Quantum Realism

Chapter 1. The physical world as a virtual reality[1]

Brian Whitworth, Massey University, New Zealand

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

Sir Arthur Eddington

1.1. INTRODUCTION

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 space contracts and time dilates in our world. Objective things should just inherently exist, but electrons are probability of existence smears that spread, tunnel, superpose and entangle in physically impossible ways. Cosmology now says that the entire physical universe just popped up, out of nothing about fourteen billion years ago. This is *not* how an objective reality should behave!

This chapter explores an alternative normally dismissed out of hand, that the physical world is a processing output, i.e. virtual. The reader is asked to keep an open mind, as the *virtual reality conjecture* is neither illogical, unscientific nor incompatible with physics. If physics describes the physical world and computing describes processing, whether physicality is a product of processing is a question that we can evaluate.

1.1.1. Strange physics

In modern physics strange theories are routine, 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 string theory has six extra dimensions curled up and hidden from view. In M-theory, the universe floats on a fifth dimension “brane” we can’t see (Gribbin, 2000) p177-180 and others suggest we are 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.

Yet the findings of physics are equally strange: the sun bends light by curving the space around it; the earth’s gravity slows down time; and atomic clocks tick faster on tall buildings than they do on the ground. Movement also slows down time, so an atomic clock on an aircraft ticks slower than a synchronized one on the ground (Hafele & Keating, 1972), and moving objects become heavier with speed as well. In our world, space, time and mass vary but the speed of light is strangely constant.

If relativity is strange then quantum theory is even stranger: 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:

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[1] The latest versions can be found at: Chapter1, Chapter2, Chapter3 and Chapter4.

"*... the weirdness of the quantum world is real, whether we like it or not.*" (Tegmark & Wheeler, 2001) p4.

In physics, theory is strange because practice is, and it is strange because our world is.

1.1.2. Hollow science

Quantum mechanics and relativity theory are the crown jewels of modern physics because they 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 later confirmed. Yet after a century of work, *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 that the calculations give right answers 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, proofs and applications, but the models that work make 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 should increase understanding, but in physics it seems to take it away. In wave-particle duality particles morph into waves, denying the very sense of what waves and particles *are*. Given a choice between meaning and mathematics, physics chose the latter and it shows. Quantum theory still isn't taught in high schools because who can teach what makes no sense? Modern physics is a mathematical feast that at its core is entirely empty of meaning. It is a *hollow science*, built on impressive equations about quantum states that everyone agrees don't exist! And physics has chosen this *way of no meaning* as 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 call a *fairytale physics* (Baggot, 2013), where virtual particles arise ex nihilo from invisible fields in empty space to satisfy equations about imaginary quantities. Physics stopped trying to make sense of its findings some time ago, and the effects are evident:

"*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 entry to the barren desert of physics today was the "shut up and calculate" policy of Copenhagen, which effectively banned all attempts to interpret quantum states. The problem is not a few anomalies in an otherwise perfect vision, as quantum theory rules the microcosmic world from which our reality emerges and relativity rules the cosmic world around it. These theories *are* physics, and physics is the bedrock of the other sciences, so that they make no sense at all is unacceptable.

These two theories, general 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 is a clear sign that something is wrong, and that something is an unwillingness to address fundamental questions:

"*… 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

The way forward proposed here is to re-examine the original "hard" question: "*What is reality?*"

1.2. WHAT IS REALITY?

Figure 1.1 The Ancient of Days measures the universe [2]

1.2.1. Idealism vs. physical realism

Computers today create virtual worlds, but that our world is virtual is usually a topic of science fiction not physics. Yet that the physical world is somehow unreal has an illustrious lineage in human thought. In Buddhism, a universal essence of mind generates the discriminated world like bubbles on a sea, and in Hinduism the world is an illusion (*Maya)* created by God's "play" (*Lila)*. In the west, Plato described the physical world as shadows flickering on a wall, like an image on a screen thrown up[3], and in Gnosticism the world is a lie created by a demiurge unaware of the original reality[4].

Nor is a digital view of the world new, as Pythagoras saw numbers as the non-material essence of the world, Plato felt that God geometrizes, and Gauss that God computes (Svozil, 2005), just as Blake's *Ancient of Days* measures the world with his compass (Figure 1.1). More recently, Zuse has argued that *space calculates* (Zuse, 1969), and others suggest that *reality computes* (Fredkin, 1990), (Lloyd, 2006), (Rhodes, 2001), (Schmidhuber, 1997), (Tegmark, 2007), (Wolfram, 2002).

For over two thousand years people have wondered if the world we see is all there is (Aristotle's *physical realism)* or if it reflects something else (Plato's *idealism*). Logically, one of these world views *must* be wrong, and orthodox science and orthodox religion take opposite sides on this issue.

1.2.2. *Dualism*

As science grew alongside religion, Descartes proposed the peace of *dualism*, that there was a realm of mind apart from the body, arguing for the former by saying: "*I think, therefore I am*". Dualism let the spirituality of religion to coexist with the physicality of science, but divided scientists into atheists who

[2] The Ancient of Days by William Blake, 1794, from http://en.wikipedia.org/wiki/Urizen

[3] 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.

[4] 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 isolates him, but he being alone and thinking only he existed, created a world in his own image, entrapping Sophia's essence in a false physical world.

believed *only* in the physical world, theists who believed in a world beyond it *as well*, and agnostics who didn't know.

Today, dualism seems increasingly an illogical kludge[5], a marriage of convenience not truth, as how can *two distinct realities co-exist?* Mind and body realms that don't interact are irrelevant to each other, as what use is a mind that can't affect the body? Or if they do interact, which one is primary? A mind emerging from the brain is superfluous and a mind-created brain is unreal. Or if the conflict is ongoing, as say between heaven and earth, why hasn't heaven purged earth already (or earth corrupted heaven)? If mind and body are two sides of the same coin, isn't reality the coin not its sides?

Faced with such challenges, *dualism* is currently in retreat before the *monism* that there is only one real world. Scientists naturally think that if there is only one reality, let it be the physical one we study. The rise of physical monism inevitably conflicts with idealistic dualism.

1.2.3. The virtual reality conjecture

Yet as science and religion fight their ideological war, another monism still logically stands on the sidelines ignored by all, namely *virtualism* (Raspanti, 2000), that physical world is the output of a non-physical quantum processing, i.e. a digital construct. If *physical realism* is that only the physical world exists, and *dualism* is that another reality also exists, then *quantum realism* is that only the other reality exists. In this *monism,* the ghostly world of quantum physics is real and physical world we see is just an image thrown up on a screen. It denies the *presumed* "prime axiom" of physics, that:

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

And instead proposes the antithesis that:

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

If the *physical world* is defined as the physical events we experience, two mutually exclusive hypotheses are formulated about it:

1. *The objective reality conjecture:* The physical world is an objective reality that exists in and of itself, and being self-contained, it needs nothing other than itself to exist.

