THE COPENHAGEN TRIP

quantum physical wierdness explained away

Jeremy Fiennes (jeremyfiennes@gmail.com)
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"*Behold the turtle. He only progresses when he sticks his neck out.*"
James Conant

ABSTRACT

Quantum physics works exceptionally well in practice. It has justifiably been called "the most successful scientific theory ever". Its problems are interpretational: how to make sense of its various rational contradictions. The question having occupied some of humanity's best brains for nearly a century with spectacular lack of success, one is led to suspect its fundamental assumptions. Two such are that 1) the quantum/photon is the minimum existing energy/matter packet; 2) subatomic reality is inherently indeterminate. Neither is justified. The quantum could simply be our minimum observable energy/matter packet. Physical reality could be essentially determinate. But due to quantum measurement uncertainty, in the subatomic domain it appears to us to be indeterminate. In each case there are two hypotheses, neither of which can be proved nor refuted. Meaning that both must be considered. Quantum physics fails to do this. The article adopts the neglected alternatives, and thereby makes better sense of apparent quantum wierdness. Due to its analogy with classical dice-throwing, we call it the 'Dicey Interpretation' of quantum physics. It is conceptual and 98% non-mathematical.

CONTENTS

INTRODUCTION

General

Einsteinian[a] Relativity asserts that two clocks can each run slower than the other, and is evidently nutty[1]. Quantum physics, however, holds that things can be in more than one place at a time. And when it goes on to maintain that cats can be both half-alive and half-dead, and that the Moon doesn't exist when no-one is looking at it, it could well claim front-runnership in the World Nuttiness Stakes.

The difference is that whereas Einsteinian relativity is wrong, being conceptually incoherent[b] and refuted by experiment[c], quantum mechanics works exceptionally well in practice. It has justifiably been called "the most successful scientific theory ever". Without it there would be no computers, no Internet, and you wouldn't be reading this.

Quantum physics' problems are *interpretational*: how to explain its various rational contradictions. The article does not claim to do this. But rather to "explain them away", providing a rational explanation for why there can be no rational explanation. And to show further that the contradictions are essentially illusory, a consequence of our necessarily partial view of the universe.

On the practical side, to leave the main body of the text as uncluttered as possible, cross-references and 'asides' are placed in footnotes. The end-notes contain source references only. In the Internet case they comprise the main site name with the year and month of access in brackets.

Contrary to custom, quotations in general are not *de rigeur*, with all the (...)s and [...]s in the right places. They may be abridged or combined with others from the

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[a] Albert Einstein (1879–1955), German theoretical physicist.
[b] Leading to the clock absurdity (Einstein article).
[c] Starting with the 1887 Michelson-Morley result, which was very definitely not 'null' (appendix p.85, Aether article).

same source. But their meaning is never consciously distorted. Whenever possible, original source references are given.

Since the English language in its wisdom does not provide a non-gender-specific pronoun, for "he", etc. in general read "he/she" etc.

The article is intended for those already familiar with the basic questions of quantum physics. For those who are not, resumés of its principal items (the wave-particle[a] duality, the double-slit experiment, etc.) are included. The more familiarized reader can skim lightly over these.

The 'we' in the text is the 'authorial we' comprising the writer and himself – a device used by authors to surreptitiously solicit the complicity of their readers. When we say “we say”, what we really mean is "I say", if you see what we mean.

Thanks are due to Arthur Maher, who read the original draft and made many useful comments.

WAVE}{PARTICLE (1)[b]

Double-slit experiment (1)

Quantum physics effectively dates from the year 1803, when the English phsician and polymath Thomas Young (1773–1829) performed his classic *double-slit experiment*[2]. He shone a beam of light through two close narrow slits onto a screen. With only one slit open, an image of it appears, Fig.1a. This is accounted for by light as a *stream of particles*.

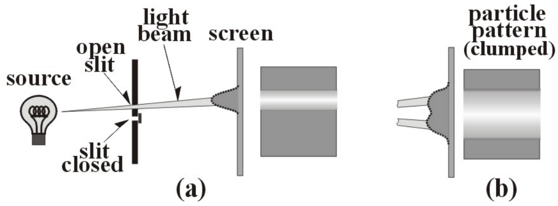

Fig.1. Double-slit experiment (1).

With both slits open, however, what is found on the screen is not the clumped 'particle' pattern of Fig.1b that would be expected on a particle model. But an *interference* pattern of light and dark fringes, Fig. 2, a phenomenon shown by *waves* but not by particles. Where the peaks of the waves from the two slits coincide, there is a point of maximum intensity on the screen. Where a positive peak from one slit coincides with a negative peak from the other there is a zero intensity point.

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[a] For the '}{' symbol, see the appendix p.81.
[b] Rather than a "duality" (appendix p.81).

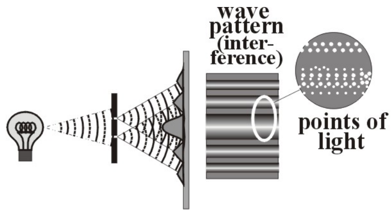

Fig. 2. Double-slit experiment (2).

Light is thus apparently better represented by a *wave model*. The spacing between the fringes allows its wavelength to be calculated.

If one examines the fringes closely, however, they are not found to be a continuous gradation as would be expected on a wave model. But to comprise *little points of light*, Fig. 2c. This is again consistent with a particle representation. On a flourescent screen the points manifest as visible flashes of light. And on a photographic plate as clumps of dissociated silver nitrate molecules.

The same result is obtained if photons are fired at the slits one at a time, Fig. 3. The overall interference pattern here builds up gradually.

Fig. 3. Double-slit experiment (3).

Individual photons are found to pass through *either* one slit *or* the other, but never both simultaneously. And to form *one and one only* screen point. We will call this property *particularity*. It can be resumed by saying that particles have *definite positions* and a *continuous existence*[a]. If a particle is somewhere, it cannot also be somewhere else. Nor can it simply vanish and be no place at all:

particularity **=** *definite position*, *continuous existence*

The query arises: if an individual photon passes through one slit only, Fig. 4a, how can it form a *'wave'* screen point[b] which requires something passing *both* slits, Fig. 4b?

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[a] 'Existence' is here always *physical existence*, what can be experienced physically.
[b] One forming part of a 'wave' interference pattern.

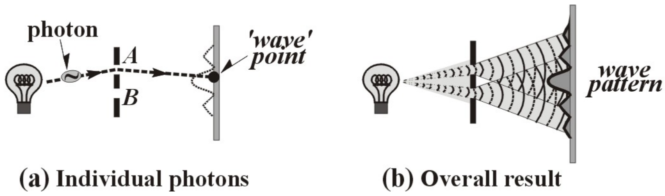

Fig. 4. Double-slit experiment (4).

This is distinctly wierd. The fundamental question being: *what determines* an *individual outcome*, a single screen point? What physical mechanism is involved?

what determines an individual outcome?

Double-slit interference is not restricted to photons. Electrons, protons, water molecules, and even heavier objects have all been shown to exhibit it[3]. The wave behaviour becomes increasingly difficult to demonstrate at higher object masses. We discuss this further later.

So although it is sometimes said that light cannot exhibit simultaneously its wave and particle properties, this is strictly not true. Both are seen in the double-slit experiment.

Split-beam experiment

An analogous case is the Mach-Zender *split-beam experiment* of Fig. 5a. A beam of light is shone onto a half-silvered mirror, that reflects half the incident light and transmits the other half.

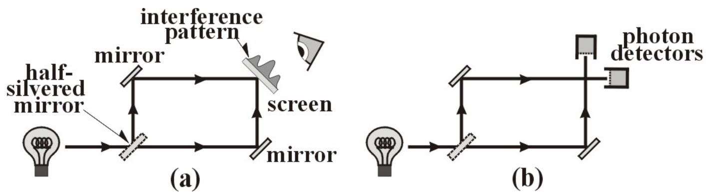

Fig. 5. Split-beam experiment.

When the two beams are brought together on a screen, they form an interference pattern as in the double-slit case. This again shows the wave properties of light. If the screen is removed and replaced by two photon detectors, Fig. 5b, individual photons appear in either one detector or the other, but never in both simultaneously. This is particularity, discrete particle behaviour.

Light thus shows *both* wave *and* particle properties. Waves, however, are *continuous*; they have *no definite positions*; require a *medium* for their propagation;

and are *events*, functions of time[a]. Whereas particles are *discrete*; do have definite positions; need no medium; and are *material objects*[b] with no time dependency.

Rationally, however, nothing can be 'both continuous and discrete'; nor 'both have and not have' a definite position; nor 'both require and not require' a medium; nor 'both be and not be' time dependent.

The concepts 'wave' and 'particle' are *rationally mutually exclusive*. Making the wave}{particle model an *irrational dichotomy*[c] with no possible rational relation between its two sides:

*wave}{particle model**:** an irrational dichotomy*

Given the wave representation of Fig. 6a, for instance, one cannot deduce its particle equivalent, Fig. 6b. Given the particle representation of Fig. 6d, even less can one deduce its wave correlate, Fig. 6c.

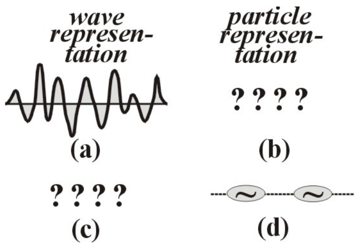

Fig. 6. Photon (1).

Our *everyday physical reality*[d] we however experience as *coherent* and *rational*. Everything is related at least spatially to everything else, with no contradictions. So when we find light, a component of that reality, behaving in an irrational way, we cannot understand it.

Light is often accused of *inconsistency*: "acting sometimes as waves and sometimes as particles". This is unjustified. Light is admirably consistent in its behaviour. It always responds in the same way, namely "according to its nature". If we ask it to demonstrate its wave properties[e], it obligingly does so in a consistent replicable manner. And similarly for its particle properties.

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[a] Aether article.
[b] 'Matter-ial'. Made of matter, essentially protons, neutrons and electrons.
[c] Rather than a "duality" (appendix p.81**)**.
[d] Defined as "what we physically experience, either directly with the senses or indirectly via instrumentation".
[e] By setting up a suitable experiment.

It is *we* who have a consistency problem, being unable to understand how any component of our essentially rationally coherent everyday reality can show apparently contradictory behaviour. Richard Feynman[a] wrote:

> "The double-slit experiment is impossible, absolutely impossible, to explain in any mechanical way. It has in it the heart of quantum mechanics. In reality it contains the only mystery." [4]

Absorbtion, scattering

If light of a certain frequency is shone onto a solid material, those of its outer electrons with that natural frequency *vibrate*. Their motion is passed onto neighbouring electrons, and ultimately converted into heat. Light of that frequency is *absorbed*.

Compared to the wavelength of light, however, atoms are miniscule, with diameters some 0.1% of that wavelength. A photon-wave would simply 'go around' an atom and not be affected by it. A wave model cannot represent absorbtion, which is discrete particle behaviour.

The same holds for the *photo-electric effect*, where light impinging on an atom causes an electron to be emitted.

Also for the so-called *Compton*[b] *scattering* of photons by electrons, where the interactions have the nature of *collisions* between inelastic spheres with the conservation of momentum[c]. With the difference that since photons always travel at the speed of light, a reduced momentum here manifests as a *lower frequency*[d] rather than a lesser speed[e].

Waves in general *don't* however interact. They 'superimpose', passing through each other and continuing on their way as if nothing had happened. Absorbtion, the photo-electric effect and Compton scattering are all discrete particle behaviour.

Optical dispersion, on the other hand, where a beam of white light is split up by a glass prism into a rainbow of colours, cannot be represented on a particle model. Neither can *diffraction*, where light passing though a small hole or a narrow slit causes fringes on a screen. That light has a *characteristic speed c* and a *frequency f* are likewise wave properties.

Light thus behaves neither totally as classical waves, nor totally as classical particles. But as a strange combination of the two: 'waves' that interact like classical particles. And 'particles' with a characteristic speed and a frequency like classical waves:

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[a] Richard Feynman (1918-88), American theoretical physicist.
[b] Discovered in 1923 by Arthur Compton (1892–1962), American physicist.
[c] Below.
[d] Below.
[e] Photon 'mass' is discussed in the appendix (p.88).

wave}{particle = waves with some particle properties }{ particles with some wave properties

Remembering always that what we fondly imagine to be solid concrete matter, is in fact essentially *empty space* permeated with *electrostatic fields*. If an atom were blown up to fill the dome of St Peter's, its nucleus would be a grain of salt and its electrons specks of dust[5]. If all empty space were eliminated, the whole of humanity could fit into a sugar cube. If our eyes were sensitive to neutrinos[a] rather than photons, our present concrete physical reality would appear as no more than a vague wispiness.

It is therefore hardly surprising to find that subatomic phenomena don't always conform to models derived from our classical everyday reality.

Photon (1)

In an attempt to reconcile its wave and particle properties, light has been conceived as *little wave-packets* travelling at the characteristic speed *c*=300k[b] km/s, Fig. 7a.

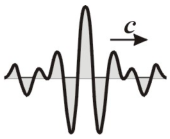

Fig. 7. Photon (2).

Waves[c] have no specific *positions*. To define one requires in principle specifying the state of the whole of its medium. The light medium, the hypothetical 'luminiferous aether'[d], being conceived as occupying the entire universe, one basically has to define the condition of this, and not just the region adjacent to the wave-packet.

Mathematically[e], any wave pattern can be represented as the sum of an in principle infinite set of *harmonic components* uniformly distributed over the whole of space. Those of Fig. 8b, for instance, give the wave-packet of Fig. 8a[f]. Where the component peaks coincide, there is a peak in the resultant. Where they cancel out,

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[a] Below.
[b] 'k' = thousand, 'mn' = million, 'bn' = billion.
[c] Discussed in detail in the Aether article.
[d] Defined for present purposes as "that which light is conceived as a disturbance travelling through".
[e] Fourier's theorem.
[f] Illustrative. To zero a single wave-packet over the whole of space would in fact require an infinite number of harmonic components, with at the limit infinitely small magnitude.

there is a zero. The components and the resultant all travel at the same characteristic speed *c*.

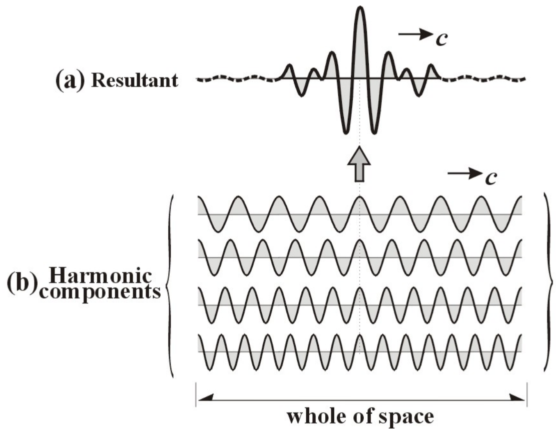

Fig. 8. Photon (3).

A wave being an *event*, a disturbance propagating though a medium, and not itself a material object, to experience[a] one implies experiencing its respective medium. We experience the water medium, and we see water waves. We don't experience the light medium, the hypothetical aether, and we don't see light waves.

No-one therefore ever saw a photon wave-packet as such, for instance as a trace on an oscilloscope screen. Fig. 8a is what we *imagine* such a light wave-packet would look like *if* we could see one, which we inherently can't.

Photon (2)

In spite of the apparent equivalence of its wave and particle representations, light is in fact far more 'wave' than 'particle'. The classical phenomena of interference, dispersion, diffraction, etc. are all representable in wave terms only. As are also its having a frequency and a characteristic speed.

Light's only effective 'particle' behaviour is its *interactions with charged particles*, normally electrons[b], as in absorbtion, the photo-electric effect and Compton scattering. Photons themselves being chargeless, they don't interact with each other[6]. If two beams of light are shone in opposite directions down tubes, as in Fig. 0-9, no evidence of photon-photon collision and resultant scattering is seen on the screen.

[a] As always, in the sense of experiencing physically (p.5, note).
[b] Can also be protons.

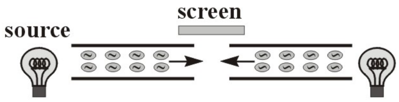

Fig. 0-9. Photon-photon interaction.

We will therefore conceive light as "being essentially" *waves*. But which interact with charged particles[a] in a particle-like way:

*light**:** waves that interact with charged particles in a particle-like way*

WAVE}{PARTICLE (2)

Which path?

Imagine a double-slit experiment, but now with electrons rather than photons as the object particles, Fig. 10a, and that we wish to determine which slit an individual electron went through, obtaining so-called *which-path information*.

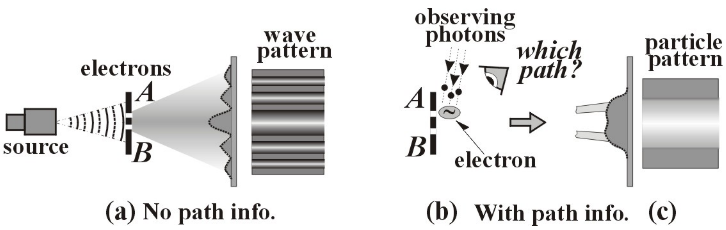

Fig. 10. Which path? (1).

We fire a beam of observing photons at the slit region, Fig. 10b. And find that electrons also exhibit particularity[b]. Individual electrons pass through one slit or the other, but never both simultaneously. And cause one and one only screen point.

We however now find that the wave interference pattern *vanishes*, being replaced by a clumped particle pattern, Fig. 10c[c].

The same applies to the split-beam experiment. If in the wave set up of Fig. 5a we determine which path an individual photon takes, the 'wave' interference pattern disappears from the screen.

One possible explanation is that the observing photons *disturb* the electrons, destroying the interference effect. But should we try to avoid this by using low-

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[a] A photon not being a charged particle.
[b] p.5.
[c] Cf Fig.1b.

energy photons, we get to the point where their wavelength is so long that the slits can no longer be distinguished. As in velocity}{position measurements[a], quantum uncertainty conspires to prevent us obtaining a precise result.

Simple eraser

The 'disturbance' explanation for the disappearance of the interference pattern on gaining which-path information is however refuted by so-called *eraser experiments*. A simple setup is shown in Fig. 11a. Rather than obtaining the which-path information directly, the photon detector output is *recorded*. As expected[b], a clumped 'particle' pattern is found.

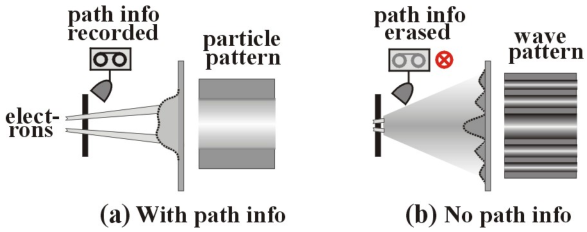

Fig. 11. Simple eraser.

But should the recording be *erased*, Fig. 11b, the *wave pattern returns* as if no which-path measurement had been made. The determining factor is not, it seems, the measurement itself. But rather the *availability of which-path information*. If the information is kept, a particle pattern results. If not, a default wave pattern is found:

which-path information available ⇒ particle behaviour
not-available ⇒ default wave behaviour

The question here is: how can the *availability of abstract information* determine a *concrete physical result*, a screen pattern? This too is distinctly wierd.

Delayed eraser

Even wierder is that if we *delay* obtaining the which-path information till *after* the photon[c] has hit the screen, we get the same result. A corresponding experimental set-up is shown in Fig. 12.

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[a] Below.
[b] 'Which-path' information being available (below).
[c] Now again the object particles.

