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Can we Crack the Mind-Body Problem?

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PART ONE [May 20th, 2020]

PART ONE: Making Sense of Quantum Randomness

PART TWO: Matter and the Poached Egg

PART THREE: Psychism, the Deed, and Beyond

ABSTRACT

This paper is in three parts. In this Part One, the randomness displayed by quantum objects is explored. The notion of quantumhood in then introduced. It refers to a kind of "wave wholeness" of elementary particles that, most significantly, turns out to be necessary to sustain nature's consistency. When this quantumhood is in danger of being lost, a wave collapse, or quantum jump, is in order.

Wavy lumps and random jumps

Subatomic or elementary particles are the tiniest specks of matter known today. They make up everything there is, be it atoms, ordinary objects, living organisms, and all the way up to planets, stars and galaxies. These particles are nothing like classical point particles. They'd rather be called "wavicles" on account, as we'll see, of their surprising but well-established wave-particle nature. Quantum mechanics is the science which deals with them. According to it, subatomic particles behave as lumps most of the time and as jumps occasionally. Here I use the word "jump" as an umbrella word for the discontinuous events that take place in the microworld of quantum objects. These jumps are random and last virtually no time. We can describe lumps and jumps as follows:

- **Lumps** are wave-like and deterministic. They are somewhat fuzzy and can be thought of as bundles of waves huddled together. These waves interfere mutually if and only if they belong to the same lump. They propagate in space in a smooth and relativistic way.[1] In the theory, lumps are known as wave packets, wave functions and even state vectors.

[1] Lumps behave in a wave-like, reversible, relativistic and unitary way (unitarity is an important mathematical property). Being relativistic, they comply with Einstein's theories of relativity, both special and general. They are also fuzzy, given their wavy nature and because of the superposition and of the (Heisenberg's) uncertainty principles of quantum mechanics. Formally, lumps are bunches of mutually interfering waves. The received wisdom says that these quantum waves are nonphysical and probabilistic entities. However, they might be "substance waves" instead (more on this in Appendix 1B).

- **Jumps**, or leaps, are wave-less and random. They are sudden and discontinuous events. When they kick in, the quantum waves vanish and are said to collapse. A prime example is when a quantum measurement is carried out. They also arise in a wide range of microscopic events that share the same core features.[2]

Lumps and jumps are worlds apart. They behave in many opposite ways, even when they relate to the same "wavicle" or subatomic particle. This is weird![3] Can we explain this lump-jump duality? I believe so, as this paper will hopefully show. It is important to note at the outset that a jump brings an elementary particle from an initial state that is fuzzy and smeared-out, to a final one that is always sharp and well defined. In other words, a jump typically shrinks a lump to a pinprick size. This being so, a lump or an elementary particle puts on a point particle appearance right after a jump. Because of this, the lump-jump duality comes across as a wave-particle duality. Another important consequence of this "fuzziness-sharpness duality" is that jumps *need* to be random. We'll soon figure that out.

Consistency and the principle of quantumhood

As far as we can tell, nature is consistent. It complies with the acknowledged rules of logic. Indeed, nature's consistency in the microworld rests heavily on quantum wholeness. Quantum wholeness, or **quantumhood** for short, is an all-or-nothing affair whereby we may find, say, 4 or 19 electrons, but never 2.28 or 17.165 of them. It relates to the wholeness of lumps and hence, to that of elementary particles: quantumhood means wholeness or fullness of elementary particles. Somewhat surprisingly, this wholeness is a matter of wave interference. It really is wave wholeness and it is utterly blind to spatial closeness. Concretely speaking, it means for example that if, with a half-silvered mirror, we split a photon into a reflected bit and a transmitted one that go their separate ways, this doesn't, as such, run afoul of quantumhood – *provided*, that is, these (wavy) bits can still interfere mutually.[4] To find out whether the mutual interference still holds its sway is easy. It suffices to bring the two bits together again by an appropriate setup, and watch how their interference plays out.