2. *The virtual reality conjecture:* The physical world is a virtual reality, generated on demand by processing[6], without which it would not exist at all.

These statements are mutually exclusive, as an objective world not made of or by anything else can't be a virtual world, and vice-versa. One can't logically prove reality assumptions (Esfeld, 2004), so that the world is virtual can't be proved but by the same logic nor is objective reality theory. It is unfair to demand that a new theory be proved if the old one isn't proven either. The contrast can however be submitted to the court of scientific experiment.

1.2.4. The reality options

Historically, one can distinguish four different world-views on reality:

1. *Physical realism.* Only the physical world exists, so it is observing itself.
2. *Solipsism.* Only the mind exists, so the physical world is like a dream created by the mind.
3. *Dualism.* The physical world exists, but is also observed by another higher world beyond it.

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[5] A kludge is a (computer) system made up of badly matched components.

[6] If *information* is choosing a value from a set (Shannon & Weaver, 1949), then *processing* is the changing of information. A classical bit is the choice between two distinct physical states while a quantum bit (qubit) is the choice between them and their combinations.

4. *Quantum realism.* The physical world is a construct generated by quantum processing.

In *physical realism, a self-existent physical world observes itself just as it is.* We see the world as solid, real and self-existent, even though it implies that the self is an illusion of the brain (Chapter 6). Yet the problem with physical realism is not that it denies our free will but that it denies our physics,

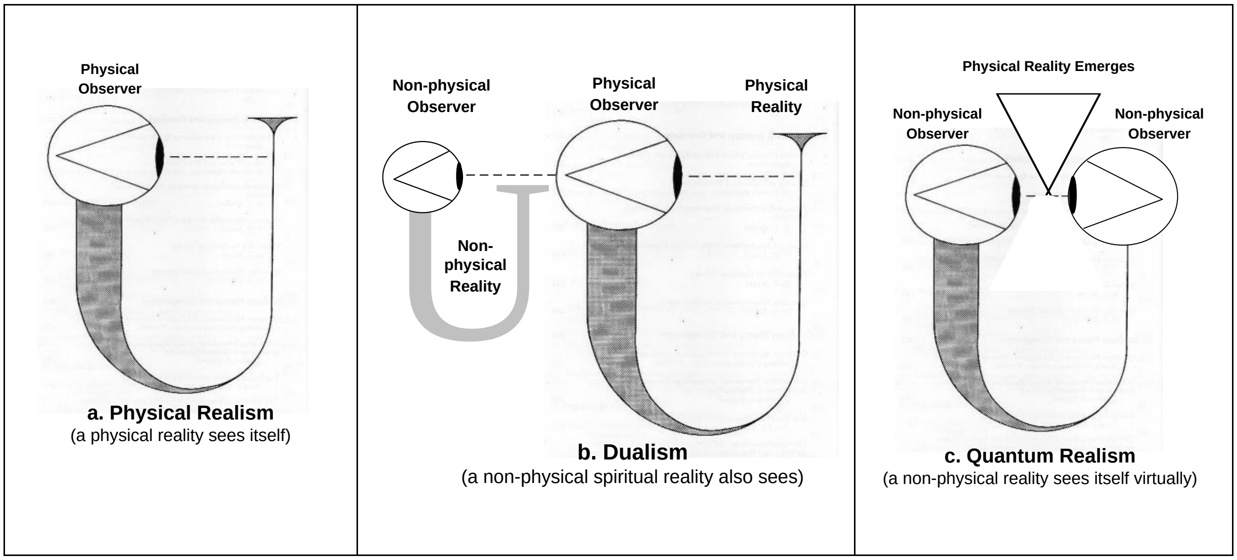

Figure 1.2. The "What is Reality?" candidates

e.g. a purely physical world cannot have the randomness that our world has.

In *solipsism*, *a self-existent observer is dreaming a physical world* that isn't really there at all. The *esse est percipi*[7] thesis that the mind creates reality is illustrated by optical illusions, but that our brain constructs our reality doesn't mean that there isn't a real world out there. As Einstein said, surely the moon still exists if no-one is watching it? And it doesn't generalize well, as you don't exist until I dream you. Solipsism solves the quantum observer effect[8] by making everything an observer effect, but if no tree falls in a forest if no-one sees it, what made history? Did we fabricate the millions of years of dinosaurs before we came along? If I am dreaming, why can't I dream the body I want? Almost no-one today takes solipsism seriously. In quantum realism, no tree can fall in a forest unseen because the ground it hits "sees" it[9].

In *dualism, a self-existent physical world sees itself but another reality beyond it is also watching*, so the physical world is still real, but there is also a heaven, hell or spirit world. However conventional religions based on dualism result in a *God of the gaps*, only explaining what remains after science advances, which gets smaller every day.

In *quantum realism*, the physical world is *a construct* created by quantum events. So there is a real world out there, it just isn't the physical world we see. The physical world as an *interface*, generated by an underlying quantum reality, isn't objectively real but neither is it a fantasy. It *mediates* reality, as an

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

[8] 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.

[9] Knox's limerick on Berkeley's 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."*

email mediates a person but is not itself human. A physical construct that represents a quantum reality is not itself real, but it can signify what is. In physical realism, an observed physical reality somehow makes a conscious observer but in quantum realism a real observer makes a virtual reality. If solipsism is one player game, then quantum realism is a massively multi-player game, with every photon, electron and quark a “player”.

Based on Wheelers universal eye, Figure 1.2 compares the three main “What is Reality?” candidates: physical realism, dualism and quantum realism. Physical realism denies that quantum states are real, quantum realism denies the physical world is real, and dualism denies neither, as it has both a physical world and a spiritual world beyond it.

In our world, miracles are at best rare. Physical realism denies them, as everything has a physical cause. Dualism accepts them, as it implies a spiritual reality that science can’t verify. Quantum realism doesn’t deny them but neither does it advocate them. Online games don’t let players alter the rules, so why should a simulated world allow either miracles or miracle workers to invoke them. This is a system that must generally run without miracles, as if our world was being tweeked by external input, we would see it.

A game like World of Warcraft seems real because if a player looks left a left view is shown and if they look right, a right view is shown. Everywhere one looks, reality presents, but *only when we look*. Quantum theory now tells us that *the same is true of our reality* - that physical events only occur only when we observe them, just like in a video game. And just as when a computer game is busy the frame-rate drops, giving *a slow motion screen,* relativity tells us that in our world *time slows down* near a heavy mass or at high speeds. If our world acts like a virtual one, how do we know it isn’t?