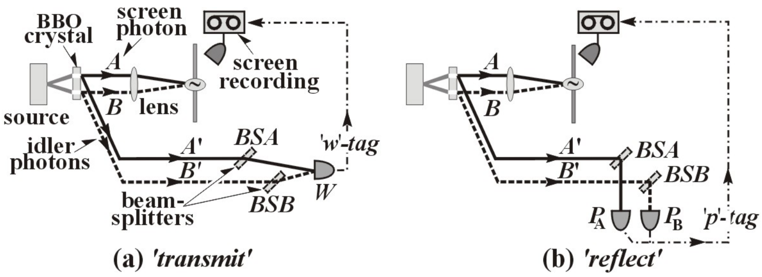

Fig. 12. Delayed eraser (1).

Monochromatic photons are fired at a "BBO"[a] crystal. This serves firstly as a *double-slit*; and secondly as a *photon divider*. A photon emerging from a 'slit'[b] is replaced by a *photon pair*, each with half the frequency of the original[c].

Of such a pair, the *screen photon* is directed via a lens onto a screen. The other *idler photon* is directed to a *beam-splitter*, *BSA* or *BSB*. These are essentially half-silvered mirrors[d] that randomly transmit or reflect idler photons with a 50% probability of each.

The distance between the slits and the screen being *less* than that between the slits and the beam splitters, by the time an idler photon arrives at a beam-splitter, the position of its respective screen photon has already been recorded.

Consider a slit *A* photon. After division, the screen photon *A* hits the screen. Since at this point no which-path information is available, a default 'wave' point[e] is presumably registered[f].

Somewhat later the associated idler photon *A'* arrives at the beam-splitter *BSA*. Should this *transmit*[g], the photon is directed to photon detector *W*. Because a slit *B* idler photon *B'*, transmitted by the bean-splitter *BSB*, would arrive in the *same* detector, this gives no which-path information, and the corresponding screen point is tagged *'w'*[h].

Should the beam-splitter *BSA reflect*[i], the idler photon *A'* is directed to the photon detector P_A. Because a slit *B* idler photon *B'*, reflected by the beam-splitter

[a] Beta barium borate.
[b] A gap in the crystal lattice.
[c] eq.4 (p.20).
[d] Cf p.6.
[e] One forming part of an overall 'wave' interference pattern (p.5, note).
[f] Fig. 11b.
[g] Fig. 12a.
[h] For 'wave'.
[i] Fig. 12b.

BSB, would arrive in the *adjacent* detector P_B, these two detectors *do* give which-path information, and the corresponding screen point is tagged *'p'*[a].

Once sufficient measurements have been made, the '*w*' and '*p*' tagged points are plotted separately against their screen positions. The former are found to give an interference wave pattern, Fig. 13a. And the latter a clumped particle pattern, Fig. 13b.

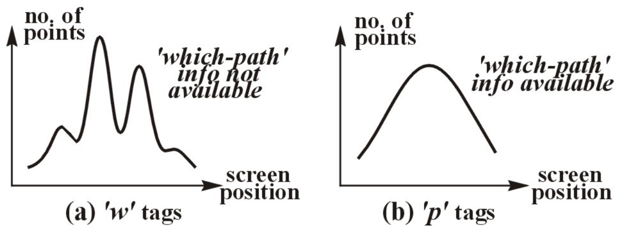

Fig. 13. Delayed eraser (2).

As in the simple eraser case[b], the screen pattern form[c] depends on the *availability of which-path information*. The experimenters state:

> "It's not the detector that is causing the collapse[d]. It is the *fact that we can know*."[7] (italics ours)

The questions here are:

– 1) how do the correlations arise, given that the *'w'* and *'p'* tags are attributed firstly r*andomly*[e]. And secondly, *after* the respective screen points have been recorded?

– 2) again[f], how can the *availability of abstract which-path information* determine a *concrete physical result*, a screen pattern?

– 3) in the case of a *'p'* tag: how did the screen point end up as 'particle' when a 'wave' point was presumably originally recorded[g] – apparently *changing the past*?

This last idea is however nonsensical. As is seen in the classic 'grandfather paradox'[h][8].

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[a] For 'particle'.
[b] Fig. 11.
[c] 'Wave' or 'particle'.
[d] Wave-function collapse (below).
[e] Depending on whether a beam-splitter transmits or reflects.
[f] p.12.
[g] No 'which-path' information being available at the time of recording.
[h] SpaceTime article .

One possible explanation is that the photon screen position *determines* the subsequent beam-splitter mode[a], and hence the screen point tag, Fig. 14a. A corresponding physical mechanism can however hardly be conceived.

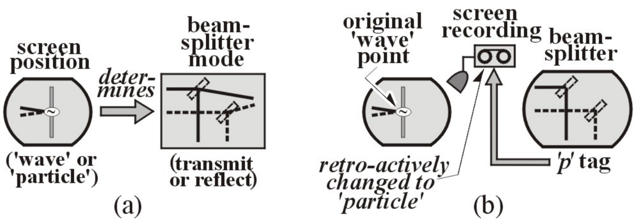

Fig. 14. Delayed eraser (3).

Another possibility is that the 'reflect' beam-splitter mode, associated with 'which-path' information and a *'p'* tag, *retroactively changes* the previously-recorded wave screen point to a particle point, Fig. 14b. But again, how this could occur in practice is scarcely imaginable.

A further possibility is that *some unknown factor*[b] determines both the screen position and the beam-splitter mode, Fig. 15. But *what* (or *Who*) could this factor be? None of these "explanations" makes any rational sense.

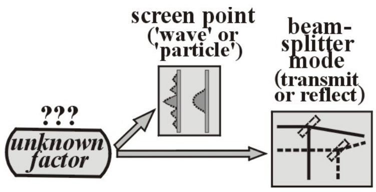

Fig. 15. Unknown factor.

Noting that any hypothetical 'changing the past'[c] cannot in practice be observed. Principally because the presumed original wave point only exists over the nano-second interval between the screen photon hitting the screen and the respective idler photon being reflected by a beam splitter, giving which-path information. In any case, the nature[d] of an individual screen point is only seen *after* the experiment is over and the points are all plotted.

We can also note that in an analogous experiment using polarized light, the 'erase-keep' decision is not made mechanically by inert beam-splitters as here. But

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[a] 'Transmit' or 'reflect'.
[b] In quantum physical jargon this would be called a "super-deterministic" model.
[c] Fig. 14b.
[d] 'Wave' or 'particle'.

consciously by the experimenter, who can choose whether to insert a polarizing filter, erasing the 'which-path' information[9].

The results are however essentially the same in the two cases. Meaning that "observer consciousness" – whatever that might or might not be[a] – has no effect.

Polarization

Light comprises longitudinally-propagating transverse electric and magnetic fields, Fig. 16. As such it can be *polarized*, so that rather than being randomly oriented, the fields of individual photons all act in the same directions[b].

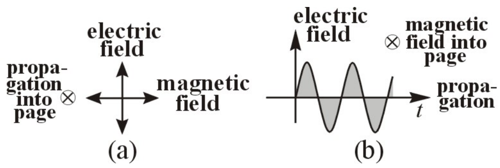

Fig. 16. Light.

Consider a beam of unpolarized light impinging on a *polarizer filter*, whose output is a beam of intensity I_0 polarized at angle θ to the vertical, Fig. 17a[c].

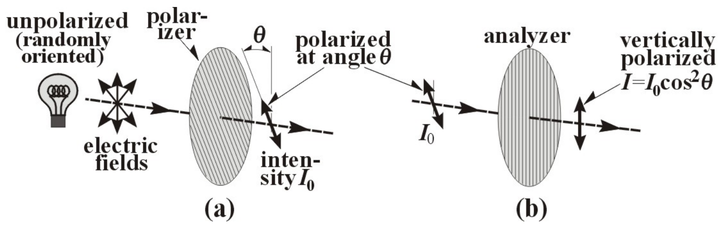

Fig. 17. Polarization (1).

Pass this polarized beam through a second, vertical*ly*-oriented *analyzer filter*, Fig. 17b. The output intensity I is given by[d]:

$$I = I_0 \cos^2\theta \qquad \text{(eq.1)}$$

Comparing the input and output intensities[a], the polarization angle θ of the input beam can be determined. Noting, however, that since the original input beam is lost, polarizer measurements *inherently disturb* the measured object.

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[a] Appendix p.80.
[b] The electric field is normally taken as the reference.
[c] The polarizer lines are for clarity shown in the direction of polarization. The string-like molecules of physical absorbtion polarizers run perpendicular to these.
[d] Malus' law.

Now repeat the experiment, but this time with single photons, Fig. 18.

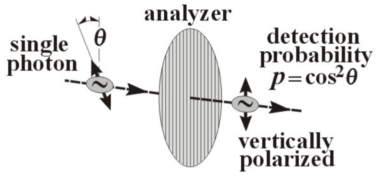

Fig. 18. Polarization (2).

On a classical approach, one would expect output photons with a reduced intensity (energy) and hence a lower frequency[b]. What we however get is a *reduced probability p* of detecting a photon with the *full input frequency*, given by:

$$p = \cos^2\theta \qquad \text{(eq.2)}$$

The probability relation for individual photons[c] being the same as the intensity relation for a strong beam[d], summing measurements for a large number of photons gives the overall result.

This has to be the case, since the intensity of an overall beam is proportional to its photon density, the number of photons comprising it:

overall result = Σ(individual measurements)

For a strong input beam polarized at $\theta = 45^{\circ}$ to the vertical, for example, the output intensity is 50% of the input. And for single input photons, there is correspondingly a 50% probability of an output photon being detected.

This is an instance of the general principle that in the subatomic domain things are *quantized*. Rather than measuring a *fractional amount*, we get a *fractional probability* of obtaining the *full amount*:

fractional amount ⇒ fractional probability of measuring the full amount

This too is distinctly wierd. The question again[e] being: *what determines* whether an output photon will be detected in an individual case; what physical mechanism is involved?

Noting that the polarization angle θ of a single input photon cannot in practice be determined. Detecting an output photon only tells us that the input photon axis

---

[a] I_0 and I.
[b] eq.4 (p.20).
[c] eq.1.
[d] eq.2.
[e] p.5.

was not exactly perpendicular to that of the analyzer[a]. Detecting no output photon only tells us that the two were not exactly aligned[b].

Electron spin

An analogous case is *electron spin*. Electrons behave as little magnets, Fig. 19a. When subjected to a strong magnetic field, they flip into line with it while emitting a *photon* of radiation energy, Fig. 19b.

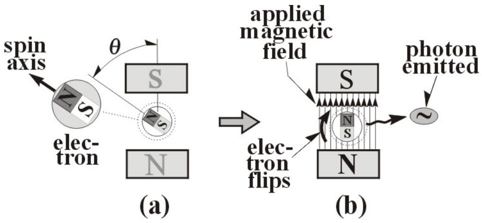

Fig. 19. Electron spin (1).

An originally 'spin-up' electron[c], Fig. 0-20a, emits no photon. An initially 'spin-down' electron [d], Fig. 0-20b, emits a maximum energy photon.

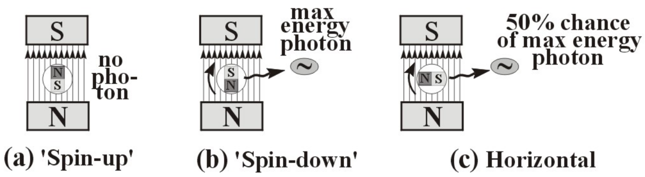

Fig. 0-20. Electron spin (2).

For an electron with an initial axis at some intermediate angle θ[e], one would again[f] expect a lower-frequency intermediate-energy output photon.

But here too, things in the subatomic domain being quantized, what we actually get is *either* a full-frequency photon[g] *or* none at all[h], with a probability p given by:

$$p = (1 - \cos\theta)/2 \qquad \text{(eq.3)}$$

[a] When no output photon is ever found.
[b] When an output photon is always emitted.
[c] One whose initial axis is aligned with the applied magnetic field (up-pointing north-pole).
[d] One whose initial axis directly opposes that field (down-pointing north-pole).
[e] Fig. 19a.
[f] As for polarization.
[g] 'Spin-down', Fig. 0-20b.
[h] Spin-up', Fig. 0-20a.

For an initially spin-up electron[a], no output photon is ever detected. For an initially spin-down electron[b], an output photon is always found. For an electron with a horizontal initial axis[c], Fig. 0-20c, there is a 50% probability of detecting an output photon.

As for polarization, quantization involves a *fractional probability* of measuring the full amount. The question again being: *what determines* whether an output photon will be detected in an individual case; what physical mechanism is involved?

Spin measurements likewise[d] inherently disturb the measured object. A measurement on a given axis aligns the electron with that axis[e]. And thereby destroys all information as to its original spin components along the other two spatial axes.

Particle anomalies (1)

We now have a number of unanswered questions:

– 1) how can light behave both as waves and as particles, when the two are rationally mutually exclusive?[f]

– 2) in the double-slit experiment, if an individual particle passes through one slit only, how can it form part of an overall interference pattern which requires something passing both slits?[g]

– 3) in the single-photon double-slit, polarization and electron spin cases: what determines whether an output photon will be detected?[h]

– 4) in eraser experiments: how can the availability of abstract information determine a concrete physical result, a screen pattern?[i]

– 5) in the delayed eraser case: how do the correlations arise, given that the *'w'* and *'p'* tags are attributed randomly[j]

– 6) also in this case: how can an already recorded 'wave' screen point be apparently retroactively changed to a 'particle' point?[k]

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[a] Fig. 0-20a, $\theta = 0^\circ$.
[b] Fig. 0-20b, $\theta = 180^\circ$.
[c] $\theta = 90^\circ$.
[d] As for polarization (p.16).
[e] Fig. 19b.
[f] p.6.
[g] Fig. 4a.
[h] pp.6,17,19.
[i] pp.12,14.
[j] p.14.
[k] p.14.

Because these all involve individual particle behaviour, we will call them the *particle anomalies*. Noting that the list is by no means exclusive. There are many others. The above will however suffice.

COPENHAGEN INTERPRETATION

Planck

If quantum physics originated with Thomas Young's double-slit experiment, it was effectively "born" – i.e. first saw the light of day – over the question of *black body radiation*. The hotter a body is, the lighter its colour, and the higher the frequency of the emitted radiation. The current theory could not, however, explain the respective frequency spectrum.

Fig. 0-21. Max Planck[10].

The problem was finally solved in 1900 by Max Planck[a]. He made the heuristic – and as it turned out brilliantly intuitive – hypothesis that matter consists of "material oscillators"[b]. And that these emit radiation not continuously, but in *discrete packets* that he called "quanta[c] of action". The energy E_0 of the fundamental energy packet, the *quantum*/*photon*[d], is given by:

$$E_0 = hf \qquad \text{(eq.4)}$$

where f is the frequency and h is *Planck's constant*.

The quantum was at the time taken to be the *minimum existing* energy packet. We discuss this aspect later.

[a] Max Planck (1858–1947), German physicist.
[b] Later identified as atoms, which only started to be conceived in their present form after Rutherford's 1911 discovery of the atomic nucleus.
[c] From the Greek *quanta* ('quantity').
[d] The two are equivalent.

Indeterminacy (1)

If Planck was the progenitor of quantum physics, its effective "stepfather", who oversaw its upbringing virtually to its present day state, was the Danish physicist Niels Bohr[a]. A Nobel laureate and one of the most influential physicists of the 20th century, he was also a passionate footballer and had at one point even considered turning professional.

Fig. 22. Niels Bohr[11].

Bohr studied in Manchester, England under Ernest Rutherford[b], the discoverer of the atomic nucleus, for which he received a Nobel prize.

Back in Denmark, in 1913 Bohr extended Rutherford's theory to form the "planetary" *Rutherford-Bohr model* for the atom comprising a nucleus and orbiting electrons. With later refinements, it is essentially the model still in use today.

Bohr and his assistant Werner Heisenberg[c] were the principal authors of the currently orthodox *Copenhagen Interpretation* of quantum physics, developed in the 1920s with further contributions from Max Born, Erwin Schroedinger, Wolfgang Pauli, Louis de Broglie, Paul Dirac and others[12]. Although no longer quite as 'orthodox' as it used to be, it is still the main contender[d][13]. By "quantum physics" we will normally mean this interpretation.

Its basis is Heisenberg's 1927 *Uncertainty Principle*. He illustrated it with the following thought exercise[14]. Imagine that we wish to determine the position of a 'classical' object like a gold atom, too heavy to be affected by our observations[e]. We fire a burst of observing photons at it, and observe their reflections in a microscope, Fig. 23. This locates the atom in space.

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[a] Niels Bohr (1885–1962), Danish physicist.
[b] Ernest Rutherford (1871–1937), New Zealand physicist.
[c] Werner Heisenberg (1901–1976), German theoretical physicist.
[d] A 2013 poll of quantum physicists as to their favourite interpretation gave: Copenhagen 48%, informational 24%, Many Worlds 18%.
[e] The definition of 'classical' (below).

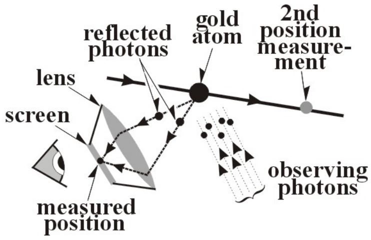

Fig. 23. Uncertainty (1).

Should we also wish to know the atom's velocity[a], we repeat the process at a later instant, dividing the difference in positions by the time interval[b]. This gives the atom's *overall state*, its velocity[c] and position:

state = velocity + position

Should we try to do the same for a far lighter *electron*, however, the observing photons *disturb* it, Fig. 24.

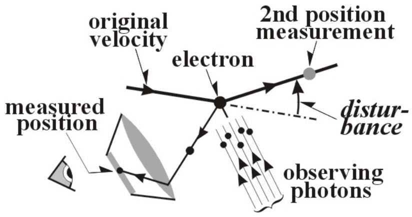

Fig. 24. Uncertainty (2).

We might attempt to reduce the velocity disturbance by using low-energy observing photons. But because their wave-length is long, this gives an inexact value for the electron's position. Should we try to avoid this by using short-wavelength photons, we get a nice crisp value for the position. But since the photon energy is here high, we get a large velocity disturbance.

Because we don't know the path an observing photon takes through the microscope, which could be anywhere through its lens, we cannot calculate the exact disturbance. The photon of Fig. 25a, for instance, strikes the electron more directly and causes a greater deflection than that of Fig. 25b.

[a] A *vector*, comprising a speed (magnitude) and direction (angle).
[b] Remembering that this is a thought exercise, and not a practical proposal.
[c] Strictly *momentum* (mass x velocity). At constant mass, ignoring relativistic effects, momentum is proportional to velocity.

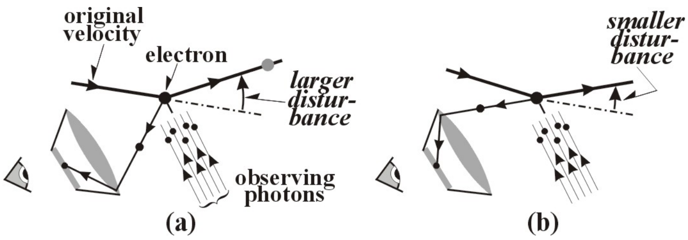

Fig. 25. Uncertainty (3).

A more fundamental consideration is that to determine the exact initial state of the *measured object*, the electron, we would need to know those of the *measuring objects*, the observing photons. But this gives us the same problem: that of determining the state of a subatomic particle.

We cannot therefore determine precisely *both* the velocity *and* the position of an electron, its overall state. The higher the accuracy for the one, the lower it is for the other:

we cannot determine exactly both the velocity and the position of an electron

This is the essence of *Heisenberg's uncertainty principle*. It says that the overall uncertainty, the product of the position uncertainty Δx and the momentum[a] uncertainty Δp, is given by[b]:

$$\Delta x . \Delta p \geq \frac{h}{4\pi} \qquad \text{(eq.5)}$$

where *h* is Planck's constant[c].