Why should nature bother about quantumhood? The answer hinges on a distinction between *motion* waves and *substance* waves. Ripples in water and sounds propagating through the air are examples of motion waves while quantum waves epitomize substance waves. The snag, with substance waves, is that when left to their own device, they can wreck nature's consistency. This is due to their mutual interference, which is not a zero-sum game as far as they go (more on this and on motion and substance waves in Appendix 1B).

Since consistency is absolutely vital for nature, it has to be sustained everywhere and everywhen. This is the role of the **principle of quantumhood**, which oversees the way substance waves interfere. It manages it so that this interference doesn't undermine nature's consistency. This watertight principle is not about spatial closeness. It may allow a particle to be scattered into many shards that can be near or far, as long as these shards keep their ability to cross-interfere. This is the key. The principle of quantumhood only rules out *independent* bits of subatomic particles (these bits are independent if they cannot interfere mutually). This is why no one has ever found, say, independent pieces of electrons hanging out on their own.[5] Whenever an electron is found, it is found whole. Even when it is scattered far and wide, it is still whole nonetheless.[6] Recall that this wholeness is strictly a matter of wave interference within each lump. It is lump or wave wholeness, not spatial nearness.

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[2] Here the word "jump" labels all the sudden, discontinuous, wave-less, irreversible and point particle-like events that take place in the microworld. Furthermore, these events are nonrelativistic, random and non-unitary too. Jumps (or leaps, or collapses) are involved in quantum measurements, radioactive decays, inelastic collisions and so on. Arguably, they are also the root cause of the photoelectric, Compton and tunnel effects (I explain why it should be so, in French, in my books HUIT LECONS ESSENTIELLES SUR LA SCIENCE QUANTIQUE and L'UNIVERS QUANTIQUE ENFIN EXPLIQUE). Let me add that waves, being smooth, don't sit well with discontinuous events. This is why jumps are wave-less, even though they take a subatomic particle from a wave-like initial state to a wave-like final one.

[3] The property of quantum entanglement is even weirder. I'll come to it and explore its meaning in Part Two.

[4] Waves are wont to spread far and wide, so the mutual interference of two apparently distant lumps can still hold far away from their apparent peak of maximum density. Wave interference combines or superimpose various waves, in a way that somehow adds them up. It can be either constructive (then it strengthens the waves) or destructive (then it weakens the waves), or anywhere in-between.

[5] We may wonder why this principle has been overlooked thus far. I believe that it is because our understanding is unconsciously muddled by the phony notion of point particle, which still haunts the back of our minds.

[6] Alternatively, an elementary particle may occasionally vanish by being absorbed or by giving rise to "daughter" particles, as is the case in inelastic collisions. This doesn't go against the principle of quantumhood. This principle also forbids, by the way, "cross-lump" wave interference, viz., interference between waves belonging to different lumps.

The challenge of remaining whole: threats and jumps

The principle of quantumhood is ironcast. It brooks no transgression. At times however, remaining whole can be quite challenging for a lump. Then we'll say that the principle of quantumhood is under threat as far as this lump, or elementary particle, is concerned. Such a situation is a **quantum threat**. To help gather how such a threat may arise and how nature may handle it, here is a short narrative:

> Imagine that you're about to cut a potato laying on a table in front of you, with a knife that can only be moved up and down but not sideways. The potato stretches on both sides of the knife, to its left and to its right, and therefore, cutting it is child's play. There's a catch however: the potato is a magic one and cannot be split. This is quantumhood-principle-for-magic-potatoes! Try as you may, it will remain uncut. What will happen instead is this. As you start chopping the magic tuber, it will suddenly shrink or "jump" to one side only – either to the right or to the left – of your threatening blade. In this squeezed-out new shape, in which the knife can only cut the air, the potato is no longer at risk. It is threat-free. This is exactly what its jump was meant and designed to achieve.

This little bit of a story provides a graphic insight into the ways of nature. It shows how nature might respond to a quantum threat. The potato was initially in a "fuzzy" state spread out on both sides of the knife. Because of this very fuzziness, the knife could cut it – a real threat was looming. Contrariwise, the potato's final state, reduced or shrunk to one side only as it was, was accordingly "sharp".[7] It was also threat-free, since in this new setting, the knife was harmless as it could no longer split the tuber in two chunks.[8] Similarly, an electron facing a quantum threat will suddenly jump. This jump or leap will also shrink or collapse it from a fuzzy (and hence threatened) initial state to a sharp (and hence threat-free) one.

