Article

Reflections on Materialist Metaphysical Dogmatism (Part II)

Graham P. Smetham*

Abstract

Whilst it is true that a great deal of the details of the experimental science which is presented in programmes presented by Cox, Al-Khalili and others is correct, the overall metaphysical perspective within which these details are presented is for the most part appallingly incorrect because they do not accord with the details of modern physics, quantum physics in particular. The metaphysical framework which underpins the general worldview of the programmes presented by both Cox and Al-Khalili largely corresponds to what Stapp refers to as a 'known-to-be-false' materialist perspective. The inappropriate materialist metaphysical dogmatism which underlies such programmes leads to some silly nonsense being presented without any challenge. This article cuts through the metaphysical madness.

Keywords: Quantum theory, quantum 'particles', quantum 'woowoo', quantum entangle-ment, Brian Cox, Jim Al-Khalili, Hawking and Mlodinow, Richard Feynman, Henry Stapp, Rupert Sheldrake, Schrödinger, Planck, Heisenberg, Rosenblum & Kuttner, Robert Maxwell, Anton Zeilineger, Buddhist metaphysics, Madhyamaka, sum over histories, ESP, parapsychology, telepathy, reincarnation, mind and matter, consciousness, quantum metaphysics, incorrect representation of science, Diamond Cutter Sutra.

This universal interconnectedness is also embodied in the central Buddhist doctrine of dependent origination and interconnection (*paticcasamuppada*) which asserts that at the fundamental level of reality there is absolutely no aspect of phenomenon which is disconnected from any other.

It is worth noting Cox's remark during his exposition of the Pauli Exclusion Principle concerning what he referred to as "*the illusion of solidity*" which is produced because of the fact that electrons try to "avoid each other" which, Cox says "is the reason I don't fall through the empty atoms in the floor." It is at points such as this that I feel a desperate need to be in the audience with a dispensation to stop the lecturer at any salient point and question them more deeply on the meaning of comments such as this, which are thrown in such a throwaway fashion despite the fact that they are deeply significant. This observation indicates that the appearance of solidity in the floor beneath one's feet, which is Planck's early notion that the there is continuous 'stuff' beneath ones feet, or Cox's assertion that there is the solid 'rock' of planet Earth beneath one's feet, and so on, is an illusion. None of it is there in the way that it appears to be. The reason that he, and we, do not fall through floors and cannot walk through walls is not that there actually is

* Correspondence: Graham Smetham, http://www.quantumbuddhism.com E-mail:graham@quantumbuddhism.com
Note: This article is adopted from the first chapter of the author's next book "'Quantum Buddhist Wonders of the Universe'.

solid stuff supporting or obstructing us, it is because of the electromagnetic forces acting between our bodies and floors and walls The material world, including our bodies, is made up of force fields rather than solid stuff.

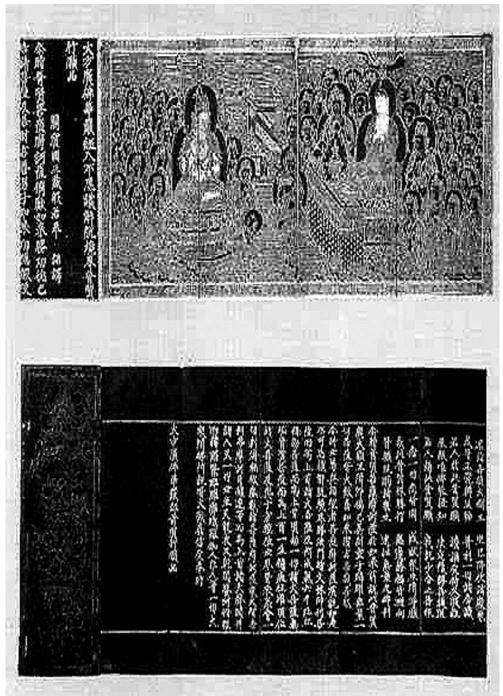

Figure 9 – Avatamsaka Sutra

Remember Cox's dramatic statement to the audience that they were 'empty'? This also means that the way in which they appear to themselves is an illusion precisely because, when analyzed to the atomic level, Dharmakirti's observation that all 'conventional' phenomena, including sentient beings, are comprised of "some mutually supporting infinitesimal particles that, through that causal support, serve the functions associated with the concept" that they appear to be (e.g. water jugs, rocks, trees, ponds, sentient beings etc.) is precisely correct. Even if the apparent 'particles' of the quantum realm were to be ultimate entities, by which we must mean if we are being honest about the meanings of our terminology, that they are indivisible, completely independent and eternal bits and pieces of reality, then the everyday world would be an *illusion* created from the 'real' atomic bits and pieces.