As an analogy, imagine photographing a moving car. A slow shutter speed gives a blurred image, Fig. 26a. But its extent enables the car's velocity to be estimated. It however gives no exact value for the position. Whereas a fast shutter speed gives a clear image and a precise position, Fig. 26b. But little or no indication of the car's velocity.

Again, we can obtain *either* an accurate velocity, *or* an accurate position, but not both together.

[a] p.22, note.
[b] ≥' = greater than or equal to.
[c] p.20.

Fig. 26. Uncertainty (4).

Quantum uncertainty doesn't therefore depend on the accuracy of our *instrumentation*. It is inherent in the way we 'see' – i.e. determine the states of – subatomic particles: in this case by using other subatomic particles that disturb the first[a].

Uncertainty is equivalent to *indeterminacy*. If the position of an electron is *uncertain* for us, it is also *indeterminate* for us: we cannot determine its precise value:

uncertainty ⇔ indeterminacy

As a further analogy, imagine that I have a 'continuous' metre rule infinitely subdivided into tenths, hundredths, thousandths, etc. of a millimetre. With it, and a suitably powerful magnifying glass, I can measure lengths to any desired accuracy.

But should I only have a standard 'discontinuous' rule with a minimum subdivision of, say, 0.1 mm, with this I can measure with certainty down to the nearest tenth of a millimetre. But after that uncertainty rules, so to speak.

As for electrons, the indeterminacy derives from the *observational threshold*, the minimum observable quantity, there the quantum/photon and here the rule's smallest subdivision:

indeterminacy ⇐ observational threshold

We will define the *classical domain* as that where the observations *don't* affect the observed, and there is no measurement uncertainty. And the *quantum domain* as that where they do and there is:

*classical domain**:** our observations don't affect the observed;*
*quantum domain**:** they do*

individual electrons, for instance, are quantum objects. We cannot determine their exact states. Making measurements on large numbers of them, however, we increase their *effective mass*, for practical purposes turning them into a *classical object* where quantum uncertainty averages out.

Many electrons form an *electric charge;* and when in motion an *electric current.* Both of these are classical objects whose values can in principle be determined to any required accuracy[b].

We can also note that, velocity and position being *particle* properties, a 'measurement' is always effectively a *particle measurement*. A wave description of an

---

[a] Normally photons.
[b] Subject to *experimental error*, which we discuss in a moment.

electron, for instance, would comprise the amplitudes, phase angles and frequencies of its potentially infinite series of component waves[a]. But who ever saw an electron defined in this way? To 'measure' something in general is to treat it as a particle.

We pay lip service the wave properties of subatomic matter. But in practice we treat it almost exclusively as particles. This is implied by the terms we use: "photon", "electron", etc.

Experimental error

We need to distinguish between *measurement indeterminacy* and *experimental error*. The last is due to practically uncontrollable factors such as minor temperature variations, instrument hysteresis, experimenter's poor eyesight, etc. In a practical situation is always present to some degree.

Position measurements on a classical object like a gold atom, for instance, give results as in Fig. 0-27a. The whole spread is due to experimental error.

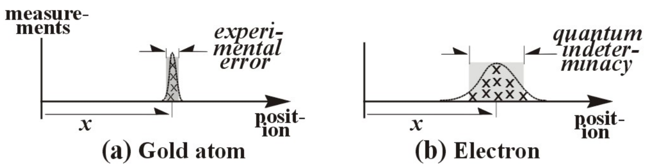

Fig. 0-27. Position uncertainty.

Whereas position measurements on an electron give results as in Fig. 0-27b. Although the spread here includes *some* unavoidable experimental error, it is mainly due to quantum measurement uncertainty.

Because experimental error is always present, however, and applies equally to the classical and quantum domains, it doesn't affect our arguments and for simplicity we will in general ignore it. Terms such as 'exact', 'precise', 'accurate', etc. thus always carry with them the implicit or explicit rider:

to within experimental error

Photon ratio

Protons, water molecules, and even heavier objects can as seen[b] exhibit double-slit interference. The wave behaviour becomes less apparent at higher object masses.

To quantify this, define an object's *photon ratio* as its energy/mass divided by that of the observing objects, normally photons:

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[a] Fig. 8b.
[b] p.6.

$$\textit{photon ratio} = \textit{energy/mass of } \frac{\textit{observed object}}{\textit{observing objects}}$$

The lighter the observed object, the lower its photon ratio, the greater the measurement disturbance, and the more evident its wave behaviour. Low photon ratios and wave behaviour are associated with *indeterminacy*.

High photon-ratio gold atoms suffer little or no observational disturbance, behaving essentially as particles. Lower photon-ratio electrons are more subject to disturbance. Although they still act principally as particles, they more readily show wave phenomena.

Whereas for unity-photon-ratio *photons* the wave and particle behaviours are in equal evidence. As is seen in the double-slit and split-beam experiments[a]. This is resumed in Fig. 28.

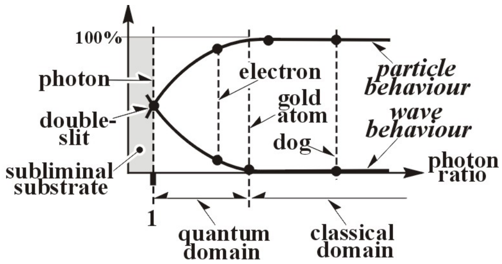

Fig. 28. Photon ratio.

Photon ratios less than unity are for practical purposes meaningless. Neutrinos[b] have sub-unity photon ratios, and cannot be 'seen'[c] using standard photons.

Indeterminacy (2)

Returning to the fundamental question of what determines the outcomes of individual quantum measurements[d], the Copenhagen Interpretation answer is very simple: *nothing does*.

According to it, subatomic reality is *inherently indeterminate* and before being measured *has no definite pre-existing properties*. The *measurement itself* creates the reality being measured:

*physical reality**:** inherently indeterminate*
reality ⇐ *measurement*

John Wheeler[a]:

[a] Fig.1, Fig. 2, Fig. 5.
[b] Below.
[c] In the sense of determining their individual states.
[d] Particle anomaly no. 3) (p.19).

> "No elementary phenomenon is *real until it is observed*. Quantum phenomena are neither waves nor particles, but until measured are *intrinsically undefined*."[15][b]

John von Neumann[c]:

> "Physical objects *don't have any attributes* unless a conscious observer is looking at them".[16]

Fritjof Capra:

> "Heisenberg's Uncertainty Principle says that one can never measure with accuracy both the position and the velocity of a particle. This has nothing to do with our measuring techniques. It is *inherent in reality*. If we measure a particle's position accurately, *it simply does not have* a well-defined velocity; and vice versa."[17]

David Lindley[d]:

> "You can only describe a photon in terms of probabilities, and these change depending on what you plan to do to it. A photon has *no properties of its own*, but only a ghostly range, each with some probability of being measured. The photon only reluctantly acquires properties as a sort of *conspiracy* between itself and the measuring device. There's nothing about it, no secret or hidden clue, that can tell you precisely what it will do. Its *unpredictability is innate*."[18]

Niels Bohr:

> "The quantum postulate implies that any observation of subatomic phenomena will involve an interaction with the agency of observation. Accordingly, *an independent reality* in the ordinary physical sense cannot be ascribed to the phenomena." [19]

Since physical reality overall is made up of subatomic particles, this too is ultimately indeterminate. Stephen Hawking[e]:

> "Indeterminacy is a *fundamental inescapable property of the world*, that puts an end to Laplace's dream of a totally deterministic universe[f]. Even

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[a] John Wheeler (1911–2008), American theoretical physicist.
[b] Italics ours in this and the following quotes.
[c] John von Neumann (1903–1957), Hungarian mathematician and physicist.
[d] David Lindley (1956–), English theoretical physicist and scientific author.
[e] Stephen Hawking (1942–2018), English theoretical physicist, cosmologist and popular author.
[f] This never was Laplace's dream. He only said that *if* it were possible to comprehend the universe, *then* it would be possible, which seems pretty irrefutable.

> God is limited by the uncertainty principle, and cannot know both the velocity and position of a particle, but only its wave function[a]."[20]

If things only exist when observed, then when not observed they don't exist. This applies not only to micro-objects like electrons. But also to macro-objects such as the Moon and the overall universe. Amit Goswami[b]:

> "Does the Moon exist when no-one is observing it? Quantum physics says no. Between observations the Moon is only a *transcendent possibility in spacetime*, till consciousness[c] collapses its probability function[d] causing it to manifest in physical reality."[21]

David Mermin[e]:

> "We now know that the Moon is *demonstrably not there* when no-one looks".[22]

Lindley again:

> "Measurements are what make things happen. When a measurement is made, one definite answer emerges from a range of possibilities. Without measurements the whole universe would *languish in permanent indeterminacy*. We must ask: did the universe remain in cosmic quantum indeterminacy till humans evolved consciousness? And at what point during the dawning of human consciousness was it forced to drop its cloak of indeterminacy and take on solid form? Or if it congealed into a classical solidity before we came on the scene, what 'measurements' accomplished the transformation? "[23]

Wave-function collapse (1)

Imagine an electron pursuing a linear path, Fig. 29. A state measurement[f] is made at point A.

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[a] Like Einstein (below), Dr Hawking presumes to know what God can and cannot do.
[b] Amit Goswami, Indian quantum physicist.
[c] The 'consciousness interpretation' (appendix, p.80).
[d] Below.
[e] David Mermin (1935–), American quantum physicist.
[f] Velocity (momentum) and position (p.22).

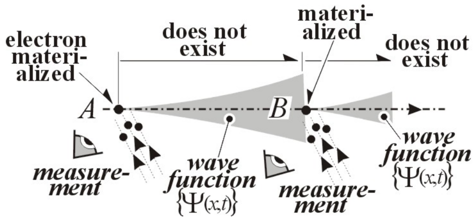

Fig. 29. Wave function collapse.

According to the Copenhagen Interpretation, once the electron leaves this point it *ceases to exist* as a physical object. It becomes a *probability wave*, or *wave function*, a linear superposition of transcendent possibilities in spacetime, unmanifest in physical reality[a]. The probability of measuring an electron at a point is given by the *Schroedinger wave equation*, due to Austrian physicist Erwin Schroedinger[b].

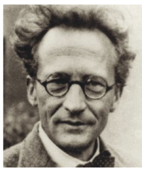

Fig. 30. Erwin Schroedinger.

Since the equation is fundamental to the Copenhagen Interpretation, and looks nice, we include it here in its simplest linear form:

$$i\mathrm{h}\frac{\partial\Psi(x,t)}{\partial t} = -\frac{\mathrm{h}^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial^2 x} + V(x)\Psi(x,t) \qquad \text{(eq.6)}$$

but won't go into details.

Having traversed the intervening space as a set of immaterial probabilities, a new measurement at point B *collapses the wave function* there, re-concretizing a material electron at one of the possible locations given by the Schroedinger equation[c].

After which the wave function starts to evolve again, and the electron spreads out in space, once more only "existing"[d] as an immaterial probability wave. Till a further measurement at some more distant point reconcretizes it as a physical object there. And so on over as many observations as one cares to make.

Heisenberg:

---

[a] Cf Goswami, p.28.
[b] Erwin Schroedinger (1887–1961), Austrian theoretical physicist.
[c] The probability of finding a particle at a point being given by the square of its magnitude (below).
[d] In quotes, 'existence' here always being *physical* (p.5, note).

> "The path of the photon *only comes into existence* when we observe it."[24]

Goswami:

> "We *cannot say that a quantum object exists* in spacetime until we observe it as a particle (the collapse of the probability function). The act of measurement reduces the wave-object to a particle[a]. When we are not measuring it, a quantum object spreads out in space and *exists in more than one place at a time*."[25]

Schroedinger's cat

In spite of being the author of the wave equation, and one of the Copenhagen Interpretation's principal contributers, Erwin Schoedinger never fully accepted it. To demonstrate the absurdity of wave function collapse, "as a ludicrous example"[b][26] he conceived[c] a cat.

He imagined a closed box containing the cat, a vial of poison, and a device activated by a radioactive atom, Fig. 31. Should the atom decay within its half-life, a hammer is released that breaks the vial of poison and kills the cat; which thus has a 50% chance of survival.

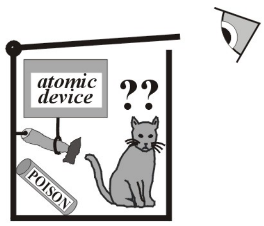

Fig. 31. Schroedinger's cat.

The question is: what is the cat's existential status *after* the atom's half-life has expired but *before* a measurement has been made, i.e. before someone has opened the box and looked in, collapsing the cat's probability function?

The Copenhagen answer is admirably clear and distinct. It is a *linear superposition* of half-alive and half-dead cat states. In Erwin's own words

> "The wave function for the entire system would express this by having the living and the dead cat – *sit venia verbo* ('pardon the expression') – 'mixed' or 'smeared out' in equal parts."[27]

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[a] Measurements being essentially 'particle' (p.24).
[b] His words.
[c] More politely: "thought of".

This obviously being ridiculous, the absurdity of wave function collapse – and by extension the Copenhagen Interpretation itself – is thereby conclusively demonstrated.

No way! Despite the nearly 100 years that have passed since its conception, like many real cats this one simply won't go away. Not only is it still with us. But judging by the interminable discussions on the subject, it is not only as both-half-alive-and-half-dead as ever, but is positively thriving on it. He who miaows last miaows best. (Miaow!)

Niels Bohr was notoriously coy on the subject:

> "Bohr's cardinal principle was not to get agitated about the seemingly impossible or contradictory nature of intermediate states that are by definition unobserved."[28]

Measurement creates reality. What is not measured doesn't exist. And is therefore lamentable metaphysics. Schroedinger's cat is a non-question. Don't ask it. This became known as the "Shut up and calculate" approach to quantum physics[a][29]:

> "Don't ask awkward questions. Keep your nose down to your sums and the answers will come out right."

And amazingly, in spite of its contorted conceptual structure, quantum physical answers *do* in practice come out right – normally with impressive accuracy. We return to the topic.

Particle anomalies (2)

Notwithstanding its apparent conceptual absurdity, the Copenhagen Interpretation "explains" (well, maybe better: "manages to sqirm out of") the particle anomalies.

To the question of how light can be both waves and particles, for instance, its answer is that before a measurement is made it is neither[b]. But merely a probability wave, a range of transcendent possibilities in spacetime unmanifest in physical reality. Till a 'measurement' – e.g. a screen observation – concretizes it as a material object.

In the double-slit experiment[c], individual photons arrive at the screen as probability waves and manifest as default 'wave' points when observed there. The same holds for the simple electron double-slit case[d].

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[a] Attributed to David Mermin. His verbatim 1989 words: "If I were forced to sum up the Copenhagen Interpretation in one sentence, it would be 'Shut up and calculate!'"
[b] Cf Wheeler, p.26
[c] Fig. 2.
[d] Fig. 10a.

But should a prior 'which-slit' measurement be made[a], this collapses the electron's wave function already at the slit. After which it continues as a particle, and forms a 'particle' point on arrival at the screen.

For polarization[b], before being observed individual photons don't exist. A measurement either materializes one or not according to the probabilities given by the Schroedinger equation. The same applies to electron spin[c].

In the simple eraser experiment, a recorded 'which-slit' measurement gives a potential 'particle' screen point. But since the recording is not observed, no 'measurement' has technically been made. The electron continues as an abstract probability function. Should the recording then be erased, there is no longer any 'measurement'. And the electron continues as a wave, manifesting as a default wave point when observed at the screen.

In the delayed eraser experiment, before anyone has looked at the recorded screen points, they are only abstract probabilities. When later plotted and observed, the locations for which no 'which-slit' 'particle' information is available[d] concretize as default wave points. And those where the information is available[e] concretize as particle points. Because all of this only occurs after the experiment is over, there is no changing the past. And so on.

Noting, however, that this is not to defend the Copenhagen Interpretation. But rather to try to understand how it ever came to be taken seriously. Don't examine the arguments too closely. They're not ours!

Measurement problem

One of the principal questions in relation to the Copenhagen Interpretation (for those who accept it) is its so-called *measurement problem*:

> "How does a particle go from being a superposition of mathematical possibilities when not observed to a concrete physical object when it is? The Schrödinger equation holds all the time – except when one makes a measurement. When it is temporarily suspended, and collapses everywhere except at some random point."[30]

In other words, *what causes* the wave function to collapse in a specific way, as opposed to any of the other possible ways allowed by the Schroedinger equation? We return to the topic.

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[a] Fig. 10b-c.
[b] p.16.
[c] p.19.
[d] *'w'* tags.
[e] *'p'* tags. Where a particle measurement has been made.

Wave-function collapse (2)

Continuing with wave function collapse, there are at least three massive conceptual objections to it that have apparently never been satisfactorily answered, or even seriously addressed.

The first is: how can a transcendent possibility in spacetime, unmanifest in physical reality, reflect the observing photons required by the measurement that will cause it to materialize in that same reality?

In the Heisenberg thought exercise[a], for instance, some physicists would hold that a measurement is made when an observing photon arrives at the microscope screen, position information then being available. Schroedinger cat lovers could however differ, arguing that a measurement only occurs when someone *consciously observes* the screen position.

All would however presumably agree that *before* any observing photon arrives at the screen there is no measurement. But in this case there is *no material object* in the observing photons' path, but only a range of transcendent probabilities unmanifest in spacetime.

Wave function collapse thus effectively requires that physically inexistent "particles" *anticipate* the measurements that will bring them into existence:

physically inexistent 'particles' anticipate the measurements that bring them into existence

This is maybe what Lindley means with his:

> "The photon only reluctantly acquires properties as *a sort of conspiracy* between itself and the measuring device."[b]

And since the *observing photons* themselves are only observed when they hit the screen, *they too* only come into existence at this point. A Copenhagen 'measurement' effectively entails firing immaterial probability waves at an immaterial probability wave:

'measurement' = firing immaterial probability waves at an immaterial probability wave

With a probability of success given by ...? Well, I don't know. Ask Niels and Werner. They're the ones who thought all this up. It pertains to their measurement problem[c].

Einstein held that:

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[a] Fig. 23.
[b] A somewhat indeterminate statement, as befits Copenhagen indeterminacy (p.27).
[c] p.32.

> "Without the conviction that what exists in different areas of space possesses an independent and real existence, I cannot understand what physics is trying to describe."[31]

Neither can I.

The second main objection to wave function collapse is that *energy/mass* is apparently not conserved. Most writers simply ignore the question, as though it didn't exist[a]. The few that do consider it seem to agree that conservation is violated:

> "A characteristic feature of the wave function collapse is that energy appears not to be conserved. There is no indication as to where the energy-momentum comes from or goes."[32]

The conservation of energy/matter is however a fairly fundamental property of our universe. We have the atom bomb to prove it. That retina-searing flash you just saw? And that cosmic mushroom cloud where the Moon should be? Well, that's unfortunately what happens to the Moon when no laggard down here on Planet Earth can be bothered to keep on looking for it[b].

Are we really to believe that Bohr, Heisenberg & Co. never heard of energy/-mass conservation? Maybe they had it at school, but forgot it. Or maybe they remembered it. But since it didn't fit in with their theory, they simply ignored it.

Thirdly, should one ask a physicist "What is a dog?", he might look around for a bit. And then point to some material object saying "*That* for instance is a dog", answering one's question.

But should one ask him "What is a wave function?", there is no physical object he could point to and say "*That* for instance is a wave function". Requesting pen and paper, he would set down on it a string of abstract symbols[c].

The question then is: how can a *string of abstract symbols* "collapse" into a *concrete physical object* such as an electron? This is another good question for Niels and Werner, and another aspect of their measurement problem.