Of course, this picturesque outline of how nature might handle the daunting challenge of a quantum threat is not to be taken at face value. It is merely symbolic. It gives no more than a rough and exploratory idea as to why, when a particle faces a quantum threat, a jump that will shrink the particle to a sharp final state is in order. This shape shifting trick, away from a fuzzy initial state, wipes the threat out. For example, an unstable system like a radioactive atom is under threat because of its fuzzy energy state and hence ill-defined energy level.[9] Therefore, it will eventually jump, or decay, to a definite (or sharp) one.

Detectors and measurements

In light of the above, the jump appears to be both a game-changer and a fuzziness buster. It is a game-changer, as it abruptly waives the wave-like evolution of a quantum object. It is a fuzziness buster, as it deflates the object away from its fuzzy state to a sharp one.[10] This is what makes jumps nature's weapons of choice to do away with quantum threats. They aren't pointless oddities; and they explain why measurements are effective. To see that, let us recall how a measurement procedure works in practice. First, the quantum object involved, say a particle, must be fuzzy as regards the attribute to be measured, *e.g*. the position, the energy level, the spin, the speed or momentum, and so forth. If it isn't fuzzy, the analyser of the measuring apparatus will strive to make it so. Then the detector pitches in.[11] It produces a threat which eventually forces the particle to jump to a sharp, and hence threat-free, end-state. This sharp new state yields a precise and well-defined value for the attribute; which is none other than the sought-after measurement result.

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[7] It should be noted that quantum fuzziness is context dependent. It is not intrinsic to a lump or to a quantum object, except for its energy level. This was clearly illustrated by the magic potato, whose initial and final states, as such, were neither sharp nor fuzzy. What made them so was their *relative* position with respect to the knife. This is incidentally why, for the story to work, the knife was not allowed to move sideways. Indeed, just moving the knife to one side away from the potato (which was forbidden in my narrative) would have made the initial state of the potato sharp with respect to the knife, and hence unthreatened by it. We thus go from a fuzzy initial state to a sharp one *without changing the state in any way*. Let me add that the jump selects one possible (sharp) end-state out of a (broader, and hence fuzzy) range of possibilities. The jump being random, this selection is unpredictable – and so is the measurement outcome.

[8] It turns out that the initial fuzzy state is somehow a sum, or superposition, of the possible sharp final states. In that sense the final states always "belong" to the initial state.

[9] This threat, linked to a fuzzy energy level, is here intrinsic to the system at stake, unlike what is the case when the fuzzy attribute is not the energy (it could then be the position, the spin, etc.). We remember that, in the non-energy case, the threat is context dependent.

[10] At times, though, the particle may be destroyed, *e. g*. absorbed, in the process. This however does not modify this analysis of the lump-threat-jump interplay in a fundamental way.

[11] A measuring device is typically made up of two parts: an analyser and a detector. The role of the analyser is to put the quantum object in a fuzzy state with respect to the physical quantity to be measured. The role of the detector is then to build on the fuzziness of this state to produce a quantum threat.

The bottom line is that measuring a quantum object is about triggering an evolution that, were it wave-like throughout, would flout the principle of quantumhood. It would thus create a risk of contradiction. Such an evolution can't take place, so a sharpness-producing (or fuzziness-busting) jump is in order. The Stern-Gerlach experiment is a case in point. It aims to measure the spin of an electron.[12] The setup, which comprises an analyser and a detector as it should, is designed to tear the particle in two independent halves, each being in a sharp or precise, and different, spin state. This creates a quantum threat since such an evolution would go against the quantumhood principle. We already know what's next. The threat prompts a collapse, which gives rise to a definite spin value. This value is the measurement result. It is unpredictable, as a straightforward consequence of the randomness of the collapse or jump. Prior to this event, the electron was in the fuzzy state of spin, and its spin value was ill-defined. It didn't even exist.