Cox is, perhaps unconsciously, aware of this which is why he used the term. However, as we shall see, if one was to push him on this point the evidence is that he would resist the notion that the reality we experience *really is an illusion* precisely because his mission seems to be to rescue the reality of what is actually an illusion. Only in off guard moments would he use such words as 'illusion', probably thinking he was using the term metaphorically, because for Cox *reality is a real illusion.* His entire metaphysical makeup requires him to somehow cook the quantum books in order to try and *pretend that the illusory nature of reality is an illusion and reality is really real!* Cox wants to have the intellectual kudos of saying such mind-boggling things as "you are vast and empty" at the same time as reassuring his audience that they *really are real* in just the way that classical physics always thought of reality! To do this however he has to indulge in remarkable amounts of evasion and obfuscation, not to mention illusion!

Anton Zeilinger is professor of physics at the University of Vienna and director of the Vienna branch of the Institute for Quantum Optics and Quantum Information at the Austrian Academy of Sciences. Zeilinger is a pioneer in the new field of quantum information and is renowned for his experimental demonstration of quantum teleportation with photons. Zeilin-ger has received many awards for his scientific work and is a member of six Scientific Academies. I think we can be pretty sure that his bottom is unmarked by Zodiacal symbolism. However, in an article in the volume of cutting edge quantum theory *Science and Ultimate Reality* in appreciation of the work of the famous twentieth century physicist John Archibald Wheeler he wrote of Wheeler's:

…realisation that the implications of quantum physics are so far-reaching that they require a completely novel approach in our view of reality and in the way we see our role in the universe. This distinguishes him from many others who in one way or another tried to save pre-quantum viewpoints, particularly the obviously wrong notion of a reality independent of us.[1]

In other words Zeilinger is telling us that quantum theory requires that reality is *not* independent of observers. In his more recent book *Dance of the Photons: From Einstein to Quantum Teleportation* he writes in similar vein about Einstein's attitude to the phenomenon of entanglement, which is the fact that just like Cox's electrons any entangled quantum entities can have instantaneous influence on each other over vast distances, that:

It now becomes clear why Einstein had to criticize quantum mechanics, why he called entanglement "spooky." His picture of the real, factual reality that exists in its essential properties indepen-dent of us, this picture of a separation of reality and information, does not seem to be tenable in quantum physics.[2]

Einstein's criticism was based on his mistaken determination to resist the quantum evidence. He stuck to his prejudice that an 'objective' 'real' world independent of observers *must* exist whereas the quantum evidence, as indicated by Zeilinger, is just the opposite. Cox, however, is someone who is trying "to save pre-quantum viewpoints, particularly the obviously wrong notion of a reality independent of us."

The realization that the notion of ultimate elementary particles is ruled out by quantum theory came quite early on. This realization was expressed by physicist David Bohm as follows:

…one finds, through a study of quantum theory, that the analysis of a total system into a set of independently existing but inter-acting particles breaks down in a radically new way. One discovers, instead, both from consideration of the meaning of the mathematical equations and from results of the actual experi-ments, that the various particles have to be taken literally as projections of a higher-dimension reality which cannot be accounted for in terms of any force of interaction between them.[3]

More recently quantum physicist H. Dieter Zeh, in his paper '*There are no Quantum Jumps, nor are there Particles!*', writes that:

…there does not seem to be any reasonable motivation (other than traditionalism) for introducing concepts like particles, quantum jumps, … or classical properties on a fundamental level.[4]

Cox, however, is having none of it. For him people like Zeilinger and Zeh, and a whole lot more respectable and respected non-hippy physicists, must surely be labeled woo-woo merchants (in fact we shall see shortly that in Cox's view this must extend to Stephen Hawking) because they clearly assert that the realm of reality which classical physics considered to be independent of consciousness cannot be so. Cox's worldview, however, ignores the phenomenon of consciousness except for the odd offhand remark such us "we are the way in which the Universe becomes conscious of itself."[5] How this happens is not explained. Despite this oversight Cox indicates to his audience of stars that he is engaged in explaining the entire nature of the universe!

In their recent book *The Quantum Universe: Everything that can happen does happen* Cox and Forshaw resort to some dubious intellectual techniques in order to "save pre-quantum viewpoints, particularly the obviously wrong notion of a reality independent of us." They try to convince their readers that the ultimate nature of reality is made up of 'real' quantum particles. They begin, ironically, by quoting Richard Feynman's observation concerning the impossibility of taking the notion of ultimate particles seriously:

Subatomic particles, Feynman wrote, "do not behave like waves, they do not behave like particles, they do not behave like clouds, or billiard balls, or weights on springs, or like anything that you have ever seen."[6]

Then, because Feynman has used the term 'subatomic particles' in a passage which clearly shows that *such entities cannot be 'particles'*, they incoherently assume that such entities can be claimed to inherently and independently exist *as* 'particles':

Let's get on with building a model for exactly how they do behave. As our starting point we will assume that the elemental building blocks of Nature are particles. This has been confirmed … by the double slit experiment, where particles always arrive at specific points on the screen.[7]

But this is simply not true. The double slit experiment does not in any way prove that "the elemental building blocks of Nature are particles". The double slit experiment indicates that the assumed 'particles' seem to arrive as 'particles' but, when there are two slits open and no-one trying to detect which slit the 'particle' goes through, they must travel as spread out waves of potentiality.

