

Quantum Realism Part I. Physical Reality

Chapter 1. The physical world as a virtual reality¹

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“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 in our world space contracts and time dilates. Objective things should inherently exist, but in our world electrons are probability of existence smeared 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!

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 physical events and computer science describes processing, whether quantum processing produces physical events is a question we can evaluate.

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, the universe floats on a fifth dimension “brane” we can’t see (Gribbin, 2000) p177-180 and in ekpyrotic theory 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.

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 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:

“... the weirdness of the quantum world is real, whether we like it or not.”

(Tegmark & Wheeler, 2001) p4.

¹ For the latest chapter versions see <http://thephysicalworldisvirtual.com/>

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

1.1.2. 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:

"It's 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 theory lets particles morph into waves which denies the very meaning 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 because 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 *fairytale physics* (Baggot, 2013), where virtual particles arise ex nihilo from invisible fields in empty space to fit equations that work. 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 problem is not a few anomalies in an otherwise perfect vision. Quantum theory rules the microcosmic world from which reality emerges and relativity rules the cosmic world around it. These theories *are* physics which is the bedrock of science, so for it to make no sense at all is unacceptable. The problem is that 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.” (Nikolić, 2008) p43

This is the original “hard” question of physics - “What is reality?”

1.2. WHAT IS REALITY?

For thousands of years, people have wondered what is reality? Over time, these views crystallized into Aristotle's *physical realism* that what we see is what there is, and Plato's *idealism* that what we see reflects something else interacting with our mind. Logically, one of these world views *must* be wrong, and orthodox science and orthodox religion have taken opposite sides on this issue.



Figure 1.1. [The Ancient of Days](#) measures the universe²

1.2.1. Idealism vs. physicalism

Aristotle and Plato were students of Socrates, an ancient Greek *philosopher* when that word then meant literally lover (*philo*) of wisdom (*sophia*). Science based on outer observation took Aristotle's view that the physical world was real in itself, but religion based on inner observation agreed with Plato that there was something beyond the physical. Orthodox religion's vivid descriptions of a heaven and hell beyond this life dominated thought in the west for most of the last two thousand years.

In the West, some held to Plato's original idea, that the physical world is shadows flickering on a wall³, e.g. Gnostics saw the world as a *lie* created by a demiurge ignorant of the original reality⁴. 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 world is an illusion (*Maya*) created by God's “play” (*Lila*). Yet at any moment, only a tiny few ever really believed the physical world wasn't real.

1.2.2. Dualism

In the west, as the ideological war between science and religion grew, Descartes proposed the truce of *dualism* since “*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 until now scientists mostly deny the spiritual.

The problem 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 heap,

² The Ancient of Days by William Blake, 1794.

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 accidentally 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.

while if a non-physical mind creates the brain, it's unreal and doesn't matter. Either way, if one is real the other isn't, or at best 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 retreating before the *monism* that there is only one reality and it is physical. Monism is simpler than dualism, so if scientists say the physical world they study now is real, and theologians say a future spiritual world is real, most people prefer now to later.

1.2.3. The virtual reality conjecture

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. It seems new but actually traces back to Plato's view that the physical world is shadows on a wall that reflect another reality. Idealism leads to the idea that the physical is a digital construct. Pythagoras saw numbers as the non-material essence of the world, Plato felt that God geometrizes and even Gauss believed that *God computes* (Svozil, 2005), just as Blake's *Ancient of Days* measures the world with his compass (Figure 1.1).

Computers today create virtual worlds but that the physical world is virtual is usually a topic of fiction not physics. Virtualism, that physical reality is a shadow of something else, leads to ideas like that *space calculates* (Zuse, 1969) and *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* another reality creates physical reality as an output which 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.

These statements about the observable world give mutually exclusive hypotheses:

1. *Physicalism*: The physical world is an objective reality that exists in and of itself that needs nothing other than itself to exist.
2. *Virtualism*: The physical world is a virtual reality output by some "other" without which it would not exist at all.

These statements are mutually exclusive. An inherently real objective world can't be a virtual world and vice-versa. One can't logically prove reality statements (Esfeld, 2004), so that our world is virtual isn't provable, but by the same logic neither can one prove that the physical world is real. So 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. *Physicalism*. That only the physical world exists and it observes itself.
2. *Virtualism*. That the physical world is a construct created by another observer outside itself.
3. *Dualism*. That the physical world exists but it is also observed by higher reality beyond it.

In *physicalism*, a self-existent physical world observes itself just as it is, so we see the world as it is. Unfortunately this denies our physics, e.g. in a purely physical world random events like radioactivity that aren't predicted by any prior events can't happen, yet in our world they do.