Now we gather that to carry out quantum measurements rests on an aptitude to produce quantum threats, as measurements trigger fuzziness-busting jumps that bring about definite measurement results. The gist is that fuzzy states feed quantum threats whilst sharp states are free from them. In all this, the conscious observer in charge of the measurement plays no essential role, other than carrying out the measurement. The crux of the matter is elsewhere. It involves a jump-prompting detecting device.

Causation twice over

Conventional thinking has it that a lack of determinism and a lack of causation are one and the same, and we routinely take it for granted that true randomness is identical with plain (causeless) chance.[13] Barring randomness-by-ignorance, we unwittingly conflate causation and *deterministic* causation too, and we take it for granted that quantum randomness is causeless. No need to think twice about this, it is so obvious! Or so we think. However, it could be that nature's randomness isn't always down to blind chance. It could also be, as I'll propose here, that quantum randomness is a matter of in-causation. Let me explain. We recall that most of the time, an elementary particle behaves as a lump. Then it is smooth, wavy, fuzzy and thoroughly deterministic. Every now and then, though, it jumps and evolves in a sudden, wave-less and random way that leaves it sharp.[14] There is a complete mismatch between these two behaviours, and this lump-jump duality it quite baffling. It calls for an explanation. My insight is that these behaviours are grounded in two different types of causality or causation. I call them out- or exo-causation, and in- or endo-causation.

Exo-causation is deterministic causation as we know it. Simple enough. It holds its sway over quantum waves. It is causation from outside or from without, and hence its alternative name: out-causation. In a way, this outer kind of causality is out of reach and cannot be tampered with. Thus it is unchanging and deterministic. **Endo-causation**, on the other hand, is causation from inside or from within; and so can be dubbed in-causation too. This inner kind of causality is somehow within reach and can be modified. This is why it is nondeterministic and seems random. By the same token, in- or endo-causal events are not deterministic. They come out as chance events. It is therefore not too much of a stretch to surmise, as I do, that endo-causation underlies quantum randomness and pulls its strings. So, again barring randomness-by-ignorance,[15] a lack of determinism may be a matter of *non-deterministic* causation rather than of blind chance. I believe that this so far overlooked assumption is worth exploring. Here is how I present out- of exo-causation and in-causation in my contributing essay to *Expanding Science*:[16]

> Both deterministic and non-deterministic causations share the same birth right […]. The first one is forced upon things from the outside. I call exo- or out-causation this deterministic strain. Obviously enough, the fall of an apple under the pull of gravity and the thawing of ice under the sun are out-causal. The second strain [is] endo- or in-causation. An in-causal evolution or behaviour wells up from inside. Strange though it sounds, it is even, in a way, chosen. This is precisely what makes it non-deterministic. In-causation is creative. (…) Planning ahead, deciding to smile or whistle on whim and actually doing it, is somehow to behave in-causally. To recap, (…) out-causation feeds determinism whereas in-causation comes across as random. It drives quantum randomness.

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[12] As the name suggests, the spin of a quantum particle is a sort of rotation with no classical equivalent. When fuzzy, the spin is in a state that combines different values. It has no definite value.

[13] Randomness-by-ignorance is not genuine randomness. It has a deterministic cause, but this cause is hidden and unknown.

[14] At times, instead of leaving it in a sharp state, the jump destroys the particle, *e.g.* by having it absorbed by another quantum micro-system (such as an atom).

[15] The possibility that quantum randomness is really a matter of randomness-by-ignorance rather than true randomness has given rise to the so-called hidden variable theories.

[16] *Expanding Science. Vision of a Post-Materialist Paradigm*, AAPS, 2020 (forthcoming).

Clues that give the game away

Why should nature occasionally drop determinism, as it does with jumps? Can we tease out the secret of quantum randomness? I already hinted that quantum randomness could be richer and more interesting than an empty box – empty in the sense of being causeless. At least two clues point in this direction. The first one is that a quantum jump, in its role as fuzziness buster, is goal-directed and seems purpose-built; to the obvious benefit of nature's consistency as the notion of substance wave makes it clear. This purposefulness tips the balance in favour of endo-causation. We recall, by the way, that a (pre-jump) fuzzy state is a combination, or superposition, of all the possible (post-jump) sharp states. This being so, shrinking from a fuzzy to a sharp state at the hand of a jump requires a selection. The story of the magic potato made it plain. This selection is akin to a choice.