1.2.5. *This is not The Matrix*

In The Matrix, a virtual reality looked real to its inhabitants because they only knew it by the information it gave them, *just as we know ours*. Then when the hero disconnects from the matrix he falls back into another world, where machines in a post-nuclear world farm people in vats for energy. The physical world he previously saw was an illusion, a *construct* created by programs in another physical world. *This theory is not that idea,* that our physical world is created by another physical world.

In virtual realism, the quantum world that creates ours is not physical. Quantum theory tells us that quantum states appear and disappear in a way that physical states cannot, tunnel past barriers no physical particle can pass, ignore speed of light limits when entangled and superpose as physical states cannot, e.g. a quantum current can go both ways round a circuit at once. *What quantum theory describes is in every way physically impossible,* so physicality cannot be its base.

Conversely, a physical processor that created what we see would be bigger than the universe. By the Church-Turing thesis, a finite classical program can simulate any specifiable output (Tegmark, 2007), but while classical processing can simulate quantum processing *in theory*, *in practice* trying to simulate even a few hundred atoms with a conventional computer[10]:

“… *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.

Even processing one quantum event, say an electron wave function that spread over a galaxy then collapsed to a point, is beyond our best super-computers today[11]. Only quantum computers approach this power, but do so by tapping the same non-physical quantum source.

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[10] As Yogi Berra said: *“In theory there is no difference between theory and practice. In practice there is.”*

[11] 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.

The basis of quantum processing is not "hardware" as we know it, as if it were, that would give us:

"…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 another physical world creates the physical world we see is not logical, possible or necessary. Quantum theory already describes the processes that create physical events, but we deny them as impossible on the hardware we know. Yet since when did we *define* how the universe works?

Another concern is that science will fail in a virtual world, but suppose some NPCs in The Sims started to think. They could still test their theories against the information their world gives, just as we do. If they discovered a world of pixels with a malleable time and space that began at a past instant, as we have, they might deduce it was a virtual reality. They couldn't *perceive* the processing behind it but they could *conceive* it, as we do now. Indeed physics today is increasingly about quantum states that are patently not physical at all. So whether the virtual reality conjecture is true or not, science can still flourish. We can still test theories if the physical world is not real, as long as it is an *interface to reality*.

If *things of the same nature are real to each other,* if pixels are real to pixels, then our world can be a *local reality*[12], real from within but not from without. For example, the game money of a virtual world is "unreal" to us but it still affects what you can buy in the game. Likewise the earth is "solid" to us who are made of the same stuff but to a speeding neutrino from the sun our whole planet is just a ghostly shadow through which it flies. We assume that what we see is what is, but it could be generated on demand when we look, just as quantum theory says it is.

1.3. THE PHYSICS OF VIRTUALISM

Is quantum realism denied or supported by modern physics?

1.3.1. Fifteen reasons why we live in a virtual reality

How can we know if our world is a digital construct or not? One way is to look for tell-tale signs, like pixels, processing limits, channel bandwidths and a system boot-up. A virtual reality should behave like one, so a critical analysis should reveal it. Surprisingly, physics tells us that our world:

1. *Had a beginning.* All the distant galaxies are receding from us at known rates, so it is possible to calculate back when our universe started up[13] about fourteen billion years ago, in a first event that 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 it to create it and to create itself, it would have to exist before it began. This leaves physics speculating on D-branes, alternate universes, wormholes, teleporting worlds, quantum tunneling, big bang-big crunch oscillation theories and other steady state variants. In contrast, every virtual reality has a boot up that creates its pixels and its space-time operating system, based on *nothing within itself* (See 2.5).
2. *Has a maximum speed.* In our world, a light shone from a spaceship moving at almost the speed of light still leaves the ship at the speed of light, which is impossible in an objective reality. Einstein proved that the speed of light is a maximum, but gave no reason for it. The equations increase an object's *inherent mass* as it increases speed *relative* to other objects, which works but doesn't really explain anything. In contrast, every screen has a fixed refresh rate that no pixel-to-pixel transfer "speed" can exceed (see 3.2.4).

As our best supercomputers are only just breaking the PetaHertz barrier (10^{15}Hertz), to calculate even the simplest quantum processes takes months or even years.

[12] A local reality appears real to its inhabitants but is inside another reality that generates it. In contrast, an objective reality exists in and of itself and is not contained by anything.

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

3. *Is digital.* Everything at the quantum level is quantized, including time and space, but field theory assumes continuity, so it has to avoid the infinities that implies by a mathematical trick called renormalization. We *think* our world has no gaps but actually Planck length and time are irreducible and calculus implies infinitesimals. In quantum realism, pixels and cycles are expected (see 2.2.2).
4. *Has quantum tunneling.* For an electron to suddenly appear outside a field barrier it can't penetrate is like a coin in a perfectly sealed glass bottle suddenly appearing outside it. Again, this is impossible for an objective reality although quantum theory permits it. In contrast, a digital reality allows "cuts" between one probabilistic frame (quantum state) and another (Ch5).
5. *Entangles entities.* Entangled photons maintain opposite spins no matter how far apart they go because quantum collapse works *instantly* across the universe. An objective reality limited by the speed of light can't do this, so Einstein called entanglement *spooky action at a distance*. In contrast, a program can instantly alter any pixel anywhere on a screen, even if the screen is our universe. In this view, entangled photons just merge their processing until the next processing reboot (see 3.6.5).
6. *Space curves*. In Einstein's vision, the sun keeps the earth in orbit by "curving" the space around it, but what exactly does space curve into? Space needs another dimension to do this, but string theory's extra dimensions are "curled up" in our space, so they don't allow it. In quantum realism our 3D space is a just a "surface" that can curve into a fourth dimension (see 2.3.5).
7. *Time dilates.* In Einstein's twin paradox, one twin travels the universe while the other stays on earth, and the first twin returns after a year to find his brother an old man of eighty! In an objectively real world time is fixed but in our world it slows down as we go faster. Likewise, every gamer knows that the frame rate of a game slows down if the server is busy (see 2.4.1).
8. *Randomness occurs*. In our world, radioactive atoms emit alpha particles randomly, i.e. in a way that no prior physical "story" can explain. Randomness implies a physically uncaused cause that isn't possible in a complete physicality. The many-worlds fantasy, or today the multiverse, was invented solely to deny quantum randomness. In contrast, the processor of a virtual construct can *choose* which quantum state becomes a physical state in quantum collapse (see 4.3.1).
9. *Empty space is not empty*. An objective space should be nothing but our space exerts a pressure. In the *Casimir effect*, flat plates in a vacuum placed close together experience a force pushing them in. Current physics attribute this to virtual particles created by the vacuum, but space as null processing is a simpler explanation (see 2.5.5).
10. *Waves are particles*. In Young's two-slit experiment, *one* electron goes through *two* slits, interferes with itself to give an interference pattern, but still always arrives at *one* screen point. A particle can't do this but a program can spread instances of itself like a wave but still restart at a point (quantum collapse) to arrive as a particle in one place (see 3.3.5). Processing can spread like a wave but reboot like a particle.
11. *Every electron is identical*. In our world, every photon, electron and quark is indistinguishable from every other one, just as if the same code generated all of them (see 3.3.5).
12. *Quantum superposition*. In quantum theory, currents can simultaneously flow both ways around a superconducting ring (Cho, 2000), and an electron can spin both up and spin down – until observed. Such combinations are not physically possible, so in current physics quantum states don't exist, but in quantum realism an electron program can instantiate its code to explore both options (see 3.6.1).
13. *Non-physical detection.* Imagine a bomb so sensitive that even one photon will set it off. It should be impossible to detect, but scientists have done the physically impossible with a Mach-Zehnder interferometer (Kwiat, Weinfurter, Herzog, Zeilinger, & Kasevich, 1995). Current physics attributes this to quantum states that don't exist but quantum realism lets those quantum states exist (see 3.6.4).
14. *Retrospective action occurs.* 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 quantum realism program instances take *all* paths and the observation picks the physical event (see 3.6.3), so there is no time travel.