In *dualism*, a real physical world exists but another reality beyond also observes, like a heaven, hell or spirit world. This gives 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, but opinion is divided on what this “other” is:

- a. *Physical*. In the Matrix movie, a virtual reality looked real to its inhabitants because they only knew it via 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 computer⁵:

“... would need more memory space than 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 a computer as big as our universe couldn't remotely do the job, this option is unlikely.

- b. *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*⁶ thesis, that the mind creates reality, is proved 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 pixel. It solves the quantum observer effect⁷ 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.
- c. *Quantum*. In this view, quantum processing⁸ creates physical events on demand, which otherwise don'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)

In this circular argument, only the physical is real so what we can't understand physically can't be real. Quantum entities can't be real because they appear and disappear in physically impossible ways, tunnel past barriers physical particles can't pass, ignore the speed of light limit on physical interactions and superpose in ways that can't physically interchange! What quantum theory describes, like currents going both ways round a circuit at once, is in every way physically impossible so physicality cannot be its base. Indeed there is no way to interpret quantum theory physically nor any quantum “hardware” but *who made physics the arbiter of reality?* It is logically possible that a *real* quantum world creates a *virtual* world, and this project now considers that.

⁵ As Yogi Berra said: “*In theory there is no difference between theory and practice. In practice there is.*”

⁶ “Existence is perception”, i.e. what is real is created by what we see.

⁷ 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.

⁸ *Information* is defined as choosing a value from a set (Shannon & Weaver, 1949), and *processing* is defined as the changing of information.

Quantum realism is the theory that the ghostly quantum world is real on its own terms and the physical world is “imaginary”. It isn’t the matrix movie idea that another physical world creates this one, because even *one* electron wave function that spread over a galaxy and collapsed to a point is beyond our best physical computers⁹. Only quantum processing has enough power to output physical reality. Nor is it that we are dreaming because if I dream you, then you don’t exist, leading to solipsism.

In quantum realism you and I are real and the physical world is the *interface* between us. There is a real world out there but it isn’t the physical one we see. The physical world *mediates* quantum interaction just as email mediates human interaction – it isn’t a person in itself but it represents a person. A physical event is a *construct* created on demand by quantum processing. Quantum reality works just as quantum theory describes, which isn’t physical. It has to work that way to generate the physical world we see.

In this monism, quantum reality is both observer and the observed. It provides the ability to observe we call consciousness. Since quantum reality inherently observes, a tree can’t fall in a forest unseen because the ground it hits “sees” it¹⁰. By analogy, physical realism is a game running amok with no-one in charge. Dualism is a designer vainly trying to regain control of a game that is again running amok. Solipsism is a single player game where an all-powerful program is just testing us. Quantum realism is a massively multi-player game, with every photon, electron and quark a “player”, and it is underway.

Figure 1.2 compares the reality candidates based on Wheeler’s universal observing eye. In physical realism, a physical reality observes itself but this gives no basis for consciousness. In dualism, a higher

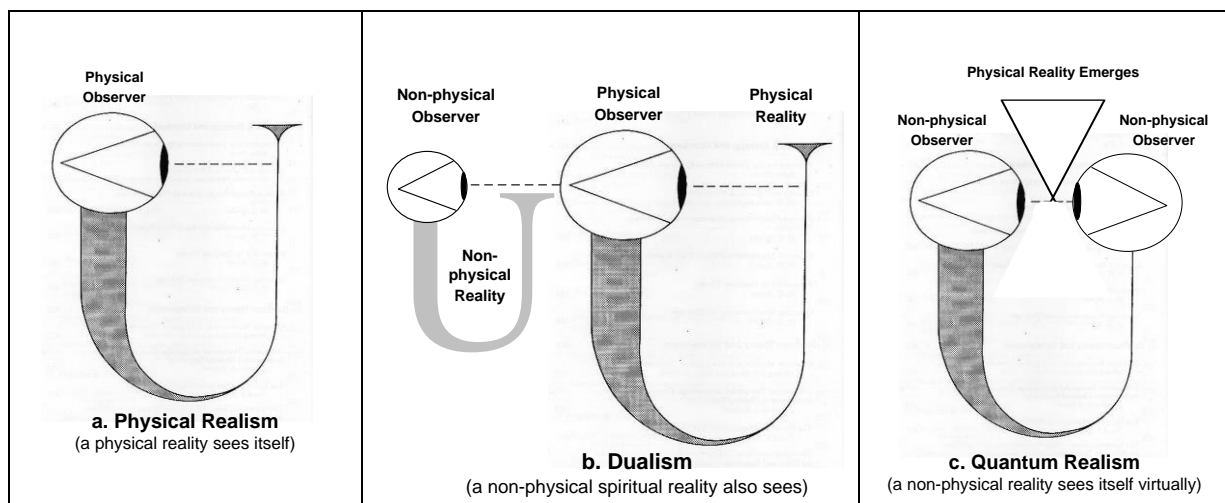


Figure 1.2. The “What is Reality?” candidates

reality observes the physical but how can two realities co-exist? In quantum realism, a quantum reality observes itself via a physical world interface, so there is only one reality and it is inherently conscious.

