THE COPENHAGEN TRIP

quantum physical wierdness explained away

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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 a) the quantum/photon is the minimum existing energy/matter packet; b) subatomic reality is inherently indeterminate. Neither is justified. The quantum could 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 be indeterminate. In each case there are two hypotheses, neither of which can be proved nor refuted, meaning that both must be considered. Mainstream QM fails to do this. The present article adopts a realist approach. Physical reality is conceived as essentially classical and determinate. But due to the limitations of our neurone-based perceptual mechanism, we experience it in terms of three 'perceptual categories': 1) 'classical', where observations don't affect the observed, and our knowledge is certain to within experimental error; 2) 'quantum' where they do, and our knowledge is uncertain; 3) a hypothetical undetectable 'subliminal substrate'. Our overall universe view is then inherently incomplete. Apparent quantum indeterminacy is then due to this. 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'. Being based on the differing ways in which we obtain knowledge, we call it the Epistemological Interpretation of quantum physics. It is conceptual and 98% non-mathematical.

CONTENTS

INTRODUCTION

WAVE}{PARTICLE (1)

PHOTON

WAVE}{PARTICLE (2)

COPENHAGEN INTERPRETATION

SUBLIMINAL SUBSTRATE

CONCEPTUAL

PERCEPTUAL CATEGORIES

PARTICLE ANOMALIES

CONTINUOUS UNIVERSE (2)

COPENHAGEN TRIP

APPENDIX

INTRODUCTION

General

Einsteinian[a] Relativity predicts 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 for 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[c2], 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 explanations. And to show further that the contradictions are essentially *illusory*, a consequence of our necessarily incomplete 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 are not in general *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 indisputably 'not-null' 1887 Michelson-Morley result (appendix p.83, Aether article).

same source. Their meaning is however never consciously distorted. Whenever possible original source references are given. Italics in general are "ours".

The English language in its wisdom not having provided us with non-gender-specific pronouns, 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 and go directly to the 'subliminal substrate' section on p.51.

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 Thomas Young[c] performed his classic *double-slit experiment*[3]. He shone a beam of light through two close narrow slits. With only one slit open, an image of it appears on the screen, Fig.1a. This is accounted for by light as a *stream of particles*.

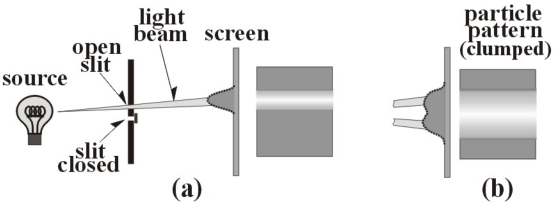

Fig.1. Double-slit experiment (1).

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.84.

[b] Rather than a "duality" (appendix p.84).

[c] Thomas Young (1773–1829), English phsician and polymath.

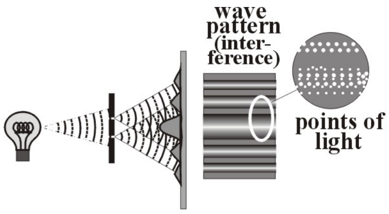

Fig. 2. Double-slit experiment (2).

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.

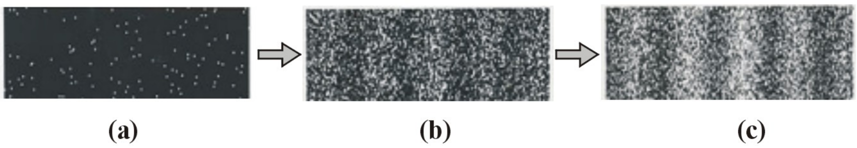

Fig. 3. Double-slit experiment (3).

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

particularity = *definite position*, *continuous existence*

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

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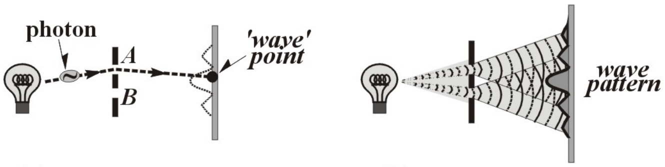
[a] With reservations for photons that we discuss below.

[b] Defined as "what is physically experiencible".

[c] One forming part of a 'wave' interference pattern.



(a) Individual photons (b) Overall result

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

This is distinctly wierd. The fundamental question being: what determines an *individual outcome*, an individual 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[4]. 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 its wave and particle properties simultaneously, 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*, Fig. 5a. A beam of light is shone onto a half-silvered mirror that reflects half the incident light and transmits the other half.

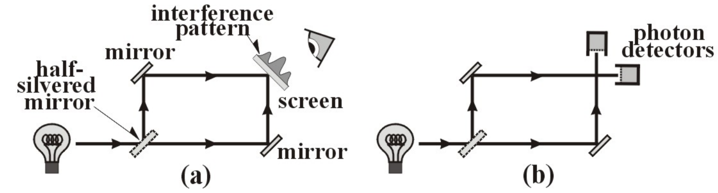


Fig. 5. Split-beam experiment.

When the two beams are brought together on a screen, they form an interference pattern as in the double-slit case, again showing 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][5]. 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* 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.

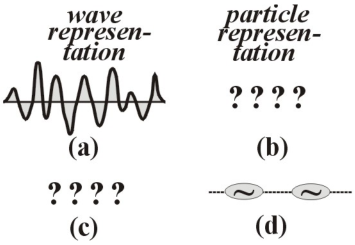


Fig. 6. Photon (1).

Our *everyday physical reality*[c] 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 by setting up a suitable experiment, it obligingly does so in a consistent replicable manner. And similarly for its particle properties.

It is *we* who have a consistency problem. Being unable to grasp how any component of our essentially coherent everyday reality can show contradictory behaviour. Richard Feynman[d] wrote:

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[a] Aether article.

[b] 'Matter-ial'. Made of matter, essentially protons, neutrons and electrons.

[c] Defined as "what we physically experience, either directly with the senses or indirectly via instrumentation".

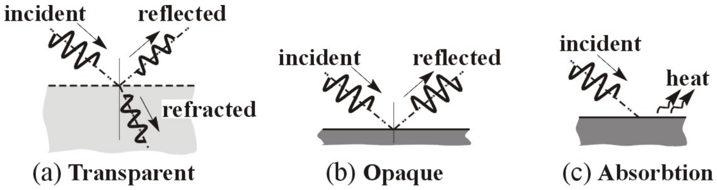
[d] Richard Feynman (1918-88), American theoretical physicist.

> "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."[6]

PHOTON

Reflection/refraction

Electromagnetic energy interacts with atomic matter in various ways. On a 'semi-classical' model, atoms can be visualized as nuclei with electrons attached to them by springs. Light falling on a material causes its electrons to *briefly vibrate*. The energy then being *re-emitted* as light at the same frequency. In transparent materials the re-emission occurs both externally (*reflection*) and also internally (*refraction*), Fig. 0-7a. Opaque materials exhibit external reflection only, Fig. 0-7b.



(a) **Transparent** (b) **Opaque** (c) **Absorbtion**

Fig. 0-7. Reflection/refraction.

But should the incident light hit the *resonant frequency* of an electron, it vibrates with a much larger amplitude, its motion then being passed onto neighbouring atoms and ultimately converted into *heat*, Fig. 0-7c. Light of that frequency is *absorbed*.

Photo-electric effect

At higher incident light energies[a] electrons, can be *ejected* from their atoms altogether giving the *photo-electric effect,* Fig. 0-8.

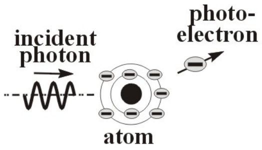


Fig. 0-8. Photo-electric effect.

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[a] Frequencies (below).

Compton scattering

Still higher incident light energies can result in *Compton*[a] *scattering*. In addition to an ejected electron, a *photon* with a lower frequency than that of the input is emitted, Fig. 0-9.

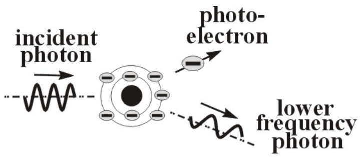

Fig. 0-9. Compton scattering.

The interactions have the nature of *collisions* between inelastic spheres, with the *conservation of momentum*[b]. With the difference that since photons always travel at the speed *c* of light, the lesser momentum of the emitted photon manifests as a *reduced frequency*[c] rather than a lower speed[d].

Photon detection

Photon detectors utilize a wide range of materials and techniques: semi-conductor, vacuum-tube, gaseous, etc. But all essentially use the photo-electric effect. Incident light displaces an *electron*, which is then 'multiplied' via avalanche methods to give a current impulse sufficient to produce an audible detector 'click'.

Detection efficiencies vary widely, depending on the method used, but never reach 100%. So there is always some *uncertainty*. No photon being detected doesn't necessarily mean there wasn't one. Typical efficiency curves[e] are shown in Fig. 0-10.

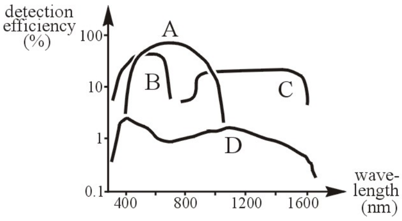

Fig. 0-10. Photon detector efficiency[7].

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[a] Discovered in 1923 by Arthur Compton (1892–1962), American physicist.
[b] Below.
[c] Below.
[d] Photon 'mass' is discussed in the appendix (p.88).
[e] The probability of a photon being detected.

Noting that all methods *absorb the original photon*, meaning that after detection it is no more. A photon-detector click says "That *was* a photon".

We can define a photon operationally as "the electromagnetic energy that gave a photon detector click":

photon: gave a photon detector click

Parametric down-conversion

A further effect used in photon 'detection' is *spontaneous parametric down-conversion* (SPDC). A photon fired at a non-linear crystal[a] generates *two output photons* – conventionally called the 'signal' and the 'idler' – each with half the frequency of the original[b], Fig. 0-11.

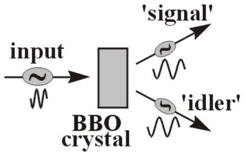

Fig. 0-11. SPDC.

Detecting an idler 'heralds' the existence of a signal photon without destroying it.

Photon-photon

Photons being chargeless, they don't in general interact with each other[8]. If two beams of light are shone in opposite directions down tubes, as in Fig. 0-12, no evidence of scattering due to photon-photon collision is observed on the screen.

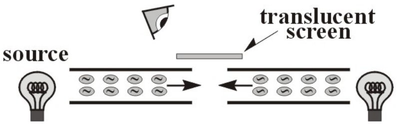

Fig. 0-12. Photon-photon interaction.

Wave}{particle (1)

Compared to the wavelength of light, 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. And waves in general *don't interact*. They *superimpose*, passing through each other and continuing on their way as if nothing had happened.

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[a] For instance a 'BBO' (beta barium borate) crystal.
[b] Energy conservation.

Absorbtion, the photo-electric effect and Compton scattering are all *discrete particle behaviour*, that cannot be represented on a wave model.

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 in particle terms. 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 also wave properties.

Light 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.

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[9]. 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 reality would appear as no more than a vague wispiness.

It is therefore hardly surprising to find that subatomic matter[b] doesn't always conform to models derived from our classical everyday reality:

subatomic matter: *cannot always be expected to conform to classical models*

In spite of the apparent equivalence of the wave and particle representations, however, 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.

What we strictly have is a wave}{*"particle"* dichotomy, between classical waves on the one hand, and not-so-classical "particles" on the other:

wave}{"particle" = classical waves}{not-so-classical "particles"

We will thus conceive light as *being really* waves, but that *interact* with charged particles[c] in a "particle"-like way[d]:

light: *waves that interact with electrons in a "particle" -like way*

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[a] Below.

[b] 'Subatomic' is discussed below.

[c] In practice: electrons.

[d] The Compton effect (p.9).

For simplicity we will however continue to talk of a "wave}{particle"[a] dichotomy. And will conceive a photon as the electromagnetic energy packet[b] that interacts with an electron:

photon = electromagnetic energy packet that interacts with an electron

We discuss all this further below.

Wave-packet

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[c] km/s, Fig. 13a.

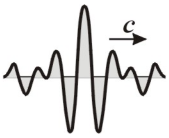

Fig. 13. Photon (2).