15. *Anti-matter*. Quantum equations predicted anti-matter, but no reason has ever been given why matter that inherently exists needs an inverse, of the same mass but opposite charge, at all. In Feynman diagrams, an anti-electron colliding with an electron goes backwards in time, but how it can *enter* an event in *reverse* time not explained. In contrast, processing by definition implies anti-processing, and if time is the processing sequence, anti-processing implies anti-time (see 4.3.6).

Each of the above alone is just odd, but together they form what courts call *circumstantial evidence*. They imply that the physical world is a processing output, so by the duck principle:

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

The 'duck' here is a virtual reality generated by quantum processing. Note that we would not doubt that the physical world was objectively real, if only it would behave so, but it doesn't. 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 up out of nowhere. Since no-one has ever proven that the universe is not virtual, why is this option always dismissed out of hand? For example, Hawkings 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."* (Vacca, 2005) p131

Then his next sentence was "*Joking apart…"* But why must it inevitably be a joke? Conversely, if we find that physical realism is impossible, the Sherlock Holmes dictum should apply, that:

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

If the physical world can't be an objective reality, science must consider whether it is a virtual one.

1.4. SOME IMPLICATIONS

Taking the physical world to be a virtual reality implies:

1. Processing,
2. A boot-up,
3. Null processing, and
4. A finite processing rate.

In this view, computing is the key to understanding modern physics.

1.4.1. What is processing what?

Some think that the physical word is both the program 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 brains and 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. If physical systems have physical inputs and outputs, and computers input and output information, most of the universe doesn't compute anything at all. That the physical world generates quantum calculations that generate physical events is an impossible circularity. In a virtual reality, the processor must be outside it. A system can no more compute itself than two hands can draw each other (Figure 1.3). So it is quite impossible for our world to be the output of quantum processing occurring in *our* space and time:

"*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.

Embedding quantum processing in a fixed space and time contradicts relativity. Quantum processing can't exist in our space-time if *it creates our space-time*. If the physical world is virtual, it is *all* an output, so one can't have the virtual cake and keep the physical world too.

Conversely, a virtual word must be finite, because what is infinite can't be computed, so the laws of physics must be calculable, as they all are. An abstract like π can be infinite, as long as it doesn't represent a physical thing, which it doesn't. Physical laws can then connect to information in three ways:

1. *Calculable universe hypothesis:* that processing *could* calculate physical reality is accepted by most scientists based on the Church-Turing thesis, that a finite program can simulate any output that is specified (Tegmark, 2007). It doesn't imply determinism as not all definable mathematics is calculable, e.g. an infinite series. If our world is lawfully 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, so this thesis doesn't directly contradict objective reality, but it is the "thin edge of the wedge". It could be falsified by a non-computable laws 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 hypothesis*: Supporters of the idea that some calculations create physicality include main-stream physicists like Wheeler, by whose "*It from Bit"* processing (bit) somehow creates things (it). Now processing doesn't just *model* the universe, it *causes* it (Piccinini, 2007).

3. *Calculated universe hypothesis:* That processing calculates *all* physical reality is the final step, that the physical world is just an output, but few in physics support this "strong" view (Fredkin, 1990).

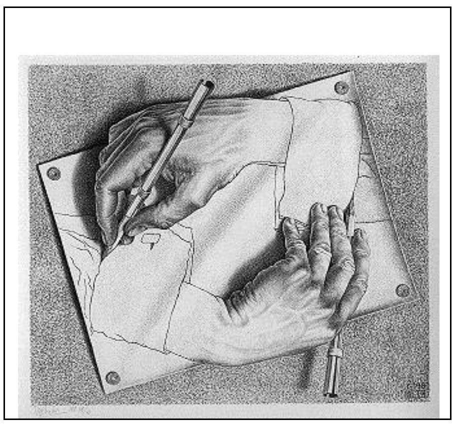

Figure 1.3. The <u>physical</u> universe can't do this [14]

These statements cumulate, as each assumes the previous, so what isn't calculable can't be a calculation, and without some calculating everything can't be calculated. It is a slippery slope as a *calculable* physical reality could be caused by *calculating* and so *calculated*, i.e. virtual. Most prefer the second option compromise that the physical world somehow calculates itself, but processing can't compute itself. There is no half-way point, so the three options reduce to the first and the last: either the physical world is entirely calculated or it is not calculated at all.

1.4.2. Booting the system up

The parts of a *complete* universe may transform, but its total *steady state* must just be, yet last century big bang theorists challenged steady state proponents on the stage of science, and won. The latter were respected scientists, who naturally felt that a universe "exploding" out of nothing was highly unlikely, until Hubble found that all the galaxies are receding from a first event that occurred billions of years ago.

Finding the cosmic background afterglow still visible around us sealed the deal, but left physical realism in a quandary, as a physical universe that began was either created or created itself. If it was

[14] "Drawing Hands" by M. C. Escher, 1948; from https://en.wikipedia.org/wiki/File:DrawingHands.jpg

created, as a child is from parents, something outside itself did that, so it can't be complete. If it created itself, it had to exist before its own creation, which is impossible. A complete system can't just "begin".

Yet that the universe is both complete and also just began is oddly enough what most physicists believe today. In philosophy "*From nothing, nothing comes*" but in physics it seems that from nothing can come everything, and calling this nothing "something that fluctuates" (Atkins, 2011) doesn't help. Physicists speculate that the first event was a "quantum fluctuation of the vacuum", but that event also began our space, so if matter just popped out of space, what did space pop out of? A better story is needed than that nothing exploded from a dimensionless point to create everything.