Even if the Schroedinger equation *was* a physical wave[d], it would still be an *event*, a function of time[e], and not itself a concrete object. The question then being: how can a *non-material event*, a function of time, collapse into a *concrete object* with no time dependency? This is another good one to save up for Niels' and Werner's question time.

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[a] Mainstream Science's preferred way of dealing with inconvenient data.
[b] Goswami (p.28).
[c] eq.6 (p. 29).
[d] Which it cannot be, since it contains the imaginary operator *'i'* (square root of –1).
[e] The Schroedinger equation contains a '*t*' for 'time'.

Entanglement

Subatomic particles can be generated in *correlated pairs* with complementary properties, their states being described by a *common wave function*. Imagine two such electrons created with opposite spins[a], Fig. 32a.

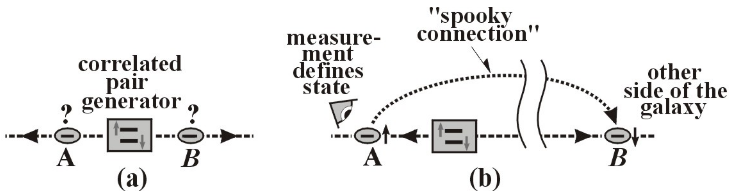

Fig. 32. Entanglement.

We don't know what the individual spins are. But we do know that, because they are complementary, if electron A is measured on some axis and found to be 'spin-up', then electron B must be 'spin-down' on that same axis; and vice versa[b]

So far so good. The problem is that on the Copenhagen Interpretation, particles only aquire definite states *when measured*[c]. Initially, each observer could obtain either spin polarity[d]. But should A measure his electron and find it to be, for instance, 'up', this collapses the common wave function and means that from that instant on B can only measure 'down' – even if he is on the other side of the galaxy, Fig. 32b. This in turn implies an *effect*[e] *travelling faster than light*[f], contravening Einstein's Special Relativity.

Einstein in particular obviously disliked the idea. He derisively called the implicit 'instantaneous action at a distance' the "spooky connection". And held it to demonstrate the *incompleteness* of the Copenhagen Interpretation: that it is not a complete description of physical reality:

> "The present quantum theory is unable to provide the description of a real state of physical facts, but only *an incomplete knowledge* of such. Moreover, the *very concept of a real factual state* is debarred by the orthodox theoretician[g]."[33] (italics ours)

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[a] Entanglement is normally illustrated with polarized photons. The same principles hold.

[b] Assuming that nothing untoward happens to either electron between its creation and measurement.

[c] p.26.

[d] Except in the limiting cases of initially completely spin-up or spin-down electrons (Fig. 0-20a,b).

[e] The restriction of B's possible measurement outcomes.

[f] The collapse on the common wave function being instantaneous at all points in space.

[g] Cf Bohr, p.27.

This is the essence of his famous *EPR*[a] *thought exercise*.

Fig. 33. Bohr x Einstein[b][34].

Far from demonstrating the incompleteness of the Copenhagen Interpretation as Einstein had intended, however, the spooky connection – also known as *non-locality*[c] – is today quantum-physical conventional wisdom. Quantum physicists talk blithely of:

> "Phenomena determined by a non-local reality outside spacetime, with particles far apart in space linked by instantaneous non-local connections that transcend our conventional notions of information transfer."[35]

All of which (to our maybe overly suspicious ears) sounds suspiciously like a "mystery too profound for the human mind to fathom" characteristic of other dogma approaches to reality that we know. But since our quantum-physical mentor David Lindley also says:

> "Quantum theory is non-local. A measurement at one point has an elusive, instantaneous, quantifiable influence at another. However you look at it, non-locality just happens in the quantum world. There's no getting away from it"[36]

the spooky connection is evidently the official Copenhagen line.

Entanglement derives further support from *Bell's theorem*[d], which says that:

> "No deterministic local 'hidden variables'[e] theory can reproduce the statistical predictions of quantum mechanics."[37]

It is further held to have been:

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[a] Einstein, Podolsky and Rosen.
[b] At the 1927 Solvay conference.
[c] Literally: 'being no place'.
[d] Due to John Bell (1928–1990), Irish particle physicist. Aka "Bell's inequality".
[e] Below.

> "Verified by a series of experiments[a] showing that entanglement does in fact occur over large distances."[38]

We[b], however, predictably don't buy entanglement. Firstly and foremostly because it depends on *wave function collapse*. No collapse of the common wave function; no instantaneous action at a distance; no spooky connection. And as just seen[c], wave function collapse is highly suspect – to say the least.

Secondly, non-locality is incompatible with a *continuous universe* model[d] where effects propagate at *finite speeds* determined by their respective media. This model is of course not necessarily correct. But it seems compatible with most things, except quantum entanglement.

Returning to Bell's theorem, it would in fact seem obvious that no *deterministic* theory can reproduce the *probabilistic* predictions of quantum physics. Deterministic models give deterministic outputs. Probabilistic models give probabilistic results. For a deterministic model to give a probabilistic output it would have to include a random number generator – and would then no longer be 'deterministic'.

With regard to the assertion that Bell's theorem has been "verified by a series of experiments": well, the same source asserts that the alleged 'null' result of the 1887 Michelson-Morley aether-wind experiment has likewise been "verified by a series of experiments". In fact the result *wasn't* 'null'. And *this* has been verified by a series of experiments[e39].

We therefore take its assertion with a wee pinch of salt. "Once bit, twice shy", as they say in my native England. And in Brazil:

> "*Gato ecaldado tem medo até de água fria*."

('A scalded cat is afraid even of cold water'.)

Well! This last is evidently not a particularly "scientific" argument. But it has nevertheless been "verified by a series of experiments" (practical cases).

Probabilities

Returning to Einstein's objection that quantum physics can only predict *probabilities*, and is therefore incomplete[f]: in the individual case probability predictions are *unfalsifiable*, and hence on Karl Popper's[g] "falsifiability" principle [a] are meaningless.

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[a] Notably by Alain Aspect et al. in 1982.
[b] I-the-author (p.4).
[c] p.33.
[d] Below.
[e] Discussed further in the appendix (p.85).
[f] p.35.
[g] Karl Popper (1902-1994), Austrian philosopher.

Imagine that my cat (somewhat unwisely in my own opinion) volunteers for a Schroedinger box experiment. And that on opening the box, alas! it materializes as a 100% dead cat.

> "Too bad!", says the experimenter sympathetically, "But be consoled that it had a 50% chance of surviving".

He could equally well have said a 99.9% chance, and I couldn't have faulted him. Even with only a 0.1% probability, something can still happen.

In the 'overall' many measurements case where quantum physics is effectively classical and can make falsifiable predictions[b], it is rational and complete. In the 'individual' single particle case where it can only "predict" unfalsifiable probabilities, it is irrational and incomplete:

(Before you accuse my late cat of rashness, however, it left a note saying that it had become a Many Worlds[c] adept. A 100% dead cat in this universe being a 100% alive cat in a parallel universe; and assuming that the cat food there couldn't possibly be worse than it is here; it reckoned it was onto a no-lose option.)

Continuity

A further ambivalence in the Copenhagen Interpretation is its position on *continuity*. It for instance states that:

> "Quantum theory reveals a basic oneness of the universe. The world cannot be decomposed into independently existing smallest units."[d]

And then goes on to do exactly that: decomposing the world's energy into independently existing smallest quanta[e] . We return to the topic.

Mathematics

Quantum physics normally seeks to interpret its *mathematics*, in particular the Schroedinger wave equation, in physical terms. The mathematics is not, however, the physical reality itself. It is an *abstract representation* of a minor part of it, for instance the probability of a certain measurement giving a certain result.

To attempt to obtain the overall reality from the abstract representation of a minor part of it, is to put the cart before the horse:

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[a] That to be meaningful a scientific theory must be *falsifiable*, capable of being proved wrong.
[b] p.24.
[c] p.43 below.
[d] p.50 below.
[e] p.20.

to attempt to obtain the reality from the mathematics, *is to put the cart before the horse*

Returning to the wave equation , it seems that *no-one* – not even Schrödinger himself – really knew where it came from or what it means. In December 1925 Schroedinger took de Broglie's[a] wave-particle dissertation[b] and a girlfriend to a Swiss Alpine resort – and returned with the wave equation[40]. Like Moses' tablets, the wave equation was "brought down from a mountain". Richard Feynman:

> " It's impossible to derive the Schroedinger equation from anything you know. Where did come from? Out of Schroedinger's mind."[41]

As to the *meaning* of the wave equation, Max Born[c] later "interpreted" its magnitude at a point as representing the probability of finding a particle there. But this too seems to have been "plucked out of thin air", with no scientific derivation or justification. Schroedinger himself never accepted it, commenting in a 1952 talk:

> "M. de Broglie disliked the probability interpretation of wave mechanics as much as I did."[42]

The same effectively applies to Heisenberg's *matrix mechanics*, mathematically equivalent to the Schroedinger equation:

> "In June 1925 Heisenberg came down with a hideous case of hay fever. Sneezing, nearly blind, and with tears streaming down his swollen face, he desperately took two weeks' vacation on Heligoland, a small barren island in the North Sea utterly devoid of trees and flowers. After several days he recovered. And at three o'clock one morning, in a shack on a rock battered by a frigid sea, he made his breakthrough. 'I had the feeling I was looking at a strangely beautiful interior, a wealth of mathematical structures generously spread out before me', he later said"[43]

Leonard Susskind[d] comments:

> "No-one knows what Heisenberg was thinking when he invented matrix mechanics – what mystical experience he had or what he was smoking. It can't be derived from anything. It's a set of empirical formulae deduced by guessing."[44]

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[a] Luis de Broglie (1892–1987), French physicist, who first proposed that *all matter* can show both wave and particle properties.

[b] "*Recherches sur la théorie des Quanta"* ('Researches on quantum theory').

[c] Max Born (1882-1970), German mathematician and physicist, one of Bohr's principal collaborators.

[d] Leonard Susskind (1940–) American physicist.

The Schroedinger wave function was "brought down from a mountain". Born's interpretation of it was "plucked out of thin air". And Heisenberg's matrix equations were "brought in from the sea".

The same holds for the *Lorentz transformations*, a backbone of Einsteinian Relativity, which were likewise apparently "plucked out of thin air" with no derivation or justification[a][45].

Susskind's "deduction by guessing"[b][46] nicely sums up this particular aspect of scientific methodology.

Mathematics in general is an essentially 'mechanical' means of manipulating abstract relations, and so cannot go beyond its initial data. Given, for instance, that x=2 and y=3, mathematics can tell us things like $x+y$=5, $x-y$=–1. But it cannot introduce anything new. Only *experiment* can do this. Henri Poincaré[c]:

> "Experiment is the sole source of truth. It alone can teach us something new and give us certainty."[d][47]

Niels Bohr:

> "Mathematics in the final analysis is a *mental game* that we can *play* or not as we choose."[48] (italics ours)

So when Stephen Hawking wrote:

> "Reasonable solutions to Einstein's General Relativity equations allowing time travel have now been found. Spacetime could be so deformed that you could set off in a spaceship, travel down a wormhole to the other side of the galaxy, and return before starting your journey, in time for dinner."[49]

this was totally invalid.

Just because something is *mathematically possible*, that doesn't necessarily make it *physically feasible*[e]. A reasonable solution to Newton's second law of motion has also now been found, allowing a body with negative mass to accelerate in the opposite direction to the force applied to it. To date, however, this has never been actually observed.

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[a] Relativity article.
[b] Aka 'serendipity': "That the universe naturally bends in our direction, providing us with apparently fortuitous good luck".
[c] Henri Poincaré (1854-1912), French mathematician, theoretical physicist, engineer, and philosopher of science.
[d] In his 1900 article "*Relations entre la Physique Expérimentale et la Physique Mathématique*" ('Relations between Experimental and Mathematical Physics').
[e] A logical fallacy of the form "cats are animals; Fido is an animal; therefore Fido is a cat".

Hawking's argument also evidently assumes that Einstein's General Relativity is correct, which it isn't[a][50].

The complexity of much of contemporary physics' mathematics readily lends to *obfuscation*[b]. On submitting quantum physics questions to a certain Internet forum, I for instance almost invariably ended up with replies of the form:

> "It is explained by the mathematics ... What?! You're not familiar with the mathematics?! ... Oh dear! That *is* a pity! Look: why don't you read this article; and study that textbook; and do this online course. And if after all that you *still* have a problem, get back to us and we'll be glad to help."

Apart from all of which, mathematics is in fact *essentially irrelevant* to the interpretational questions of quantum physics being discussed here. Richard Feynman noted that the double-slit experiment "Has in it the heart of quantum mechanics, and in reality contains the only mystery"[c]. The double-slit result involves no mathematics.

Language

A further problem with the Copenhagen boys (and girls) is their *use of language*. For instance Goswami's:

> "When we are not measuring a quantum object, it *exists in more than one place at a time*."[d] (italics ours)

Nothing (no physical thing) can however exist in more than one place at a time. If Fido is here, he cannot also be there; and vice versa.

Quantum physicists might explain that what they *really* mean is that if one makes a measurement, then there are *probabilities* that the object could be found either here or there.

But that is not the same. And if this is what they *do* mean, then why don't they say so in clear everyday language, rather than enshrouding it in obfuscation? (rhetorical question)

A further example is Mermin's above:

> "The Moon is *demonstrably not there* when no-one looks."[e]

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[a] Relativity article.
[b] *Obfuscation*: "deliberately making something obscure or unclear."
[c] Essentially: how light can show both wave and particle behaviour when the two are logically contradictory (p.8).
[d] p.30.
[e] p.28.

The word "demonstrate" derives from the Latin *demonstrare*: 'to point out'. And hence implies at least two "lookers": a demonstrater and demonstratee. There inherently being nothing one can point to and say:

> "Look! *That* is something no-one is looking at it"

To say that the Moon is demonstrably not there when no-one is looking, is demonstrably nonsensical.

And when an *eminence grise*[a] of a scientific discipline can make a logically totally nonsensical statement and get away with it, one could say that discipline has credibility problems:

> "Ach!" people will say, " They already spew out so much nonsense. This is simply a bit more."

David Albert[b]:

> "The Copenhagen Interpretation is not just weird. It's unintelligible gibberish."[51]

You can say that again, Dr Albert!

In one of his customarily frank utterances, Einstein described quantum physics as:

> "An epistemology-soaked orgy, that reminds me of the delusions of an intelligent paranoiac."[c52]

And on first encountering quantum physics as a university student in Belfast, the futurely famous John Bell[d] said:

> "I hesitated to think it was wrong. But I knew it was rotten." [53]

Quantum physicists' basic approach seems to be:

> "We say that something can be in more than one place at a time, which is wierd and incomprehensible. Proving conclusively that quantum physics is wierd and incomprehensible."

Many worlds[e]

In the double-slit experiment of Fig. 10b, a photon was detected at slit A. Why wasn't it slit B? Hugh Everett[f] had a creative answer. *Both* possibilities occur, he

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[a] Grand old man.
[b] David Albert (1954–), American physicist and philosopher of science.
[c] In a letter to a friend. (One could query the "intelligent" bit.)
[d] Of Bell inequality fame (p.36).
[e] An alternative to the Copenhagen Interpretation, included here for convenience.
[f] Hugh Everett (1930–1982), Princeton University physicist.

said, but in different universes. This is the *Parallel Universes*, or *Many Worlds Interpretation* of quantum physics. Lindley:

> "Whenever a quantum measurement is made, different universes split off, one for each of the possible outcomes. We see a particular result because we are in the universe in which it happens. In the other universes our counterparts are seeing one of the other results. And so on through as many universes as you like."[54]

I-the-author in this present universe observed a slit A photon. At the same moment my parallel-universe counterpart observed a slit B photon. And is at this very instant writing for you-the-reader's parallel-universe counterpart to read:

> "My parallel-universe counterpart observed a slit A photon".

(It's very simple, really, once you get the hang of it.)

Not only can I bring a zillion-ton Moon into existence merely by looking for it (assuming no other sneaker has already done so). I can create a *whole parallel universe* with a simple glance at a photon detector!

Wow! This one *really* separates the men from the gods! What do You have to say to *that*, Yahweh? Thanks to quantum physics I Your humble creature can now do in an instant what took You a whole working week. And as far one can make out, You have been resting from Your exertions ever since, taking off the longest recorded long weekend in the history of this universe at least. Come on Old Chap! None of Your customary "noble silence". We want Your clear and distinct answer. And we want it *now*!

Amazingly, however, loads of eminent scientists, who one might have expected to know better, believe (strictly: *say* they believe) in the Many Worlds interpretation[a]. Rupert Sheldrake[b]:

> "Lord Rees, British Astronomer Royal, president of the Royal Society, Master of Tinity College, Cambridge, member of the House of Lords, believes in multiple universes. He hasn't got a shred of scientific evidence for them. "[55]

Completeness

The further one delves into the Copenhagen Interpretation, the more absurd it becomes. And the more one tries to extricate oneself in its own terms, the further one ends up bogged down in even more absurdity. "Quagmire physics" it might well be called. Prince Hamlet could have said:

> "Something is uncertain in the quantum state of Denmark."[56]

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[a] p.21, note.

[b] Rupert Sheldrake (1942–), English biochemist.

Einstein queried the completeness of quantum physics[a]. In one sense at least, however, it can reasonably be said to be complete – completely bananas:

quantum physics is completely bananas

Do we really need things existing in more than one place at a time, Moons and universes popping in and out of existence, half-alive-and-half-dead cats, spooky connections outside of space and time – and the whole cornucopia of mind-blowing quantum-physical inanities – to explain why we down here on Planet Earth cannot measure precisely both the velocity and the position of an electron? That is what it boils down to.

SUBLIMINAL SUBSTRATE

Sensory threshold

Our fundamental biological organ of aprehension, the neurone, is a *binary*[b] *'fired][not-fired'* device. As such it has a *sensory*, or *perceptual threshold*, the minimum energy required to trigger it:

sensory/perceptual threshold = minimum energy to fire a neurone

For our most sensitive neurones, those of the retina, the threshold is of the order of a few light photons.

Imagine I am watching the lights of a receding aircraft at night. The photon density, the rate at which the plane's photons reach my eyes, decreases continually till at some point it falls below my visual sensory threshold, Fig.34a. After which I no longer experience the airplane, and it ceases to exist for me. Even though *some* of its emitted photons must still be reaching my eyes. My eyes are *photon detectors* with a *finite sensitivity*.

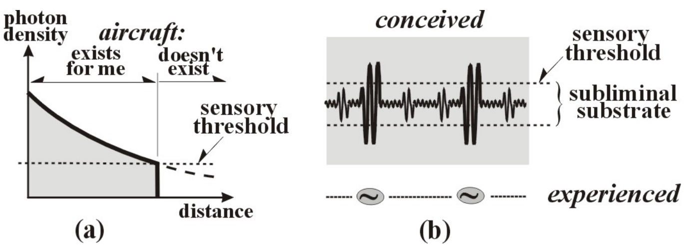

Fig.34. Sensory threshold.

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[a] p.35.
[b] Effectively 'digital'.

Einstein held the probability of finding a particle at a point to be given by the electromagnetic field density there:

> "A particle can only appear as a limited region in space where the field strength, or the energy density, is particularly high. We can consider as matter those regions of space when the field is extremely intense."[57]

We can conceive of light in these terms as "being really" continuous waves[a]. But because we only apprehend those wave-packets whose energies surpass our sensory threshold, we *experience* it in terms of discrete particles[b], Fig.34b. We conceive light in one way and we experience it in another:

we conceive light as waves; we experience it as particles

Extending the idea, what we *physically experience* in general is at the limit always effectively *particles*. If something fires a retinal neurone, we say "Aha! That was a particle". If it doesn't, we don't:

what we experience is always effectively particles

Another way of looking at this is that the basis of our perceptual mechanism is light interacting with the electrons of our retinal neurones. And since light-electron interaction is a *particle* phenomenon[c], again, we necessarily *perceive* things in 'particle' terms.