⁹ A Milky Way volume of 1.6×10^{60} cubic meters divided by a Planck volume of 4.2×10^{-105} cubic meters is about 551 bits, which for a 10^{-43} seconds Planck time is over 5×10^{45} Hertz of processing power for one quantum event. 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.

¹⁰ 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."*

Physical realism denies quantum reality, dualism lets us have two realities, and quantum realism says the physical world is entirely virtual. Humanity should choose between them based on science not tradition.

1.2.5. Is this the end of science?

If physicality is virtual, is it 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 suggest now. If they looked like a world of pixels with a virtual time and space that began at a specific past instant, they might conclude they were in a virtual reality. They couldn't *perceive* the processing behind their world but they could *conceive* it, as we now do.

Modern physics is increasingly about quantum states that are patently not physical at all but science still works. A virtual world has action and feedback so science will still flourish in it. The physical world as an *interface to reality* is enough to test theories.

It is proposed that we occupy a *local reality*, one that seems real to its inhabitants but is within another reality that generates it¹¹. A local reality is real from within but not from without, e.g. Monopoly money is unreal but in the game it affects what you can buy. In general, pixels are real to pixels because *they are of the same nature*. Hence 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. In this view the physical world is real to our physical bodies but not to our consciousness which is outside it.

1.3. THE PHYSICAL EVIDENCE

How can we know if the world is a digital construct or not? Just looking isn't enough. A game seems real if when I look left, a left view is shown and when I look right, a right view is shown. Wherever I look reality presents, but the catch is *only when I look*. Quantum theory now tells us that *the same is true of our reality*, that physical events only occur when we observe, so a photon from a distant star only chooses its physical path *after* it arrives. This sort of spooky action makes physicists call quantum theory imaginary, even though it works 100%. But why not *look* for the tell-tale signs of a digital system, like pixels, cycles, bandwidths, servers and a boot-up? A virtual reality should behave like one, right?

1.3.1. Fifteen physics facts that suggest we live in a virtual reality

Physics tells us that our universe:

1. *Began*. All distant galaxies are receding from us at known rates, so we can calculate back to say our universe started up¹² 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 it to create it. And to create itself, it would have to exist before it began. So physics speculates on D-branes, alternate universes, wormholes, teleporting worlds and big bang oscillation theories. 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 work but don't explain why. In contrast, a photon as a screen pixel can only move point-to-point as fast as the screen refresh rate allows. The screen cycle rate defines a maximum “speed” for the pixel (see 3.2.4).

¹¹ In contrast, an objective reality exists in and of itself and is not contained by anything.

¹² Colloquially called the “big bang”, as if it were an explosion in an existing time and space, which it was not.

3. *Is digital.* 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 (see 2.2.2).
4. *Has quantum tunneling.* In tunneling, 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. Quantum theory permits this, which is objectively impossible, so again it is called "unreal". In contrast, a digital reality can "cut" between one probabilistic frame (quantum state) and another (see 5.3.1).
5. *Entangled entities.* 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, so Einstein called this *spooky action at a distance*. In contrast, a program can instantly change any pixel anywhere on a screen. So for the screen of our universe, all points on it are equidistant to a quantum server (see 3.6.5).
6. *A space that 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 extra dimensions are "curled up" so they don't allow it. In quantum realism our space is a 3D "surface" that can curve into a fourth dimension (see 2.3.5).
7. *A time that dilates.* In Einstein's twin paradox, one twin who travels the universe for a year returns to find his brother on earth 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 2.4.1).
8. *Randomness.* In our world, radioactive atoms emit alpha particles randomly, i.e. in a way that no prior physical "story" can explain, implying caused beyond physicality. The many-worlds fantasy of a multiverse was invented solely to deny quantum randomness. In contrast, in this model quantum randomness is attributed to quantum server choices (see 4.3.1).
9. *A non-empty space.* An objective space should be nothing 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 explains this as virtual particles but quantum 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 processing wave can spread to interfere with itself like a wave but still reboot at a point (quantum collapse) to arrive like a particle in one place (see 3.3.5).
11. *Identical electrons.* 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 electrons spin both up and down until observed. This is not physically possible so in current physics quantum states don't exist, but in quantum realism copies of one quantum program can explore all possible 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 a Mach-Zehnder interferometer does just that (Kwiat, Weinfurter, Herzog, Zeilinger, & Kasevich, 1995). Current physics predicts this by quantum acts it says don't occur, but in quantum realism they do (see 3.6.4).
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 quantum realism, processing spreads to take *all* paths until an observation picks a physical event, so there is no time travel (see 3.6.3).