Waves[d] having *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'[e], being conceived as occupying the whole of space, one essentially has to define the state of this, and not just the region adjacent to the wave-packet.

Mathematically, 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[f]. Those of Fig. 14b, for instance, give the wave-packet of Fig. 14a[g]. Where the component peaks coincide, there is a peak in the resultant. Where they cancel out there is a zero. The components and the resultant all travel at the same characteristic speed *c*.

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[a] Rather than "wave}{"particle"".

[b] Next section.

[c] 'k' = thousand, 'mn' = million, 'bn' = billion.

[d] Discussed in detail in the Aether article.

[e] Defined for present purposes as "that which light is conceived as a disturbance travelling through".

[f] Fourier's theorem.

[g] Illustrative. To zero a single wave-packet over the whole of space would require an infinite number of components with at the limit infinitely small magnitude.

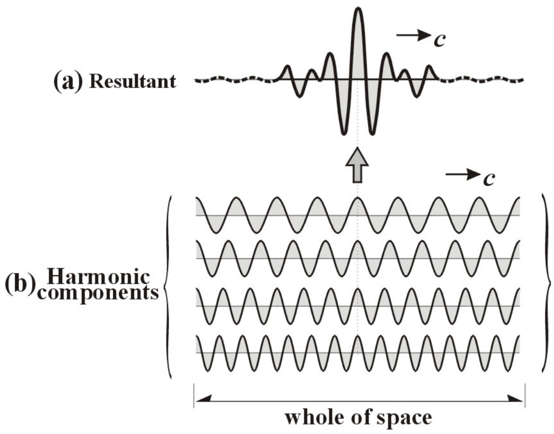


Fig. 14. Photon (3).

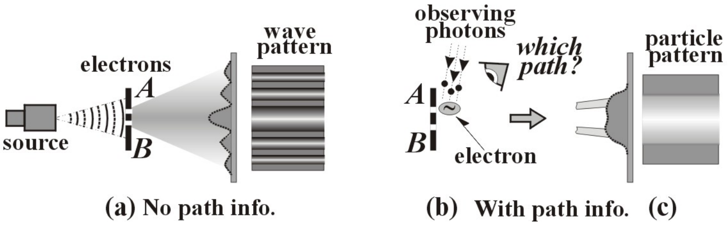
A wave being an *event*, a disturbance propagating though a medium, and not itself a material object, to experience[a] one implies experiencing its medium. We experience the water medium and we see water waves. We don't experience the light medium, the hypothetical aether, and we don't see light waves.

No-one therefore ever saw a photon wave-packet as such, for instance as a trace on an oscilloscope screen. Fig. 14a is what we *imagine* such a light wave-packet would look like *if* we could see one, which we inherently can't.

WAVE}{PARTICLE (2)

Which path?

Imagine a double-slit experiment, but now with *electrons* rather than photons as the object particles, Fig. 15a. And that we wish to determine which slit an individual electron went through, obtaining so-called *which-path information*.



(a) No path info. (b) With path info. (c)

Fig. 15. Which path? (1).

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[a] As always: experience *physically* (p.5, note).

We fire a beam of observing photons at the slit region, Fig. 15b. And find that electrons exhibit particularity[a]. Individual electrons pass through either one slit or the other, but never both simultaneously. And cause one and one only screen point. But we now find that the previous wave interference pattern *vanishes*, being replaced by a clumped particle pattern, Fig. 15c[b].

The same applies to the split-beam experiment. If in the 'wave' set up of Fig. 5a we determine which path an individual photon took, the 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-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[c], 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 *eraser experiments*. A simple setup is shown in Fig. 16a. Rather than obtaining the which-path information directly, the photon detector output is *recorded*. As expected[d], a clumped 'particle' pattern is found.

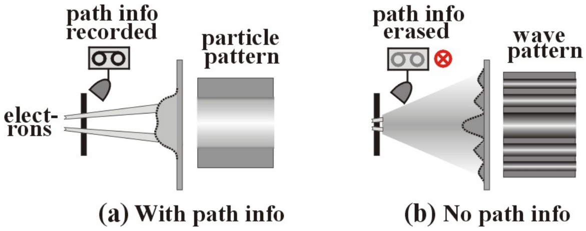

Fig. 16. Simple eraser.

But should the recording be *erased*, Fig. 16b, 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

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[a] p.5.

[b] Cf Fig.1b.

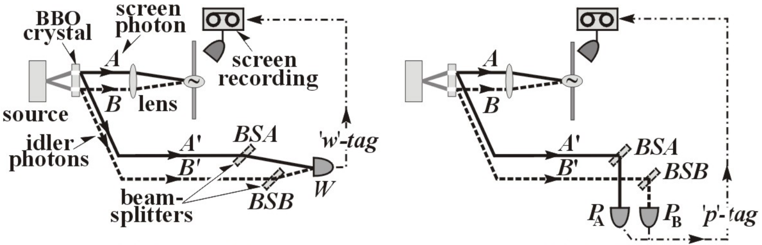
[c] Below.

[d] 'Which-path' information being available (below).

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[a] has hit the screen, we get the same result. A corresponding experimental set-up is shown in Fig. 17.



(a) ***'transmit'*** **(b)** ***'reflect'***

Fig. 17. Delayed eraser (1).

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

Of such a pair, the *screen*[e] *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[f] 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[g] is presumably registered.

Somewhat later the associated idler photon *A'* arrives at the beam-splitter *BSA*. Should this *transmit*[h], the photon is directed to photon detector *W*. Because a slit *B*

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[a] Now again the object particles.
[b] p.10.
[c] A gap in the crystal lattice.
[d] Energy conservation (eq.4, p.22 below).
[e] 'Signal'.
[f] p.6.
[g] One forming part of an overall 'wave' interference pattern, Fig. 16b.
[h] Fig. 17a.

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'*[a].

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

Once sufficient measurements have been made, the screen positions of the '*w*' and '*p*' tagged points are plotted separately. The former are found to give an interference 'wave' pattern, Fig. 18a. And the latter a clumped 'particle' pattern, Fig. 18b.

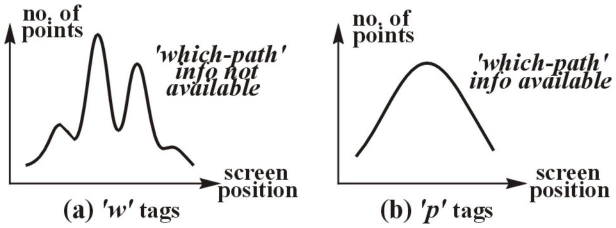


Fig. 18. Delayed eraser (2).

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

> "It's not the detector that is causing the collapse[f]. It is the *fact that we can know*."[10]

The questions here are:

- 1) how do the correlations arise, given that the *'w'* and *'p'* tags are attributed firstly r*andomly*[g]. And secondly, *after* the respective screen points have been recorded?
- 2) again, how can the *availability of abstract which-path information* determine a *concrete physical result*, a screen pattern[h]?
- 3) in the case of a *'p'* tag: how did the screen point end up as 'particle', when a

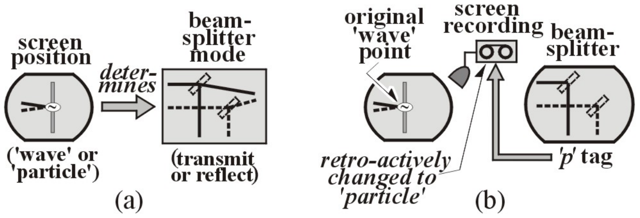
---

[a] For 'wave'.
[b] Fig. 17b.
[c] For 'particle'.
[d] Fig. 16.
[e] 'Wave' (interference, Fig. 2) or 'particle' (clumped, Fig.1b).
[f] Wave-function collapse (below).
[g] Depending on whether a beam-splitter transmits or reflects.
[h] Cf p.14.

> 'wave' point was presumably originally recorded[a] – apparently *changing the past*?

This last idea is however nonsensical. As is seen in the classic 'grandfather paradox'[b][11].

One possible explanation is that the screen-photon position *determines* the respective beam-splitter mode[c], and hence the screen point tag, Fig. 19a. A corresponding physical mechanism can however hardly be conceived.



(a) (b)

Fig. 19. 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. 19b. But again, how this could occur in practice is scarcely imaginable.

A further possibility is that *some unknown factor*[d] determines both the screen position and the beam-splitter mode, Fig. 20. But *what* (or *Who*) could this factor be? None of these "explanations" makes any rational sense.

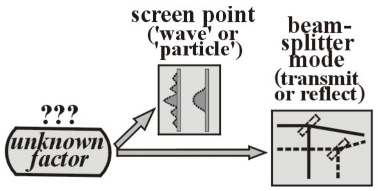


Fig. 20. Unknown factor.

Noting that any hypothetical 'changing the past'[e] cannot be observed in practice. Principally because the presumed original wave point only exists over the nano-second interval between the screen photon hitting the screen and the respec-

---

[a] No 'which-path' information being available at the time of recording.

[b] SpaceTime article .

[c] 'Transmit' or 'reflect'.

[d] In QM jargon this would be called a "super-deterministic" model.

[e] Fig. 19b.

tive idler photon being reflected by a beam splitter, giving which-path information. In any case, the nature[a] 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 *consciously* by the experimenter, who can choose whether to insert a polarizing filter erasing the 'which-path' information[12].

But since the results are essentially the same in each case, 'observer consciousness' (whatever that might be[b]) has no effect.

Polarization

Light comprises longitudinally-propagating transverse electric and magnetic fields, Fig. 21. As such it can be *polarized* so that rather than being randomly oriented, the fields of individual photons all act in the same directions[c].

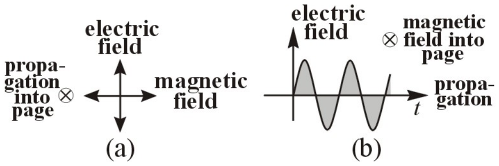


Fig. 21. Light.

Consider a beam of unpolarized light impinging on a *polarizer filter* whose output is a beam of intensity I_0 polarized at an angle θ to the vertical, Fig. 22a[d].

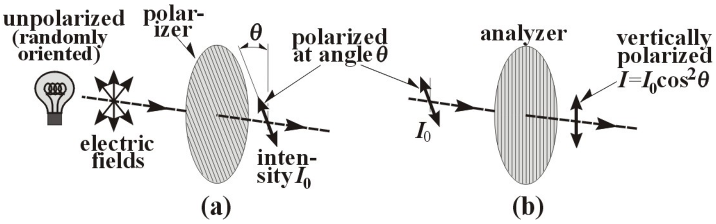


Fig. 22. Polarization (1).

Pass this polarized beam through a second, vertically-oriented *analyzer filter*, Fig. 22b. The output intensity I is found to be [a]:

---

[a] 'Wave' or 'particle'.

[b] Appendix p.83.

[c] The electric field is normally taken as the reference.

[d] The polarizer lines are for clarity shown in the direction of polarization. The string-like molecules of physical absorbtion polarizers run perpendicular to these.

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

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

Now repeat the experiment with *single photons*, Fig. 23.

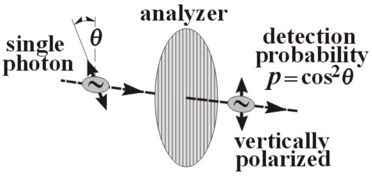


Fig. 23. Polarization (2).

On a classical approach, one would expect output photons with a reduced intensity (energy) and hence a *lower frequency*[d]. What we in fact 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[e] being the same as the intensity relation for a strong beam[f], summing the results for a large number of photons gives the overall value.

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

$$\textit{overall result} = \Sigma(\textit{individual measurements})$$

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

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

fractional amount ⇒ *fractional probability of the full amount*

---

[a] Malus' law.

[b] I_0 and I.

[c] Here the input beam.

[d] eq.4 (p.22 below).

[e] eq.1.

[f] eq.2.

[g] Assuming 100% detection efficiency, which in practice is never the case (Fig. 0-10).

This too is distinctly wierd. The question again[a] being: what determines an *individual outcome*, 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 be determined. Detecting an output photon only tells us that the input photon axis was not exactly perpendicular to that of the analyzer[b]. Detecting no output photon only tells us that the two axes were not exactly aligned[c].