So in the double-slit experiment, the apparently continuous overall interference pattern is at the limit[d] experienced as light *particles* (photons) distributed in wave pattern form.

in this experiment, the energy-density distributions at the slits and at the screen are firstly *different*. And secondly, they only represent the *probability* of finding a particle there. On this model one could conceivably detect an electron at a slit but not on the screen; or vice versa.

The Einsteinian model doesn't therefore contain any *inherent* reason why a electron detected at a slit should always correspond to one and one only screen point. It doesn't represent *particularity*, and from now on we will drop it.

Again, we need *both* the wave *and* the particle representations to account for the observed properties of subatomic matter. However hard we try, we seem unable to escape the wave}{particle model with its attendant dichotomy and irrat-ionality.

Towards the end of his life Einstein lamented that:

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[a] Default photon behaviour being 'wave' (p.12).
[b] Particles by nature being discrete.
[c] Compton scattering (p.8).
[d] In the closeup view, Fig. 2.

> "All these fifty years of conscious brooding have brought me no nearer to answering the question 'What are light quanta?'"[58].

Hardly surprisingly. Light having rationally contradictory properties, it is nothing (no physical thing) that we can comprehend rationally.

Subliminal substrate

The energy-density representation of Fig.34b implies a *subliminal substrate*, a domain of wave magnitudes that we *conceivably could* apprehend, were our retinas sensitive enough. But since they aren't, we don't.

In practice we cannot circumvent this innate sensory threshold, no matter how fiendishly subtle our measuring devices. Imagine that in the subliminal substrate there were ξ-*particles*'[a] with energies below our sensory threshold. And that in our experienced universe there was a micro-organism that gave a visible jump when, and only when, hit by a ξ-particle.

The organism might seem a godsent ξ-particle detector. But since we don't know about ξ-particles, we wouldn't realize that its jumps were due to these. For us they would simply confirm the inherent randomness of things at the subatomic level[b].

Our *observational threshold* on this basis, the smallest energy packet we can detect, either 'directly' with our senses or 'indirectly' using instrumentation[c], is determined by our *sensory threshold*, the minimum energy required to fire a retinal neurone[d]:

$$\textit{observational threshold} \Leftarrow \textit{sensory threshold}^{e}$$

This agrees with practice. Our sensory threshold is of the order of a single photon[f]. As is also our observational threshold, the photon/quantum. And since, given the enormous scale differences existing in the universe, this is highly unlikely to be due to chance, it effectively supports the ξ-particle argument, and by extension a subliminal substrate.

Noting further that there is no *a priori* reason why the subliminal substrate should not be as highly differentiated and structured as our observable physical reality. James Jeans[g] wrote:

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[a] *Zeta*-particles'.
[b] p.26.
[c] p.7, note.
[d] p.44.
[e] The '⇐' symbol means "derives from" or "is due to".
[f] p.44.
[g] James Jeans (1877–1946), English astronomer.

> "We can receive *no message* from the outer world smaller than that conveyed by a single photon."[59] (italics ours)

John Bell:

> "To admit things not visible to creatures as gross as we, is to show decent humility, and not a lamentable addiction to metaphysics[a]."[60]

Grover Maxwell[b]:

> "There are no *a priori* philosophical criteria for separating the observable from the unobservable."[61]

Neutrinos

Neutrinos are miniscule subatomic particles that interact so little with normal matter that they don't leave tracks in cloud chambers; cannot be "seen"[c] by any scientific instrumentation; can pass right through the Earth undeflected; and don't affect us in the slightest even though an estimated 100bn of them are zinging through each of our thumbnails every second.

How do we know about neutrinos at all? Their 'existence'[d] was first proposed in 1930 by Wolfgang Pauli[e] to balance nuclear energy equations, which don't add up without them.

In an attempt to detect neutrinos in practice, in 1968 Raymond Davies[f] placed 600 tons of dry-cleaner fluid in a tank in a disused mine 2 km underground. He calculated that if neutrinos really did exist in the predicted numbers, by the laws of probability some should occasionally collide with chlorine nuclei in the fluid, converting them into readily detectable radioactive argon[62].

This actually happened – at a rate of about one such reaction every two days. Hardly excessive, considering the number of neutrinos said to be around! But because neutrinos are the only particles with the theoretical capacity to penetrate that deep into the earth, this was taken as evidence for their existence. Since later experiments confirmed the result, most physicists today say that neutrinos exist.

The evidence for neutrinos is however *circumstantial*. We cannot "see" them in the sense of determining their individual *states*: their velocities and positions[g]. For practical purposes neutrinos belong to the subliminal substrate.

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[a] Cf p.31.
[b] Grover Maxwell (1918–1981), American philosopher of science.
[c] In the sense of determining their individual states (p.22).
[d] p.5, note.
[e] Wolfgang Pauli (1900–1958), Austrian theoretical physicist.
[f] Raymond Davies (1914-2006), American physicist.
[g] p.22.

Radioactive decay

In *radioactive decay*, unstable atoms break down into smaller components with the emission of radiation, Fig. 35a. A typical decay curve is shown in Fig. 35b. The half-life is the time for half the atoms of a sample to break down.

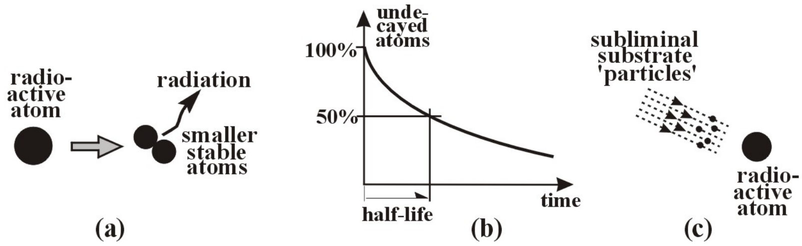

Fig. 35. Radioactive decay (1).

According to standard theory, the decay of an individual atom is *inherently indeterminate*. One can only predict the *probability* of its occurring within a given period. The chance of an atom decaying within its half-life, for instance, is 50%.

On a subliminal substrate model, however, the *apparent* randomness can be conceived as due to this. If we knew precisely the state of a radioactive atom, and also of all the subliminal particles in its vicinity, we could calculate which would hit the atom and when, and could predict its breakdown, Fig. 35c.

If things as ephemeral as neutrinos can break down stable chlorine atoms[a], they can certainly trigger the decay of inherently unstable radioactive atoms on the verge of breaking down anyway

The *apparent* randomness of radioactive breakdown on this approach becomes *circumstantial evidence for* a subliminal substrate. The probability of an atom decaying within a given period, for instance, is that of its being hit by a sufficiently energetic subliminal particle. The more stable the atom, the more unlikely such an event, and the longer the half-life.

And because the chance of this happening within a given period of time is invariant, it results in the exponential decay curve found in practice[b].

We will call radioactive decay *pseudo-classical*. And conceive it as being *essentially classical* and *determinate*, had we knowledge of the subliminal substrate. But since we inherently cannot have, it necessarily *appears to us* as random and indeterminate.

Noting also that since the detection of emitted radiation is not subject to measurement uncertainty, on the above definition[c] radioactive decay is not a 'quantum' phenomenon.

---

[a] p.47
[b] Fig. 35.
[c] p.24.

Dark matter

Then there is the "missing", or "dark", 24% of the universe's matter whose 'macro' gravitational effects are observed, but no corresponding particles have yet been found[63]. Where is all this dark material? On the present hypothesis it is hidden in – or better: *is* – the subliminal substrate.

Together with the further 72% of the overall universe[a] that is currently held to comprise "dark energy", *ninety-six percent* of the universe's energy/matter – *twenty-four times* what we actually experience – is invisible to us. Our experienced physical reality[b] is but the tip of the universal iceberg, Fig. 36. We return to the topic.

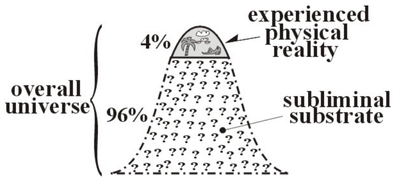

Fig. 36. Overall universe (1).

Wave}{particle

A further argument for the subliminal substrate is the wave}{particle model itself, taken together with Niels Bohr's concept of *complementarity* – that things can be described either in one way, or in another, but not both simultaneously[c].

Waves are *continuous* with no lower limit to their magnitude. The Fourier components of a single wave-packet[d] comprise a potentially infinite series of harmonics with, at the limit, infinitely small magnitude. A minimum wave amplitude would invalidate the Fourier representation.

And if there is no lower limit in the wave domain, neither can there be in the Bohr-complementary particle domain, Fig. 0-37. This again implies a subliminal substrate.

---

[a] 'The universe' is here always the 'overall universe', everything we conceive as 'existing' (p.5, note).

[b] Defined as "what we experience" (p.7, note).

[c] E.g. light as either waves or particles, but not both together.

[d] Fig. 8a.

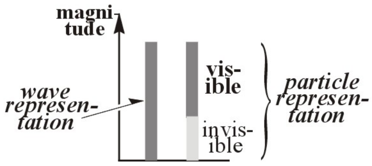

Fig. 0-37. Wave}{particle.

CONTINUOUS UNIVERSE (1)

Big Bang

On the currently orthodox *Big Bang model*, the universe is[a] a continuously expanding configuration of its 10^{80} fundamental particles – protons, neutrons and electrons. A *universe state* being a specific arrangement of these:

universe state = specific arrangement of the 10^{80} *fundamental particles*

Such a universe is[b] *continuous* and *determinate*. Everything comes from something according to the Laws of Nature:

continuous/determinate universe = everything comes from something according to the Laws of Nature

Today's universe state is a direct and inevitable consequence of yesterday's state; which was a direct and inevitable consequence of the day-before-yesterday's state; and so on all the way back to the Big Bang[c].

A metaphor for a continuous universe is the *ocean*, where every water molecule affects its neighbours, and they their neighbours, and so on around the globe. When I give a shout, the sound waves I emit will travel around the world, and will eventually return to me, even though imperceptibly. David Bohm[d]:

> "The fundamental reality is an unbroken wholeness, an inseparable interconnectedness of the whole universe, where relatively independently behaving parts are merely contingent forms within this whole."[64]

Fritjof Capra[e]:

---

[a] "Is conceived as being". 'Is' and 'are' normally have this sense.
[b] Again: is conceived as being.
[c] The hypothetical origin of everything (don't ask where *it* came from!)
[d] David Bohm (1917–1992), American quantum physicist.
[e] Fritjof Capra (1939-), Austrian physicist and scientific author.

> "Quantum theory reveals a basic oneness of the universe. The world cannot be decomposed into independently existing smallest units, basic building blocks. It rather appears as a web of relations between parts of the whole."[65]

In such a universe, *effects* propagate at *characteristic speeds* determined by their respective media:

effects propagate at characteristic speeds determined by their media

When one throws a pebble into a pond, the disturbance spreads out as ripples propagating over its surface at a characteristic speed given by the properties of the water medium. Sound waves, pressure disturbances in the air, propagate through it at a characteristic speed c=343 m/s determined by the properties of the air medium[a].

Electromagnetic disturbances similarly propagate through their medium, the luminiferous aether[b], at a characteristic speed c=300k km/s given by its electric and magnetic properties[c]; and so on. As Einstein correctly surmised[d], in a continuous universe the idea of instantaneous action at a distance is senseless.

To say that the universe "is continuous", is not however necessarily to assert that this is the way it "really is". A continuous universe is a *model*, a way of thinking that we adopt in our attempt to make sense of things, fitting them into our overall conceptual structure:

model = way of thinking about things

When we *say* that the Big Bang "caused our present universe", what we *really* mean is the opposite: that our *experiencing* of our present universe caused our Big Bang model for it:

present universe ⇒ Big Bang model

We discuss continuity further in the 'Intervention' sections of the appendix[e].

Dice-playing

Einstein in particular disliked the Copenhagen Interpretation's 'inherent randomness' postulate[a][66]. He believed that as yet undiscovered "hidden variables"

---

[a] Its mechanical density and compressibility.
[b] p.9, note.
[c] Magnetic permeability (electromagnetic density) and electric permitivity (electromagnetic compressibility).
[d] p.35.
[e] p.82.

would one day explain the *apparent* indeterminacy of quantum phenomena in deterministic terms[67]. This is what he meant by his famous:

"God does not play dice"[b]

However, although Albert was indubitably right in asserting that on a continuous model God is a clockmaker outside the universe rather than a dice-player within it, this is not the real reason for His not-dice-playing. Secretly He is dying for a game. His problem is that, being omniscient, He knows all one's future throws. And being omnipotent, He throws Himself anything He likes. He needs a Divine Straight Flush? Well, He simply throws Himself one.

The real and sad reason for God's not-dice-playing is not His inherent lawfulness, as Albert seems to have assumed. But simply that He cannot find anyone willing to play Him. Really Albert! You're not telling us you fell for *that* one! With *your* intelligence! And *your* family background!![c]

Fig. 38. Anyone for dice?

Although universally taken as the paradigm of a *random* process, dice-throwing is in fact *strictly deterministic*, rigorously subject to the laws of classical mechanics. If one knew precisely a dice's initial position, velocity and angular momentum; and also the frictional coefficient, elasticity, etc, of the table; and could feed all this data in time into a sufficiently powerful computer; one could infallibly predict which number would come up. We will call dice-throwing '*quasi-classical*'.

It is interesting that our prefered metaphor for a *random* process is one that *we ourselves* conceive as being essentially determinate. This maybe reflects the general confusion that the freedom}{determination question creates in our minds.

In practice, of course, we don't have all this data on the dice. The best we can do is to reason that, since the numbers on a dice's faces don't affect the way it falls, by the laws of statistical probability for a large number of throws, each number should come up equally often.

---

[a] Interestingly, having done a hatchet job on Einstein's Relativity, when it comes to quantum physics we normally agree with him.

[b] To which Niels Bohr is said to have retorted "Stop telling God what he can do!"

[c] As one of the Great Not-Dice-Player's chosen people.

This is what happens. Dice-throwing is an inherently deterministic phenomenon rigorously subject to the laws of nature. Our inability to predict the outcome in an individual case is not due to any randomness in the *process*. But rather to *our own lack of knowledge* of it:

apparent randomness $\Leftarrow$ *our own lack of knowledge*

We *conceive* dice-throwing as deterministic. But we *experience* it as indeterminate. The same holds for the overall universe that God created for our benefit. We conceive it as determined[a] and experience it as indeterminate.

Dice-throwing and the overall universe are thus strictly analogous. And on this basis we would have to say yes, God *does* play dice:

God does play dice

This fortunately doesn't conflict with Albert E's famous utterance. He was using 'dice-throwing' in its popular sense of something inherently random. We use it in the more sophisticated sense of something *conceived* as determined but *experienced* as random.

And because for God *everything* in our universe, including dice-throwing, is determined by Him, from His viewpoint too He does play dice[b].

Returning to radioactive decay, like dice throwing this obeys the laws of statistical probability overall, but we cannot predict an individual outcome, the breakdown of a single atom. The two cases being strictly analogous, we again[c] justifiably suspect that radioactive decay is likewise *essentially deterministic*. Its *apparent* randomness being due to our own lack of knowledge, in this case of the subliminal substrate.

Indeterminacy (3)

The terms 'random', 'uncertain'[d], 'indeterminate', etc. are effectively equivalent. If something is random for us, it is also uncertain, unpredictable and indeterminate for us: we cannot determine or predict its state with certainty[e]:

randomness $\Leftrightarrow$ *uncertainty* $\Leftrightarrow$ *indeterminacy, etc.*

On a continuous universe model, however, where everything comes[f] from something and the Laws of Nature always hold, the idea of 'absolute' indeter-

---

[a] On a continuous model.
[b] Certainty dice.
[c] p.48.
[d] p.24.
[e] Defining 'indeterminate' as "what cannot be determined with certainty".
[f] Is conceived as coming (p.50, note).

minacy – something happening for absolutely no reason at all, not coming from anything – is senseless:

absolute indeterminacy: a nonsense

When we say that something "is indeterminate", what we really mean is firstly that it is *apparently* indeterminate *for us* – that *we ourselves* cannot predict it.

Secondly, that its indeterminacy is *limited*: it has an indeterminate *component*. Because if something were *truly* indeterminate, i.e. random in *all respects*, it would have no consistent characteristics and we wouldn't discriminate or have a concept of it.

And thirdly, that its apparent indeterminacy is ultimately due to *our own lack of knowledge*. Knowing the exact initial Big Bang conditions[a] and all the Laws of Nature, we could predict the precise future course of the universe and would experience no indeterminacy[b]:

indeterminacy: 1) apparently for us[c]; 2) within limits;
3) due to our own lack of knowledge

'Indeterminacy' terms[d] thus always carry with them the explicit or implicit rider "apparently for us".

In the Heisenberg thought exercise[e], for instance, an electron's state is firstly *apparently* indeterminate *for us*. Knowing the precise initial states of the observing photons and their paths through the microscope lens, we could calculate the exact measurement disturbance and the electron's original undisturbed state.

Secondly, the electron's state is apparently indeterminate[f] *within the limits* given by *a)* the uncertainty[g] in the observing photon states[h]; *b)* the range of possible paths through the microscope lens;.

And thirdly, the apparent indeterminacy is ultimately due to *our own lack of knowledge*. With precise universe information we would experience no uncertainty.

The indeterminacy question is highlighted by that of *random number generation*. Two principal methods are used[68]. In *pseudo-random* generation a computer algorithm produces a sequence of seemingly random numbers. But since, knowing the algorithm and its initial value, one could predict the entire sequence, the "randomness" is again 'apparent', 'for us', and 'due to our lack of knowledge'.

---

[a] Or those at any other point in time.
[b] A somewhat blanket statement that we qualify later.
[c] Strictly redundant. is always being "apparently for us".
[d] 'Indeterminacy', 'uncertainty', 'randomness', etc.
[e] p.29
[f] For us.
[g] Ditto.
[h] p.65 below.

The second method uses an *external phenomenon* perceived as random – atmospheric noise, the cosmic background radiation, radioactive decay, etc. On a continuous universe model, however, these things are also conceived as determinate, and with exact knowledge could be predicted.

Again: in a continuous universe there is no such thing as absolute indeterminacy.

Partial universe

Imagine a hypothetical *E.U.* (Extra-Universal) whom we will call *Euclid*. From his completely objective viewpoint outside our universe, Euclid sees it as a swirling – but nevertheless essentially determinate – mass of particles with no lower limit to particle size, Fig. 0-39a.

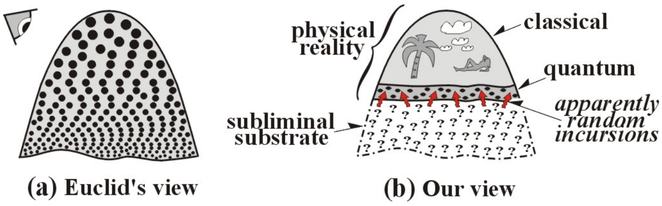

Fig. 0-39. Overall universe (2).

We ourselves, however, as part of that universe, and with an innate perceptual threshold, conceive it in terms of, Fig. 0-39b[a]:

– 1) a *physical reality*, what we actually physically experience, either directly with our senses or indirectly via instrumentation[b], subdivided into[c]:
  – a) a classical domain where our observations don't affect the observed
  – b) a quantum domain where they do
– 2) an inherently unexperienceable *subliminal substrate*

Our universe view is *inherently partial*[d], or *incomplete.* Paraphrasing Einstein[e], one could say:

> "*We ourselves* are inherently unable to provide the description of a real state of the universe, but only of an incomplete knowledge of it."