15. *Anti-matter*. Quantum equations predicted anti-matter, but no reason has ever been given why matter inherently needs an inverse of the same mass but opposite charge. In contrast, matter created by processing inevitably implies anti-matter created by anti-processing (see 4.3.6).

1.3.2. The initial case for virtualism

No-one has ever proved the universe **isn't** virtual yet this option is always dismissed out of hand:

“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 Hawking's next sentence was *“Joking apart...”*. Why is virtualism inevitably a joke? Indeed, given the previous facts physical realism isn't possible, so Sherlock Holmes dictum applies:

“When you have excluded the impossible, whatever remains, however improbable, must be the truth”

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. If the physical world **can't** be objectively real, we must consider if it is virtual. As a case for this, each fact listed above is odd but together they form what the courts call *circumstantial evidence*. We would not doubt the physical world was objectively real - if only it behaved so. The case for this investigation into quantum realism is the duck principle:

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

1.4. SOME IMPLICATIONS

Suppose for now that the physical world is a virtual reality. This implies:

1. A processor,
2. A boot-up,
3. Null processing, and
4. A maximum cycle-rate.

In this view, quantum computing is basis of all physics.

1.4.1. The processor

Some suggest that the physical world 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/output, so the universe mostly doesn't compute anything at all. That the physical world generates quantum events that generate physical events is impossibly circular. For any virtual reality, the processor is always outside the world created. It is impossible for two hands to draw each other (Figure 1.3) and it is impossible for the physical world to compute itself. Yet physicists glibly talk of quantum processing occurring in *our* spacetime:

“Imagine the quantum computation embedded in space and time. Each logic gate now sits 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.

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, it can't exist in that space-time.

Our world as a virtual word must be finite because what is infinite can't be computed, so all the laws of physics must be calculable, which they 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. This thesis doesn't directly contradict objective reality but is the thin edge of the wedge. 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 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).

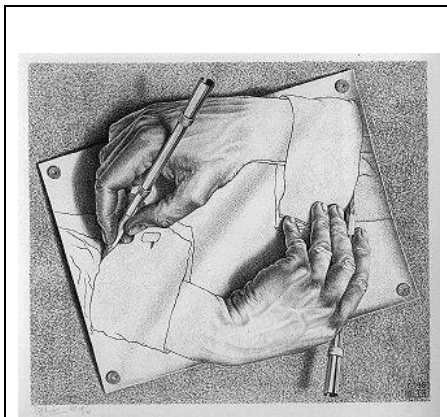


Figure 1.3. A physical world can't do this¹³

These statements cumulate, as each assumes the previous, so that which isn't calculable can't from some calculation, and that which isn't from some calculation can't be calculated. It is a slippery slope as a *calculable* physical reality that can be caused by some *calculating* could be *calculated*, i.e. virtual. The second option, that the physical world somehow calculates itself, sounds good but processing can't compute itself. This slope has no half-way point once you begin. Three options reduce to two: either the physical world is entirely calculated or it is not calculated at all.

1.4.2. The system boot-up

Last century science saw the physical universe as *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 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 can't be complete. If it created itself, it had to exist before its own creation which is impossible. The fact is that a *complete* system can't just *begin*.

Yet that our universe is both complete and also began is oddly enough what most physicists believe today. In logic *"From nothing, nothing comes"* but physicists believe that from nothing everything came.

¹³ ["Drawing Hands"](#) by M. C. Escher, 1948

Calling this cause “something that fluctuates” (Atkins, 2011) doesn’t help because nothing doesn’t fluctuate. Some 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? If nothing comes from nothing, how did an entire universe come from nothing? A better story is needed than that nothing “exploded” from a dimensionless point to create everything in an instant.

To the question “*What was there before the big bang?*” the current response is that there was no time before the big bang, but “defining away” the question like this is a cop out. A universe that *began* was made, so what made it is a valid question, as if our time and space were created could the same cause suddenly stop them today?

The questions current physics is mostly trying to ignore are:

1. How could matter begin if there was no time or space to begin in?
2. How could space begin, with no “now” for it to exist 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 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 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*. From a quantum processing perspective, the “big bang” was simply when our universe booted up, i.e. quantum realism *requires* a big bang.

1.4.3. Space is null processing

When a processor in a computer has nothing to do it doesn’t sit idle, but runs a *null program*¹⁴. If one isn’t pressing keys or moving the mouse, a four GHz computer still processes about 4,000 times a second. Therefore, 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 changed the issue from how light vibrates empty space to how it vibrates a space-time matrix that give no basis for elasticity either. 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 choice, to apply physics in reverse to fit the facts is why modern physics is in a rut, a fate sealed by its rejection of “philosophical” logic.

Consider the idea that space contains things as an ocean contains fishes:

1. An inherent object needs a not-object boundary.
2. Unless a world is entirely objects, it must contain a “not-any-object” (space).
3. If that space is nothing at all, the world is only objects and so 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.