Electron spin

An analogous case is *electron spin*. Electrons behave as little magnets, Fig. 24a. When subjected to a strong magnetic field they flip into line with it with the emission of a *photon* of radiation energy, Fig. 24b.

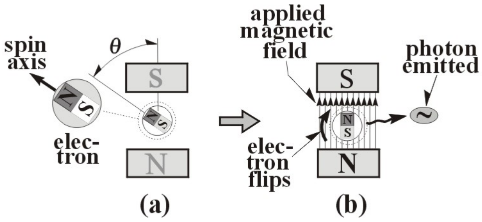
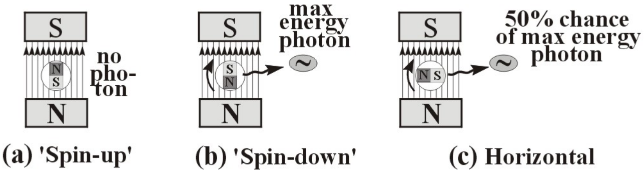


Fig. 24. Electron spin (1).

An originally 'spin-up' electron[d] never results in an output photon, Fig. 0-25a. An initially 'spin-down' electron[e] always emits a maximum energy photon, Fig. 0-25b.



(a) 'Spin-up' (b) 'Spin-down' (c) Horizontal

Fig. 0-25. Electron spin (2).

For an electron with an initial axis at an intermediate angle θ[f], one would again[g] expect an intermediate-energy lower-frequency output photon. But here too, things

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[a] As for the double-slit experiment (p.5).

[b] When no output photon is ever detected.

[c] When an output photon is always found.

[d] One whose original axis is aligned with the applied magnetic field (up-pointing north-pole).

[e] One whose original axis directly opposes that field (down-pointing north-pole).

[f] Fig. 24a.

[g] As for polarization.

in the subatomic domain being quantized, what we in fact get is *either* a full-frequency photon[a], *or* none at all[b], with a probability p given by:

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

For an initially spin-up electron, no output photon is ever detected[c]. For an initially spin-down electron, one is always found[d]. For an electron with an initially horizontal axis[e], there is a 50% probability of detecting an output photon. And so on.

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

Spin measurements likewise[f] inherently disturb the measured object. A measurement on a given axis aligns the electron with it[g]. 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?[h]
– 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?
– 3) also in this experiment, what determines an individual outcome, the screen position of a single photon?[i]
– 4) for polarization and electron spin: what determines an individual outcome, whether an output photon will be detected?[j]
– 5) in eraser experiments: how can the availability of abstract information determine a concrete physical result, a screen pattern?[k]
– 6) in the delayed eraser case: how do the correlations arise, given that the *'w'*

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[a] 'Spin-down', Fig. 0-25b.
[b] Spin-up', Fig. 0-25a.
[c] Fig. 0-25a, θ=0°.
[d] Fig. 0-25b, θ=180°.
[e] θ=90°, Fig. 0-25c.
[f] As for polarization (p.19).
[g] Fig. 24b.
[h] p.6.
[i] Fig. 4a.
[j] pp.6, 20, 21.
[k] pp.15, 16.

and *'p'* tags are attributed randomly[a]

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

Since all of these 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 its emitted radiation. The current theory could not, however, explain the respective frequency spectrum.

Fig. 0-26. Max Planck[13].

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

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

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

---

[a] p.16.

[b] p.16.

[c] Max Planck (1858–1947), German physicist.

[d] Later identified as atoms, which only started to be conceived in their present form after Rutherford's 1911 discovery of the atomic nucleus.

[e] From the Greek *quanta* ('quantity').

[f] The two are equivalent.

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

Uncertainty (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. 27. Niels Bohr[14].

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 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[15]. Although no longer quite as 'orthodox' as it used to be, it is still the main contender[d][16]. 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[17]. 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. 28. This locates the atom in space.

---

[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).

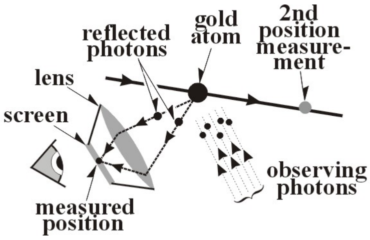

Fig. 28. Uncertainty (1).

Should we also wish to know the atom's velocity[a], we repeat the process at a later instant and divide 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. 29.

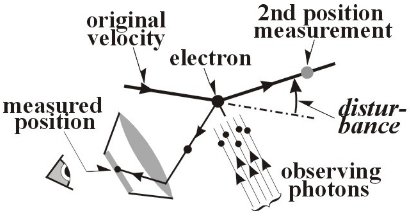

Fig. 29. Uncertainty (2).

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. 30a, for instance, strikes the electron more directly and causes a greater deflection than that of Fig. 30b.

---

[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.

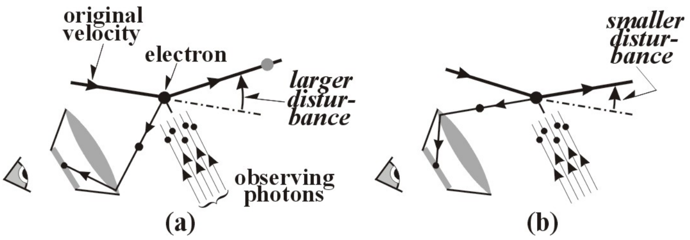

Fig. 30. Uncertainty (3).

A more fundamental consideration is that to determine the exact initial state of the *observed object* (the electron), we would need to know the precise states of the *observing objects* (photons). This then gives us the same problem: that of determining the state of a quantum 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 momentum[a] uncertainty Δp and the position uncertainty Δx, is given by[b]:

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

where h is Planck's constant[c].

As an analogy, imagine photographing a moving car. A slow shutter speed gives a blurred image, but whose extent enables the car's velocity to be estimated, Fig. 31a. It however gives no exact value for the position. Whereas a fast shutter speed gives a clear image and a precise position, but little or no indication of the car's velocity, Fig. 31b.

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

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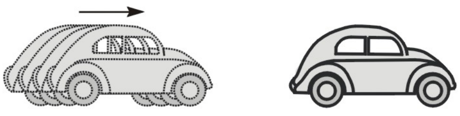
[a] p.24, note.
[b] ≥' = greater than or equal to.
[c] p.22.



(a) Slow *shutter speed:* (b) Fast

Fig. 31. 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 – quantum particles. In this case by using other quantum particles that disturb the first.

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 it I can measure with certainty down to the nearest tenth of a millimetre. But after that uncertainty rules, so to speak.

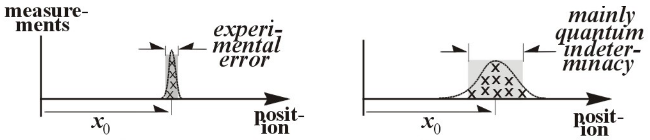
As for electrons, the indeterminacy derives from the *observational threshold*, the minimum observable quantity, there the quantum/photon and here the rule's smallest subdivision:

uncertainty/indeterminacy $\Leftarrow$ *observational threshold*

Experimental error

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

Position measurements on a classical object like a gold atom, for instance, give results as in Fig. 0-32a. The whole spread is here due to experimental error.



(a) Gold atom (b) Electron

Fig. 0-32. Position uncertainty.

Whereas position measurements on an electron give results as in Fig. 0-32b. The spread here includes *some* unavoidable experimental error. But is mainly due to quantum uncertainty.

In general, repeated measurements of a quantity that varies randomly about a mean give the "normal", or "bell", curve of Fig. 0-33. It is characterized firstly by its *mean value* x_0. And secondly by its *standard deviation* σ, given by:

$$\sigma = \sqrt{\frac{\Sigma(x-x_0)^2}{\mathrm{n}}} \qquad \text{(eq.6)}$$

where x is an individual measurement and n their total number.

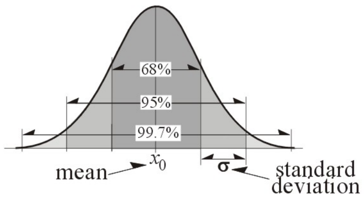


Fig. 0-33. Normal/bell curve.

68% of measurements fall within one standard deviation from the mean. 95% within two deviations. And 99.7% within three.

Any further measurement then has a *65%* probability of falling within the range $x_0 \pm \sigma$; a *95%* probability of falling within the range $x_0 \pm 2\sigma$; and so on.

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

"to within experimental error"

Classical/quantum

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

The terms 'certain', 'determinate', 'replicable', 'predictable', 'classical', etc. are effectively synonymous. The position of a gold atom is determinate[a], and hence replicable, predictable and classical for us[b]:

certain = determinate = replicable = predictable = classical

The same holds for their opposites. A quantity with a random component is to the extent of that randomness 'uncertain', 'not-replicable', 'unpredictable', 'indeterminate' and 'quantum' for us.

---

[a] Defined as "determinable with certainty" (ignoring experimental error, p.26).

[b] 'Determinacy' terms always carry an implicit "for us"

'*Objective*' is analogous, defined in a dictionary as "external to the mind, uncoloured by feelings or opinions". An individual mind being *personal*, as are also feelings and opinions, 'objective' is "impersonal, not pertaining to a specific individual":

objective = impersonal, not pertaining to a specific individual

The position of a gold atom[a] is replicable by anyone using any valid experimental procedure, and so is impersonal. Whereas the position of an electron is not. Firstly because the observing photons disturb it in a random manner. And secondly, because the result depends on the observing photon frequency, which is chosen by the experimenter. Making the setup *personal* and *unobjective*[b].

Such cases are *self-dependent*: the result of the observation depends on the the way it is performed, i.e. on itself,:

*self-dependence**:** the result of the observation depends on itself*

Noting that the terms 'subatomic' and 'quantum' are not synonymous. Protons and neutrons are subatomic particles. But having masses an order of magnitude greater than that of an electron[c], they are undisturbed by observing photons, and effectively classical.

Quantum objects are in practice restricted to *electrons*, and to a certain extent *photons*. Though with reservations with regard to the latter that we discuss below[d].

Photon ratio

Protons, water molecules, and even heavier objects can as seen[e] exhibit double-slit interference, with the wave behaviour becoming 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:

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

The lighter the observed object, the lower its photon ratio, the greater the measurement disturbance, and the more evident is 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, and although they still act principally as particles, they more readily

---

[a] Here visualized as suspended in thin air. Cf Fig. 28.

[b] We discuss self-dependence further below.

[c] For a single proton or neutron: about two thousand times.

[d] Cf p.5, note.

[e] p.6.

show wave phenomena. Whereas for unity-photon-ratio *photons* the wave and particle behaviours are in equal evidence, as is seen in double-slit and split-beam experiments[a].

This is resumed in Fig. 34.

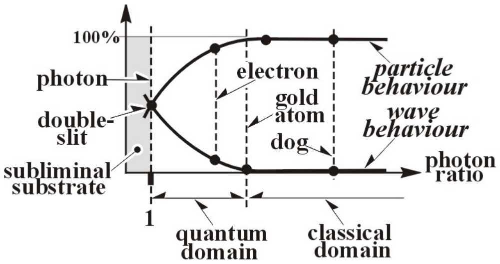


Fig. 34. Photon ratio.

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.

Due to the low photon ratios of quantum objects[d], we cannot determine their precise individual states. By making measurements on *large numbers* of them, however, we *increase their effective mass*, and for practical purposes turn them into a *classical object* where quantum uncertainty averages out:

many measurements ⇒ *classical object*

Uncertainty (2)

Returning to the question of what determines the outcomes of individual quantum measurements[e], the Copenhagen answer is very simple: *nothing does*. According to it subatomic reality is *inherently indeterminate*, and before being measured has *no definite pre-existing properties*. It is the *measurement itself* that creates the reality being measured:

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

John Wheeler[f]:

---

[a] Fig.1, Fig. 2, Fig. 5.

[b] Below.

[c] In the sense of determining their individual states.

[d] A quantum object being by definition one with a low photon ratio.

[e] Particle anomaly no. 3) (p.21).

[f] John Wheeler (1911–2008), American theoretical physicist.