---

[a] Cf Fig. 36. The 'random incursions' are discussed in a moment.
[b] p.46.
[c] p.24
[d] 'Inherently' for us.
[e] p.35.

And so in trying to model our overall universe, we are trying to do so based on *incomplete knowledge*. This evidently leads to *indeterminacy* – especially when that 'part' could well be a mere 4% of the whole[a]:

partial/incomplete knowledge ⇒ indeterminacy

Imagine trying to model the behaviour of icebergs based only on what we see above the sea surface. We would be postulating "dark iceberg matter".

The 'classical', 'quantum' and 'subliminal' domains that we subdivide our universe into do not, therefore, actually "exist" in 'out-there' physical reality. They are *mental categories* that we create in our minds, based on our *differing experiential modes*[b], in turn due to our innate sensory threshold:

*classical/quantum/subliminal domains**:** mental categories based on our differing experiential modes*

As Niels Bohr so truly said – though he maybe didn't mean it in quite this way:

"There is no quantum world."[69]

And with no such domains existing in 'out-there' physical reality, there are no corresponding *physical boundaries*. Meaning that each domain is experienced as subject to *incursions* from the one below it.

Photons, for instance, belong to the subliminal substrate. We cannot determine their exact individual states[c], But they nevertheless affect our experienced physical reality[d] by firing retinal neurones, dissociating silver nitrate molecules and disturbing our electron measurements[e]. And because the subliminal substrate is inherently indeterminate for us, we experience such incursions as *apparently random*[f] – as we saw for radioactive breakdown[g]:

*quantum domain**:** subject to apparently random incursions from the subliminal substrate*

. But since the subliminal substrate by definition comprises phenomena with energies *below* our perceptual threshold[h], the *magnitudes* of these incursions is intrinsically *limited*:

---

[a] Fig. 36.
[b] As 'determinate' (classical), 'indeterminate' (quantum) and 'inexperienceable' (subliminal substrate).
[c] p.65.
[d] The next domain up. By definition "what we actually experience" (p.7, note).
[e] This also holds for the quantum-classical boundary (cf p.24).
[f] Fig. 0-39b.
[g] p.53
[h] p.46.

substrate incursions: limited in magnitude

This ties in with what we saw: that we experience physical reality overall as essentially determinate, but with a limited indeterminate *component*[a].

CONCEPTUAL

Reality (1)

Now for a brief conceptual interlude. Starting with *reality*, the question is: what do we really mean when we say that something is "real", or "absolute", or "true"[b]? 'Absolute' being defined in the dictionary as:

"*absolute:* not qualified or diminished in any way, totally objective"

Our hypothetical extra-universal Euclid[c] has by definition an absolute view of things, and hence the final word on reality. We down here on Planet Earth, however, part of our universe and with an innate perceptual threshold, do not have his privileged position. For us the 'reality' of something is in practice our *ultimate perception* of it, the one that won't go away no matter how hard we test it:

our 'reality' = the ultimate perception that won't go away

Imagine that my friend Jim and I are hung over a garden gate looking at a house, Fig. 0-40. We see a red roof, white walls, blue door and windows, and a tree with a dog asleep in its shadow.

Fig. 0-40. Reality.

– "Jim!", I say nervously, "There's a dog asleep under that tree!".
– "Idiot!", says Jim derisively, "That's not a dog! It's a sack of potatoes!"

---

[a] p.54.
[b] Taking the terms as equivalent.
[c] p.55.

Opening the gate he walks up to the object and kicks it. Since it doesn't yelp or bite him, my perception of it as a dog was wrong and Jim's was right. In real reality the object is a sack of potatoes.

A few seconds after Jim had kicked the sack, however, there was an almighty explosion that tore all the leaves off the tree and a whole side off the house. In *real* real reality the house was a terrorist cache. And the sack was full, not of potatoes, but of hand grenades. Well, so much for Jim's "real" reality! And also, unfortunately, for Jim himself.

But when the police arrived the next day and did their forensic analyses, they found no, the sack *had* in fact been full of potatoes. But some fiendish and hitherto unknown bacteria had turned all their starch into nitro-glycerine **...** And so on *ad inf.*

All of which complicates even further our quest for an absolute 'real reality'. Because even if we could all agree today on what the real reality of something really is, this would still be subject to overthrow by some "even more real" real reality that might turn up tomorrow or sooner. As they say in Ireland:

> "You can never be sure, to be sure."

Ashleigh Brilliant[a] laments:

> "Whatever became of Eternal Truth?"[70]

Just because in practice we can't ever know for sure the real reality of anything, however, doesn't mean that the *idea* can't be useful. Our present objective is to set up a *model*[b], an overall *conceptual structure* that will give *coherence to our experiencing*:

*our objective**:** a conceptual structure to give coherence to our experiencing*

A conceptual structure being a set of interrelated *ideas*, any idea that furthers that objective is useful, independently whether it has a correlate in experiencible physical reality. Our hypothetical extra-universal Euclid[c], for instance, in Copenhagen terms is lamentably metaphysical[d]. But he nevertheless contributes usefully to our discussions.

The same holds for 'real reality'. Even though in practice we can never determine its nature, we can nevertheless *conceive* of such a thing, *imagining* it in our minds. In one's imagination one can imagine anything one cares to imagine:

*'real reality'**:** unknowable, but conceivable*

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[a] Ashleigh Brilliant (1933–), English epigramist and 'tee-shirt philosopher'.
[b] p.51.
[c] p.55.
[d] In Bohrian terms.

In fact, the statement "There is no such thing as real reality" *presupposes* a concept of a 'real reality'.

Reality (2)

Continuing with 'reality', Niels Bohr continued his above quote:

> "There is no quantum world, but only abstract description. The task of physics is not to determine what nature *is.* But rather, *what we can say* about it."[71] (italics ours)

The distinction is however meaningless, since "nature" for us collectively *is* what we can say about it. Fido for me, for instance, is really a fetid brute. But for his owner Jim he is really a scented cutie. So what is his true nature, his 'real reality'?

Well, as we just saw, for me individually he is really a fetid brute. For Jim individually he is really a scented cutie. And for us collectively he is:

> "The entity that John[a] says is really a fetid brute, and Jim says is really a scented cutie".

This being the most one can say in our society with regard to Fido's real reality without fear of contradiction.

What something 'is' for us collectively *is* what we can say about it. Or better: what we can *agree to say* about it:

collective 'is' = what we can agree to say

Reality (3)

Going a step further, and turning to 'we-here'[b], I-the-author and you-the-reader in our present situation, our *real* 'real reality' right-here-right-now is me writing these words and you reading them. Since you probably have little idea of who I am; and I have absolutely no idea of who you are[c]; the only things the two of us have in common are:

– 1) the *English language*[d]
– 2) *these words*

In our present situation we-here are constrained to the *verbal domain of words*, comprising words, all words, and nothing but words. As Jean-Paul Sartre[e] might have said[a]:

---

[a] Assuming my name is John, which it isn't.
[b] As opposed to the 'authorial-we' (p.4).
[c] Except that at this very instant you are reading these words.
[d] If you didn't speak English, you wouldn't be understanding this.
[e] Jean-Paul Sartre (1905-80), French philosopher and father of existentialism.

we-here are condemned to words:

Meaning that all the two of us can ever effectively *do* is to *exchange words*. You might disagree with my words and proffer others. I might disagree with those, and counter with still others. And so on *ad inf*.

'We-here' cannot go beyond words. As Niels B. so truly said, we are not in fact discussing physical reality, but *what we can agree to say* about it.

we are discussing what we can agree to say

This hopefully is also something we can agree to say.

Realism

In holding physical reality to be essentially indeterminate, and with no pre-existing properties[b], the Copenhagen Interpretation is philosophically *anti-Realist*, with no concept of an underlying 'real reality'. The only 'reality' worthy of the name it recognizes is the *outcomes of scientific measurements*[c].

A further essential component of any self-respecting Realist philosophy is the *Law of Causality*: that everything has a *proximate cause*. This too, however, the Copenhagen Interpretation rejects. Heisenberg in 1927:

"Quantum mechanics has definitely invalidated the law of causality"[72]

Opposing this is philosophical *Realism.* It conceives of there being a real 'out-there' reality existing independently of our observations. And that is essentially determinate, subject to causality. But in the subatomic domain, due to inherent quantum measurement uncertainty, it necessarily *appears to us* to be uncertain and indeterminate, even though it isn't really[d]:

physical reality exists and is essentially determinate;
in the subatomic domain it appears indeterminate

It is effectively a *continuous universe model*[e].

We thus have *two competing hypotheses*: that physical reality is essentially:

– 1) indeterminate
– 2) determinate

---

[a] His actual words: "We are condemned to freedom".
[b] p.26.
[c] Below.
[d] From a completely objective Euclidian viewpoint (p.55).
[e] p.50.

Because – again due to quantum measurement uncertainty – neither hypothesis can be proved nor refuted, for completeness *both* must be considered. This is shown schematically in Fig. 41.

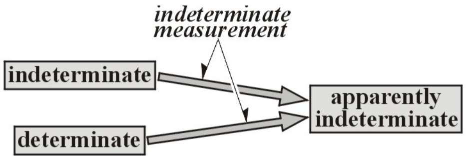

Fig. 41. Overall reality.

Similar considerations apply to the quantum/photon conceived as the *smallest existing* energy/matter packet[a]. An alternative hypothesis is that it is simply *our minimum observable* energy/matter packet[b], Fig. 0-42. Again, since neither hypothesis can be proved nor refuted, for completeness both must be examined.

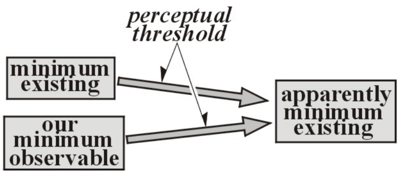

Fig. 0-42. Quantum.

Possible reasons for the Copenhagen Interpretation's failure to consider the realist alternatives are discussed below.

Rationality

According to René Descartes[c], a *rational concept* is a *clear and distinct mental category* with a *definite content*. One can say definitely what is and what is not it – what it includes and what it doesn't:

rational concept = mental category with definite content

'Dog' is a rational concept. Everything (every physical thing[d]) either is a dog or it isn't, i.e. either falls into the category 'dog' or it doesn't. Nothing can be "both 'dog' and 'not-dog'". Nor can it be "neither 'dog' nor 'not-dog'".

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[a] p.20.
[b] Again implying *a* subliminal substrate.
[c] René Descartes (1629–1649), French philosopher, mathematician and scientist, the "father of modern philosophy".
[d] Limiting discussion for the moment to the physical domain.

An 'electron's state', on the other hand, is not a rational concept. Depending on the method chosen, one measurement can say it is this; another that; and another something else – with no way of knowing which, if any, is correct. An electron's state is *inherently fuzzy*. We cannot say definitely whether something is or is not it.

Rational concepts can be *manipulated rationally*. If Fido is definitely a dog, and all dogs are definitely animals, then Fido is definitely an animal, Fig. 0-43a.

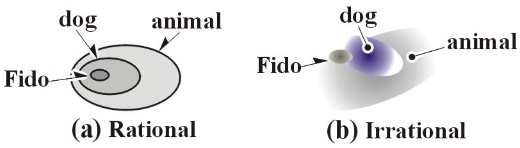

Fig. 0-43. Fido is an animal.

But if it is *uncertain* whether Fido is a dog; and *uncertain* whether any specific dog is an animal – and maybe even uncertain whether any specific entity is Fido – then the most one can say definitely about him in this respect is that he may or may not be an animal, Fig. 0-43b – which doesn't say much.

Indeterminacy in general leads to *irrationality*, things not susceptible to rational manipulation:

$$\textit{indeterminacy} \Rightarrow \textit{irrationality}$$

Comprehension

The word *comprehension* derives from the Latin *con* + *prehendere*: to "seize" or "grasp". It is defined in the dictionary as "to grasp mentally, hold in the mind".

The same physical image is found in other languages. The German *Begriff* (concept), for instance, derives from the verb *greifen* (to grasp); and so on.

The 'grasping' metaphor could well derive from our experience of trying to comprehend an elusive *mental concept*, such as the Theory of Relativity, being like trying to grasp an elusive *physical object*, such as the soap in the bath.

And when we do succeed in grasping the elusive object, physical or mental, in each case we say we "get" it. 'Get' then becomes a synonym for comprehension. As in the story of the two nuns, where one was explaining to the other about sex. When she finished the other one said "I don't get it".

Mental concepts in general (mental grasping) derive from *physical concepts* (physical grasping):

$$\textit{mental concepts} \Leftarrow \textit{physical concepts}$$

John Locke[a] said:

[a] John Locke (1632-1704), English philosopher, the "father of British Empiricism".

"There is nothing in the mind except that it was first in the senses."[73]

For the 'grasping' image to make sense, the grasping subject must be *distinct* from the grasped object. The concept of a hand grasping something other than Itself, such as an egg, Fig.44a, is meaningful. But that of a grasping hand grasping itself is senseless, Fig.44b.

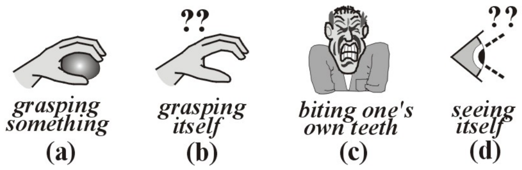

Fig.44. Self-incomprehension (1).

Based on its fundamental image of physical grasping, the idea of 'self-comprehension' – something comprehending itself – is therefore senseless. It's not just that something *cannot* comprehend itself in the sense of *not being able to*. But rather: our concept 'comprehension' is such that the idea 'self-comprehension' is nonsensical. We will call this the *self-incomprehension principle*:

'self-comprehension' is a nonsense

Alan Watts[a], Fig.44c:

"Trying to comprehend oneself is like trying to bite one's own teeth."[74]

Imagine that in a valiant attempt to comprehend my own mental state I wire all my 100bn neurones up to a giant TV screen, Fig.0-45. But I can never mentally grasp the image before me, because it is being continually modified by the neural impulses involved in my attempts to do so. I cannot comprehend myself.

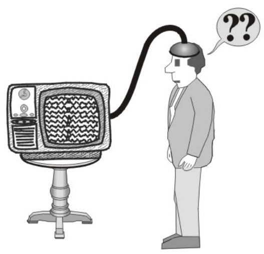

Fig.0-45. Self-incomprehension (2).

[a] Alan Watts (1915–1973), English philosopher.

The setup here is *self-referential*. The observer is *involved* in his observed. And in trying to comprehend it, he is to that extent trying to comprehend himself, which is irrational.

A classic example of self-referentiality is King David's[a] "All men are liars"[b]. Since David himself was a man, if his statement was true it would be false. The irrationality is due to David's statement referring back to himself.

Self-referentiality in general leads to *indeterminacy* and *irrationality*[c]:

self-referentiality ⇒ indeterminacy/irrationality

Apart from the conceptual objection to 'self-comprehension', there is a further logistical problem. To comprehend oneself, in the sense of being able to predict one's own behaviour, would require among other things knowing the states of all the neurones in one's brain. All one's brain neurones would then be taken up storing the states of all one's brain neurones, leaving no space for anything else.

Even if the idea of self-comprehension weren't *conceptually* senseless, nothing could comprehend itself for *logistic* reasons due to lack of computational capacity.

St Augustine[d] said:

> "I cannot grasp all that I am. The mind is not large enough to contain itself."[75]

Lyall Watson[e]:

> "If our brains were so simple that we could understand them, we would be so simple that we couldn't."[76]

And if nothing can comprehend *itself*, even less can it evidently comprehend the *whole of which it is part*:

nothing can comprehend the whole of which it is part

For us to predict the future course of our overall universe, for instance, would firstly involve comprehending ourselves[f], which is senseless. And secondly, would require storing the instantaneous states of all the universe's 10^{80} elementary particles, which would need a computer bigger than the universe.

Self-incomprehension provides another way of looking at quantum irrationality. The quantum domain being by definition that where the observer affects his observed, he is *involved* in it. And in trying to understand it, he is to that extent trying to understand himself.

---

[a] David (1040–970 b.c.), second king of Israel.
[b] For this to work, it has to be strictly "All men *always* lie".
[c] p.62.
[d] St Augustine (354-430), bishop of Hippo (in modern Algeria).
[e] Lyall Watson (1939-2008), South African anthropologist and author.
[f] We being part of that universe.

Should I measure an electron's state in one way[a], I get one result. In another way I get another result; and so on. But what determines *my choice* of measurement method? I cannot say. I cannot comprehend myself. Electron states for me have an inherently indeterminate component[b].

Seeing

Seeing is another 'comprehension concept' requiring the subjective seer to be distinct from his objective seen. The idea of an eye seeing itself is senseless (Fig.44d).

Another approach. When I look at a classical object like a dog, its reflected photons arrive at my retinas and I consciously experience a dog, Fig. 46. The photons themselves, however, I do not see. They form part of my 'seeing'.

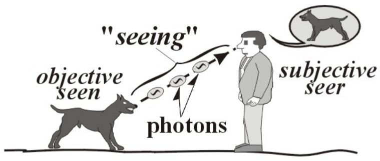

Fig. 46. Seeing.

Photons effectively *are* our 'seeing'. Not just by virtue of being the essential link between our outer and inner experiential worlds. But more fundamentally: as our smallest detectable observing particles they determine our *observational threshold*, the lower limit to our aprehension in general, both with and without instrumentation[c].

To attempt to deduce the nature of photons from experiments involving photons only[d], where the observing and the observed particles are one and the same, is to try to use photons to see themselves – or alternatively, to "see our own seeing".

Both of these ideas being irrational, individual photon states[e] are *inherently indeterminate* for us. The most we can hope for is to *estimate* them based on the way they are prepared:

individual photon states: inherently indeterminate for us

Indeterminacy (4)

Our innate sensory threshold firstly obliges us to make measurements on subatomic particles using other subatomic particles[a], which disturb the observed par-

[a] For instance with one observing photon frequency (p.21).
[b] For me (p.54).
[c] p.46.
[d] E.g. in a double-slit experiment.
[e] Velocities and positions.

ticles and cause *indeterminacy*. And secondly, in using subatomic particles to 'see' other subatomic particles, we are trying to use things to see themselves, which is *irrational*.

The *indeterminacy* of the quantum domain and its *irrationality* correlate[b]. Both derive from our innate perceptual threshold, the quantum/photon:

$$\textit{indeterminacy/irrationality} \Leftarrow \textit{perceptual threshold}$$

This is shown schematically in Fig. 47.

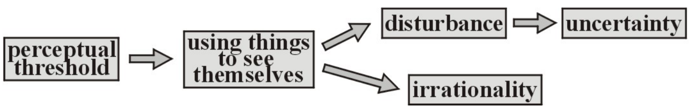

Fig. 47. Uncertainty/irrationality.

The relation is further reflected in *Planck's constant h,* which firstly determines the extent of Heisenbergian *uncertainty*[c]. And secondly, in defining the value of the quantum/photon[d] it determines our observational threshold[e] that in the subatomic domain obliges us to use things to 'see themselves', the root of quantum *irrationality*.

There are further such correlations. A wave has a characteristic *velocity*, but no definite *position*[f]. A particle has a definite position, but no characteristic velocity. *Velocity* correlates with *waves* and *position* with *particles*:

$$\textit{velocity} \Leftrightarrow \textit{waves};\ \ \textit{position} \Leftrightarrow \textit{particles}$$

And just as an exact *velocity* measurement on a subatomic particle leaves its *position* uncertain; and an exact position measurement leaves its *velocity* uncertain; so the wave side of the wave}{particle model leaves the particle behaviour undetermined; and the particle side leaves the wave behaviour undetermined. Velocity}{position *uncertainty* and wave}{particle *irrationality* again correlate[g].