The next few paragraphs are for those readers not familiar with the double slit experiment. According to Richard Feynman the double slit experiment is 'designed to contain all of the mystery of quantum mechanics.'[8] Jim Al-Khalili refers to the behavior displayed in this experiment as 'nature's conjuring trick'[9], which is a very apt rubric. When light is shone through two narrow slits onto a screen beyond the slits as shown in Figure 10, the two light rays which emerge from the slits, which have a wave-like behaviour, interact with each other to produce a pattern of light and dark stripes. This happens because the light waves which meet from the different slits are either in phase, in which case they reinforce each other, or they are out of phase, in which case they cancel each other out; areas where the light waves are in phase are bright, and where they cancel dark areas are produced.

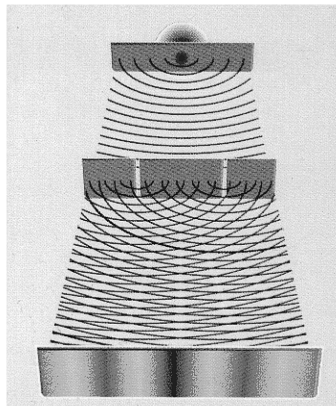

Figure 10

Light is generally thought of as being comprised of 'particles' of electro-magnetic wave-energy called photons; little pieces of electromagnetic vibra-tion that should be indivisible. The conjuring trick occurs when we send the photons, each one of which should be an indivisible wave-particle, through the slits one at a time. Because we are sending light particles through the apparatus one at a time it would seem reasonable to suppose that they would go through one of the slits, not both. It also seems reasonable to suppose that there will be no other wave-particles on the other side to interact with, so we would not expect to get the light and dark stripes, which should only occur because of the interaction of many waves going through slits at the same time. There should be just two stripes, one for each slit.

This, however, does not happen. The light and dark interference pattern still remains just as it was when a lot of wave-particles were going through the slits. And it is this behaviour which presents the conundrum as to how a supposedly indivisible 'particle' can spread out to pass through both slits and yet arrive at the screen as an apparent 'particle'. Although the wave-particle does have a wave aspect it is also supposed be an indivisible particle which should travel like a particle, which means it should go through just one of the slits.

Now suppose we decide to really find out what is going on; we change the experiment so that we place a detector at one of the slits to see which slit the wave-particles travel through. As soon as we do this the interference stripes disappear. It seems as if just looking at the slits to see what is happening changes the way that the wave-particles behave. It actually appears that if we do not look the wave-particle divides itself up, in a way that it should not be able to, in order to go through both slits. As soon as we look, however, it changes its behavior so that it goes through just one of the slits. It appears to 'know' when we are looking. When we look, then, we find that it is a particle. But when we do not look, it becomes something else. And this something else seems to be able to do the impossible. It divides itself up, whilst still remaining one indivisible thing, and then comes back together on the other side. Jim Al-Khalili likens this to a skier going around a tree on both sides (figure 11).

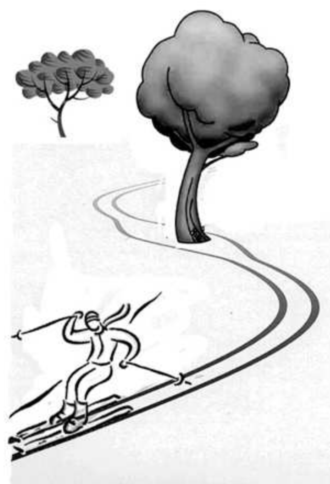

Figure 11

This not only happens with light wave-particles, it also happens with electrons, protons, atoms, and molecules, all of which have a quantum wave aspect (figure 12). When there is no way of knowing which path the 'particles' take the interference pattern appears, which seems to suggest that they take both paths, even though this should be impossible because the particle aspect should be indivisible. When we know which path is taken, however, the interference pattern disappears. The remarkable implication of this evidence is that conscious interference in the experiment has a direct effect at the quantum level. As Rosenblum and Kuttner say:

Physics had encountered consciousness but did not yet realize it.[10]

It looks as if the nature of the quantum realm is surprisingly mutable and is able to respond to the entire configuration of the experimental apparatus, including the observers and the nature of the observation.