> "No elementary phenomenon is *real until it is observed*. Quantum phenomena are neither waves nor particles, but until measured are *intrinsically undefined*."[18][a]

John von Neumann[b]:

> "Physical objects *don't have any attributes* unless a conscious observer is looking at them".[19]

Fritjof Capra:

> "Heisenberg's Uncertainty Principle says that one can never measure with accuracy both the position and the velocity of a [quantum] 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."[20]

David Lindley[c]:

> "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*."[21]

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." [22]

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

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

---

[a] Italics in general being "ours" (p.4).

[b] John von Neumann (1903–1957), Hungarian mathematician and physicist.

[c] David Lindley (1956–), English theoretical physicist and scientific author.

[d] Stephen Hawking (1942–2018), English theoretical physicist, cosmologist and popular author.

[e] 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]."[23]

If things only exist when observed, 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."[24]

David Mermin[e]:

> "We now know that the Moon is *demonstrably not there* when no-one looks".[25]

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? "[26]

Wave-function collapse (1)

Imagine an electron pursuing an essentially linear path, Fig. 35. A state measurement[f] is made at point A.

---

[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.83).

[d] Below.

[e] David Mermin (1935–), American quantum physicist.

[f] Velocity (momentum) and position (p.24).

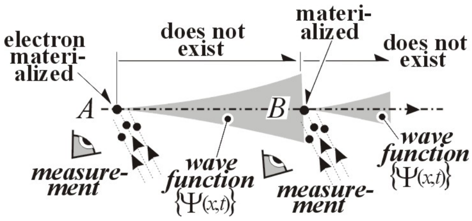


Fig. 35. Wave function collapse.

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].

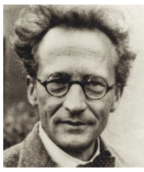


Fig. 36. Erwin Schroedinger.

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

$$i\text{h}\frac{\partial\Psi(x,t)}{\partial t} = -\frac{\text{h}^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial^2 x} + V(x)\Psi(x,t) \qquad \text{(eq.6*7)}$$

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. And so on over as many observations as one cares to make.

Heisenberg:

---

[a] Cf Goswami, p.31.

[b] Erwin Schroedinger (1887–1961), Austrian theoretical physicist.

[c] The probability of finding a particle at a point is 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."[27]

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*."[28]

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 the idea of wave function collapse, "as a ludicrous example"[b][29] 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. 37. 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.

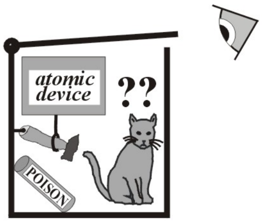


Fig. 37. Schroedinger's cat.

The question then 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."[30]

---

[a] Measurements being essentially 'particle' (p.65).

[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 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."[31]

Measurement creates reality[a]. 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[b][32]:

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

Amazingly, in spite of its contorted conceptual structure, quantum physical answers *do* in practice come out right – and 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[c]. But merely a probability wave, a range of transcendent possibilities in spacetime unmanifest in physical reality. Till a 'measurement'[d] concretizes it as a material object.

In the double-slit experiment[e], 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[f].

---

[a] p.29.

[b] Attributed to David Mermin.

[c] Cf Wheeler, p.29

[d] E.g. a screen observation.

[e] Fig. 2.

[f] Fig. 15a.

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 has not yet been observed, the electron continues as an abstract probability function. Should the recording then be erased, there is no 'measurement', and the electron continues as a wave, manifesting as a wave point when observed at the screen.

In the delayed eraser experiment, before anyone has seen the recorded screen points, they are simply abstract probabilities. When they are later plotted and observed, the locations for which no 'which-slit' 'particle' information is available[d] concretize as default wave points. And those where this 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 that all this is not to *defend* the Copenhagen Interpretation. But simply 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. Then it is temporarily suspended, and collapses everywhere except at a random point."[33]

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.

---

[a] Fig. 15b-c.

[b] p.18.

[c] p.21.

[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[b]. 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 no measurement has been made. But in this case there is *no materialized object* in the observing photons' path. But only a range of transcendent probabilities unmanifest in spacetime.

Wave function collapse 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."[c]

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

Copenhagen 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 stuff up. It pertains to their measurement problem[d].

Einstein held that:

---

[a] Fig. 28.

[b] pp 14, 16.

[c] A somewhat indeterminate statement, as befits Copenhagen indeterminacy (p.30).

[d] p.35.

> "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."[34]

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."[35]

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 nothing physical 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 symbols[c].

The question then is: how can a *set of abstract symbols* "collapse" into a material object like an electron? This is another good one for Niels' and Werner's question time. And another aspect of their measurement problem.

Even if the Schroedinger equation *was* an actual physical wave[d], it would still be an *event*, a function of time[e], and not itself a concrete object. The corresponding question would be: 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.

---

[a] Mainstream Science's preferred way of dealing with inconvenient data.

[b] Goswami (p.31).

[c] eq.6 (p. 32).

[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 with opposite spins[a], Fig. 38a.

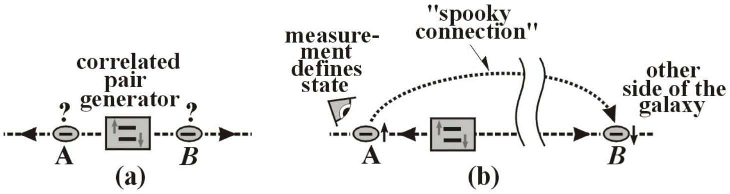


Fig. 38. Entanglement.

We don't know what the spins of the individual electrons are. But we do know that because they are complementary, if electron A is found to be 'spin-up' on some axis, 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 possibly obtain either spin polarity[d]. But should A make a measurement on his electron and find it to be for instance 'up', this would collapse the common wave function. And would mean that from that instant on B could only measure 'down' – even if he was on the other side of the galaxy, Fig. 38b. 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]."[36]

---

[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.29.

[d] Except in the limiting cases of initially completely spin-up or spin-down electrons (Fig. 0-25a,b).

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

[f] The common wave function collapses instantaneously at all points in space.

[g] Cf Bohr, p.30.

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

Fig. 39. Bohr x Einstein[b][37].

Far from demonstrating the incompleteness of the Copenhagen Interpretation, however, as Einstein had intended, 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."[38]

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"[39]

the spooky connection is evidently the official Copenhagen line.

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

> "No deterministic local 'hidden variables' theory[f] can reproduce the statistical predictions of quantum mechanics."[40]

And is further held to have been:

---

[a] Einstein, Podolsky and Rosen.

[b] At the 1927 Solvay conference.

[c] Literally: 'being no place'.

[d] John Bell (1928–1990), Irish particle physicist.

[e] Aka "Bell's inequality".

[f] Below.

> "Verified by a series of experiments[a] showing that entanglement does in fact occur over large distances."[41]

We[b] however predictably won'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 and no spooky connection. And as just seen[c], the idea of wave function collapse is highly suspect – to say the least.

And secondly, non-locality is incompatible with a *continuous universe* model where effects propagate at *finite speeds* determined by their respective media[d]. The continuous model is not of course 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 and 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". When in fact the result *wasn't* 'null'. And *this* has been verified by a series of experiments[e][42].

We therefore take the "verified by a series of experiments" assertion with a 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 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 an individual case probability predictions are *unfalsifiable*. And hence on Karl Popper's[g] "falsifiability" principle [a] are meaningless.

---

[a] Notably by Alain Aspect et al. in 1982.

[b] I-the-author (p.4).

[c] p.36.

[d] Below.

[e] Discussed further in the appendix (p.83).

[f] p.38.

[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 overall 'many measurements' cases where quantum physics is effectively classical[b], and can make falsifiable predictions, it is rational and complete. In individual single-particle cases 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]

But 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 generally 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 an abstract representation of a minor part of it, is to put the cart before the horse:

---

[a] That to be meaningful a scientific theory must be falsifiable, capable of being proved wrong.

[b] p.29.

[c] p.45 below.

[d] p.47 below.

[e] p.22.

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 mistress to a Swiss Alpine resort, and came back with the wave equation[43]. 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."[44]

As to the equation's *meaning*, Max Born[c] later "interpreted" its magnitude at a point to represent the probability of finding a particle there. But this also seems to have been plucked out of thin air, with no scientific derivation or justification. And 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."[45]

The same holds for 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"[46]

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."[47]

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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 essentially 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][48].

Susskind's "deduction by guessing"[b][49] nicely sums up this particular aspect of scientific methodology.

In general, mathematics is an essentially "mechanical" means of manipulating abstract relations, and as such *cannot go beyond its initial data*. Given for instance that x=1 and y=2, mathematics can tell us things like $x+y$=3, $x-y$=–1, etc. But it cannot introduce anything new:

mathematics: cannot go beyond its initial data

Should it transpire from later experiment that $x+y$ is *not* always equal to 3, then there is evidently something missing. But what? Well, there's obviously no point looking for it in the maths. Only *experiment* can provide an answer. Henri Poincaré[c]:

> "Experiment is the *sole source* of truth. *It alone* can teach us something new and give us certainty."[d][50]

Niels Bohr:

> "Mathematics in the final analysis is a *mental game* that we can *play* or not as we choose."[51]

So when Stephen Hawking stated that:

> "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."[52]

this was totally unjustified. Something being *mathematically possible* doesn't necessarily make it *physically feasible*. A reasonable solution to Newton's second

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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').

law of motion has also been found, allowing a body with negative mass to accelerate in the opposite directions to the force applied to it. Even though to date this has never been actually observed.

Hawking's argument also evidently assumes that General Relativity is correct, which it isn't[a][53].

Further, the *complexity* of the mathematics in much of contemporary quantum physics readily lends to *obfuscation*[b]. On submitting quantum-physical questions to a certain Internet physics forum, the author for instance normally ended up getting 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 which, mathematics is *essentially irrelevant* to the basic quantum-physical questions under discussion here. Richard Feynman noted that the double-slit experiment "has in it the heart of quantum mechanics and contains the only mystery[c]". The double-slit experiment 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]

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

Quantum physicists might explain that what they *really* mean is that if one makes a measurement, there is a custom *probability* of finding the object either here or there. But that is not the same. And if this is what they *do* mean, why don't they say so in clear everyday language, rather than enshrouding it in meaningless obfuscation (rhetorical question)?

A further example is David Mermin's above:

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

---

[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.7).

[d] p.33.

"Demonstrate" derives from the Latin *demonstrare*: 'to point out'. And necessarily involves at least two 'lookers': a demonstrater and a demonstratee. There is inherently 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*[b] of a scientific discipline can make a logically nonsensical statement, and apparently get away with it, one could well say that discipline has credibility problems. And could say that again. David Albert[c]:

> "The Copenhagen Interpretation is not just weird. It's unintelligible gibberish."[54]

That too is something you can say 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."[d][55]

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

> "I hesitated to think it was wrong. But I knew it was rotten."[56]

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[f]

In the double-slit experiment of Fig. 15b, a photon was detected at slit A. Why wasn't it slit B? Hugh Everett[g] had a creative answer. *Both* possibilities occur, he said, but in different universes. This is the *Parallel Universes*, or *Many Worlds Interpretation* of quantum physics. Lindley:

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[a] p.31.

[b] Grand old man.

[c] David Albert (1954–), American physicist and philosopher of science.

[d] In a letter to a friend. (One could query the "intelligent" bit.)

[e] Of Bell inequality fame (p.39).

[f] An alternative to the Copenhagen Interpretation, included here for convenience.

[g] Hugh Everett (1930–1982), Princeton University physicist.

> "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 that happens. In the other universes our counterparts are seeing one of the other results. And so on through as many universes as you like."[57]

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. Rupert Sheldrake[a]:

> "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. "[58]

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."[59]

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

---

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

[b] p.38.

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.

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* is 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 now 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."[60]

Fritjof Capra[e]:

---

[a] "Is conceived as being". 'Is' and 'are' normally have this sense.

[b] Idem. We won't push the point any further.

