Quantum

Addendum

1.1 Quantum Addendum

Note: This page is presented as a later addendum to the last page of the original review of quantum physics entitled 'An Unqualified Commentary', which veered off into some of the wider issues surrounding modern science. As such, it was felt that some form of summary of the issues that ordinary people, i.e. me, find so hard to accept about quantum physics might be useful.

The *opening page* of this discussion made reference to a quote by Richard Feynman, in 1965, where he made the suggestion that '*nobody understands quantum mechanics'*. Whether this statement remains true today after some 50 years or so of additional research might be debated, but not necessarily refuted. However, it was also highlighted that this review of quantum theory did not pretend to carry any weight of authority regarding this subject, although it had tried to carry out an honest duty of inquiry, as far as it might be understood by somebody in general. Possibly, due to both these limitations, the outcome of the initial review led to a sense of '*confusion*' about many of the apparent contradictions underpinning the current *particle model* predicated on so many *mathematical abstractions* and *philosophical interpretations* linked to modern *quantum field theory*.

But where to start given the overall complexity of quantum theory?

In some ways, we might start at the beginning, where the work of *Planck* and *Bohr* first introduced the idea of quantisation. Without going into the details outlined in the links provided, the idea of the quantisation of energy in a black-body radiator or the definition of atomic orbitals appears very difficult to explain in terms of any particle model, but may make more sense, if considered as a wave model. For in both cases, the quantisation might be linked to the fact that energy or orbitals might only be supported, if considered in terms of integral wavelengths. Therefore, in this context, one of the first issues that anybody has to overcome is the ambiguity that the fundamental workings of the universe require the acceptance of a *wave-particle duality*. Of course, in many ways, human perception was also to blame for this situation as it had led *classical physics* to be predicated on just 4 fundamental units of tangible measurement, i.e. *time, distance, mass and charge*. In this respect, energy [$kg.m^2/s^2$] could only be described using the notion of physical mass [kg] rather than in terms of an energy-density [$joules/m^3$]. In this context, there was an enduring legacy that *energy* was associated with, and transported by, some form of mass particle, although this was clearly understood not to be the case in *electromagnetic theory* as early as the 19th century. If the idea of energy-density is pursued, it might also be realised that a wave mechanism might be the only realistic causal solution for transporting scalar energy of rest mass in space-time. As such, the duality of the semantics within quantum physics might be described as a fundamentally problematic assumption, which then led to other problems.

But was this duality the only issue of confusion?

As a single page addendum, there is no exhaustive attempt being may to list all of the issues that might generally be characterised as '*quantum weirdness*'. However, when first trying to understand quantum physics, there are possibly a number of key assumptions that have to be kept in mind. One of the most important, is the '*knowledge gap'* between the initial and final state of a quantum system, where the description of cause and effect might appear to be missing. In this context, there is a quantum assumption that some processes are simply '*unobservable*', but which then opens the door to other assumptions. For example, the *wave-particle duality* might also be considered as an aspect of the '*unobservable*' nature of the quantum realm characterised in terms of the *double slit experiment*. According to quantum theory, this experiment might initially be considered from a particle perspective that produces a statistical interference pattern that disappears when we try to measure which slit the particles are passing through. Of course, we might also revert back to a wave perspective to explain the interference patterns although the same *'measurement problem'* is still encountered and the interference pattern is again lost. However, although not an accepted position of quantum theory, might we consider the idea that any measurement of a wave, existing on the quantum scale, may be disrupted due to *decoherence* of the wave structure passing through the slit being measured. If so, might we then consider whether the '*unobservable*', but disturbed, state of this quantum system has an understandable effect that destroys the interference pattern.

What else might be described as unobservable?

We might also consider the *'unobservable*' nature of the quantum universe in terms of its description of the *particle-like nature* of the photon rather than its wave-like nature, as originally proposed by *electromagnetic theory*. As far as is known, there is no accepted structure for a photon, such that within a quantum system we might only define an initial state source and final state destination in terms of cause and effect. As such, a photon is also an '*unobservable*' quantum effect, but one assumed to be capable of transporting energy [E=hf] between two points as a function of time, as defined by its velocity [c] in vacuum. Of course, we might add many other unobservable quantum mechanisms, such as *virtual particles*, which are require to explain a transition between the initial and final state of a quantum system. However, within the wider description of *Quantum Electro-Dynamics*, the unobservable nature of photons and virtual particles might only be seen as the '*tip-of-the-iceberg*' when trying to describe the actual causal mechanisms at work within these unobserved transition between the initial and final state of a quantum system. As such, much of the verification of quantum theory now appears to come to rest based on a mathematical vindication.