Micro-photons

A thought exercise. Imagine *micro-photons* with energy/masses an order of magnitude below those of standard photons. And that our eyes were sensitive to

---

[a] Normally photons.
[b] Cf p.62.
[c] eq.5 (p.23).
[d] eq.4 (p20).
[e] p.46.
[f] p.7.
[g] p.62.

these – effectively that our sensory threshold was an order of magnitude lower than it actually is.

Electrons and standard photons would become as gold atoms for us. We could determine their states to any desired accuracy[a]. There would be no uncertainty[b]. And because we would no longer be trying to use things to see themselves[c], there would also be no irrationality. The uncertainty and the irrationality again correlate[d].

DICEY INTERPRETATION

Overall}{individual

Consider a piece of textile. From an *overall 'macro-'* viewpoint[e] it is experienced as continuous and uniform, Fig. 0-48a. And in a *closeup 'micro-'* view as discrete individual fibres, Fig. 0-48b. Two different viewpoints. Hardly surprisingly, two different views.

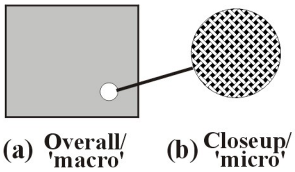

Fig. 0-48. Textile.

Both views are here *classical*, unaffected by our observations. And both being *rational* and *determinate*, so also is the corresponding *overall}{individual relation*. Given the closeup view, and the eye's resolving power, the overall view can be predicted to any required accuracy[f].

Now consider quasi-classical *dice-throwing*. Numbers initially come up apparently randomly. We might get a five, then a two, then a three, and then a five again, with no seeming rhyme or reason. Should we start over, we get a different sequence of numbers: this time maybe a three, then a six, and then two fours in a row; and so on. But after many throws we always get the *same determinate overall result*[g], namely equal frequencies for each number.

---

[a] To within experimental error (p.25)
[b] Provided we don't try to determine the states of micro-photons themselves.
[c] Ditto.
[d] p.62.
[e] Observed from a certain distance.
[f] The limitations of this analogy are discussed in the appendix (p.88).
[g] As always, ignoring experimental error (p.25).

The overall}{individual relation is here again essentially determinate. Knowing the exact initial states of dice and table, and with a sufficiently powerful computer, one could predict the individual outcomes and thence the overall result[a].

The same essentially applies to pseudo-classical *radioactive decay*. The overall curve is replicable and determinate. And individual breakdown times are *conceived* as in principle determinate, had we knowledge of the subliminal substrate. But since we inherently cannot have, the overall}{individual relation is here only *conceivably* determinate.

Turning to the "quantum" cases, in the *double-slit experiment* the overall 'macro-' view is again classical and determinate. With a strong light beam and the screen observed from a certain distance, a replicable determinate wave pattern is found. From it the wavelength of the light can be determined to any desired accuracy[b].

Whereas in the closeup 'micro-' view, with single photons and examining the screen through a magnifying glass, as for dice-throwing the initial points are *apparently random*. One trial gives one set of points; another trial gives a different set; and so on, with no apparent rhyme or reason.

But since the individual measurements always build up to the *same determinate overall result*[c], they too must be *essentially determinate*. Even if we, with our innate perceptual threshold and hence necessarily partial view of the universe[d], cannot conceive the corresponding physical mechanism.

An overall result being the sum of its individual measurements[e], if the former is determinate so must also essentially be the latter, even if we cannot visualize how. There is no way *indeterminate*[f] individual measurements can build up to a *determinate* overall result. We will call this the *overall}{individual determinacy* principle:

determinate overall result $\Leftarrow$
determinate individual measurements

Similar considerations apply to *polarization*[g]. In the overall 'macro-' case with a strong light source, analyzer output intensities can be predicted to any desired accuracy. But in the closeup 'micro-' view with single input photons we cannot predict whether an output photon will be detected. And again, cannot visualize a

---

[a] p.52.
[b] Ignoring experimental error (p.25).
[c] A replicable interference pattern.
[d] p.55.
[e] p.17.
[f] Apparently random.
[g] p.16.

corresponding physical mechanism, even though we reason that there must be one. Electron spin is analogous.

Resuming: in the "classical" 'macro-' cases[a] where measurements don't affect the measured, individual outcomes are both conceived and experienced as determinate. We can at least imagine predicting individual outcomes and thence the overall result.

Whereas in the 'micro-' quantum domain where measurements do affect the measured, individual outcomes are *conceived* as *in principle* determinate, even though in practice we *experience* them as indeterminate.

This correlates with the indeterminacy for us of individual photon states[b]. If we cannot even ever *know* the exact state of an individual photon, even less can we evidently ever hope to *predict* it. All of this is summed up in Fig. 49.

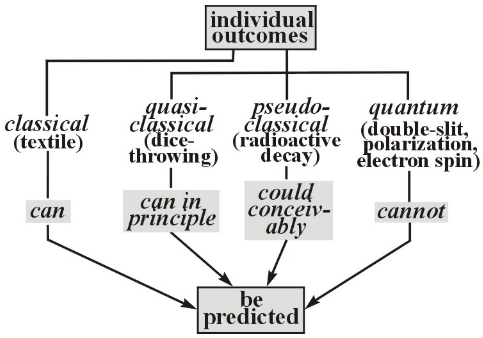

Fig. 49. Individual outcomes.

Nano-photons

Imagine *nano-photons*, infinitesimally small micro-photons[c], and that our eyes were sensitive to these. Effectively, that our sensory and observational thresholds were now both *vanishingly small*.

The double-slit interference pattern would comprise an infinite number of infinitely small points, a *continuous gradation*[d]. And there being an infinite number of infinitely small nano-photons, the question of which slit any one of them went through would be meaningless.

---

[a] Quasi-classical dice-throwing, pseudo-classical radioactive decay.
[b] p.65.
[c] p.66.
[d] p.5.

The particle domain as such would vanish. And together with it the particle anomalies, which all depend on it[a]. Because our observations would no longer affect our observed, there would be no uncertainty and no irrationality[b].

The whole of physical reality would then be *classical/determinate* for us. And we would experience reality as it really is, namely as *continuous* and *'wave'* with not a discrete particle in sight:

real reality = continuous / 'wave'

Subatomic "particles" as such on this approach are *mental constructs*, models that we create in our minds to account for the way our binary perceptual mechanisms respond to waves at their lower sensory limit:

'particle' = a binary perceptual mechanism's response to a wave at its lower sensory limit

Remembering always that we are not dealing with systems of hard little balls, but with essentially *empty space* permeated with *electrostatic fields*. And that cannot always be expected to conform to concepts derived from classical everyday physical reality[c].

Erwin Schroedinger wrote:

> "What we observe as material bodies are nothing but shapes and variations in the structure of space. Particles are *Schaumkommen* (appearances)."[77]

We noted that with eyes sensitive to neutrinos rather than photons, our present concrete physical reality would appear to us as no more than a vague wispiness[d].

The 'particle' reality of discrete objects that we actually experience is on this basis essentially *unreal*, or *illusory*, a consequence of our necessarily partial view of the universe[e], in turn due to innate sensory threshold.

Eastern religions have also long taught that the reality we perceive with our physical senses is in essence illusion.

And if the particle domain itself is illusory, so also are the particle anomalies that derive from it:

particle anomalies: essentially illusory

---

[a] p.19.
[b] p.62.
[c] p.9
[d] p.9.
[e] p.55.

Irrationality

We now effectively have "explanations" for the particle anomalies[a], based on 1) *irrationality* and 2) *illusion*.

Taking irrationality first, and the double-slit result as the paradigm particle anomaly[b], the question is: how can *apparently random* initial 'particle' screen points build up to a *determinate overall result*, a 'wave' interference pattern[c]?

how can apparently random initial screen points build up to a determinate overall result?

This, however, is to try to relate the 'wave' and the 'particle' sides of the wave}-{particle model, which is an irrational dichotomy with *no possible rational relation* between its two sides. Meaning that there *can inherently be* no rational explanation.

That's about it. We predicted an irrational model for quantum phenomena 'seen' in our way[d]. True to our prediction, in the wave}{particle dichotomy we got one:

we predicted an irrational model for the quantum domain;
in the wave}{particle dichotomy we got one

When trying to understand rationally something that we *inherently cannot* understand rationally, the most we can hope for is to understand rationally *why* we cannot understand rationally – which we now hope to have done:

the most we can hope for is to understand rationally why we cannot understand rationally

This may seem small consolation. But that's life. For beings like us with a binary perceptual mechanism; and hence innate sensory threshold; trying to comprehend a universe that we ourselves are part of [e]; in terms of itself [f]; and based on incomplete knowledge of it[g]; this is about as far as we can go.

Everything has its limits, and that includes our capacity to comprehend rationally a universe that we ourselves are part of. The limt is reached at the point where, due to our sensory threshold, our observations cease to be observer independent.

Ashleigh Brilliant would say:

"We don't have an explanation. But we sure admire the problem."[78]

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[a] p.19.
[b] Cf Feynman's: "The double-slit experiment contains the only mystery" (p.8).
[c] Fig. 3.
[d] Using measurements that disturb the measured.
[e] Self-incomprehension (p.63).
[f] Concepts derived from that same universe.
[g] p.55.

In fact, given the essential irrationality of what we are trying to do, it would be a conceptual problem for us if we *did* have rational models for subatomic phenomena 'seen' in our way[a].

Illusion

Turning to the *illusion* aspect of the particle anomalies, the nano-photon thought exercise showed that the overall universe can be conceived as essentially *continuous* and *wave*, with particles as *Schaumkommen*, illusions deriving from our binary perceptual mechanism.

And if particles themselves are illusory, so also are the corresponding particle anomalies:

particle anomalies: essentially illusory

Our lack of rational explanations for the individual anomalies is then *essentially irrelevant*. In an ideal case with a nano-photon perceptual threshold, we would experience no particles, and no corresponding anomalies.

Resuming: we *conceive* the overall universe as continuous and determinate, with no physical boundaries between the classical, quantum and subliminal domains. These are abstract categories that we create in our minds, due to our differing experiential modes[b], in turn due to the nature of our binary perceptual mechanism.

Apparent quantum wierdness is not, therefore, inherent in physical reality as the Copenhagen Interpretation holds[c]. It *derives from us*, specifically from *our* inability to make measurements on subatomic objects without disturbing them, in turn due to *our* innate perceptual threshold:

apparent quantum wierdness derives from us

Arthur Eddington[d] wrote:

> “We found a strange footprint on the shores of the unknown. We devised profound theories to account for its origin. At last we have succeeded: it is our own.”[79]

The above approach being based on the analogy with quasi-classical dice-throwing[e], we will call it the *Dicey Interpretation* of quantum physics. Noting that it is essentially *epistemological*, based on considerations of *what we can know*. And that the difference between it and the Copenhagen interpretation is *purely*

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[a] Using things to see themselves.
[b] p.56.
[c] p.26.
[d] Arthur Eddington (1882-1944), English astronomer.
[e] p.52.

conceptual. Subatomic reality necessarily *appears to us* to be indeterminate[a]. The question is: does *conceiving* it as such give us greater peace of mind:

does conceiving the universe as essentially determinate give us greater peace of mind?

Let the reader be the judge.

CONTINUOUS UNIVERSE (2)

General

On the Dicey Interpretation, and in line with David Bohm[b], we conceive the overall universe as a determinate unbroken wholeness. But due to our perceptual threshold we *experience* it subdivided into:

– a *classical domain* where our observations don't affect our observed, and that is determinate/rational[c]
– a *quantum domain* where they do, and that has an indeterminate/irrational component
– a hypothetical *subliminal substrate* that we cannot know at all

Fig. 50 shows a wave}{particle representation.

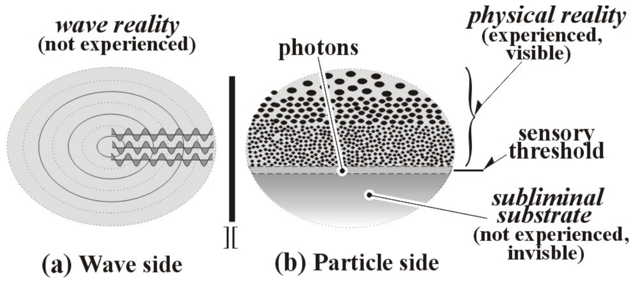

Fig. 50. Continuous universe.

The wave side is[d] as always *continuous* with no lower limit to wave amplitude[e]. But because we don't experience electromagnetic waves as such[f], this side is

[a] Fig. 41.
[b] p.50.
[c] As always: 'for us'.
[d] Is conceived as being (p.50, note).
[e] Waves being inherently continuous (p.6).
[f] p.10.

conceptual. It is what we *imagine* wave reality would look like *if* we could experience it, which we inherently can't.

As the counterpart to the continuous wave side, the particle side overall is *conceived* as being likewise "continuous" with no lower limit to particle size[a]. But due to our sensory threshold we experience it as *truncated*, subdivided into:

– 1) *physical reality*, the objects and events that we actually physically experience, either directly with our senses or indirectly with instrumentation
– 2) a hypothetical *subliminal substrate* of "particles"[b] that we inherently cannot experience, and whose states we cannot determine

particle side = physical reality + subliminal substrate

River analogy

We visualized a continuous universe in terms of the ocean[c]. A more sophisticated analogy is a *fast-flowing river*, Fig. 51.

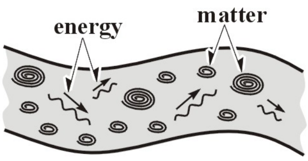

Fig. 51. River model (1).

The river surface comprises standing waves (not shown) and *swirls*, both due to submersed objects – rocks, tree trunks, etc. Since these are essentially stationary[d], we take them to represent *concrete matter*. We ourselves being material objects, we are likewise represented by swirls on the river surface.

Now imagine the river *stationary*, but maintaining its original swirly surface. Disturbances such as a stone thrown in cause *travelling waves* that propagate across the water surface at a characteristic speed *c* determined by its properties[e]. We take these to represent *radiation energy*: heat, light, gamma rays, etc.

Imagine further that swirls *reflect* travelling waves, Fig. 52a. When such a reflection reaches my eyes I experience a physical object, for instance a dog, Fig. 52b.

---

[a] The 'particle' definition of "continuous".
[b] Photons, neutrinos, ξ-particles, etc.
[c] p.50.
[d] With regard to a river bank observer.
[e] p.6.

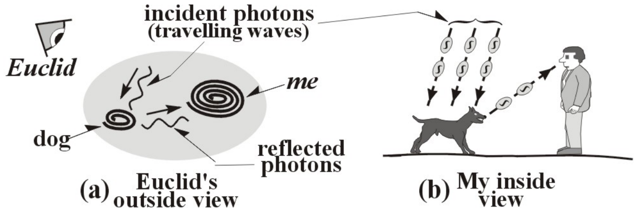

Fig. 52. River model (2).

From his totally objective viewpoint outside our universe, Euclid sees it as *continuous* and *'wave'*[a]. We ourselves, however, as part of that universe, and seeing it from the inside with a binary perceptual mechanism, *experience* it as *discrete* and '*particle*' comprising:

– essentially stationary *concrete matter* ('knotted energy'), swirls on the river surface
– *radiation energy*, waves travelling across it, experienced at the limit as single photons

It is interesting that the 5th century b.c. Greek philosopher Anaxagoras similarly conceived atoms as vortexes in the aether[b][80], an idea that was taken up in modern times by Lord Kelvin[81].

Theory of Everything

Our universe for Euclid is a swirling, but nevertheless essentially determinate, mass of particles with no lower limit to their size[c].

We ourselves, however, as part of that universe, and with an innate perceptual threshold, experience it subdivided into:

– 1) a *classical domain* of things we are not involved in, and that are too large to be affected by our observations (galaxies, rocks, gold atoms): both conceived and experienced as *determinate*
– 2) our *individual worlds* of things we are involved in, and do affect (spouses, offspring, dogs, etc.): both conceived and experienced as *indeterminate*[d]
– 3) a *quantum domain* of things we are not involved in[e], but that are too small *not* to be affected by our observations (electrons, photons): conceived as determinate and experienced as indeterminate

[a] Fig. 52a.
[b] The term derives from the Sanskrit *akasha*, which in traditional Indian cosmology means "space" or aether".
[c] Fig. 0-39a.
[d] Self–incomprehension (p.63).
[e] Except in our observing them.

– 4) a hypothetical *subliminal substrate* of things (photons, neutrinos, dark matter) too small for us to experience at all

Fig. 53 shows the overall universe in these terms.

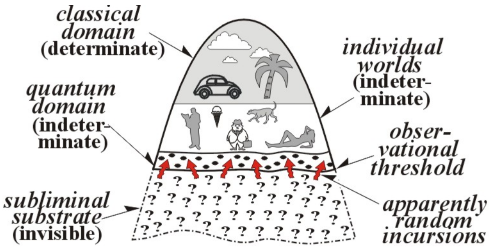

Fig. 53. Overall universe (4).

Compared with Fig. 0-39b, there is the additional domain of *our individual worlds*, things that we personally affect at least to some extent, and that are consequently indeterminate for us[a].

Einstein spent his final years seeking to unite the classical and quantum domains into a single grand *Theory of Everything*. He failed. Hardly surprisingly, given that the classical domain is determinate for us, and the quantum domain is indeterminate. And rationally, nothing can be 'both determinate and not-determinate', nor 'both affected and not-affected' by our observations.

The classical and quantum domains being *rationally disparate*, we cannot hope to ever combine them into an overall rational whole. We are doomed to experience "physicists' reality" (the one studied by physicists, made out of galaxies, rocks, electrons, photons, etc.) as a *classical}+{quantum conjunction* comprising independent:

– 1) *determinate classical*
– 2) *indeterminate quantum*

domains, with no possible rational relation between them:

physicists' reality = classical}+{quantum conjunction

Stephen Hawking noted that:

> "A Theory of Everything would have to predict the outcome of our search for it. "[82]

This also makes a nonsense of the idea.

And if, as it seems, there is a subliminal substrate, this would put a final nail in the Theory of Everything coffin. We cannot expect to model a system based on

[a] Self–incomprehension (p.63).

only partial knowledge of it. Especially when that 'partial' could be a mere 4% of the whole[a].

All of this evidently ignores that other fundamental component of our 'reality', namely *we ourselves*, inherently incomprehensible to we ourselves[b].

Max Planck:

> "Science cannot solve the ultimate mystery of nature. For in the final analysis *we ourselves* are part of the mystery we are trying to solve."[83] (italics ours)

COPENHAGEN TRIP

Logical positivism

The penultimate question is: how come the founding fathers of quantum physics[c] conceived physical reality to be inherently indeterminate, and with no pre-existing properties, when a realistic approach avoids many of its conceptual pitfalls?

As often in such cases, the answer seems to be *dogma*. The fashionable philosophy of the 1920s was *Logical Positivism*, due principally to the 19th century French philosopher Auguste Comte[d]. He held that the only valid knowledge is that based on "sense experience" and "positive verification" – effectively *scientific measurement*[84]. Because in the subatomic domain scientific measurements are inherently indeterminate, so on this doctrine is physical reality itself.

That would seem to be it. Niels Bohr was apparently bit of a control freak, having managed to impose his logical positivist "reality=measurement" dogma[e] not only onto his own generation of quantum physicists, but onto most of today's as well! Murray Gell-Mann[f]:

> "That an adequate philosophical presentation of quantum physics has been so long delayed, is no doubt caused by Niels Bohr having brainwashed a whole generation of theorists."[85]

Alfred Landé[g] spoke of most quantum physicists:

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[a] Fig. 53.
[b] Self–incomprehension (p.63).
[c] Bohr, Heisenberg, Born & Co.
[d] Auguste Comte (1798–1857), French philosopher.
[e] p.26.
[f] Murray Gell-Mann (1929-), American particle physicist; in 1976
[g] Alfred Landé (1888-1976), German quantum physicist.