[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."[61]

In a continuous 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 radiation similarly propagates through its 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 to assert that it "really is" this way. It is a *model*, a way of thinking that we adopt in our attempt to make overall sense of things, to fit them into a coherent conceptual structure:

model = way of thinking about things

So when we *say* that the Big Bang "caused our present universe", what we in fact mean is the opposite: that our experiencing of our present universe caused our Big Bang model for it:

present universe ⇒ Big Bang model for it

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

Dice-playing

Einstein[f] in particular disliked the Copenhagen Interpretation's 'inherent randomness' postulate[62]. He believed that as yet undiscovered "hidden variables"

---

[a] Its mechanical density and compressibility.
[b] p.12, note.
[c] Its magnetic permeability μ and electric permitivity ε.
[d] p.38.
[e] p.85 ...
[f] Having done a hatchet job on Einstein's Relativity, when it comes to quantum physics we interestingly normally agree with him.

would one day explain the *apparent* indeterminacy of quantum phenomena in deterministic terms[63]. This is what he meant with his famous:

> "God does not play dice"[a]

However, although Albert was indubitably right in asserting that on a continuous model God is a clockmaker outside the universe, and not 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!![b]

Fig. 40. 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.

This is what actually happens. Dice-throwing is a *deterministic* phenomenon rigorously subject to the Laws of Nature. Our inability to predict the outcome in an

---

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

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

individual case is not due to any randomness in the *process*. But rather to *our own lack of knowledge* of it:

apparent randomness ⇐ our own lack of knowledge

We *conceive* dice-throwing as deterministic, but *experience* it as indeterminate. The same holds for the overall universe that God created for our benefit. We conceive it as determined[a] but 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* in fact 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. Whereas 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].

Uncertainty (3)

On a continuous universe model, where everything comes[c] from something, and the Laws of Nature always hold, the idea of *absolute indeterminacy* – something happening for 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*[d] – that *we ourselves* cannot predict it.

Secondly, that its indeterminacy is *limited*: it has an *indeterminate component*. If something were *truly* indeterminate – i.e. indeterminate 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[e] and all the Laws of Nature, and with a sufficiently powerful computer[f], we could predict the precise future course of the universe and would experience no indeterminacy[g]:

---

[a] On a continuous model.

[b] Certainty dice.

[c] Is conceived as coming (p.47, note).

[d] Cf p.27.

[e] Or those at any other specific point in time.

[f] Subject to overall considerations discussed below.

[g] A somewhat blanket statement, that we qualify later.

*indeterminacy***:** *1) apparently for us*[a]*; 2) limited;*
3) due to our own lack of knowledge

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

In the Heisenberg thought exercise[c], 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 disturbance and hence the electron's original state.

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

And thirdly, the apparent indeterminacy is ultimately due to *our own lack of knowledge*. With precise information on the overall universe and a big enough computer, we would experience no uncertainty.

The indeterminacy question is highlighted by that of *random number generation*. Two principal methods are used[64]. In the first, *pseudo-random* generation, a computer algorithm produces a sequence of seemingly random numbers. However, knowing the algorithm and its initial value, the entire sequence could be predicted. The "randomness" is again 'apparent', 'for us', and 'due to our lack of knowledge'.

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 likewise conceived as essentially determinate, and with exact knowledge predictable.

Again, in a continuous universe the idea of 'absolute' indeterminacy is senseless.

SUBLIMINAL SUBSTRATE

Sensory threshold

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

---

[a] The 'for us' is strictly redundant, everything we experience being "apparently for us".

[b] Indeterminate', 'uncertain', 'unpredictable', 'random', etc. (p.27)

[c] p.32

[d] Below (p.60).

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 that 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.41a. 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*.

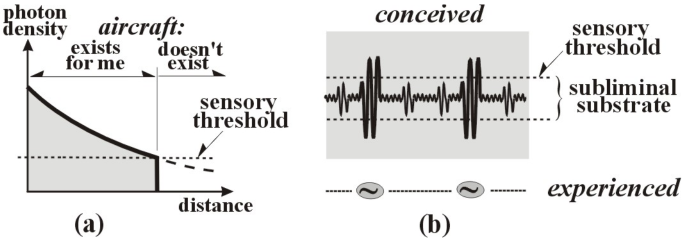

Fig.41. Sensory threshold.

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."[65]

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 as discrete particles[b], Fig.41b. 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[c] always effectively *particles*. If a photon fires a retinal neurone, we say "Aha! That was a particle". If it doesn't we don't:

*lower perceptual limit**:** things experienced as particles*

---

[a] Default photon behaviour being 'wave' (p.14).

[b] Particles are by nature discrete.

[c] Our lower perceptual limit.

Another way into this is that the basis of our perceptual mechanism is a light photon dispacing an electron in a retinal neurone, causing an electrical impulse to be sent to the brain, Fig. 0-42. Because photons interact with electrons in a *particle-like*[a] *way*, at our perceptual limit we necessarily perceive things in *'particle' terms*:

perceptual limit: *we perceive in 'particle' terms*

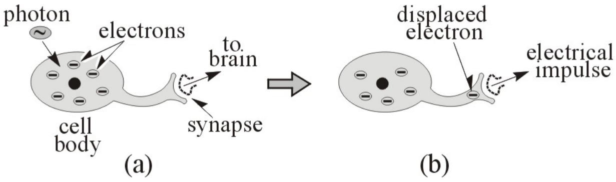

Fig. 0-42. Retinal neurone.

In the double-slit experiment, for instance, the continuous overall screen pattern is experienced in the closeup 'micro' view as *light particles*[b] distributed in wave-pattern form[c].

Energy-density

In the double-slit experiment, the energy-densities at the slits and at the screen are firstly *different*. And secondly: they only represent the *probability* of finding a particle there. The energy-density model thus allows a particle[d] to be detected at a slit, but not on the screen, or vice versa. It doesn't represent *particularity*[e]. From now on we will drop it.

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

In spite of which, the wave-packet image is however useful in that it incorporates both the wave and the particle aspects of light with the emphasis on the former. We will have cause to use it.

Towards the end of his life Einstein lamented that:

---

[a] Classical 'particles', as in Compton scattering (p.9).

[b] Photons, defined as the light energy that interacts with an electron (p.12).

[c] Fig. 2.

[d] Quantum particle: photon or electron (p.28).

[e] Due to detection uncertainty (p.9), photon particularity cannot be conclusively demonstrated. A photon not being detected doesn't necessarily mean that there wasn't one. But most experiments point to photon particularity as a reasonable hypothesis.

> "All these fifty years of conscious brooding have brought me no nearer to answering the question 'What are light quanta?'"[66].

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.41b 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 our innate threshold, no matter how fiendishly subtle our measuring devices. Imagine that in the subliminal substrate there are ξ-*particles*'[a] with energies below our sensory threshold. And that in our experienced universe there is a micro-organism that gives a visible jump when, and only when, it is hit by a ξ-particle.

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

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

observational threshold ⇐ *sensory threshold*[d]

This is confirmed in practice. Our sensory threshold is of the order of a single photon[e]. 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.

James Jeans[f] wrote:

> "We can receive *no message* from the outer world smaller than that conveyed by a single photon."[67]

John Bell:

---

[a] *Zeta*-particles'.

[b] p.29.

[c] p.51.

[d] The '⇐' symbol means "derives from" or "is due to".

[e] p.51.

[f] James Jeans (1877–1946), English astronomer.

> "To admit things not visible to creatures as gross as we is to show decent humility, and not a lamentable addiction to metaphysics[a]."[68]

Grover Maxwell[b]:

> "There are no *a priori* philosophical criteria for separating the observable from the unobservable."[69]

Noting that there is likewise no *a priori* reason why the subliminal substrate should not be as highly differentiated and structured as our observable physical reality.

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.

So 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[70].

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. Later experiments having 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 being able to determine their individual *states*: their velocities and positions[g]. For practical purposes neutrinos belong to the subliminal substrate.

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[a] Cf p.34.

[b] Grover Maxwell (1918–1981), American philosopher of science.

[c] In the sense of determining their individual states (p.24).

[d] p.5, note.

[e] Wolfgang Pauli (1900–1958), Austrian theoretical physicist.

[f] Raymond Davies (1914-2006), American physicist.

[g] p.24.

Radioactive decay

In *radioactive decay*, unstable atoms break down into smaller components with the emission of radiation, Fig. 43a. A typical decay curve is shown in Fig. 43b. The half-life is the time for half the atoms of a sample to decay.

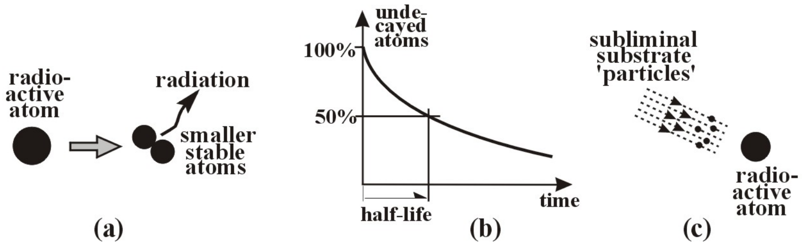

Fig. 43. Radioactive decay (1).

According to standard theory, the breakdown 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 is for instance 50%.

On a subliminal substrate model, however, the *apparent* randomness of radioactive decay 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. 43c.

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 basis is in fact *circumstantial evidence for* a subliminal substrate. The probability of an atom decaying within a given period 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. 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].

Radioactive decay like dice-throwing obeys the laws of statistical probability overall. But we cannot predict an *individual outcome*, the breakdown of a single atom. And the two cases being strictly analogous, we again justifiably suspect that radioactive decay is in fact essentially *deterministic*. And that its *apparent* randomness is due to our own lack of knowledge – in this case of the subliminal substrate.

As for dice-throwing, we will classify radioactive decay as *pseudo-classical*. With precise knowledge of the subliminal substrate, we would experience it as

---

[a] p.55

[b] Fig. 43.

classical and determinate. Without this knowledge, it *appears to us* to be random and indeterminate, even though it isn't 'really'.

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

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 been found[71]. 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[b] 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[c] is the tip of the universal iceberg, Fig. 44. We return to the topic.

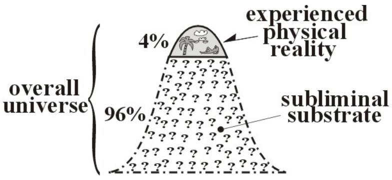

Fig. 44. Overall universe (1).

Wave}{particle (2)

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

Waves being by nature *continuous*, there is no lower limit to their magnitude. The Fourier components of a single wave-packet comprise a potentially infinite series of harmonics with at the limit infinitely small magnitude[e]. A minimum wave amplitude would invalidate the Fourier representation, which is a mathematical identity, and would therefore be senseless.

---

[a] p.27.

[b] 'The universe' in general is the *overall universe*, everything conceived as 'existing' (p.5, note).

[c] Defined as "physically experiencible" (p.5, note).

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

[e] Fig. 14a.

And if there is no lower limit to the wave domain, neither can there be in the Bohr-complementary particle domain, Fig. 0-45, which again implies a subliminal substrate.

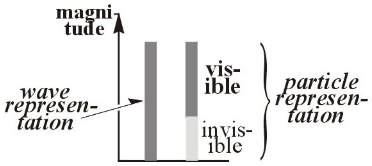

Fig. 0-45. Wave}{particle.

CONCEPTUAL

Self-incomprehension

Now for a short conceptual interlude. The word "comprehension" derives from the Latin *con-+ prehendere*, to "grasp" or "seize", and is defined in a dictionary as "to grasp mentally, hold in the mind". The basic metaphor for *mental comprehension* is *physical grasping*.

The same image is found in other languages. The French *comprendre* has the Latin root of the English 'comprehend'. The German *Begriff* ('concept') derives from the verb *greifen* (to grasp); and so on:

comprehension = mental grasping

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.46a, is meaningful. But that of a grasping hand grasping itself is senseless, Fig.46b. The same applies to an eye seeing itself, Fig.46c; and so on.

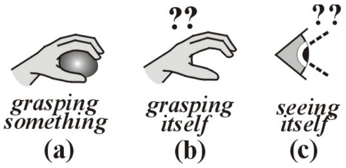

Fig.46. Self-comprehension (1).

It is not, therefore, that something *cannot* comprehend itself in the sense of *not being able* to. But rather that our concept 'comprehension' is such that the idea 'self-comprehension' is senseless. We will call this the *self-incomprehension principle*:

self-comprehension is a nonsense

Imagine that in a valiant attempt to comprehend myself[a] I wire all my 100bn neurones up to a giant TV screen, Fig.47. 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.