OK, but what other issues of concern might be cited?

Another fundamental assumption associated with any quantum system is often described in terms of *Heisenberg's uncertainty principle,* although Heisenberg himself only described this effect in terms of an *'indeterminacy*' of either position or momentum. According to quantum physics, we might consider this assumption in terms of either a point-particle within a wider *particle model* or some sort of wave structure within a conceptual *quantum field* of some description. Of course, we might immediately question the physical reality of a '*point-particle*' that has no obvious existence beyond being a concept within a mathematical model. However, if we switch to a wave model, we might consider whether the description of any wave-particle has to ultimately give way to a degree of positional ambiguity based on an energy-density distribution spread across some possibly extended standing wave structure. If so, might we then begin to understand why the idea of an exact position within any wave structure might be subject to a degree of uncertainty or indeterminacy, which would also lead to a similar problem with momentum as it is predicated on a change in position as a function of time. However, the *semantics of quantum physics* appears to favour the somewhat ambiguous description of quantum fluctuations, where any causal wave mechanisms are subsumed into the mathematical abstraction of the *quantum wave interpretation* and the classical idea of a *force replaced by an interaction* mediated by a force-carrier '*particle*', i.e. a type of boson.

So, what is the fundamental causal mechanism in quantum physics?

Following on from previous concerns, one of the fundamental uncertainties in quantum mechanics might be said to be the *interpretation of the wave-function* itself, if it only describes a mathematical probability, where its time evolution proceeds on the assumption that *matter waves* are subject to *dispersion*.

> *Note: The dispersion assumption has been questioned on the grounds that the implied velocity [v], linked to classical kinetic energy [$mv^2/2$], is dependent on the mass [m] of the wave-matter particle as a whole, i.e. $E=hf=mc^2$. However, there might be a suggestion that each frequency [f] within the assumed harmonic frequency distribution of a matter-wave, which is classically assumed to lead to the dispersion of the matter-wave, would have its own implied energy-mass [$m=hf/c^2$].*

> *Note: It is also highlighted that a matter-wave particle with zero velocity [v=0] would have an infinite wavelength [κ=2π/λ] or zero frequency [ω=2πf], such that its wave structure might conform to some form of 3D standing wave. If so, would we also need to understand how this standing wave structure might propagate in space-time with velocity [v=0..c] - see Beat Waves by way of illustrative example. In such a speculative 3D wave model, the underlying travelling waves that form the composite beat wave might all propagate with velocity [c] in free-space, where the composite matter-wave would not really be a wave, but rather an interference effect with an associated energy distribution at some given point in space. If so, might we still need to question what it physically means for a wave-matter particle to 'disperse' in space as a function of time as described in the wave function collapse.*

Within the limited space of this addendum of perceived quantum weirdness, we might now turn our attention to the issue of *quantum entanglement*, which is described as a phenomenon that occurs when pairs or groups of *'particles'* are said not to exist in independent quantum state. As such, any measurement of one component of an entangled quantum system is assumed to cause an '*unobserved*' collapse of a mathematical probability wave-function after which any component *'particles'* of the final state have to assume certain physical characteristics irrespective of the distances between these particles. While most modern descriptions of entanglement quickly resort to the mathematical abstractions and assumptions of quantum theory, we might initially reference the historical example of the EPR paradox.

> *Note: While the term 'EPR paradox' has been used to link to the Wikipedia description, it is possibly misleading of the original 1935 intention of Einstein, Podolsky and Rosen. For it is possibly more accurate to simply describe their 'preference' for physics to be predicated on causality rather than philosophical conjecture of unobserved transitions. In this context, the EPR paper forwarded the basic argument that if physical reality could be described in terms of causal mechanisms, then aspects of the quantum model were incomplete and that some elements of reality were simply not understood within the limits of quantum theory. In this context, it might be argued that the purpose of the 1935 EPR paper was only to raise a debate about the 'incompleteness' of quantum mechanics, at that time, rather as a total rejection of the model.*

We will generalise the EPR example in terms of an initial quantum state being associated with a *'particle'* with quantum *'spin-0'* that eventually decays into a final state consisting of two '*particles*', e.g. A and B. However, because the initial state *'particle'* had a quantum '*spin*' of 0, the final state '*particles*' are required to have quantum '*spin*' of [±1/2].