> "Following Bohr's Sunday word of worship"[86]

After reading Einstein's EPR paper[a], Schrödinger wrote to him saying:

> "I am very pleased you have publicly called dogmatic quantum mechanics to account."[87]

Another dyed-in-the-blood logical positivist was Ernst Mach[b]. An excellent professional physicist, noted principally for his work on shock waves[c], he dogmatically resisted the idea of atoms to his dying day on the grounds that they cannot be seen. In spite of the overwhelming experimental evidence for them, already in his time[88].

And when in 1930 Wolfgang Pauli proposed the neutrino[d] to explain the missing energy in radioactive beta decay, he felt obliged to excuse himself for having adopted "the desperate remedy"[e] of assuming the existence of something that cannot be measured:

> "I have done something very bad today", he wrote to a group of prominent nuclear physicists in Tuebingen, Germany, "by proposing a particle that cannot be detected. It is something no theorist should ever do."[89]

We already noted John Bell's:

> "To admit things not visible to creatures as gross as we is not a lamentable addiction to metaphysics."[f]

Bohr's acolyte Werner Heisenberg once commented:

> "I avow that the term Copenhagen 'interpretation' is not a happy one, since it suggests that there could be others. We of course all agree that the other interpretations are nonsense."[90]

Another of Bohr's protégés, Léon Rosenfeld, once sent David Bohm a letter saying:

> "I notice in you disquieting signs of a primitive mentality. I shall not enter into any controversy with you on complementarity[g], for the simple reason that there is not the slightest controversy about it."[91]

Not much room for open-minded scientific debate there!

---

[a] p.26.
[b] Ernst Mach (1838-1916), Austrian physicist and philosopher.
[c] The ratio of a speed to that of sound is named the "Mach number" in his honor.
[d] p.47.
[e] His words.
[f] p.47.
[g] p.49.

It is interesting that the fundamental problems of both Einsteinian Relativity and quantum physics derive from their *initial assumptions*. Einstein's conceptually nonsensical and experimentally refuted[a][92] postulate of a invariant speed of light in all inertial reference frames leads to the logical absurdity of two clocks each running slower than the other.

Quantum physics' likewise experimentally unfounded[b] postulates of the quantum as the smallest existing energy packet, and physical reality as inherently indeterminate, lead to the rational absurdities of wave function collapse, half-alive-and-half-dead cats and non-existent Moons.

'As if'

The final question is:

> "Given that quantum physics is conceptually incoherent, how come it works so well in practice?"

The answer could be in "*as if*" terms. Given our innate perceptual threshold, for us it is *as if* the quantum/photon were the minimum existing energy packet, even if it isn't really. An electron for us is *as if* it cannot have both a precise velocity and a precise position, even if it can really. The Moon for us collectively is *as if* it doesn't exist when no-one is looking at it, even if it does really. Given wave function collapse, it is *as if* a measurement on a particle instantly determined the state of its distant correlated pair, even if it doesn't really[c]; and so on.

But if, as the Copenhagen Interpretation does, one takes these "as if"s to be "is really"s, then one comes up against that other "is really". Namely our classical everyday reality where things *are* conceived as having definite properties, even if we can't measure them precisely. And the Moon *is* conceived as still existing, even when no-one is looking at it.

Copenhagen trip

The effective root of the quantum-physical absurdities being the quantum/-photon taken as the *minimum existing*, rather than *our minimum observable* energy packet, one could reasonably say that:

quantum physics' problem is the quantum

Once, therefore, this prize quantum-physical sacred cow is sacrificed on the altar of a truly deterministic universe model, with continuous both wave and particle domains[d], everything clicks neatly into place.

---

[a] By the 1887 Michelson-Morley result 18 years before it was formulated! (Appendix, p.85)
[b] Being based on logical positivist dogma, and not scientific experiment.
[c] Both being in fact determined from the outset.
[d] Fig. 50.

The Great (Not-)Dice Player is restored to His heavenly throne, and physical reality back onto its classical pedestal. Ripe apples once again fall with reassuring Newtonian gravity onto the firm lawns of deterministic reality[a][93]. The Moon is there even when no-one is looking for it. Physical reality really exists. And as far as we are concerned this is the only universe there is.

The whole quantum-physical trip is then seen to have been just that: a mind-blowing "trip" that dissipated once the Copenhagen effect wore off, dumping us unceremoniously back where we are, always were, and always will be: namely right here right now in boring old classical everyday reality. (Oh dear! We hope we haven't been a spoil-sport.)

> "Science", said Isaac Newton[b], "was such a quarrelsome lady that one would rather deal with the law than with her."[c][94]

Erwin Schroedinger towards the end of his life:

> "I oppose not just a few special statements of quantum mechanics, but the whole of it. I don't like it. I'm sorry I ever had anything to do with it."[95]

(Anyone for physics?)

APPENDIX

(in alphabetical order)

Consciousness interpretation

In whatever way we conceive light, it behaves coherently for us according to that conception. If we ask to demonstrate its wave properties[d], it obligingly does so in a consistent replicable manner; and similarly for its particle properties[e]. In eraser experiments, the outcome depends on the availability *to us* of 'which-path' information[f] – whether *we* can know. And so on.

All of this could seem to support a *Consciousness Interpretation* of quantum physics: that human mental processes affect physical reality. As in Goswami's:

> "The Moon is only a transcendent possibility in spacetime, till consciousness collapses its probability function ..."[g]

---

[a] Adapted Paul Strathern words.
[b] Isaac Newton (1643-1727), English physicist.
[c] By some accounts Sir Isaac was none too unquarrelsome himself (Einstein article).
[d] By setting up a suitable experiment.
[e] Fig. 5b.
[f] pp.12,14
[g] p.28.

The objections to it are firstly the delayed eraser experiment showing that an observer's conscious choice has no effect[a]. The outcome is the same, independently of whether the 'erase-keep' decision is taken mechanically by a beam-splitter or consciously by a human experimenter.

Secondly, if human mental processes were to affect physical phenomena, there would have a corresponding *energy transfer* from a human brain to the physical equipment. This has apparently never been detected.

Thirdly, a non-physical mechanism would contravene a *continuous universe model* where everything physical derives from something physical[b]. And although as noted this model is not necessarily correct[c], it seems compatible with most things.

And lastly, Science on its own admission doesn't know *what consciousness is*. It has for instance been said to be:

– "The castle keep, the core essence of true mentality, that most central of mysteries."[96]
– "Perhaps as great a mystery as the origin of life itself."[97]
– "One of the most vexing of all questions."[98]
– "One of the most profound mysteries of existence."[99]
– "The greatest of all the problems confronting man."[100]
– "A riddle wrapped in a mystery wrapped in an enigma."[101]
– "How the subtle processes of the conscious Self came to be associated with a material structure, is beyond our comprehension."[102]

To which we can add T. H. Huxley's[d]:

> "How anything so remarkable as a state of consciousness comes about as a result of irritating nervous tissue, is as unaccountable as the appearance of the Djin when Aladdin rubbed his lamp."[103]

But if scientists don't even know what consciousness *is*, how can they then be telling us what it can and cannot do? (Good question!)

Duality/dichotomy

A visual analogue of a *duality* is the well-known 'vase][heads drawing' of Fig.54, due to the 19th century psychologist Max Wertheimer[e]. One experiences *either* a

---

[a] p.15.
[b] Consciousness being not-physical.
[c] p.37.
[d] Thomas Huxley (1825–1895), English biologist.
[e] Max Wertheimer (1880–1943), German-Czech psychologist, founder of Gestalt psychology.

vase, *or* two heads. But never both simultaneously; nor ever a half-way stage, a mixture of the two.

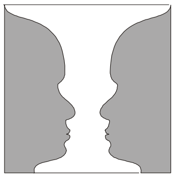

Fig.54. Vase][heads drawing.

The two perceptions are here *essentially analogous*, alternative views of the same thing. And we can comprehend rationally how they relate.

In the wave}{particle case[a], however, the two sides are *totally disparate*. A wave is an *event*, a function of time. A particle is a *material object* with no time dependency. Meaning that there can be no rational relation between them. This is why we call it a "dichotomy" rather than a "duality".

Intervention (1)

A 'law' is defined in the dictionary as "1) a rule established by authority; 2) a regularity in natural occurrences". A Law of Nature is the second kind, summarising our experiencing. When we say that according to the law of gravity[b] a glass knocked off a table will fall down and smash on the floor, this summarises our experiencing of such events to date.

Based on the Laws of Nature, we define *Interventio*n as anything contravening them:

Intervention = anything contravening the Laws of Nature

Should one day a glass knocked off a table float up to the ceiling, this would contravene the Laws of Nature and by definition be[c] Intervention.

A continuous universe model, that assumes that the Laws of Nature always hold, thus *inherently excludes* Intervention, divine or otherwise[d], Fig. 0-55a:

*continuity**:** excludes Intervention*

---

[a] p.7.
[b] One of the Laws of Nature.
[c] Be said to be (p.50, note).
[d] The 'continuity' and 'no-Intervention' principles are equivalent.

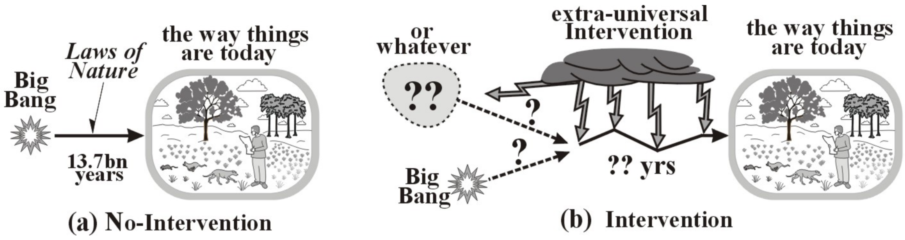

Fig. 0-55. Intervention.

Because if there *has* been Intervention, occasions on which the Laws of Nature weren't observed, then we effectively can't say anything definite about the past at all, not even if there was a Big Bang, Fig. 0-55b.

A continuous universe model doesn't therefore preclude a Big-Bang-creating Creator, personal or otherwise[a]. But it does require that, from our conceptual horizon[b] at 0.01 nanoseconds a.b.b. onwards, there has been no Intervention, no contraventions of the Laws of Nature.

Intervention (2)

To determine whether there has in fact been any post-Big-Bang Intervention, two kinds need to be considered. Firstly *blatant Intervention* that is obvious to everybody: seas miraculously divided to enable Chosen Peoples to escape from sticky situations they had got themselves into, etc. For many people there is ample evidence that such Intervention *has* occurred.

Others, however, maintain that all these things happened a very long time ago. And that our accounts of them have come down to us through generations of priests, clerks, scribes, etc, all with a vested interest in our believing in Intervention. And so are not conclusive.

The other possibility is *surreptitious* *Intervention* that occurred, but went unnoticed. A surreptitious Intervener's one-and-only act of Intervention could have been, on that very first-ever April Fool's Day (01/04/00 a.b.b.), to have surreptitiously nudged just one wee little electron just one wee little bit over to the left. Thereby, however, changing the whole subsequent course of the universe. And not leaving anyone the wiser, least of all us.

In practice, therefore, we cannot prove conclusively either that there *has* been Intervention or that there *hasn't*. So when in the early 19th century the first evolutionists came up with the idea that the universe hadn't been created during the

[a] He/She/It could have been responsible for the Big Bang.
[b] The earliest point at which the known laws of physics apply.

week ending 23rd October 4004 b.c, as was generally held till then[a], but had evolved slowly over a much longer period of time, one of the many creative arguments used by its creationist opponents was that the Creator had deliberately placed the rock-strata, fossils, etc. in the earth to confound future evolutionists, geologists, and others of little faith.

To this there is no answer. We live in the present, and no-one will ever return to the past to verify what happened there[b][104]. Any theories we construct about the past based on present evidence remain just that: *theories* about the past based on present evidence. And as such are subject to overthrow by any new evidence that might turn up tomorrow or sooner[c].

On the Intervention question, each has to make up his own mind. With the chagrin of knowing that he cannot prove himself right. And the consolation of knowing that he cannot be proved wrong.

Because neither the Intervention nor the no-Intervention hypotheses can be proved, to be fair *both* must be considered. However, if there *has* been Intervention, then to our fundamental philosophical question, that effectively lies behind all others:

> "Why are things the way they are?"

the answer is simply:

> "Because that is the way the Intervener wanted them. Or at least is prepared to tolerate".

If there *was* anything an omnipotent Intervener *wasn't* prepared to tolerate, He would change it there and then.

The only case worth discussing is thus the *no-Intervention* case, and is the one considered here. Remembering, however, that it is *only half the story*:

no-Intervention is only half the story

Michelson-Morley

Having been consistently scathing about Einstein's Relativity, we need to substantiate our remarks at least somewhat[d]. We will take the *aether* as a basis[e][105].

In his seminal 1905 Special Relativity paper "*On the Electrodynamics of Moving Bodies*"[a] Einstein wrote:

---

[a] The date calculated in 1650 by James Ussher, Archbishop of Armagh, Ireland, based on biblical genealogies.

[b] Spacetime article.

[c] Cf the above 'reality' discussion (p.57).

[d] Treated in more detail in the Aether and Relativity articles.

[e] For conceptual refutations (e.g. the clock absurdity), see the Einstein article.

"The introduction of a 'luminiferous aether' will prove superfluous."[106]

In the same article he states his 'invariant speed of light' postulate as:

"Light is propagated in empty space with a definite velocity *c* [in all inertial reference frames]."[107]

The aether's existence would firstly contradict Einstein's assertion that there is none. And secondly, would make the speed of light invariant in reference frames stationary in the aether only, and in no other.

Michelson-Morley[b] made a total of 36 sets of aether-wind measurements over four days in July 1887, during an hour at noon and an hour at six in the evening[108]. In 1998 Héctor Múnera reanalyzed their results using modern statistical methods. He found that they gave aether-wind speeds of, at a 95% confidence level[c]:

– midday readings: $v_{\in}$[d] $= 6.22 +/- 1.86$ km/s
– evening readings: $v_{\in} = 6.8 +/- 4.98$ km/s[109]

They are plotted in Fig. 0-56a[110]. And no way can be construed as "null within experimental error"[e].

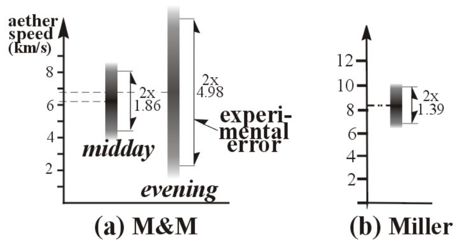

Fig. 0-56. Michelson-Morley, Miller results.

The Michelson-Morley result refuted Einstein's Relativity 18 years before it was formulated:

Michelson-Morley refuted Einsteinian Relativity18 years before it was formulated

In 1925-26 Dayton Miller[f] performed a similar series of experiments. But with a larger and more sensitive interferometer, and making ~12'000 sets of measure-

---

[a] Einstein 1905.
[b] Albert Michelson and Edward Morley.
[c] A 95% probability of the result not being due to chance.
[d] Using the subscript '$\in$' for 'aether'.
[e] The somewhat higher average value of the evening results, and their greater spread, are explicable (Aether article).
[f] Dayton Miller (1866–1941), American physicist and astronomer.

ments over the course of a year He concluded that the solar system moves through the aether at a speed[a]:

$$v_{S\in}{}^{b} = 8.22 \pm 1.39 \text{ km/s}$$

in an approximately southerly direction[c]. His results are summarized in Fig. 0-56b[d][111].

Einstein realized full well that, if valid, Miller's results would refute Relativity[e], writing:

> "*Not for one moment* did I take Miller's results seriously. I *assumed* that they were based on a fundamental error. Otherwise the Special Theory of Relativity, and together with it the General Theory in its current form, would both collapse like a house of cards. *Experimentum summus judex*[f]."[112] (italics ours)

Well! Miller's results *did* refute Relativity. But did it collapse like a house of cards? No way!

And if – as Relativity maintains – there is no aether and light is a "mediumless wonder", a disturbance of nothing propagating through nothing, then two highly pertinent questions are:

– 1) *what then determines* light's characteristic speed of c=300k km/s?
– 2) is it *simply a coincidence* that this is exactly the speed one would expect for an electromagnetic disturbance propagating though a medium with the electric and magnetic properties of a "vacuum"[g] [113]

Both these are excellent questions, to which Relativists have to date provided no coherent answers.

In spite of all of which, a recent Google search by the author[114] for "Michelson-Morley result" gave in order of appearance:

"The result was negative."
"There is no aether."
"The Michelson-Morley is a perfect example of a null experiment."
"There was no fringe shift."

---

[a] Having taken readings over a year, he could eliminate the effects of the Earth's orbit.
[b] Solar system with respect to the aether.
[c] (α=5.2, δ=–67^{o}). Towards the *Dorad*o (Swordfish) constellation in the Great Magellanic Cloud.
[d] Again at a 95% confidence level. His somewhat higher value than Michelson-Morley's is explicable.
[e] As did also Michelson-Morley's.
[f] "Experiment is the supreme judge."
[g] For which read "aether".

"Michelson found no evidence of the aether."

...

The *en.wikipedia* similarly "informs":

> "The Michelson–Morley experiment compared the speed of light in perpendicular directions in an attempt to detect the relative motion of the luminiferous aether ('aether wind'). The *result was negative*. They found *no significant difference* between the speed of light in the two directions. Such experiments have been *repeated many times* with steadily increasing sensitivity, confirming the *absence of any aether wind*."[115] (italics ours)

All of which, in the face of the experimental evidence[a], is simply *blatant lies*. The next question being: why does mainstream physics, a purportedly objective and experimentally based discipline, go the extreme of blatantly denying incontrovertible experimental evidence?

The answer once again seems to be *dogma*[b]. Einsteinian Relativity is today a "scientific fundamentalism", with a basic *credo*[c]:

Art.1) Relativity is correct
Art.2) Relativity is always correct
Art.3) Should, exceptionally,
Relativity be wrong,
arts 1) and 2) take immediate effect

Because the aether's existence would refute Relativity, according to this dogma there cannot therefore be an aether. (Q.E.D.)

Micro-, nano-photons

The micro- and nano-photon thought exercises are useful, but nevertheless somewhat artificial. With eyes sensitive to micro-photons it is questionable whether we would experience standard photons at all.

A "photon" could simply be the minimum radiation energy apprehended by a binary perceptual mechanism. With a micro-photon level sensory threshold, micro-photons could be the only "photons" we would experience. And similarly for nano-photons.

---

[a] Fig. 0-56.
[b] Cf logical positivism (p.77).
[c] Paraphrasing a sign about the boss that people sometimes stick up on their office walls.

Photon mass

It is currently fashionable is to say that photons are massless. Compton scattering[a], however, shows that they have *momentum*. And since in classical physics momentum is mass x velocity, in this respect it is *as if* they had mass.

Photons also have *energy*[b]. And on the $E=mc^2$ principle, it is again *as if* they had mass. The same holds for their deflection in a gravitational field[c][116].

One could say that photons have *no rest mass*. But since they are never at rest, always travelling at the speed of light *c*, this doesn't mean much.

We will treat photons *as if* they had mass. But won't stick our necks out by saying they actually have it.

Textile analogy

The textile analogy[d] illustrates the distinction between overall and closeup views. It is however somewhat unsatisfactory in implying that the closeup view[e] is the 'reality'. And that due to the eye's limited resolving power, the overall view is 'unreal'.

In the quantum domain[f] the opposite holds. Overall views are replicable, determinate and 'real'. While due to quantum measurement uncertainty, closeup views are indeterminate and 'unreal'.

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