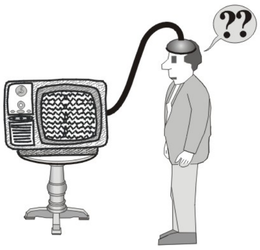

Fig.47. Self-comprehension (2).

The set up here is *self-dependent*. The observed depends – at least to some extent – on the observing Subject/Self[b]. And so in trying to comprehend it, he is to that extent trying to comprehend himself.

The irrationality of self-dependence is likewise inherent in its physical image. The word "depend" has the same root as the Latin *suspendere*, to 'hang from'. And the idea of something hanging from itself is senseless.

Another 'conceptual' approach. Comprehension of oneself would have to include one's comprehension of oneself; and hence one's comprehension of one's comprehension of oneself; and hence one's **...** (Ok, that's enough, thank you. I already got the point).

The idea 'self-comprehension' is *interminable*. It has *no limit*. And since definition implies setting limits[c], interminable ideas are *indefinable*. And hence rationally incomprehensible and senseless. No finite mind, not even one with 100bn neurones, can grasp an infinite[d] series of such 'comprehension of comprehensions'[e]:

*interminable**:** incomprehensible and irrational*

Apart from these conceptual objections to self-comprehension, there is a further logistical problem. To comprehend oneself in the sense of predicting one's own behaviour, would require among other things knowing the states of all one's 100bn

---

[a] Predict my own behaviour.

[b] Cf p.28.

[c] The word derives from the Latin *finis* meaning an 'end', or 'limit'.

[d] 'Infinite' = 'without end, or limit'.

[e] The author's limit is about four.

brain neurones. 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 'self-comprehension' weren't *conceptually* senseless, nothing could comprehend itself for *logistic* reasons due to lack of computational capacity. St Augustine[a] said:

> "I cannot grasp all that I am. The mind is not large enough to contain itself."[72]

Lyall Watson[b]:

> "If our brains were so simple that we could understand them, we would be so simple that we couldn't."[73]

Seeing

When observing a classical object like a dog, its reflected photons arrive at my retinas and I consciously experience a dog, Fig. 48. The photons themselves, however, I do not see. They are part of my 'seeing'.

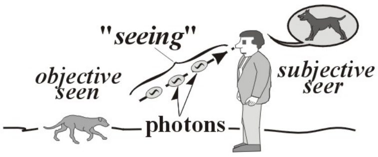

Fig. 48. Seeing.

Photons effectively *are* our 'seeing'. Not just for being the principal 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 perception 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 one's own seeing.

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

individual photon states: ***:*** *inherently indeterminate for us*

---

[a] St Augustine (354-430), bishop of Hippo (in modern Algeria).

[b] Lyall Watson (1939-2008), South African anthropologist and author.

[c] p.54.

[d] Such as the double-slit (Fig. 2) or split-beam (Fig. 5) experiments.

[e] Self-incomprehension.

[f] Their velocities and positions.

One might argue that a photon's position can be determined with a photon detector. And since its speed *c* is always the same, this would give its state.

Firstly, however, after detection the photon is no more[a], making the information for practical purposes useless. And secondly, its speed *c* is fixed *through the aether*, and not relative to the earthbound observer. This approach also doesn't work.

Realism

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

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

> "Quantum mechanics has definitely invalidated the law of causality"[74]

On the opposite side of the philosophical fence is *Realism*. It conceives of there being a real out-there physical reality existing independently of our observations, and that is *determinate*, subject to causality. It is effectively a *continuous universe model*[d].

Due to measurement uncertainty, however, in the quantum domain this reality *appears to us* to be uncertain and indeterminate, even if it isn't really:

physical reality is essentially determinate;
in the quantum domain it appears indeterminate

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

– 1) *indeterminate*, as the Copenhagen Interpretation holds
– 2) *determinate*, as Realism holds

And 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. 49.

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[a] p.9.
[b] p.29.
[c] Logical positivism (below).
[d] p.47.

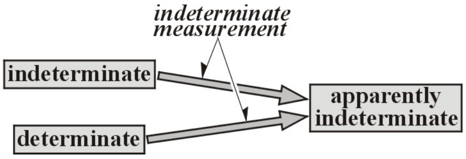

Fig. 49. Physical reality

Similar considerations apply to the quantum/photon taken as the *smallest existing* energy/matter packet[a]. An alternative hypothesis is that it is *our minimum observable* packet[b], Fig. 0-50. And again, since neither hypothesis can be proved nor refuted, both must be examined.

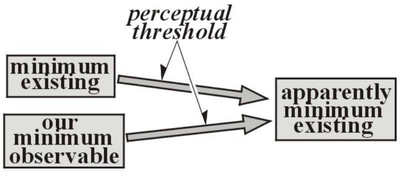

Fig. 0-50. Quantum.

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

Ontology

Following on from philosophical Realism, consider *ontology*, the question of what something "really is".

For instance a *piece of textile*. From an *'overall/macro'* viewpoint, observed from a certain distance, it is experienced as continuous and uniform, Fig. 0-51a. And in a *'closeup/micro'* view as discrete fibres, Fig. 0-51b. Two different viewpoints. Hardly surprisingly: two different views:

different viewpoints ⇒ different views

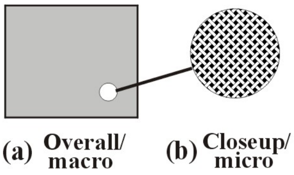

Fig. 0-51. Textile.

---

[a] p.22.

[b] Again implying *a* subliminal substrate.

So what is it "really". In the Middle Ages the answer would have been:

> "It's really discrete fibres. But due to the limitations of our perceptual mechanism, in the overall/macro view it *appears* to be continuous and uniform. With perfect vision we would only see individual fibres."

Early 1900s' physicists would however have disagreed:

> "No. We now know that everything is *really* made of *atoms*, themselves comprising fundamental particles – protons, neutrons and electrons. "

But at the end of the 1900s they would have declared:

> . "No. We *now* know that everything is *really really* made of quarks and leptons. Protons and neutrons comprise quarks. And electrons are leptons."

Maybe adding further

> "Since particles are miniscule, *really really really* everything is virtually empty space permeated with electrostatic fields[a]."

And so on, apparently *ad inf*.

The simplest way out of the ontology question is not to ask it, but use instead the concept of a *model* defined as "a way of thinking about things that represents our experiencing":

model = way of thinking that represents our experiencing

Thinking about a piece of textile as "being really" discrete fibres; but that from a distance appears to be continuous and uniform; represents the way Middle Agers experienced it. For present-day light, a wave model represents our overall/macro view; and a particle model our closeup/micro view. And so on.

What we are however essentially after is *overall models* that represent the maximum of experiencing with the minimum of mental outlay. This is effectively William of Ockham's[b] 'razor' principle:

the simpler the better

A wave model represents admirably simply our overall/macro light-experiencing. As does a particle model the closeup/micro view. But since we conceive the two as being different views of essentially the same thing, we want further an *overall model* representing both aspects.

---

[a] p.11.

[b] William of Ockham (1287-1347), English medieval Franciscan monk and philosopher.

For a piece of textile both views are classical and determinate, unaffected by our observations. As is also therefore the *macro:micro relation*. Given the closeup view and the eye's resolving power, the overall view can be deduced.

For light, our overall view is again classical and determinate. But our closeup view is 'quantum' and indeterminate. And since these are rationally incompatible, here we have a conceptual problem.

Uncertainty (4)

The terms 'random', 'uncertain', 'unpredictable', 'indeterminate' are as seen[a] for practical purposes synonymous. If something is random for us, it is also uncertain, unpredictable and indeterminate for us. We cannot determine its state with certainty.

Rationality is related. If Fido is certainly a dog; and all dogs are certainly animals; then Fido is certainly an animal. But if it is *uncertain* whether Fido is a dog; and uncertain whether dogs in general are animals; then the most one can say about Fido in this respect is that he may or may not be an animal – which doesn't say much.

Indeterminacy in general implies *irrationality*[b] , an inability to use logical deduction:

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

Returning to the quantum domain, our sensory threshold firstly obliges us to make measurements on quantum particles using other quantum particles[c], which disturb the first and cause *indeterminacy*. And secondly, in using quantum particles to 'see' other quantum particles, we are effectively trying to use things to see themselves, which is *irrational*[d].

The indeterminacy and the irrationality again *correlate*, both deriving from our innate perceptual threshold the quantum/photon, Fig. 52:

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

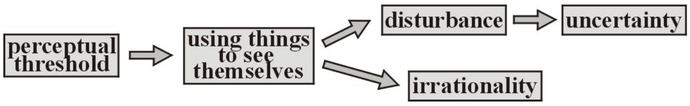

Fig. 52. Uncertainty/irrationality.

---

[a] p.27.

[b] In the wider sense of 'not-rational'. As opposed to the stronger 'contradictory' or 'nonsensical' sense.

[c] Normally photons.

[d] Self–incomprehension.

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

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

velocity}{position ⇔ wave}{particle

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.

We can also note that since velocity and position are *particle* properties, a 'measurement' is always effectively a *particle measurement*. A wave description of an electron would comprise the amplitudes, phase angles and frequencies of all its potentially infinite series of component waves[e]. 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.

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

Electrons and standard photons would become as gold atoms for us. We could determine their states to any desired accuracy[f]. There would be no uncertainty[g]. And since we would no longer be using things to see themselves, there would also be no irrationality. The uncertainty and the irrationality again correlate.

---

[a] eq.5 (p.25).

[b] eq.4 (p.22).

[c] p.54.

[d] p.7.

[e] Fig. 14b.

[f] To within experimental error (p.26)

[g] Provided we don't try to determine the states of micro-photons themselves.

Heisenbergian indeterminacy on this approach is not inherent in physical reality, as the Copenhagen interpretation holds[a]. It is a consequence of *our own inability* to make quantum measurements without disturbing the measured, in turn due to our perceptual threshold:

apparent quantum indeterminacy ⇐ *uncertain measurements*
⇐ *innate perceptual threshold*

We return to the topic.

PERCEPTUAL CATEGORIES

General

Quantum measurement uncertainty and a hypothetical subliminal substrate mean that we conceive our overall universe in terms of three distinct *perceptual categories*:

– 1) *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 our observed, and measurements are *certain*[d]
  – b) a *quantum* domain where they do, and measurements are *uncertain*
– 2) a hypothetical *subliminal substrate* that we cannot experience at all

They are shown in Fig. 0-53[e].

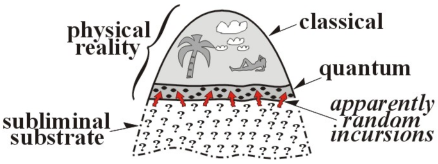

Fig. 0-53. Overall universe (2).

Our actually experienced 'physical reality', comprising the classical and quantum domains only, is therefore *inherently*[f] *partial*, or *incomplete:*

*our experienced physical reality***:** *inherently partial/incomplete*

---

[a] p.29.
[b] p.54.
[c] p.27
[d] As always, to within experimental error (p.26).
[e] Cf Fig. 44. The 'random incursions' are discussed in a moment.
[f] Inherently *for us*.

Paraphrasing Einstein, one could say that[a]:

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

In trying to model the overall universe, we are therefore trying to do so based on *incomplete knowledge* of it. This evidently leads to *indeterminacy*. And consequently to *irrationality*[b]. Especially since that "partial" could well be a mere 4% of the whole[c]:

partial/incomplete universe view ⇒ indeterminacy/irrationality

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 perceptual categories[d] being *mental*, to be 'found' only in our minds, they evidently don't exist as such in out-there physical reality. As Niels Bohr so truly said (though he maybe didn't mean it in quite this way):

> "There is no quantum world."[75]

And given that the perceptual categories don't exist physically, there are evidently no corresponding *physical boundaries* between them. Meaning that each category is inherently subject to *incursions* from the one below it[e]:

perceptual categories: each subject to incursions from the one below it

Photons, for instance, whose exact states[f] we cannot determine, belong to the subliminal substrate. But they nevertheless affect our experienced reality[g] by firing retinal neurones, dissociating silver nitrate molecules, disturbing electron measurements, etc.

And because the subliminal substrate is inherently unknowable, and hence indeterminate for us, we experience these incursions firstly as *apparently random*[h]. And secondly – since subliminal substrate energies by definition lie below our perceptual threshold – as of *limited magnitude*.

