species had to after four billion years, because it was *possible*. That evolution is random doesn't make it uncertain, as *life finds a way*. The corollary is that if we prove unstable, something else will evolve to take our place.

It might seem premature to suggest that physical reality has a purpose but a virtual reality needs power to run. And if the power cuts off, even for a second, the virtual reality proposed here would have to restart from scratch, so it must have run for billions of years without losing even one quantum cycle. The quantum power invested to maintain a universe the size of ours over this period is vast. According to quantum realism, the original reality not only began our universe from "nothing" but is also sustaining it at this moment. If the universe is a joke, it is an expensive one, even in quantum processing terms.

One can create a *thing* and walk away but *a virtual reality must be sustained every cycle*. It beggar's belief that the quantum power invested to sustain a virtual reality as big as our universe for billions of years was pointless. That our universe is an evolving virtual reality suggests it is running for some reason. Nothing in current science "proves" this isn't so, nor is it denied that humanity is an evolutionary output. Evolving virtual realities aren't run for no reason because some power is always needed to sustain them.

Quantum realism concludes that the physical world is a virtual reality on a scale we can barely imagine, for a purpose we have almost no awareness of, any more than the billions of animals that lived and died in biological history had any idea of the evolution they were part of. If the universe is some grand experiment, what is its purpose? In particular, is the sentient consciousness that we have an accidental or intended result? To explore this further, the next chapter addresses the one thing necessary for every virtual reality – *an observer*.

DISCUSSION QUESTIONS

The following questions are addressed in this chapter. They are better discussed in a group to allow a variety of opinions to emerge. The relevant section link is given after each question:

1. Are quantum theory and relativity theory both correct? How is that possible? (5.1.1)
2. Why can't quantum theory explain gravity as relativity theory does? (5.1.2)
3. If the earth is a moving platform, how fast is it carrying us? (5.2.1)
4. Explain Einstein's statement that special relativity is why our reality *isn't* weird. (5.2.2)
5. Why does causality require the speed of light to be constant? (5.2.3)

6. Could a person travel to a star that is 100 light years away and back in their lifetime? What would be the downside of doing this? (5.2.4)

7. How can the same photon pass a rocket going towards it and one going away from it at the same speed? (5.2.5)

8. What is zitterbewegung? What makes it possible? (5.3.1)

9. How can a photon move at all if time stops for it, as special relativity says? (5.3.2)

10. In what way are kinetic energy and radiant energy the same thing? (5.3.3)

11. How can earth's gravity change the time and space of objects around it? (5.4.2)

12. How can the earth accelerate a free-falling parachutist with no observed force? (5.4.3)

13. How does gravity bend light when it has no mass? (5.4.4)

14. What changes in the quantum field cause opposite charges to attract? (5.5.2)

15. What changes in the quantum field cause opposite magnetic poles to attract? (5.5.3)

16. What three quantum field properties give gravitational, electric and magnetic fields? (5.5.4)

17. According to current physics, where is potential energy stored? (5.6.1)

18. Is any physical property universally conserved? What is universally conserved? (5.6.2)

19. How did the evolution of matter increase order? (5.6.5)

20. Does evolution as an anti-entropy law deny the second law that entropy increases? If not, what does it do? (5.6.5)

21. According to quantum realism, how will our universe end? (5.6.6)

22. In what ways is quantum realism simpler than current physics models? (5.7.1)

23. How does quantum realism differ from the simulation hypothesis? (5.7.2)

24. If evolution is random, will running it again give entirely different results? (5.7.3)

25. What is the usual purpose of evolutionary algorithms? (5.7.3)

26. If the physical world is an evolutionary virtual reality, what suggests it has a purpose? (5.7.3)

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