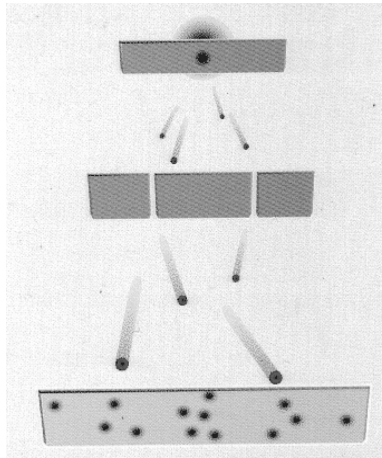

Figure 12

The development of quantum theory has required that physicists conceive that quantum sized 'particles' only 'materialize as 'particles' when they are registered in some way by consciousness, although the exact mechanism is not agreed. Between registration by consciousness or consciousnesses the quantum phenomenon which may register as a 'particle' actually travel as waves of potentiality described by a mathematical wave function, which describes the probability of 'particle' appearing in various places. The wavefunction (when squared) does not give the probabilities of where a pre-existing particle can be found. It actually gives the probabilities that, when a measurement interaction, seemingly involving consciousness, is performed at a particular time and in a particular location, the measurement will register the presence of a particle. The particle, however, does not exist prior to the interaction. According to Rosenblum and Kuttner:

The object was not there before you found it there. Your happening to find it there *caused* it to be there.[11]

Not all physicists would be happy with stating the quantum situation so bluntly, but there is a fairly impressive consensus that consciousness is implicated in some way. Many however, like Bernard d'Espagnat, are emphatic that

The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum mechanics and with facts established by experiment. [12]

A forceful observation which indicates that consciousness and the quantum realm are inti-mately interconnected.

The manner in which consciousness appears to interact at the quantum level is described by a mathematical device called a quantum wavefunction. This mathematical equation precisely describes the time evolution of the state of a quantum system, a 'state' being the, possibly infinite, collection of possibilities contained within the wavefunction. Penrose describes the situation that:

From time to time – whenever we consider that a 'measurement' has occurred – we must discard the quantum state that we have been laboriously evolving, and use it only to compute various probabilities that the state will 'jump' to one or another of a set of *new* possible states.[13]

And, significantly, the new states appear as classical 'particle' states, whereas prior to the measurement event the wavefunction is a purely abstract mathematical construction to which a 'particle' reality cannot be ascribed. It clearly appears that between measurements the wave aspect of the quantum realm is dominant.

Cox and Forshaw, however, are intent on pretending that the notion of a 'quantum particle' is a legitimate and viable account of the quantum situation even though their own discussion clearly indicates that wave behaviour is fundamental:

… the double slit experiment requires that the electrons 'interfere with themselves' when they pass through the slits. And to do so they must in some sense be spread out. This is not as impossible as it sounds: we can do it if we let any single particle be in many places at once … From now on we will refer to these counter-intuitive, spread-out-yet-point-like particles as quantum particles … we are moving away from everyday experience … and must follow Heisenberg and learn to feel comfortable with views of the world that run counter to tangible experience … because the real world simply doesn't behave in an everyday way. We must therefore keep an open mind and not be distressed by all the weirdness. Shakespeare had it right when Hamlet says: 'There are more things in the world Horatio, than are dreamt of in your philosophy."[14]

In the early days of quantum mechanics Heisenberg lamented after a late night discussing the quantum situation:

Can nature possibly be as absurd as it seems to us in these atomic experiments?[15]

This clearly indicates that Heisenberg was deeply shocked that the quantum level of reality behaved in such a deeply counterintuitive manner, as the other physicists of the time were. Physicists at the time were expecting to find some sort of inherently existing fundamental 'particles', but there did not seem to be any. Because there were, and are, no inherently existing 'particles' at the quantum level, the manner in which Heisenberg began to "feel comfortable" with the situation is indicated in the following quotes:

The conception of objective reality of the elementary particles has thus evaporated not into the cloud of some obscure new reality concept but into the transparent clarity of a mathematics that represents no longer the behavior of particles but rather our knowledge of this behavior.[16]

… the act of registration of the result in the mind of the observer. The discontinuous change in the probability function … takes place with the act of registration, because it is the discontinuous change in our knowledge in the instant of registration that has its image in the discontinuous change of the probability function.[17]

When the old adage "Natura non facit saltus" (Nature makes no jumps) is used as a basis of a criticism of quantum theory, we can reply that certainly our knowledge can change suddenly, and that this fact justifies the use of the term 'quantum jump'.[18]

It seems quite clear that Heisenberg considers the jump from quantum wave to experienced particle as involving a change of state of knowledge, and in the first quote Heisenberg clearly rules out the notion of 'elementary particles.' Stapp, who actually discussed quantum issues with Heisenberg, says regarding Heisenberg's views:

Let there be no doubt about this point. The original form of quantum theory is subjective, in the sense that it is forthrightly about relationships among conscious human experiences…[19]

By no stretch of the imagination did Heisenberg "learn to feel comfortable with views of the world" involving 'quantum particles.'