---

[a] Cf p.38.

[b] p.9

[c] Fig. 44.

[d] 'Classical', 'quantum', 'subliminal'.

[e] Fig. 0-53b.

[f] Velocities and positions (p.24). Cf neutrinos (p.55).

[g] In this case the quantum domain, the next category up..

[h] Cf radioactive breakdown (p.57).

Again, we experience physical reality overall as essentially determinate, but with a restricted indeterminate component[a]:

*physical reality**:** essentially determinate*, *with a limited indeterminate component*

Macro}{micro

Returning to the piece of *textile*[b], both views are here classical and determinate, unaffected by our observations. And so also is then the macro:micro relation. Given the closeup view and the eye's resolving power, the overall view can be predicted. The two views are *rationally relatable*.

An analogous case is *fluids* like air or water. From an overall/macro viewpoint, we can calculate the propagation speeds of pressure waves through them based on their bulk density and compressibility.

An alternative approach would be to consider collisions between individual molecules, based on their mass and elasticity. This would obviously be somewhat laborious, but could in principle be done. And the two methods should give the same result.

Now consider quasi-classical[c] *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 set of numbers: this time maybe a three, then a six, then two fours in a row; and so on. But after many throws we always get the *same determinate* overall result[d], here equal frequencies for each number:

apparently randomly individual measurements ⇒ *determinate overall result*

The overall:closeup relation is again essentially determinate[e]. Knowing the precise initial states of the dice and table, and with a sufficiently powerful computer, one could predict the individual outcomes and hence the overall result[f].

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

---

[a] Cf p.50.

[b] Fig. 0-51.

[c] p.49

[d] As always, ignoring experimental error (p.26).

[e] As for the piece of textile.

[f] p.49.

Turning to the quantum domain[a], and taking first the *double-slit experiment*, the overall/macro view is as usual classical and determinate. With a strong light source and the screen observed from a certain distance, a classical/determinate wave pattern is found. From it the wavelength of the light can be determined to any desired accuracy[b].

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

But since the individual points always build up to the *same overall classical interference pattern*, they too must be *essentially determinate*. Even though we, with our innate perceptual threshold and inherently incomplete view of the universe[c], cannot visualize a corresponding physical mechanism.

An overall result being by definition the sum of its individual measurements[d], if the former is determinate, so must also essentially be the latter. Even if we cannot comprehend how. There is no way *indeterminate*[e] 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*[f]. In the overall/macro case with a strong light source we can predict output intensities to any desired accuracy. Whereas in the closeup/micro view with single photons we cannot forsee individual outcomes[g]. And again cannot visualize a physical mechanism, even though we reason that there must be one. Electron spin is analogous.

Resuming: in classical overall/macro cases[h] where measurements don't affect the measured, individual outcomes are both conceived and experienced as determinate. Whereas in quantum closeup/micro cases individual outcomes are *conceived* as being *in principle determinate*. Even though we in practice *experience* them as indeterminate. This is resumed in Fig. 54.

---

[a] Where the observation affects the observed (p.27).

[b] Ignoring experimental error (p.26).

[c] p.66.

[d] p.19.

[e] Apparently indeterminate, or random.

[f] p.18.

[g] Whether an output photon will be detected.

[h] Quasi-classical dice-throwing, pseudo-classical radioactive decay.

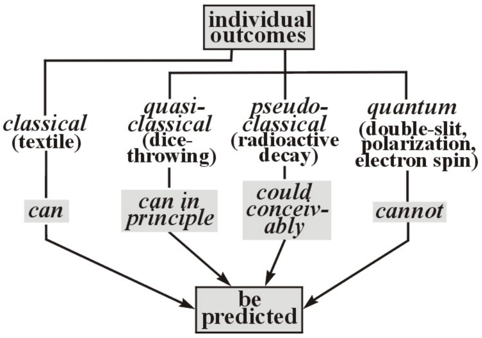

Fig. 54. Individual outcomes.

Epistemological interpretation

The perceptual domains are based on *our knowledge* of the universe, being:

– 1) *certain*[a] in the classical domain
– 2) *uncertain* in the quantum domain
– 3) *inexistent* in the hypothetical subliminal substrate

These categories being essentially *epistemological*[b], we will call it the *Epistemological Interpretation* of quantum physics;

Epistemological Interpretation ⇐ nature of our knowledge

On this approach, the indeterminacy and apparent wierdness of quantum phenomena are not then properties of *physical reality itself* as the Copenhagen Interpretation holds[c]. They *derive from us*, specifically from our partial/incomplete view of the universe, in turn due to our innate sensory threshold :

*apparent quantum indeterminacy/wierdness**:** derive 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.”[76]

Noting that the difference between the Copenhagen and the present Epistemological Interpretations is *purely conceptual*. Quantum reality necessarily *appears to*

---

[a] As always: to within experimental error (p.26).
[b] The word derives from the Greek *episteme* meaning 'knowledge'.
[c] p.29.
[d] Arthur Eddington (1882-1944), English astronomer.

us to be indeterminate[a]. The question is: whether *conceiving* it as such gives us greater peace of mind?

does conceiving physical reality as essentially determinate give
us greater peace of mind?

Let the reader be the judge.

PARTICLE ANOMALIES

Irrationality

The fundamental particle anomaly is the *wave}{particle dichotomy*: how can light show both wave and particle behaviours, when the two are rationally contradictory[b]. Effectively: how can we relate its wave to its particle properties.

But since 'wave' and 'particle' are rationally disparate, there can *inherently be* no rational relation between the two. And hence no rational explanation:

*wave}{particle**:** inherently no rational relation*

Another way into this is that due to measurement uncertainty, the quantum/-particle domain is inherently *indeterminate* for us. And hence inherently *irrational*[c]. And an irrational object evidently cannot enter into a rational relation:

*irrational object**:** no rational relations*

The same considerations apply to the remaining particle anomalies. In the *double-slit experiment*, for instance, the question is: how can *apparently indeterminate* initial screen points build up to a *determinate* overall result?

But since the former are 'particle', and the latter 'wave' phenomena, in trying to relate them we are again trying to relate the rationally unrelatable sides of the wave}{particle dichotomy, which can't be done.

For *polarization*, the question is: how can *apparently indeterminate* individual photon detections result in a *determinate* overall intensity relation[d]. But and again involves relating rationally unrelatable individual particle and overall wave behaviour. *Electron spin* is analogous[e].

In the *delayed eraser* case, the question is: how can the *availability of abstract which-path information* determine a *concrete physical result*, a screen pattern[f]?

---

[a] Fig. 49.
[b] p.7.
[c] p.64.
[d] p.20
[e] p.21
[f] p.16.

In fact, however, this is *not* strictly the question. The experimental result is that screen photons whose idlers arrive in one detector[a] form an overall 'wave' pattern. And those whose idlers arrive in one of two other detectors[b] form an overall 'particle' pattern. And is again a question of relating individual particle to overall wave behaviour.

Resuming, the particle anomalies all involve relating individual particle to overall wave behaviour. And since this can't be done, the particle anomalies *inherently have* no rational explanations:

*particle anomalies**:** inherently have no rational explanations*

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

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

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

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

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

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

As Ashleigh Brilliant[g] would say:

"We don't have an explanation. But we sure admire the problem."[77]

---

[a] 'W' in Fig. 17.

[b] 'P_A', 'P_B' in Fig. 17.

[c] Using things to see themselves (p.64).

[d] Self-incomprehension (p.58).

[e] Concepts derived from that same universe.

[f] p.66.

[g] Ashleigh Brilliant (1933-), English epigramist and 'tee-shirt philosopher'. He holds that no decent philosophical statement should ever exceed 17 words.

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 quantum phenomena 'seen' in our way.

Illusion

Imagine *nano-photons*, infinitesimally small micro-photons[a], 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[b]. And there being an infinite number of infinitely small nano-photons, the question of which slit any individual one of them went through would be meaningless.

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

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

real reality: continuous and 'wave'

Remembering always that what we are dealing with is essentially *empty space* permeated with electrostatic fields. And that cannot always be expected to conform to models derived from our classical everyday physical reality[d].

Another way into this is that our perceptual mechanism depends on *photon-electron interactions*[e] in our retinal neurones. Because photons interact with electrons in a *particle-like* way[f], in the quantum domain[g] we *necessarily* experience things in 'particle' terms.

The 'particle' reality that we actually experience is thus *essentially illusory*, deriving from our partial /incomplete view of the universe[h], in turn due to our innate sensory threshold. With no such threshold, there would be no quantum domain for us. Erwin Schroedinger:

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[a] p.65.

[b] p.5.

[c] p.64.

[d] p.11

[e] p.9.

[f] Compton scattering (p.9).

[g] At our lower perceptual limit.

[h] p.66.

> "What we observe as material bodies are nothing but shapes and variations in the structure of space. Particles are *Schaumkommen* (appearances)."[a]78

And if quantum particles themselves are illusory, so also are the particle anomalies that depend on them:

particle anomalies: essentially illusory

Our lack of rational explanations for the particle anomalies is then essentially *irrelevant*. With an ideal nano-photon perceptual mechanism, we would experience no quantum particles and no corresponding anomalies:

particle anomalies: illusory and irrelevant

Wave}{particle (3)

Returning to the piece of *textile*[b], in an overall/macro view it appears to be continuous and uniform, and in a closeup/micro view as discrete fibres. What is it "really"? Well, it is obviously really discrete fibres, but due to the limitations of our perceptual mechanism, in the overall view it *appears*[c] to be continuous and uniform. With perfect vision we would only see discrete fibres.

The same principle applies to the overall double-slit interference pattern. From afar it is seen as continuous and uniform. And in the closeup view as discrete and 'particle'. What is it 'really'?

Here the converse is the case. The continuous classical overall/macro view[d] is the real reality. But due to the limitations of our perceptual mechanism[e], in the closeup/micro view it *appears to us* to be discrete particles. With perfect nano-photon vision we would experience everything as continuous[f].

Another approach is that in overall/macro views where many retinal neurones fire, we experience things as *continuous*, effectively *'wave'*. A wave in general being a disturbance propagating though a continuous medium – water, air, the electromagnetic aether, etc.

Whereas in closeup/micro views where only single retinal neurones fire, our perception is particle-like and we necessarily experience things in discrete 'particle' terms[g]:

---

[a] Eastern religions have also long taught that the 'reality' we perceive with our senses is illusory.

[b] Fig. 0-51.

[c] As always: 'to us' (p.27).

[d] Fig.1b, Fig. 2.

[e] Sensory threshold.

[f] Cf Bohm (p.47).

[g] p.53.

overall/macro: ***:*** *many neurones ⇒ continuous/'wave'*
closeup/micro: *single neurones ⇒ discrete/'particle'*

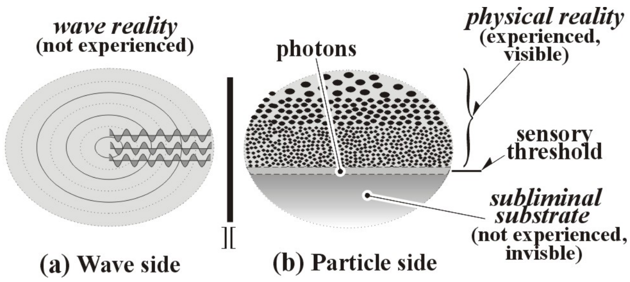
CONTINUOUS UNIVERSE (2)

General

On the Epistemological Interpretation, and in line with David Bohm[a], we conceive the overall universe as a *determinate unbroken whole*. But due to of quantum measurement uncertainty, we necessarily *experience* in terms of:

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

The corresponding wave}{particle representation is shown in Fig. 55.



(a) Wave side (b) Particle side

Fig. 55. Continuous universe.

The wave side is[c] as always *continuous*, with no lower limit to wave amplitude[d]. But because we don't experience electromagnetic waves as such[e], this side is *conceptual*. It is what we *imagine* wave reality would look like *if* we could experience it, which we inherently can't[f].

---

[a] p.47.
[b] As always: 'for us'.
[c] Is conceived as being (p.47, note).
[d] Waves being inherently continuous (p.6).
[e] p.13.
[f] p.13.