> *Note: The idea of 'quantum spin', when considered as a 'particle', is highlighted because its physical description is itself an issue of some confusion, although these issues will not be detailed at this point. However, an example based on quantum spin can lead to complications, if it is simply stated that the final state of spin of [±1/2] is required by the conservation law of quantum spin. The reason being that there is no direct conservation law of quantum spin, only a rather complicated association* with '*intrinsic angular momentum'*, *which is said to be conserved by the final state of the quantum system.*

Again, there is an '*unobserved*' process between the initial and final state of the quantum system, which quantum theory describes in terms of a conceptual superposition wave-function that collapses, on measurement, into the final state. However, the following video is possibly one of the better, i.e. simpler, explanations of the basic measurement process, although it is unclear whether the final quantum explanation can really be described as a causal mechanism – see *Quantum Entanglement & Spooky Action at a Distance*. However, this video has made reference to a number of issues surrounding quantum entanglement, which possibly need some further explanation, e.g. *hidden variables* and *Bell's inequality theorem*. However, before considering such issues, it might be useful to simply state that few physical systems, even classical ones, are completely *'unentangled'* when required to conform to the laws of physics. So, in the case of the EPR example, the initial state is required by given conservation laws to create a final state where the overall spin neutrality is preserved. In this context, we might initially assume that while the process from the initial state of spin-0 to a final state of spins of [±1/2] remains '*hidden*', there may be some underlying causal mechanism that does not require any '*spooky action at a distance*', although the video tries to explain why the quantum example may be different.

> *Note: While the video provides some insight to the complexity of the EPR example based on the notion of quantum spin, it does not really explain the abstract notion of quantum spin and its causal relationship with angular momentum. Equally, the complexity of statistical issues within Bell's Inequality Theorem are not highlighted, let alone explained. Finally, the description also appears biased towards the general idea of an electron with spin being a 'particle' rather than a wave, such that we might need to still ask how a wave would spin? In this context, we might first need to understand the wave structure of an electron before we could really understand the nature of what might be measured. Likewise, while it suggests that local-hidden variables cannot explain the random probability of the measurements, it does not explain how the correlation of the outcome is achieved.*

Again, the average reader invariably runs up against ever-mounting technical details associated with all the various measurement procedures and assumptions, such that it can become near impossible to know what may be speculative inference as opposed to a proved fact. Irrespective of this issue, we are ultimately asked to accept an explanation where causality is essentially non-local, i.e. appears to requires some form of synchronisation that is independent of spatial separation, but which does not violate the speed of light [c] postulate of special relativity. How this might be achieved appears subject to so much speculation that it is almost impossible to assess whether there is any consensus on this issue, let alone whether there is any substantive evidence in support of any causal mechanism.

Note: This situation might be considered problematic if the correlation of the final state of a quantum system cannot be linked to a causal mechanism, as science might then be left open to all manner of philosophical interpretation, as appears to be the case, including metaphysical speculation. If so, we might realise why so many are still seeking an alternative theory grounded in cause and effect.

While it will be re-iterated that the points of concern, or simply personal confusion, raised through the entire discussion and summarised in this addendum are not intended as a rejection of the quantum model, they still question whether this model is a complete description of physical reality. Of course, in some respects, the completeness of the quantum model has long been questioned in terms of the apparent incompatibility with relativity, not least, in the fundamental description of space-time. For the large-scale *cosmological model* based on *general relativity* requires the universe to be little more than *empty space*, where the present-day *energy-density* is estimated to be $8.53*10^{-10}$ joules/m^3. However, only 4% of this total can be attributed to any known mass particle, i.e. $3.41*10^{-11}$ joules/m^3, which would convert to a mass-density of ~10^{-28} kg/m^3. In contrast, quantum physics appears to suggest that every point of space might be modelled as a *quantum oscillator*, which then leads to a potential quantum energy-density in the order of the Planck energy density, i.e. $4.6*10^{113}$ J/m^3. At face value, we appear to have an energy discrepancy that differs by 120 orders of magnitude!