The irony in Cox and Forshaw's absurd attempt to 'save the appearances' of 'quantum particles' is almost painful because the apparent attempt at misdirection is so obvious: if ordinary type 'particles' do not behave the way that the quantum world does then, Cox and Forshaw declare, let's define a new kind of 'particle' which does not behave like a 'particle' at all, but mostly like a wave, and call this concoction a 'quantum particle'. Even though the behaviour of our new type of 'particle' bears no relation to the old definition of 'particle' and is actually completely contrary to the definition of a 'particle'. Who cares, the quantum world is so at variance to the everyday world we might as well just define the same words to mean completely different, even contrary, things and then use these new words to pretend that there isn't so much difference between the two levels of reality at all!

But in order to perform this illusion of undermining the reality of quantum illusion in his lecture Cox employs some desperately implausible methods. When discussing the way in which electrons behave in the double slit experiment Cox tells the audience:

[Richard Feynman] says this … [the electron] needs to be able to interfere with … so it must at least go through the other slit as well and get to that point. And there must be some mechanism for these paths interfering with each other.

Feynman, however, did not say this at all. In his lecture on the subject, after summarizing the quantum mathematical rules he said:

One might still like to ask "How does it work? What is the machinery behind the law?" No one has found any machinery behind the law. No one can "explain" any more than we have just "explained." No one will give you any deeper representation of the situation. We have no ideas about a more basic mechanism from which these results can be deduced."[20]

In their book C & F, adding insult to injury, admonish their readers that if they fail to comply with their technique of using the same word to mean completely different things whilst pretending they are the same type of thing then they are failing in imagination! The truth of the situation, however, is that it is C & F who are failing to realize that 'there are more things in the world … than are dreamt of in [C & F's] philosophy," they are failing to realize that a pretend 'particle' which does not conform to the essential characteristics of the definition of a 'particle' is not, as Feynman realized, a 'particle'. What C & F are actually doing is misusing language in order to accommodate their realist, essentially materialist prejudices. And yet, in a another spectacular piece of quantum misdirection they further admonish their readers to abandon their prejudice that words cannot mean entirely contrary things depending on whether they apply to the quantum or the everyday world:

The key ideas are very simple in their technical content, but tricky in the way that they challenge us to confront our prejudices about the world.[21]

But the really tricky aspect of C & F's exposition is the way in which they constantly explain the functioning of the quantum world in terms of waves at the same time as insisting that their new 'counterintuitive' and implausible conceptual concoction of a 'quantum particle' is up to the task of behaving exactly like a wave, even though by definition it should not be able to:

We are therefore going to have to decide how to make our quantum particle 'an extended travelling thing.'[22]

Of course we would all like to make reality conform to our prejudices, but somehow Cox has managed to persuade a large section of the scientific community and the BBC into his quantum conceptual perfidy:

We need to allow the wave to go through both slits in order to get an interference pattern, and this means that we must allow all possible paths for the electron to travel from source to screen. Put another way, when we said that the electron is 'somewhere within the wave' we really meant to say that it is simultaneously every-where in the wave![23]

Perhaps C & F feel very deeply that they "need to allow the wave… " whist pretending there is some kind of 'particle' masquerading somewhere, but if "it is simultaneously everywhere in the wave" then 'it' is not a particle!

It is intriguing in this context to recall what Jim Al-Khalili said about the quantum phenomenon of the 'collapse of the wave function' at the end of his *Atom* series:

An atom is spread out all over the place until a conscious observer decides to look at it. So the act of measurement creates the entire universe.

So at this point in his TV career Al-Khalili clearly considered that an atom was a spread out wave phenomenon and only became particle-like when consciousness got involved, a view radically at variance with Cox's idiosyn-cratic approach.

The photo (figure 10) shows Professor John Wheeler in mid flow of explaining the distinction between the 'classical' realm and the 'quantum' realm. On the left of the photo the blackboard drawing shows a 'classical' size object moving between two points. At every point in time it has a definite position and it therefore seems to follow a definite trajectory between the points. In other words it behaves like an everyday object or a 'particle. The section of the blackboard drawing behind Wheeler's head indicates the situation at the quantum level; quantum 'entities' behave in a completely different and counterintuitive manner; they spread out or 'smear out' over increasingly large areas and fade into a ghostly semi-existence of potentiality.