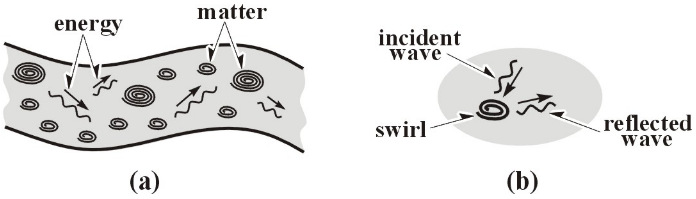
The particle side overall being the counterpart to the continuous wave side, it is likewise *conceived* as 'continuous', with no lower limit to particle size[a]. But due to our innate sensory threshold, we *experience* it as *truncated*, subdivided into:

– 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 an ocean[c]. A more sophisticated model is the *fast-flowing river* of Fig. 56a.



(a) (b)

Fig. 56. River model (1).

The river surface comprises standing waves (not shown) and *swirls*, both due to submersed objects – rocks, tree trunks, etc. The swirls being essentially stationary with regard to a river bank observer, we take them to represent *concrete matter*. Since we ourselves are material objects, we are likewise swirls on the river surface.

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

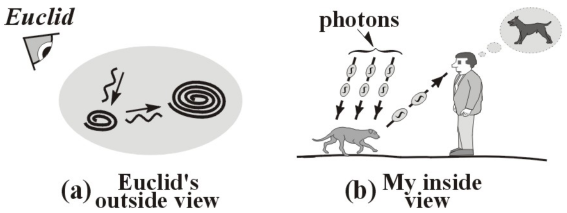
Concrete matter, represented by essentially stationary swirls, is then conceived as 'standing', or 'looped' waves. Let these swirls[e] *reflect* travelling waves[f], Fig. 56b.

Imagine further a hypothetical *E.U.* (Extra-Universal). He will need a name, so we will call him *Euclid*.

---

[a] The 'particle' definition of 'continuous'.
[b] Photons, neutrinos, ξ-particles, etc.
[c] p.47.
[d] p.6.
[e] Standing/looped waves.
[f] Radiation energy.

From his totally objective viewpoint outside our universe, Euclid sees it as a *continuum* of travelling and looped waves[a]. He could for instance see travelling waves impinging on one specific small swirl, and being reflected towards a larger one where they are absorbed, Fig. 57a.



(a) Euclid's outside view (b) My inside view

Fig. 57. River model (2).

I myself down here on Planet Earth, however, as part of the universe and seeing it from the inside with a binary/digital perceptual mechanism, *experience* a discrete object, in this case a dog.

It is interesting that the 5th century b.c. Greek philosopher Anaxagoras likewise conceived atoms as vortexes in the aether[b][79]. An idea that was taken up in modern times by Lord Kelvin[80].

Theory of Everything

Euclid sees our universe as a continuum of travelling waves and swirls[c]. We ourselves, however, as part of that universe, and with an innate perceptual threshold, experience it subdivided into:

– 1) a *classical domain*: 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*: things we are involved in and do affect (spouses, offspring, dogs, etc.), both conceived and experienced as *indeterminate*[d]

– 3) a *quantum domain*: things we aren't involved in[e], but that are too small *not* to be affected by our observations (principally electrons[f]), conceived as determinate and experienced as indeterminate

---

[a] Our matter and radiation.

[b] The term derives from the Sanskrit *akasha*, in traditional Indian cosmology meaning 'space' or 'aether'.

[c] Fig. 57a.

[d] Self–incomprehension (p.58).

[e] Except in our observing them.

[f] p.28.

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

Fig. 58 shows the overall universe in these terms.

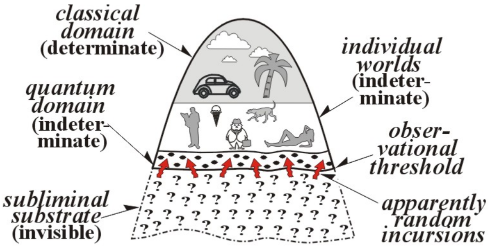


Fig. 58. Overall universe (4).

Compared with Fig. 0-53b, there is here the additional domain of *our individual worlds*, things that we affect at least to some extent, and that are correspondingly 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. 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 combine them into an overall rational whole[b]. We are doomed to experience our "physicists' reality" (the one studied by physicists, made of galaxies, rocks, electrons, etc.) as a *classical}+{quantum conjunction* comprising independent:

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

domains with no possible rational relation between them:

physicists' reality = irrational classical}+{quantum conjunction

Stephen Hawking noted that:

> "A Theory of Everything would have to predict the outcome of our search for it. "[81]

likewise making 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. One again cannot expect to model a system based

---

[a] Self–incomprehension (p.58).

[b] To say nothing of the inherently unexperiencible subliminal substrate.

on 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."[82]

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 realist approach avoids many of its conceptual pitfalls?

As often in such cases, the answer seems to be *dogma*. The fashionable philosophy in 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*[83]. 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 somewhat 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 also onto most of today's! 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."[84]

Alfred Landé[g] spoke of most quantum physicists as:

> "Following Bohr's Sunday word of worship"[85]

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

---

[a] Fig. 58. Cf the iceberg analogy.
[b] Self–incomprehension (p.58).
[c] Bohr, Heisenberg, Born & Co.
[d] Auguste Comte (1798–1857), French philosopher.
[e] p.29.
[f] Murray Gell-Mann (1929-), American particle physicist; in 1976
[g] Alfred Landé (1888-1976), German quantum physicist.

> "I am very pleased you have publicly called dogmatic quantum mechanics to account."[86]

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[87].

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.”[88]

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."[89]

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

> "I notice in you disquieting signs of a primitive mentality. And shall not enter into any controversy with you on complementarity[g], for the simple reason that there is not the slightest controversy about it."[90]

Not much room for open-minded scientific debate there!

It is interesting that the fundamental problems of both Einsteinian Relativity and quantum physics derive from their *initial assumptions*. Einstein's conceptually non-

---

[a] p.29.
[b] Ernst Mach (1838-1916), Austrian physicist and philosopher.
[c] The ratio of a speed to that of sound is called the 'Mach number' in his honor.
[d] p.55.
[e] His words.
[f] p.54.
[g] p.57.

sensical and experimentally refuted[a][91] 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 totally incoherent, how come it works so well in practice?"

The answer seems to be in "*as if*" terms. Given our innate perceptual threshold, it is for us *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. And given wave function collapse, it is for us *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 existing even when no-one is looking at it.

Copenhagen trip

The root of the quantum-physical absurdities being the quantum/photon as the *minimum existing* (rather than our minimum observable) energy packet, one can 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.

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

---

[a] By the 1887 Michelson-Morley result, 18 years before it was formulated! (appendix p.83)

[b] Being based on logical positivist dogma, and not scientific experiment.

[c] Both being determined from the outset.

[d] Fig. 55.

Newtonian gravity onto the firm lawns of deterministic reality[a][92]. 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][93]

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."[94]

(Anyone for physics?)

APPENDIX

(in alphabetical order)

Aether

Having been consistently scathing about Einsteinian Relativity, we need to substantiate our remarks at least somewhat[d][95]. We will take the *aether* as our basis[e][96].

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

> "The introduction of a 'luminiferous aether' will prove superfluous."[97]

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

> "Light is propagated in empty space with a definite velocity *c* [in all inertial reference frames]."[98]

The aether's existence would therefore 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*, and in no others.

---

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

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

[f] Einstein 1905.

Michelson-Morley[a] 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[99]. In 1998 Héctor Múnera reanalyzed their results using modern statistical methods, finding that they gave at a 95% confidence level[b] aether-wind speeds of:

– midday readings: $v_\in$[c] = 6.22+/-1.86 km/s
– evening readings: $v_\in$ = 6.8+/-4.98 km/s[100]

They are plotted in Fig. 0-59a[101]. And no way can be construed as being "null within experimental error"[d].

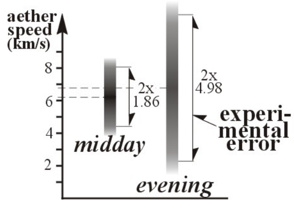


Fig. 0-59. Michelson-Morley results.

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

Michelson-Morley refuted Einsteinian Relativity18 years before
it was formulated

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[e], it obligingly does so in a consistent replicable manner. And similarly for its particle properties[f]. In eraser experiments, the outcome depends on the *availability to us* of 'which-path' information[g] – 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:

---

[a] Albert Michelson and Edward Morley.

[b] A 95% probability of the result not being due to chance.

[c] Using the subscript '∈' for 'aether'.

[d] The somewhat higher evening results, and their greater spread, are explicable (Aether article).

[e] By setting up a suitable experiment.

[f] Fig. 5b.

[g] pp.14, 16.

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

The objections are firstly the delayed eraser experiment showing that an observer's conscious choice has no effect[b]. 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, for human mental processes to affect physical phenomena, there would have to be an *energy transfer* between a human brain and the experimental equipment. This has apparently never been detected.

Thirdly, a non-physical mechanism would contravene a *continuous universe model* where everything physical comes from something physical[c]. This model is as noted not necessarily correct[d]. But it seems compatible with most other 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."[102]
- "Perhaps as great a mystery as the origin of life itself."[103]
- "One of the most vexing of all questions."[104]
- "One of the most profound mysteries of existence."[105]
- "The greatest of all the problems confronting man."[106]
- "A riddle wrapped in a mystery wrapped in an enigma."[107]
- "How the subtle processes of the conscious Self came to be associated with a material structure, is beyond our comprehension."[108]

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

> "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."[109]

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 *duality* is the well-known 'vase][heads drawing', Fig.60, due to the 19th century psychologist Max Wertheimer[a]. One experiences *either* a vase, *or* two

---

[a] p.31.
[b] p.18.
[c] Consciousness being not-physical.
[d] p.40.
[e] Thomas Huxley (1825–1895), English biologist.

heads, but never both simultaneously. Nor ever a half-way stage, a mixture of the two.

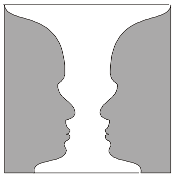


Fig.60. Vase][heads drawing.

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

Whereas in the wave}{particle case the two sides are *totally disparate*. A wave is an *event*, a function of time. And a particle a *material object* with no time dependency[b]. So here 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[c]" 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 will define *Intervention* 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 would by definition be[d] Intervention.

A continuous universe model assumes that the Laws of Nature always hold. And therefore *inherently excludes* Intervention, divine or otherwise[e], Fig. 0-61a:

*continuity**:** inherently excludes Intervention*

---

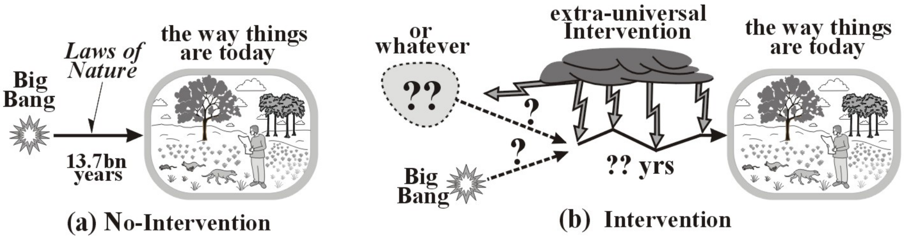
[a] Max Wertheimer (1880–1943), German-Czech psychologist, founder of Gestalt psychology.

[b] p.7.

[c] One of the Laws of Nature.

[d] Be said to be (p.47, note).

[e] The 'continuity' and 'no-Intervention' principles are equivalent.



(a) No-Intervention (b) Intervention

Fig. 0-61. 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. 0-61b.

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, scribes, clerks, 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. But thereby changing the whole subsequent course of the universe. And not leaving anyone the wiser, least of all us.

In practice we cannot therefore 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 in time 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][110]. 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.

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.

Since 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 then the *no-Intervention* case, and is the one considered here. Remembering, however, that it is *only half the stor*y:

no-Intervention is only half the story

Micro-, nano photons

The micro- and nano-photon thought exercises are useful. But are nevertheless somewhat artificial. With eyes sensitive to micro-photons, for instance, 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 perceptual mechanism[c],

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

[b] Spacetime article.

[c] Sensitive to micro-photons.

micro-photons could well be the only "photons" we would experience. And similarly for nano-photons.

Photon mass

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

They 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][111].

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.

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