To the question "*What was there before the big bang?"* the current answer is that there was no time before the big bang, so the question is invalid, but "defining away" a question like this is a cop out. A universe that *began* must be *dependent*, so what it depends on is a valid question. If nothing comes from nothing, how did the entire universe come from nothing? Or if our time and space were created then, could they equally suddenly be stopped today? The questions are:

1. How could the physical universe begin, with no time or space to begin in?
2. How could space begin, with no "now" for it to start in?
3. How could time begin, with no "there" for it to flow in?

That the physical world created itself is impossible, and that it arose from nothing is more than impossible, it is 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 big bang.

In contrast, a virtual reality *needs* a "big bang", to start up not only its programs but also its space and time. Every virtual world comes from nothing, *in that world*, and before it began there was indeed no time or space, *in that world*. In this model, the "big bang" was simply when our universe booted up.

1.4.3. A null processing ether

When a processor in our computers has nothing to do it doesn't do nothing, but runs a *null program*[15]. If one isn't pressing keys or moving the mouse, a four GHz computer still processes about 4,000 times a second. In quantum realism, empty space is null processing not nothing.

A water wave moves as fast as the elasticity of the water medium allows, and the same is true of every wave in every physical medium. So 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 it was the same in every direction, so there could not be a physical ether. Einstein then traded in Newton's absolute space and absolute time for a new, but 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 moved the issue from how light vibrates empty space to how it vibrates a space-time matrix whose mathematical properties give no basis for elasticity either. It didn't help, so the speed of light is now said to define the elasticity of space, i.e. *the wave defines the medium it passes through!* This willingness to appease the facts by applying physics in reverse, whatever the conceptual cost, is disturbing. Yet the idea that an ether contains things as an ocean contains fishes faced an even worse problem, as:

1. An inherent object needs a not-that-object boundary.
2. A world that is not entirely objects must contain a "not-any-object" (space).

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

3. If space is nothing at all, a world of only objects has no basis for movement.
4. If space exists, as objects do, the logic returns to #1, so it needs another "space" to exist in.

The boundary buck must stop somewhere and space is it, so it can't exist as the objects it contains do. Space can't be a physical thing, but a purely physical world doesn't have anything else so it must be nothing. Yet both Einstein and Newton saw that space has to be something for objects to move in it:

> *"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)

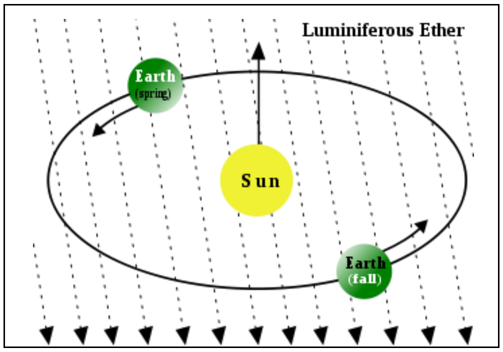

Figure 1.4. A physical ether[16]

He stopped short of saying that space is *something non-physical*, but 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

A network null processing fits the bill, as it is both nothing having no output and something that is actively processing. Now space doesn't need another space to contain it because it is an output just as an electron is. Whether the network operating system runs an electron program or a null program is like whether a screen presents an image or stays blank. A blank screen has no images so is "nothing", but it still refreshes so it is "something". Turning a blank screen off, to see it in itself, would destroy the images upon it, in this case our bodies. If this screen turned off, not only our physical universe but also its space and time would disappear instantly.

1.4.4. The universal refresh rate

This project began a decade ago, when I wondered why our world has a maximum speed? Einstein *deduced* that nothing can go faster than light from how things behave, but he didn't *explain* it. In an objective world things could just go faster and faster, so why don't they? It then occurred to me that every computer has a processing speed in Gigahertz (GHz), so is the speed of light it for our universe?

In a digital world, distance is measured in pixels and time in cycles. A simulation has no time but its cycles and no space but its pixels. The time between cycles or the space between pixels is, like a movie between its frames or a picture between its dots, non-existent. As a screen refreshing 70 times a second *seems* continuous to eyes that only refresh 30 times a second, so a universe refreshing 10^{44} times a second seemed continuous to our instruments, until recently. The speed of light in a virtual universe is always *one pixel per cycle*. For us this is Planck length divided by Planck time[17], and the values we use, like 186,000 miles per second, or 299,792,458 meters per second, just reflect our units.

While an objective reality is complete in itself, a virtual reality *requires a containing reality*, e.g. SimCity exists on a 2-D screen in our 3D world, and in general a virtual reality exists on a *surface* within its containing reality. If our 3D space is just a surface, quantum space must contain it, but unlike string theory, this extra dimension isn't curled up inside physical reality, too small to see, but *all around us*, too big to see. In physics, it is represented by the complex plane, the electro-magnetic amplitude and the

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

[17] In physics terms, it is a Planck length divided by Plank time.

quantum field vector A, all of which are currently considered "imaginary". Like Mr. A. Square of Flatland (Abbott, 1884), we have trouble with the idea that there is anything beyond our reality.

1.4.5. Reality emerges

Is a virtual world by definition a fake? Not necessarily, as the following case shows:

"*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 wasn't physically real, as it didn't physically exist, but nor was it a story made up. It was real enough for those involved to sell, buy and kill for. If reality is *that which exists to an observer*[18], this allows disciplines like sociology, psychology and computing to study real social, human and information systems that emerge from the physical, informational, personal and social levels (Whitworth & Ahmad, 2013, Ch1) (Figure 1.5). Indeed without information realism[19], cognitive realism and social realism the sciences of computing, psychology and sociology would be the study of unreality. The Mir sword didn't exist as a physical entity but it was a data object of personal value. It existed to the Mir community, to its owner and to the Mir database, and for another to sell what he didn't own is a social injustice, whether online or off. If fantasy is what is real to only one person, the Mir sword was not that. It existed by common consent so was *scientifically real* and even subject to online research[20].