¹⁴ Null processing is the program a central processing unit (CPU) runs when it is doing “nothing”.

A thing needs a not-itself boundary that must exist but if that is also a thing nothing can move. The buck of thingness must stop somewhere and for us space is it. Space can't 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:

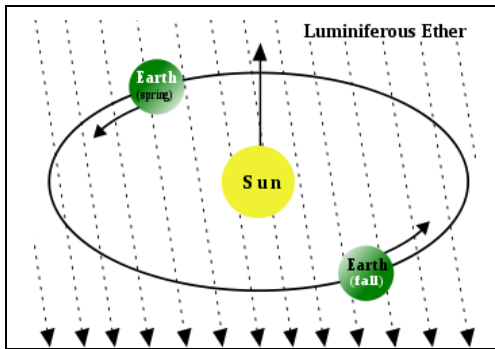


Figure 1.4. A physical ether¹⁵

"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 something that 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 paradoxical conclusion is that while space physically acts like nothing it is actually something.

In quantum realism, space is the quantum network null processing. Null processing is nothing as there is no output and something as it is an activity. Such a space doesn't need to exist in another space because it is something itself – processing. In this view, space is a virtual just like an electron or a photon but happens to be null. As a fundamental quantum entity, space is the null element. Whether the quantum network node runs a program that is an electron or the null program of space is like whether a screen point is a pixel or blank. A blank screen with no images is "nothing" but it 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 the quantum screen turned off, the physical universe and its space and time would disappear instantly.

1.4.4. The speed of light is one

This project began a decade ago, 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? I then wondered if the speed of light is a universal processing limit, just as my computer can only run a game at a certain frame rate?

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. 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 there is a Planck length and a Planck time it is impossible to divide, i.e. there are pixels and cycles.

In our universe the speed of light is always *one pixel per cycle*, which is Planck length divided by Planck time¹⁶. The values we use, like 186,000 miles per second or 299,792,458 meters per second, just reflect our units. In the units of quantum reality, the speed of light is just one.

¹⁵ See Wikipedia <http://en.wikipedia.org/wiki/File:AetherWind.svg>

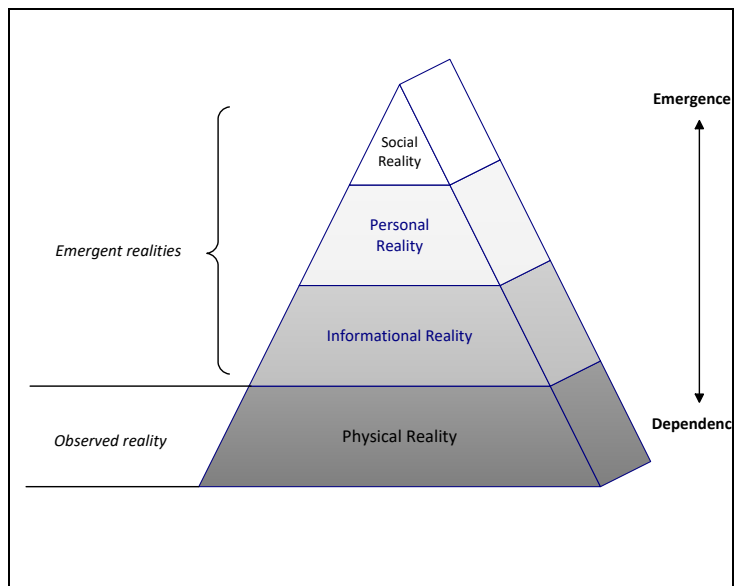
¹⁶ In physics terms, it is a Planck length divided by Planck time.

1.4.5. Reality emerges

Is a virtual world necessarily fake? Not so, 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 didn’t physically exist but nor was it fake. It was real enough for those involved to sell, buy and kill for. Reality doesn’t need to be physical. Reality is *that which exists to an observer*¹⁷. Disciplines like sociology, psychology and computing study social, human and information systems that science agrees are real. Indeed if information wasn’t real¹⁸, cognition wasn’t real and society wasn’t real, the sciences of computing, psychology and sociology would be the study of unreality. We argue



elsewhere that this is so because social, personal and information levels emerge from the physical level (Whitworth & Ahmad, 2013, [Ch1](#)).

In Figure 1.5, each level is an observer *world view*, so sociology is about social systems, psychology is about human systems and computer science is about information systems. These systems exist *at the same time* as the physical system, e.g. a cell phone is hardware *and* software, but hardware tells us nothing about the software and describing software says nothing about the hardware. Software and hardware are different views of *the same reality*. We *choose* hardware for a hardware problem and software for a software problem. Each reality level *emerges*

Figure 1.5. Scientific realities *emerge*

from the last as a way to interact with reality better. Social structures emerge from human meaning (Bone, 2005) that emerged from neural data that emerged from physical brain events because seeing ourselves as part of a community improved survival (Hogg, 1990).