When unobserved 'quantum particles' are not 'particles,' they are a 'smeared out' potentiality fields of possible 'particle' experience. Stapp says that the central distinguishing feature between these two levels of reality is that on the 'classical' level motions are "apparently independent of our human observations of them."[24] The hugely significant word in this observation is 'apparently'. Stapp, in line with Planck, Schrödinger Heisenberg, Zeilinger, Penrose and many others, indicates that quantum theory clearly indicates some kind of 'entanglement' of mind and matter. In fact according to Stapp quantum theory requires that Mind is the primary ontological aspect of reality:

There is, in fact, in the quantum universe no natural place for matter. This conclusion, curiously, is the exact reverse of the circumstances that in the classical physical universe there was no natural place for mind.[25]

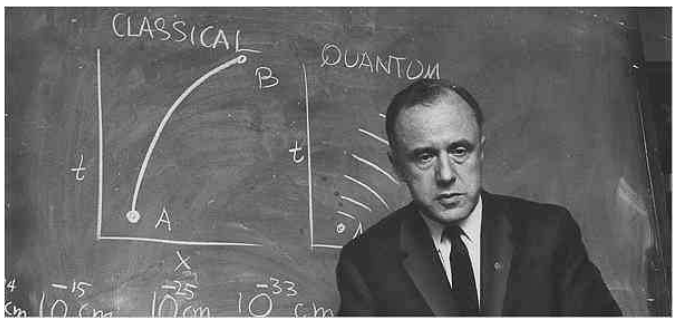

Figure 10 - John Wheeler elucidating the distinction between quantum and classical reality.

Cox, however, seems determined to avoid any mention of the quantum level entanglement with mind. The approach that Cox adopts for his explanation of the double slit experiment is the Feynman 'sum over paths' approach. In this analysis a 'particle' is *imagined* to take every possible path from one point to any other point. The reason for this is that the issue which needs to be accounted for in the situation of the double slit experiment is how it is possible for a 'particle' to 'know' about both slits in order to behave in a manner appropriate to the experimental setup. The solution that Feynman came up with, a solution which led to extremely powerful mathematical techniques for solving quantum puzzles, was that a quantum 'particle' may be considered to "explore the entire universe instantaneous-ly," as Cox described the amazing quantum vision which tells us that at every moment of time every quantum 'particle' is 'instantaneously explor-ing' every quantum nock and cranny of the entire universe. One can only wonder how such a 'particle', busily and instantaneously spreading itself over the entire universe, actually gets time to come back to itself so to speak and be a 'particle'!

Figure 11 is taken from Stephen Hawking and Leonard Mlodinow's book *The Grand Design: New Answers to the Ultimate Questions of Life* in which they also use the Feynman 'sum over paths' approach:

Feynman realized … that particles take every possible path connecting … points. This, Feynman asserted, is what makes quantum physics different from Newtonian physics. The situation at both slits matters because, rather than following a single definite path, particles take every path, and they take them all simultaneously! That sounds like science fiction, but it isn't. Feynman formulated a mathematical expression - the Feynman sum over histories - that reflects this idea and reproduces all the laws of quantum physics. In Feynman's theory the mathematics and physical picture are different from that of the original formulation of quantum physics, but the predictions are the same. In the double-slit experiment Feynman's ideas mean the particles take paths that go through only one slit or only the other; paths that thread through the first slit, back out through the second slit, and then through the first again; paths that visit the restaurant that serves that great curried shrimp, and then circle Jupiter a few time before heading home; even paths that go across the universe and back. This, in Feynman's view explains how the particle acquires information about which slits are open…[26]

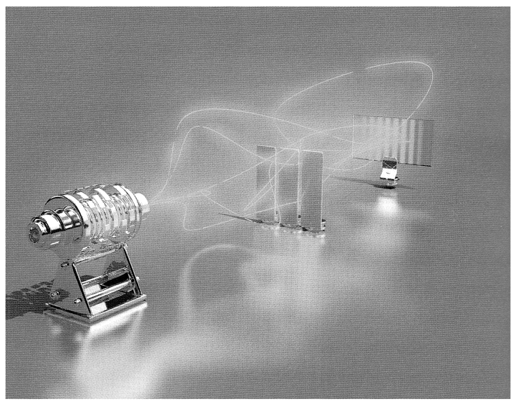

Figure 11

This description appears to imply that if it is possible to formulate a mathematical expression to describe the process of reality which appears to contravene our everyday notions then although it "sounds like science fiction … it isn't." In this case H & M are referring to the Feynman sum over histories equation, which Cox wrote out on a blackboard during his lecture (figure 12). This is the equation which, according to H & M & C & F indicates that quantum particles "take every path, and they take them all simultaneously!"

Now a significant philosophical issue which arises at this point is that, even if we accept for the sake of argument that 'quantum particles' actually exist, are such 'particles' *really and truly in reality* constantly and continuously and instantaneously traversing an infinite number of "paths that go across the universe and back?"