There is yet another clue, which is the "entanglement friendliness" of jumps or collapses. Entanglement is a mind-boggling property, one that Einstein famously called a spooky action-at-a-distance. We'll explore it in Part Two. Entangled quantum objects share characteristics and exchange information *regardless of their physical distance*. When two particles are entangled, whether near or far, some attribute of one is fixed as soon as it is fixed in the other. This instant conformity, which occurs when a jump takes place,[17] would be well-nigh impossible if the randomness of individual and local jumps were a display of sheer blind chance.

To conclude, entanglement and the jump are strong hints that quantum randomness is neither lawless nor pointless. This being so, it is rather unlikely to be cause-less. This bolsters the assumption that quantum randomness betrays an underlying endo-causation. If so, plain matter is not what it's made out to be. It actually possesses an extra endo-causal dimension and becomes holomatter; which will be the main topic of Part Two.

To conclude…

Finally, here is a reminder of the main points of Part One:

- Nature may be built on two kinds of causality: a deterministic one labelled out- or exo-causation and a nondeterministic or random one named in- or endo-causation.
- The principle of quantumhood precludes elementary particles, as they move about in their customary deterministic and wave-like fashion, from being torn into independent bits, *i. e*., bits that can no longer interfere mutually. This principle, being a matter of consistency, is iron-clad.
- Nature enforces the principle of quantumhood, or principle of quantum wholeness, by means of jumps or collapses. These are sudden, random, wave-less and sharpness-making events that make a selection, or an endo-causal "choice".

Part Two will delve into the holomatter idea and into the issue of quantum entanglement. We'll see how they both fit in together. This, along with the analysis of quantum jumps given in this Part One, will shed new light on quantum weirdness. It will even reconcile it with common sense. I believe that, with this new understanding, we'll be in a position to make sense of quantum weirdness, which seemed all but impossible hitherto. We'll then broaden our scope and introduce the notion of ur-causation, which is sheer, unmitigated in- or endo-causation. Ur-causation will take us on an exciting journey that is potentially far-reaching, as we'll find out.

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[17] A jump will take place when either one of the particles is observed or measured for instance.

APPENDIX 1A: Glossary for Part One

Endo-causation = *see at in-causation*.

Exo-causation = *see at out-causation*.

In-causation = Randomness with a twist. It comes from the inside of things that be. This causation-from-within is changeable, nondeterministic and random. It is free to fluctuate, as though by some sort of self-willed causality. *Also named in-causation*.

Jump = A sudden and random discontinuity that is also wave-less, irreversible and nonrelativistic. A (quantum) jump, leap or collapse is a response to a quantum threat that it removes by shrinking a threatened particle from its fuzzy initial state to a sharp end-state. The latter is threat-free and looks particle-like.

Lump = Bundle of mutually interfering quantum waves known as wave-packet or wavefunction. A lump is deterministic. It describes an elementary particle that evolves in a smooth, reversible, wave-like and relativistic way.

Out-causation = Deterministic causality by another name. It's outward causation or causation-from-without. Being out of reach in a way, it cannot be tampered with, which makes it unchanging and deterministic. *Also named exo-causation*.

Principle of quantumhood = All-or-nothing rule which precludes elementary particles, as they move about in their deterministic and wave-like fashion, from being torn apart in shreds or bits that could no longer interfere mutually.

Quantumhood = Wholeness of elementary particles. It really is wave or lump wholeness, and it means that any bit of the particle can always interfere with the rest of it. This wholeness does not depend on spatial nearness as such.

Quantum threat = Situation in which a lump or a particle is in danger of being shred in a way that would go against the principle of quantumhood. It is fed by the fuzziness of the lump, and it tends to elicit a fuzziness-busting jump.