Although the Mir sword didn’t exist physically, it was an information entity in the Mir database, it was a cognitive entity of value in the mind of its owner, and it existed to a Mir community that accepted social justice. If a fantasy is real to only one person, the Mir sword was not that. It existed by common consent and was also a *scientifically real* subject of online research¹⁹. 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.

¹⁷ At <https://en.wikipedia.org/wiki/Reality> reality is that which exists, but every case has an observer.

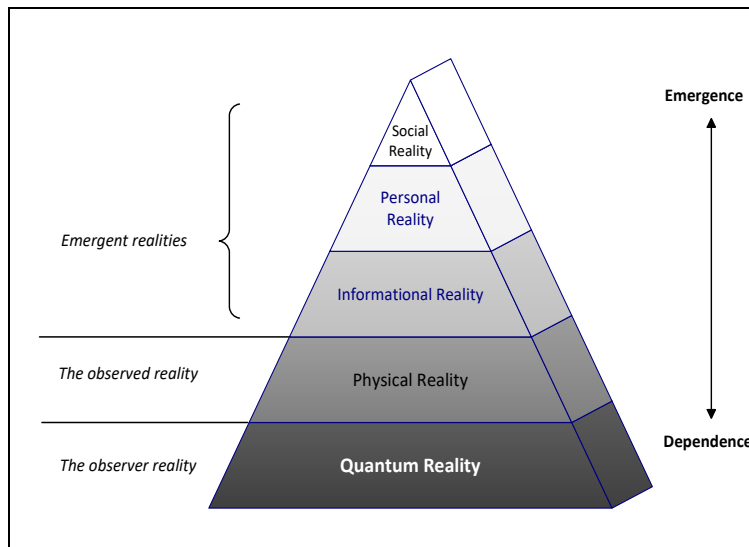
¹⁸ Also called *mathematical realism* ([Penrose, 2005](#)).

¹⁹ 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 is²⁰ arguing that everything reduces to physical reality, suggesting that only physical *really* exists. Reducing a system to its parts can be a good way to study it, but it isn't a good reality theory. Skinner's attempt to reduce psychology to physics (Skinner, 1948) wasn't successful (Chomsky, 2006), nor can computer science be reduced to physics. Information is defined as the *choice* between two physical states (Shannon & Weaver, 1949), so while a *physical state* can be seen as a bit, it is only one way and so by definition has no information per se. Only if one adds an observer to decode it as a symbol does information emerge. Indeed if data could be reduced to physicality, data compression couldn't pack the same information into a physically smaller signal! Information *emerges* from a physical event given an *observer context*.

If physics were the end of the reality line, it would be observer free, but it isn't. In quantum theory quantum waves become physical when observed, not before. Physics, like the other sciences, is just a *view of reality*. If physicists studied philosophy they would hear the great eighteenth century philosopher Kant say that we don't see *things as they are in themselves* (Kant, 1781/2002)²¹. We see is our view not what is. In quantum realism, physical reality emerges from quantum reality as information emerges from physicality, as an observer effect

(Figure 1.6).



My mirror image is unreal because it only exists when I look, so it, but surely my body exists even when I don't look? Yet if quantum waves interact to give physical events my body is created on demand as the mirror image is. In quantum theory, an electron becomes physical when its quantum wave collapses. The rest of the time it is just a quantum wave. The physical world we see is created by the quantum world we don't see.

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 spirit of inquiry. This *query of everything* is a question about this world, not some meta-physical one, cf. 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 because it is about our world.

²⁰ Physical reductionism is based on *logical positivism*, a nineteenth century ideology that only what is observed is real, that 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.

²¹ Kant called the "thing in itself" the *noumenon*, as opposed to the *phenomenon*, or view we see.

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).

Quantum theory is based on quantum states that aren't by definition 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

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 on a first event, it can decide if reality is virtual or not. The virtual reality conjecture doesn't contradict science but denying it does. Science should evaluate hypotheses not assume them wrong.

1.5.2. Reverse engineering reality

The scientific method, in a nutshell, is to make an 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 computing this involves two steps: *design* to create a logical model and *testing* to validate it. *Design science* first designs a likely information system then tests it against user requirements in an iterative way (Hevner, March, & Park, 2004). In *reverse engineering*, a first best guess at the processing at work is tested against the observed output, until one arrives at a program that consistently simulates it.