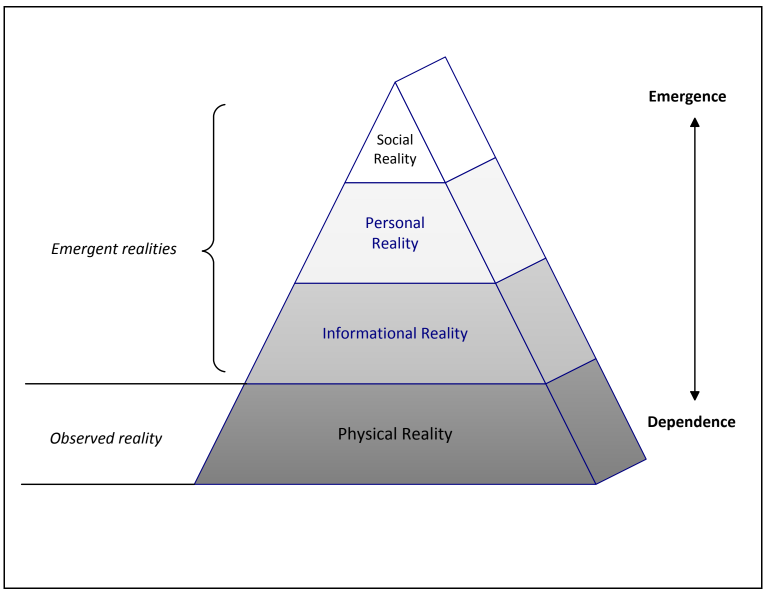

Figure 1.5. Scientific realities emerge from physical reality

In Figure 1.5, each level is an observer chosen *world view*, where sociology studies social systems, psychology human systems, computer science information systems and physics physical systems. Each is a *complete* view, so seeing a cell phone as hardware reveals no software at all, and seeing it as applications reveals no hardware. Yet the disciplines of science are *the same reality* viewed in different ways. Each level emerges from the previous as a higher system type, as social structures emerge from psychology (Bone, 2005), meaning emerges from neural data and information emerges from physical brain events. Higher levels arise because seeing reality in a new way changes how we interact with it, e.g. if I identify with a community I will defend it (Hogg, 1990).

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

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

[20] See http://monet.cs.columbia.edu/projects/virtual-worlds.html

If social constructs emerge from human thoughts that emerge from neural information based on physical events, is the latter the end of the line? *Physical reductionism* says it is[21], that only the physical really exists, so everything must reduce to it. Reducing a system to its parts is a good way to study it, but it isn't a good reality theory, e.g. Skinner's attempt to reduce all psychology to physical behavior (Skinner, 1948) didn't work (Chomsky, 2006).

Even computing doesn't reduce to physics, as software needs hardware but information defined as the choice between options is non-physical by definition (Shannon & Weaver, 1949). The *physical state chosen* is obviously physical but it is only one way, so by definition contains no information in itself. It is strange but true that Egyptian hieroglyphics in themselves have no information. Only if one adds an observer to decode the symbols can meaning emerge. If information could be reduced to physicality, data compression couldn't pack the same information into a physically smaller signal! Information *emerges* from a physicality that is *necessary* but *insufficient,* as every bit has an *observer context*.

If physics were the end of the reality line, it would be observer free, but it isn't. Quantum theory tells us that quantum waves only become physical particles when they are observed, not before. So physics, like the other sciences, is *a* view of reality not *the* view. As the great eighteenth century philosopher Kant pointed out long ago, we don't see *things as they are in themselves* (Kant, 1781/2002)[22]. Physical reality emerges from quantum reality as information emerges from physical reality, as an observer effect (Figure 1.6).

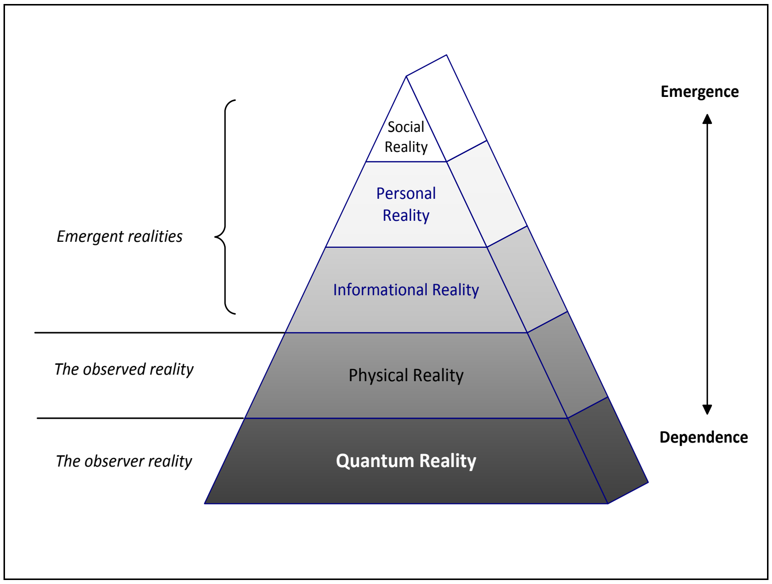

Figure 1.6. Physical reality emerges from quantum reality

My mirror image only exists if I look, so it is unreal, but my body exists even if I don't look, so I take it to be real. Yet if quantum waves interact to give physical events, my body is created on demand just as the mirror image is. According to quantum theory, an electron only becomes physical when its quantum wave collapses. The rest of the time, which is almost all the time it exists as a quantum wave. In this view, the physical world is just another view, generated on demand by a quantum world we call unreal.

1.5. EVALUATION

1.5.1. Science

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 very spirit of inquiry. This *query of everything* is a question about this

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

[22] Kant called the "thing in itself" the *noumenon*, as opposed to the *phenomenon*, or view we see.

world, not some meta-physical one, unlike untestable conjectures on universes beyond ours (Tegmark, 1997), virtual universes saved and restored (Schmidhuber, 1997), or virtualities creating each other (Bostrom, 2002). These are beyond the scope of science but this theory is not, as it is about our world.

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 did what processing couldn't, it couldn't be virtual, but it doesn't. Physical realism is also falsifiable, but its falsification has been ignored (Aspect, Grangier, & Roger, 1982). Virtual realism uses abstract constructs, but only as other theories do, as quantum theory's states are by definition not physical. 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

A current physics of unseeable quarks, invisible fields and virtual particles can hardly make visibility a demand of science. And there is no need, as only the prediction must be physically observed, not the theory, e.g. a big bang we can never see is now accepted based on the evidence we can. If science can decide that there was a first event, it can decide if reality it is virtual or not.

1.5.2. Reverse engineering reality

The virtual reality conjecture doesn't contradict science, but assuming it is impossible does. Science should evaluate hypotheses not presume them wrong. The scientific method, in a nutshell, is to make a wild assumption, then try to prove or disprove it to gain knowledge. To evaluate a scientific theory we first assume it true, then *follow the logic,* to see if it works in practice … or not.

This involves two steps: *theory design,* to create a logical model, then *practical testing* to validate it. In information systems, this *design science* method first develops a best guess information system, then tests it against user requirements in an iterative process (Hevner, March, & Park, 2004). If the research question is whether a quantum processing system can simulate our physical world, the method is:

1. *Specify*: Specify the requirements of the physical world, based on physics.
2. *Design*: Design an information system to satisfy those requirements, based on computing.
3. *Validate*: Validate the expected output against empirical reality, based on science.
4. *Repeat:* Until validation failure, logical inconsistency or further design is impossible.

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 best practices.* Based on established computing principles.
2. *Satisfy Occam's razor.* Given a design choice, take the simpler option.