Such notions really require us to examine our notions of reality! At the moment I have a glass of Chardonnay next to my computer. Is it really true in reality that there are self-enclosed independent self-contained 'particles' of the 'stuff' of reality making up my wine that are constantly traversing every quantum Planck unit of space at every moment of time? When I take a sip am I really in reality imbibing quantum bits and pieces which have just arrived back from the 'Andromeda Galaxy?' If you think I am being obtuse here I suggest you go and listen to end of Cox's lecture:

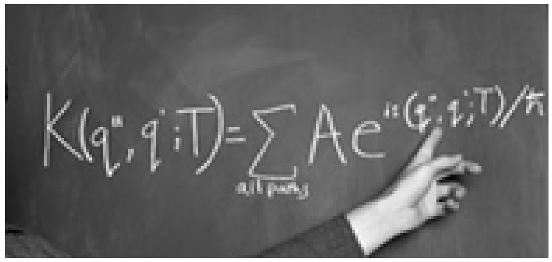

Figure 12

Quantum theory explains how the REAL world emerges from subatomic particles that explore the universe, the entire universe, in an instant!

Does Cox mean to suggest that the subatomic particles are UNREAL? Does he really know what he is talking about? If we ask for *philosophical and conceptual coherence and clarity* he clearly does not, for as Penrose has pointed out:

Undoubtedly the world is strange and unfamiliar at the quantum level, but it is not unreal. How, indeed, can real objects be constructed from unreal constituents?[27]

It is obvious that such a situation would not make sense. However, as we have seen when discussing Dharmakirti, it makes perfect sense for something unreal to emerge from real constituents. Indeed according to quantum cosmologist Lee Smolin:

How something is, or what its state is, is an illusion. It may be a useful illusion for some purposes, but if we want to think fundamentally we must not lose sight of the essential fact that 'is' is an illusion.[28]

But listening to Cox it seems that everything is REAL, there *really* are bits and pieces of reality instantaneously zooming around the entire universe at every moment in time whilst also staying put in order to constitute my glass of wine or the million pounds worth of diamond he cradled in his hand whilst informing his audience that every bit of it was instantaneously flying around exploring the entire universe! Furthermore, if every quantum particle in existence is instantaneously exploring every quantum corner of the entire universe it is absolutely amazing that every sentient being does not telepathically know everything there is to know about the entire universe, including other sentient beings. After all every quantum particle of every sentient being is instantaneously acquiring knowledge about everything there is to know about the entire universe at every moment of time!

Let us return to the issue of whether the entities imaginatively used to derive a physically significant mathematical equation must automatically be given the status of 'elements of reality', to steal a term indicating real reality from Einstein. The imaginative moves made by James

Clerk Maxwell to derive his hugely significant equations of electromagnetism provide a profound example. The following outline is taken from the book *The Great Equations: The hunt for cosmic beauty in numbers* by Robert P. Crease. Maxwell explicitly set out to use 'physical analogies' in order to derive his equations:

I shall use physical analogies to develop mathematics more suited to electrical science. Bear in mind that these are *only* analogies. If we do, we can think more clearly, for we will be neither too distracted by the mathematics on the one hand, nor too stuck on the physical conceptions from which these are borrowed on the other.[29]

Maxwell was impressed with Michael Faraday's 'vague and unmathematical' idea of an electric 'field' consisting of 'lines of force' and set out to produce a rigorous mathematical account of this 'ethereal substance'[30] through which the 'mechanical phenomena' of electromagnetic force was supposed to be transmitted. Maxwell certainly considered that his field was 'real' and his vision of it has echoes of Cox's cosmic interconnectedness:

The vast interplanetary and interstellar regions will no longer be regarded as waste places in the universe, which the Creator has not seen fit to fill with the symbols of the manifold order of His kingdom. We shall find them to be already full of this wonderful medium; so full, that no human power can remove it from the smallest portion of space, or produce the slightest flaw in its infinite continuity. It extends unbroken from star to star; and when a molecule of hydrogen vibrates in the dog-star, the medium receives the impulses of these vibrations; and after carrying them in its immense bosom for three years, delivers them in due course, regular order, and full tale into the spectroscope of Mr. Huggins, at Tulse Hill.[31]

Maxwell carried out his mathematical tour-de-force in a paper called 'On Physical Lines of Force', written in 1861-62, and, as Crease says "it contains one of the greatest uses of analogy in the history of science." The source of Maxwell's analogy was an observation by another physicist that a magnetic field could be thought of as being made up of points each of which could be thought of as a "tiny spinning 'molecular vortex'"[32]. Crease writes of Maxwell's image:

Let's say a magnetic field consists of such rotating 'cells', as he calls them, whose axes are along magnetic lines of force as if threaded on a string; the stronger the field, the more rapidly the cells spin. But Maxwell knows it is mechanically impossible to have cells on neighboring strings spin the same way - clockwise, let's say - for those on one string would rub the wrong way against those in the next. Maxwell rescues the picture by assuming that the space in between is filled with something similar to what engineers call 'idle wheels' - smaller beads, in contact with the cells, that rotate counterclockwise, permitting the cells to rotate clockwise. These beads stay in place when the neighboring cells are rotating at the same speed, but changes in the speeds of the vortices cause the beads to move in a line, and they are passed from one cell to another.[33]