The research question, whether quantum processing can simulate physical reality, gives the method:

1. *Specify*: Specify the output of the physical world (physics).
2. *Design*: Design processing to satisfy those requirements (computing).
3. *Validate*: Validate the expected output against the actual output (science).
4. *Repeat*: Given no invalidation or inconsistency, produce a feasible design (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 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). Cherry-picking cases, so that selected programs mimic some world properties is not a new kind of science (Wolfram, 2002). Science can't *choose* what a model explains, it must explain *all* physics including space, time, energy, matter, spin and charge. Reverse engineering reality could reveal the virtual reality conjecture to be:

1. *Spurious*. A spurious model adds no value because it needs a new assumption or new parameter 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. Increasingly supporters cherry-pick support cases and ignore facts that contradict the model.

3. *Useful*. A useful model isn't necessarily entirely true but it opens up productive new research. It is useful as a stepping stone to a better model.
4. *True*. A true model is based on essentially valid assumptions about reality. Given few assumptions it matches observed reality in many ways and it predicts something new that contradicts all other models but is later found to be so.

Quantum realism aims to attribute physics to quantum processing, given a few assumptions about the latter from quantum theory and general computer science. Chapter 4 predicts that matter came from light both contradicts the current model and can be decided by experiment. Whatever the outcome, the virtual reality hypothesis is a question that science can decide.

1.6. DISCUSSION

1.6.1. Occam's razor

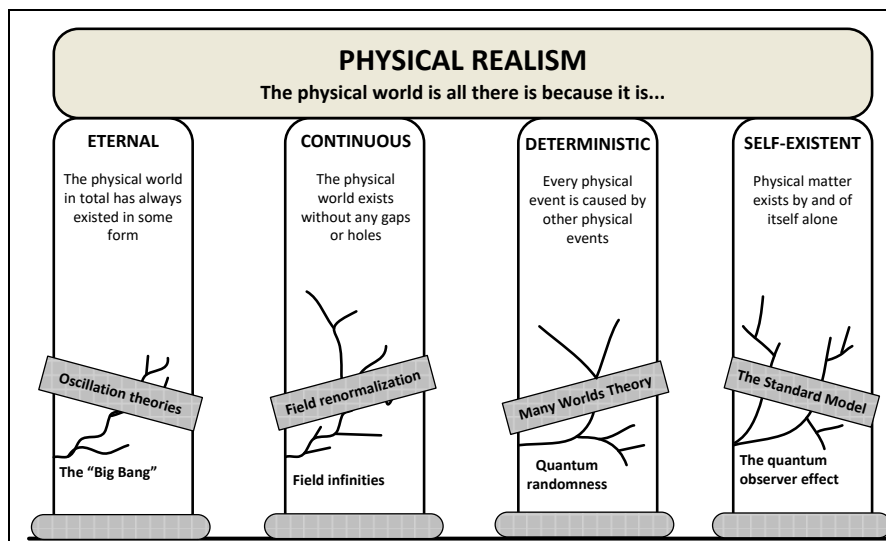


Figure 1.7 The four pillars of physical realism

A century ago, Bertrand Russell cut down the virtual reality concept using Occam's razor²²:

"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 Russel's "common-sense" physical realism is now not simple at all. What is common-sensical about the big bang, a universe of matter "exploding" from nothing? In today's computer-based world, common-sense tells us the "big bang" was the universe booting-up. What is simple about a space of *nothing* transmitting light and limiting its speed? It is simpler that empty space is the null processing of a quantum network that can only transmit light so fast? If we compare physical realism and quantum realism, the former is now the more complex theory, i.e. *Occam's razor now cuts the other way*.

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 field, e.g. inflation needs an inflaton field. It is hard to imagine anything more complicated, so if physical realism is preferred, it isn't because of its simplicity!

²² Occam's razor is not to multiply causes unnecessarily, i.e. prefer the simpler theory

1.6.2. The pillars of physical realism

It is not generally realized that the new structures of quantum theory and relativity are built on the old foundation of Aristotelian physical realism. Current physics derives from physical realism, the idea that the physical world is *real in itself* and needs nothing else to exist. The four pillars of this belief, shown in Figure 1.7, are that the physical world is:

1. *Eternal*. A complete world can't begin in time or space, so it was assumed to be eternal. The failure of steady state theory last century cracked this pillar, and oscillation theories like the big bounce are just speculative patches²³. 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 used the mathematical trick of renormalization to cover up the problem. Chapter 3 explores the alternative that our world is *quantized* because it is *digital*.
3. *Mechanical*. A complete physical world has only physical causes so why do atoms radiate randomly, i.e. for no physical reason? A machine can't do randomness, so the many worlds fairy story was invented to cover-up the problem based on no evidence at all. Chapter 4 explores the view that our randomness is server *choices* creating the variation needed to start evolution.
4. *Self-existing*. A complete physical world exists by itself alone but in quantum theory physical events only occur when entities are observed. Today, a flash of lightning event is called a "particle" but transient eddies in the quantum stream that decay and transform into each other aren't particles. They are events that don't last. Chapters 6-7 discuss the quantum world as an *observing* reality.