The aim 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). Science doesn't validate theories by finding support cases, so that selected programs mimic some world properties is an old kind of bias not a new kind of science (Wolfram, 2002). In science, one can't *choose* what a model explains. This theory must explain *all* physics including space, time, energy, matter, spin and charge. This endeavor should in the end reveal the virtual reality conjecture to be:

1. *Spurious*. A model can always be found to explain anything, but this is less likely if the assumptions made are few and reasonable.
2. *Coincidence*. The model could fit reality by coincidence, but this is less likely if the matches found are many and detailed.
3. *Useful*. The model could open up new perspectives in physics even if not literally true. This is more likely if it suggests productive new research directions, as this model does.
4. *Correct*. Our world is probably a virtual reality. This is more likely if the virtual reality hypothesis predicts something new that is later found to be true, which in this case is that light can "collide".

Whatever the outcome, the virtual reality conjecture is a question that science can decide.

1.6. DISCUSSION

1.6.1. Occam's razor

A century ago, Bertrand Russell cut down the virtual reality concept using Occam's razor[23]:

"*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)

Today, virtual particles seethe from space, quantum objects teleport and time dilates, so common-sense physical realism is no longer so simple. After all, what is simpler, that the big bang was reality booting up or that the physical universe exploded from nothing? What is simpler, that an empty space of nothing defines the speed of light or that the universe processing rate does? If physical realism is now the more complex theory, *Occam's razor now cuts the other way*.

1.6.2. The four pillars of physical realism

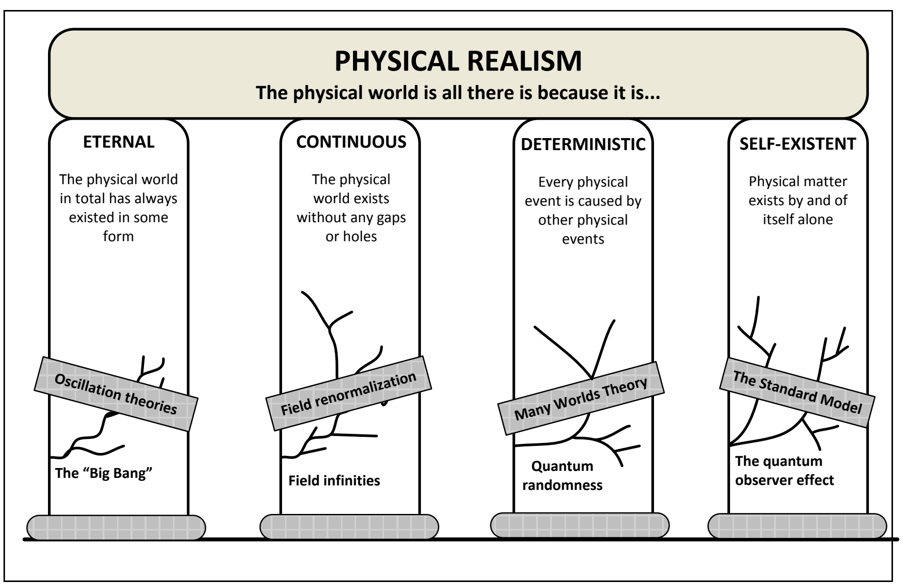

Figure 1.7 The four pillars of physical realism

The current complexity of physics derives from physical realism, the idea that the physical world is *completely real*. Its four pillars are that reality is (Figure 1.7):

1. *Eternal*. A complete world can't begin in time or space, so it must be eternal. The failure of steady state theory last century cracked this pillar, and steady state alternatives like the big

[23] Occam's razor is not to multiply causes unnecessarily, i.e. prefer the simpler theory

bounce are just speculation[24]. Chapter 2 explores the alternative that the physical world is an *event flux*.

2. *Continuous*. An inherent reality can have no gaps, but continuity creates infinities, so field theory needs the mathematical trick of renormalization to cover up the problem. Chapter 3 explores the alternate view, that a digital world is inevitably *quantized*.
3. *Deterministic*. A complete physical world has only physical causes, so how do atoms radiate randomly, for no physical reason at all? A machine can't do randomness, so the many worlds fairy story had to cover-up the problem. In Chapter 4, external *choice* creates the variation needed for physical matter to evolve.
4. *Self-existent*. A complete world exists by itself alone, but in quantum theory physical events only exist when observed. Today, even flash of lightning events are called fundamental particles, but transient eddies in the quantum stream, that decay and transform into each other, are hardly fundamental. Chapters 6-7 discuss the quantum world as an *observing* reality.

Scientists generally accept that physical reality is *everlasting, all-pervading, self-existent and the cause of all*, but cracks are now appearing in the mighty edifice of theoretical physics built up over the last half century, despite attempts to patch them. The reason is that the foundation upon which it was built, namely physical realism, is unsound.

1.6.3. The edifice of modern physics

It is not generally realized that the new structures of quantum theory and relativity are built on the old foundation of physical realism. If the physical world is real, trying to smash matter into its basic bits in particle accelerators makes sense. Yet the idea of a continuous universe made up of elementary point particles makes no more sense than a complete universe that always was. An object with an inherent mass needs a substance that extends in space. So it has left and right parts that by the same logic have still finer parts, and so on ad infinitum. The current response is that the universe consists of *point particles* with no extent, but how can something with no extent have mass? And since a billion points of no extent take up no more space than one, how then do extended objects form? It was then necessary to invent invisible *fields* continuous in space to keep these "points of no extent" apart by force. Finally, as every force needs a particle cause, the fields had to act by creating *virtual particle agents*, e.g. virtual photons. This masterpiece of circularity is immune to science, as a virtual photon is just a physical photon that can never be observed, as it is created and destroyed in the effect instant. Only physicists can see them, in equations and Feynman diagrams, which is good enough.

All was well, until new effects like neutron decay implied new forces and new invisible fields[25] whose virtual particles had mass. The solution, in what was by now a well-oiled machine, was that *another* field created the virtual particles of the first field, and so the Higgs search began. The Higgs boson is the virtual particle created by an invisible field to explain another virtual particle created by another invisible field to explain an actual effect (neutron decay). Given dark energy and dark matter, it explains at best 4% of the mass of the universe, but the standard model needs it, so when after fifty years CERN found a million, million, million, millionth of a second signal in the possible range, physics was relieved. There is no evidence this "particle" has any effect on mass at all, but the standard model survives.

By piling fields upon fields, the standard model now has at least forty eight point particles, twenty-four fitted properties, five overlapping invisible fields and fourteen virtual particles that pop in and out of existence on demand, anywhere, anytime. And *it isn't finished yet*, as each new effect needs a new

[24] Big bounce theory is that a big bang follows a big crunch in an ongoing oscillation, so what is always was (in a steady state). See https://en.wikipedia.org/wiki/Big_Bounce

[25] As well as the electro-magnetic field, there is the strong field, the weak field, the Higgs field and gravity.

field, e.g. inflation needs an inflaton field. If this approach, founded on physical realism, is preferred, it isn't because of its simplicity, as it is hard to imagine anything more complicated! Chapter 4 suggests that while the fitted calculations work, their interpretation is *a mythology on a scale not seen since Ptolemy's epicycles* (see 4.6.5).