APPENDIX 1B: Motion waves and substance waves

Why is there anything at all? Why is there something rather than nothing? This question, often attributed to Gottfried Leibniz, raises the daunting issue of ontogenesis. A much easier – and admittedly much watered-down! – version of this question reads: Why is it that some animals fly while others do not? An obvious answer is that an animal that flies can do so *because* it is fitted out for just that. Typically, it has wings. No wings, no flying! If a bird or an insect flies, we know outright, without even having to look at it, that it is capable of flying because something in it gives it this ability. It's plain and obvious and goes without saying. In like manner, coming back to Leibniz' question, anything that exists in the real world out there does so because it is capable of being and becoming. Accordingly, pure existence can be construed as the outcome of a process of self-creation. It is primarily a matter of self-generation. This prompts me to reframe the issue of existence as one about self-generation. We thus pick up an essential insight: *Existence, at heart, is the outcome of a dynamical process of self-begetting*. Even more to the point, *it is this process itself*.

This casts new light on a host of issues; but here we'll focus on waves only, as these dynamical entities are at the root of our description of physical reality at the quantum level. As seen from the ontological perspective, two kinds of waves stand out. Waves of the first kind are waves-as-usual. They are disturbances of a pre-existing medium. Let's call them "stir-waves" or **motion waves**. Sound waves in air, in water or even in stone, and ripples on the surface of a pond, are typical examples thereof. These motion waves feed on an outside medium – water, stone, air, and what have you – without which they wouldn't be. They exist and propagate by stirring or by setting this medium in motion.

If light waves, and electromagnetic radiations more generally, were stir-waves, it would be impossible for light to travel across vast expanses of empty space in the cosmos. As they obviously pull off this trick, physicists invented an invisible medium to explain it. They dubbed it the luminiferous aether. Yet, in 1905, Einstein established that this medium doesn't exist. So, light waves propagate regardless of something to propagate in. They do so because they are waves of the second kind.[18] These are "self-begetting" or "self-sustaining" waves. We can call them "stuff-waves" or **substance waves**. At a stroke, they create both themselves and the medium, or the substance, in which they move and travel. They are not only physical entities but also *metaphysical* entities. They pull off the amazing trick of yielding and upholding the world as we know it through a dynamical process. No need, for them, of an aether when they fly across empty space.[19] Quantum waves, including light waves, are a prime example of substance waves.

Now, the capacity of waves to interfere mutually when they overlap is the defining property of waves. Accordingly, both motion and substance waves are interference prone. It appears, though, that their respective interferences play out differently. To figure that out, let's consider a couple of sine wave (W) and (-W) that interfere in a plane (*see the drawing below*). These two waves are symmetric and interfere in a fully destructive way, which means that they add up to zilch. If (V) stands for the result of this interference and (Ø) stands for a lack of wave, we can then write symbolically: (V) = (W) + (-W) = (Ø). This formula is equivalent to the algebraic equality: **c** = **a** + (-**a**) = **a** – **a** = **0**. The result, (V) = (Ø), is graphically straightforward, as (V) is flat and motionless. All its points are on a straight line.

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DRAWING

(SORRY for this awful drawing… I did my best!!!!!… please can you find someone to draw it properly? THANK YOU VERY MUCH ….. (W) and (-W) are supposed to be perfect sine waves and perfectly symmetric with respect to the middle flat line (V); and (V) is supposed to be perfectly flat and horizontal….)

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From there we infer what follows:

(a) If (W) is a motion wave, so is (-W). Here (V) = (Ø) means that the outcome of the interference of (W) and (-W) is flat: nothing moves, we get no motion waves. This in turn means that the pre-existing medium that these waves stir as they propagate in it is at rest. Thus, the destructive interference has produced stillness (no motion) in the propagation medium; but the medium itself remains unscathed. No more and no less of it, it is only quieter.

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[18] Quantum waves are basic formal entities that make up what is known, in the theory, as wave-packets and wavefunctions. They are conventionally interpreted as "waves of probability", as was stated by Max Born in 1926. There is some irony in this, as these waves are the only aspect of the ultra-small quantum-mechanical domain that is deterministic through and through!