The "scientific" belief that physical reality is *eternal, continuous, mechanical and self-existing* has not handled the facts well. The cracks that appeared in the pillars of physical realism last century are still there, despite patch attempts, so the edifice of modern physics is built upon an unsound foundation.

The path taken at Copenhagen that the quantum world is imaginary led to predictions on proton decay, super-symmetry (SUSY), neutrino mass, WIMPs, anti-matter, dark energy and gravitons that didn't go anywhere leading to a sterility crisis in physics. It's time for an alternative to physical realism.

1.6.3. A new foundation

Quantum realism is the theory that quantum events really happen, so quantum theory describes actual events. It accepts the equations but rejects their particle interpretation. Chapter 2 defines the quantum network we call space, adding a fourth dimension for light to vibrate into. Chapter 3 attributes light and the electro-magnetic spectrum to the same Planck program that is the null processing of space. Chapter 4 derives matter, anti-matter and charge from light, giving an alternative to the current particle model. Chapter 5 develops the matter as a quantum standing wave idea to deduce the time and space effects of relativity. Chapter 6 addresses the question of the observer and the "hard" question of consciousness. Chapter 7 digs into the history of ideas for precedence and explores what this view means for us.

This isn't a theory in the Aristotelian framework but a *paradigm shift* (Kuhn, 1970). It aims to build an intellectual structure from the ground up based on new axioms – computing axioms. For a theory, axioms are *that upon which it is built*, like the foundations of a house, e.g. Euclidian geometry was built on the assumption that parallel lines can't converge, so changing that axiom allowed *hyper-geometries* on curved surfaces like the earth, where parallel lines do converge (at the poles). Euclid's geometry that dominated thought for a thousand years is now just the zero-curvature case.

As Chaitin, following Gödel, showed, axioms should explain more than they assume (Chaitin, 2006). In this respect, the standard model with its many fitted parameters is struggling. Currently time, space, matter, light, charge, magnetism, spin, gravity and energy, i.e. nearly everything is just *assumed*. Axioms

²³ In [Big bounce theory](#) a big crunch follows a big bang in an ongoing oscillation that is in effect steady state.

are patched because a theory, like a house, needs a foundation at all times. Current physics needs physical realism because it would have no theory at all without it. Quantum realism offers an alternative based on a better foundation. It is not an attack on physics but an offer of a new foundation based on processing not matter, on actually deriving “It from bit”. Certainly it is a disruptive innovation (Sandström, 2010), but physics isn’t new to this. Yet there is one barrier that no amount of logic will overcome – the hubris that we have already arrived.

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 Copernicus and Galileo challenged the paradigm that the Earth is the center of the universe they also challenged our ego. 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, as previously thought.

When Darwin 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 existed 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 not the last evolutionary word, and so aren’t the *biological center* of things either.

When neuroscience today challenges the paradigm of a unitary “self” it again challenges the ego. A scientist sees the brain as 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). The inevitable conclusion is that we don’t have the *psychological center* we thought we had either (Chapter 6).

We repeatedly *see ourselves at the center of things* - until science finds we aren’t. The ego makes every generation think itself smart - until the next one discovers that it didn’t know as much as it thought. So is *now*, finally, the end of the line for ego fallacies? Do we at last, thanks to science, see true or is ego still operating? Would it be a surprise to find one last ego fallacy blinding us - the idea that *reality is what we see*. Think for a moment, what qualifies our observation to define reality? Isn’t it pure ego to say reality is what we see because we see it? Who made us the *existential center* of the universe?

Quantum realism as a processing approach to physics differs from physical realism on key issues (see Table 1.1). That quantum theory describes the real shocks the ego but fits the physics. This isn’t the Matrix brain in a vat, it isn’t that life is a bad dream, or that it is a SimCity world of fake objects. It agrees that when you kick a rock it hurts, because in local reality *pixels are real to pixels*. It doesn’t deny that there is real world out there, but just puts it on the other side of the physical interface. It doesn’t deny free choice, as the observing player is not in the simulation. It ticks many boxes and fits the facts so why isn’t it more widely discussed? The answer is the ego. This approach makes us like goldfish in a bowl. We become players in a simulation, and the pixels we fight, hoard and die for are events not things. The final barrier to understanding how our reality works isn’t lack of research but excess of ego.

Table 1.1. *Physical realism vs. quantum realism*

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

DISCUSSION QUESTIONS

The following discussion questions come 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 quantum realism, which are monisms (with only one reality)? Which one(s) imply a real world out there? Which one(s) allow for free choice?
6. Why is it impossible for a complete physical universe to create itself in a "big bang"?
7. What physical facts fit the theory that the physical world is a virtual reality?
8. Can physical reality occur without an observer? Where does the observer come from?
9. How can the 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 hypothesis 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, is the observer outside or inside the simulation?

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