1.6.4. A new foundation

Quantum realism aims to reboot modern physics, by taking the path not taken at Copenhagen. That path didn't work because its predictions of proton decay, super-symmetry (SUSY), neutrino mass, dark matter particles (WIMPs) and gravitons didn't work. And there has been no progress on issues like dark energy, why the universe isn't anti-matter, how particles spin, why neutrinos are left-handed, particle generations, or why quarks have one-third charges. This sterility is a crisis in physics.

That quantum states exist elevates the current mathematics from a mathematical fiction to a reality description. This theory rejects not the equations but their particle interpretation. Chapter 2 replaces the six dimensions of string theory by *one* complex dimension. Chapter 3 derives the first photon, and the entire electro-magnetic spectrum, from *one* fundamental Planck program that is also space. Chapters 4 and 5 derive every force from *one* quantum network, in effect reducing all fields to one.

Chapter 4 dismisses the virtual particles of the standard model, as every force is derived from one program spreading on one network vibrating into one dimension outside space. This theory predicts that matter began when light collided, which the standard model says is impossible, so it isn't hard to test - if we stop colliding matter and start colliding light. It also predicts that direction is quantized, empty space is null processing, electrons are one-dimensional matter, quarks bond by sharing photons, time is processing cycles, dark energy is new space arriving and that gravity is a processing gradient.

This is a *paradigm shift* (Kuhn, 1970), rebuilding of an intellectual structure from the ground up based on new axioms. Axioms to a theory are like foundations to a house - that upon which it is built. For example Euclidian geometry was built on the assumption that parallel lines can't converge. Changing that axiom allowed *hyper-geometries* on curved surfaces like the earth, where parallel lines now do converge (at the poles). A geometry that for a thousand years dominated thought is now just the zero-curvature case. Replacing the axiom of physical realism by quantum realism will make the physical world *a* reality not *the* reality.

Quantum realism is a disruptive innovation (Sandström, 2010), but as Chaitin, following Gödel, showed, the job of axioms is to explain more than they assume (Chaitin, 2006). In this respect, the current model, with all its fitted parameters, is struggling. Old axioms are always patched up when there is no alternative, because like a house a theory always needs a foundation. Yet if a better foundation is available, the theory reconstruction may be worth it. Quantum realism is not an attack on physics, but a proposed renovation.

1.6.5. 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 Copernicus and Galileo challenged the paradigm that the Earth is the center of the universe, they also challenged our idea of ourselves. We now know that we are on a little planet circling a medium star, two-thirds of the way out of an average galaxy of a hundred billion stars, in a universe of at least as many galaxies, i.e. we aren't the *physical center* of the universe at all.

When Darwin and Wallace challenged the paradigm that we are the pinnacle of a biology built for us they also challenged the human ego. We now know that humans have only been here for three million years and that 99.9% of all species that have ever lived on the earth are extinct. Insects and plants exceed us in biomass, are more likely to survive a disaster, and often have more genes. If the evolutionary tree had a "top", we wouldn't be it. The dinosaurs dominated the earth for two-hundred million years, longer than mammals have today, but were still wiped out sixty five million years ago, apart from the birds. We are unlikely to be the last evolutionary word, so we aren't the *biological center* of things either.

Table 1.1. 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 the fastest speed, for no known reason	*Maximum rate.* The processing rate of the universe defines the speed of light
Wave function collapse. Quantum wave collapse occurs faster than light, by some miracle	*Program restart.* Quantum wave collapse as a program restart affects every screen part instantly
Time dilates. Near massive bodies and at high speeds our time dilates, for no known reason	*Frame rates drop*. Mass and speed increase network load to reduce frame rates (time)
Mass curves space. Space "curves" around a massive body, for no known reason	*Mass uses processing.* Mass creates a processing gradient around it that bends transmissions
Physical laws are simple. The laws of physics have an amazing algorithmic simplicity, for no known reason	*Physical events are calculated.* Physics laws are simple because they are actually being calculated at the quantum level
Physical randomness. Beta decay is random, i.e. not predicted by *any* prior physical event(s)	*Processing choices*. Variations random to us can arise from external processing
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 photon or electron is identical to every other one, for some reason	*Digital equivalence*. Every digital object generated by the same program is identical
Quantum tunneling. A physical quantum entity can suddenly appear past an impassible barrier	*State transitions*. Entity processing spread across a network can restart at any point

Modern neuroscience challenges the ego paradigm of a unitary "self" that acts and observes. To a scientist the brain is a set of autonomous neural assemblies interacting to maintain the convenient fiction of an "I". It has no CPU (Central Processing Unit), as if the cortical hemispheres are surgically split, each takes itself to be "I" (Sperry & Gazzaniga, 1967). So we don't have the *psychological center* we thought we had either (Chapter 6).

The trend is clear - we repeatedly *see ourselves at the center of things* until science finds we aren't. Every generation is "smart" until the next one finds it stupid. So is *now*, finally, the end of our line of ego fallacies, or is there one more? Are we, at last, the ones who see true, or would it be so surprising to discover that we aren't the *existential center* of things either?

Table 1.1 contrasts physical realism and quantum realism on key issues. The latter shocks the ego, but it fits the physics. It isn't The Matrix brain in a vat, a hallucinatory dream, or a fake SimCity world. It doesn't deny our experience, as a simulation can be locally real. It doesn't deny there is a real world out there beyond the physical interface. It doesn't deny free choice, as the observing player need not be in the simulation. It ticks all the boxes, so why isn't this option more widely discussed? Is the egoism that what we see must be real because we see it the final barrier to knowing how our world really works?

DISCUSSION QUESTIONS

The following discussion questions arise from this chapter:

1. How does an objective reality differ from a virtual reality?
2. Has science proved that the physical world is an objective reality?
3. Is the virtual reality conjecture falsifiable? Is it provable? Is it testable?
4. Could science still operate in a virtual reality?
5. Of physical realism, dualism, solipsism and virtual realism, which one(s) involve only one reality? Which one(s) imply a real world out there? Which one(s) allow for free choice?
6. Could a complete physical universe create itself in a "big bang"?
7. What physics discoveries suggest that the physical world is a virtual reality?
8. Can a reality occur without an observer? What about physical reality? Where does the observer come from?
9. How can the many different disciplines of science all study the same reality?
10. Could space as “nothing” transmit light as a wave? If not, what does transmit it?
11. If space isn’t nothing, and isn’t physical, what is it?
12. Why can’t anything go faster than light?
13. How can the virtual reality conjecture be evaluated scientifically?
14. If physics has falsified objective reality theory, why is it still accepted?
15. If the physical world is a virtual reality, who is the observer? Are they outside the simulation?

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