What other contradictions might be cited?

Of course, there are also the obvious differences between classical physics and quantum field theory (QFT) in terms of its descriptions of various quantum fields, although the physical reality of these fields is still subject to much debate. However, there is also a perceived contradiction, or semantic confusion, in a *quantum field* description that retains both *field and particle concepts*, e.g.

QFT defines 12 fundamental quantum fields for fermions, i.e. 6 quarks and 6 leptons, and another 12 fundamental fields for bosons, not forgetting the 1 for the Higgs boson.

So, within the composite description of Quantum Electro-Dynamics (QED), Quantum Chromo-Dynamics (QCD) and Electro-Weak Theory (EWT), we have the seemingly ambiguous description that requires *'conceptual'* point-mass particles, e.g. electrons, as well as an array of unobserved quantum fields. However, within this array of '*conceptual*' quantum fields, the semantics of *'particles'* is still used to described '*conceptual*' force-carrier particles, e.g. bosons. While some might rightly challenge the over emphasis on the word '*conceptual*', the concern being raised is that any description of physical reality within the quantum model might appear to be predicated on only mathematical probability, where further debate reduces to one of ontological or epistemological preference.

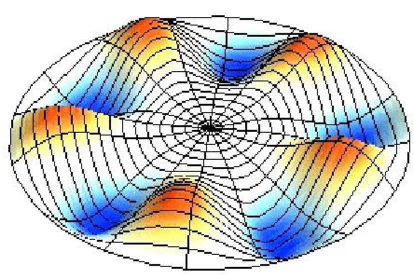
Note: In the current context, ontological is used to describe what things are, while epistemological is used to define what we think things are. As such, an ontological model would be more orientated to a physical cause and effect description, while an epistemological model might be more orientated toward mathematical abstraction.

So, it might be suggested that much of the perceive quantum weirdness appears to rest on the acceptance of quantum physics as an epistemological model, where emphasis is being placed on mathematical assumptions, which is able to predict the probability of a quantum final state, irrespective of whether any causal mechanism can be forwarded to physically explain the transition from the original initial state. In part, this issue returns us to '*The Measurement Problem*' that might be summarised in the following terms:

> *The measurement problem is related to the collapse of the wave function, which quantum theory assumes to evolve as described by the Schrödinger equation as a linear superposition of different states. However, this process is 'unobservable' and any attempt to subject this wave function to measurement is assumed to result in the collapse of the wave function into a definite state from which it will again start 'evolving' until the next measurement.*

However, hiding in this description are all the problems previously outlined, i.e. *quantisation, duality, energy structure, unobservability, uncertainty, indeterminacy, wave function reality, dispersion, coherence, semantic ambiguity etc*. Therefore, we might end this addendum with a highly speculative idea that attempts to consider the description above in a different way. For example, what if we were to assume that the wave function actually had some form of physical reality. If so, we might then proceed on the basis that this wave structure, while being unobservable, underpins the physical perception of the most fundamental subatomic particles. However, in order to support a particle having a velocity [v] ranging between zero and the speed of light [c], we shall assume this wave structure takes the form of a 3D standing wave.

> *Note: In the present context, the standing wave would be a superposition of more fundamental waves propagating with velocity [c] that form a localised energy-density of a subatomic particle in space. This structure would have somewhat ambiguous spatial dimensions being some multiple of its deBroglie wavelength, which might explain the uncertainty principle.*



As characterised, this waveform would not be subject to dispersion, such that it would have some degree of positional certainty within the ambiguity of the wavelength issue outlined above. However, such waveforms might also interconnect, as resonating 3D structures, to form larger particles within the totality of the particle model with a multitude of energy-densities, e.g. perceived mass, and half-life stability. However, we might recognise *the 'fragility'* of these wave structures to any form of measurement, i.e. interference from another waveform, such that the original waveform might be subject to decoherence and certain properties appearing to collapse when measured. Again, it needs to be reiterated that this model is entirely speculative and apparently unsupported by any obvious empirical evidence, although it is one that several people have pursued – see the '*Wave Structure of Everything'* for more details.