[19] Defining exactly what the word "substance" means in this context is an important and subtle issue of ontology, which is the branch of philosophy where ontogenesis belongs. Interestingly, the very fact that light waves sustain their own existence implies that they can self-replicate their wave-front from one moment to the next. This self-replication is nicely illustrated by Huygens' principle. According to this principle of geometrical optics, each point on the wave front of a light ray can be considered as the centre of the wavelets, or secondary waves, that propagate spherically at the common speed c (in empty space) in all directions. The new wave front at a later time is then the envelope of all these wavelets. It depends on how they interfere – they do so constructively and destructively, according to their mutual position. Interestingly enough, this principle inspired Richard Feynman to work out his path integral formulation of quantum physics, which implies that a particle evolving from an initial to a final state does so by having its quantum waves follow all the alternative paths available. The final (and least action) outcome is achieved by summing over all paths, taking again into due account their mutual interference (this is a *weighed* sum that depends on the physical action, which has the dimension of an energy times a duration).

(b) If (W) is a substance wave, so is (-W). Recall that at heart these waves are dynamical processes of self-creation. They self-generate. As such, they're not contingent on a pre-existing medium. Indeed, their propagation medium is none other than themselves. In this case (V) = (Ø) means that no dynamical process of self-creation is taking place. For want of an ongoing self-generation, what is produced is… utter emptiness. It is flat-out nothing! Here the destructive interference produces nought, which is far more troublesome than mere stillness. It and threatens nature's consistency.

We see that interference, as it runs its course, may at times yield either (a) perfect stillness (no ripples, no sound) or (b) outright nothingness. Case (a) is for motion waves and case (b) is for substance waves. Case (b) raises the possibility that something begets nothing. This results from the peculiar ability of substance waves to produce the very substance they're made of, along with the fact that their interference is not a zero-sum game. We saw that with waves (W) and (-W). So, the uncanny substance of substance waves, being interference dependent, will fluctuate. This spoils nature's conservation laws and challenges its very consistency. Nature, therefore, cannot afford such an untrammelled interference if it is to steer clear of contradiction. At this point, the principle of quantumhood comes in handy.[20] It compels quantum wave interference to be selective, which explains the build-up of lumps or wave packets that underpin elementary particles.[21] It also forces these particles to remain whole; or else, to disappear.[22] Owing to the quantumhood principle, the interference of substance waves is made into a zero-sum game. It is tamed in a consistent way.

So far so good; but there's a catch, as the wholeness of quantum objects can be threatened. When it is so, a jump is in order and saves the day (*see the main text*).[23]

Here is finally a summary of the main points of this appendix:

- The riddle of ontogenesis – to wit, the riddle of the making of whatever exists in the world out there – led us to distinguish between motion waves ("stir-waves") and substance waves ("stuff-waves").
- Motion waves feed on a pre-existing propagation medium that enjoys an independent existence. Substance waves, on the contrary, are self-contained. They are self-generating processes that need no pre-existing medium to wriggle and travel in.
- Motion waves interference is harmless. It is consonant with nature's consistency. Motion waves are therefore free to interfere with any similar wave with which they happen to overlap.
- Quantum waves, being substance waves as I assume here, are their own propagation medium. This medium, or substance, may fluctuate at the hand of their interference. This very fact may spawn potential threats to nature's consistency.
- The principle of quantumhood regulates the game of interference between quantum waves so that it will never give rise to a contradiction. This principle protects the wholeness, or integrity, of elementary particles. It is enforced by quantum jumps.

[20] The "quantumhood" of the eponymous principle is grounded in quantum wave interference. It means lump wholeness (*see main text*).

[21] Indeed, we find in the microworld elementary particles rather than untethered waves as a straightforward consequence of the principle of quantumhood, which blends quantum waves in wave-packets.

[22] When a particle disappears, as by absorption, it does so through a jump.

[23] Subatomic particles, when they jump or collapse, shrink from a fuzzy (or superposed) to a sharp (or eigen) state as we know. They may disappear altogether and then become something else, e.g. through inelastic collision or by absorption. We may imaginatively fancy that subatomic particles carry some sort of kill-switch for waves, that they turn on under a quantum threat in order to leap and shrink away from the threat.