This 'mechanical' analogy enabled Maxwell to achieve one of the most profound mathematical achievements in the history of science, in many respects setting the stage for the subsequent emphasis on mathematical formulism within physics, but:

He was under no illusion that he had created a picture, a representation, of electromagnetism. All he wanted to claim was that this strange model did whatever electrical and magnetic phenomena did, and thus that its mathematics would also work for them.[34]

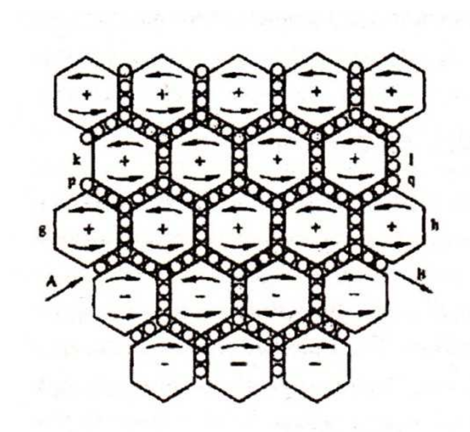

Figure 13 – Maxwell's mechanical analogy

Subsequently it turned out that the notion of a *substantial* field, which Maxwell conceived of as being really real 'out there' in reality, did not correspond to an actually independently existing 'element of reality.' The mathematical equations derived from Maxwell's work with beautiful precision to describe and predict the regularities of human experience, but none of the mechanisms and entities used in the derivation actually 'really' exist as independent and inherent bits and pieces of reality. All that 'seems' to be 'real' is the mathematics and the experiences upon which the mathematics is based. No wonder physicist Max Tegmark has gone so far as to suggest that ultimate reality is mathematics! Unfortunately, however, this view lacks experience.

There is another significant episode in the development of quantum theory which is relevant in the context of relationship between models of reality and reality as we might think it really is. This is the polarisation of viewpoints between Schrödinger and Heisenberg:

Heisenberg understood that Einstein and Schrödinger wanted 'to return to the reality concept of classical physics or, to use a more general philosophic term, to the ontology of materialism.' The belief in 'an objective real world whose smallest parts exist objectively in the same sense as stones and trees exist, indepen-dently of whether or not we observe them', was for Heisenberg a throw-back to 'simplistic materialist views that prevailed in the natural sciences of the nineteenth century'.[35]

We have already noted Heisenberg's rejection of any kind of naïve realism concerning elementary 'particles.' Although Schrödinger's viewpoint was not quite as crudely rooted in materialism as Heisenberg perhaps presented it, he did want to think of his equation as representing something 'physically' and independently existent, suggesting that it might be "intimately connected to the cloud like distribution of electric charge as it travelled through space."[36] Heisenberg, on the other hand, emphasised the:

…subjective element in atomic events, since the measuring device has been constructed by the observer, and we have to remember that what we observe is not nature in itself, but nature exposed to our method of questioning.[37]

Heisenberg's 'matrix mechanics,' therefore brings to the fore a kind of discontinuous spontaneity within the interdependent matrix of observer and observed which did not necessarily entail the necessity for a deeper substantiality.

Both Schrödinger and Heisenberg were thoroughly convinced of the correctness of the truth of their respective positions; each considered that their representation in some sense captured the structure of reality as it really is. Because of the 'lack of visualisation' in matrix mechanics Schrö-dinger felt 'repelled' by Heisenberg's view. Heisenberg, on the other hand told Wolfgang Pauli:

What Schrödinger writes about the visualizability of his theory is probably not quite right,' in other words its crap.[38]

How remarkable, then, that eventually Schrödinger demonstrated that these two ways of conceiving the quantum realm are mathematically equivalent, or are different mathematical formulations of the 'same' underlying process of reality! Although this discovery did not give the final honours to either of the two quantum perspectives, it did indicate the essential correctness of Heisenberg's view that any physical theory describes 'nature exposed to our method of questioning.'

Heisenberg's insight prefigured the metaphysical position advanced by Hawking and Mlodinow in their recent book *The Grand Design*:

Model-dependent realism short circuits all this argument and discussion between the realist and anti-realist schools of thought. According to model-dependent realism, it is pointless to ask whether a model is real, only whether it agrees with observation. If there are two models that both agree with observation … then one cannot say that one is more real than another. One can use whichever model is more convenient in the situation under consideration.[39]

In Hawking and Mlodinow's discussion the terms 'realist' and 'anti-realist' are used quite loosely for, in fact, model-dependent realism necessarily will have to impute unreality to models, such as the existence of ultimate little balls of 'matter' which have been shown to be non-existent by experiment. And, on the other hand, a 'provisional' reality would have to be accorded to those models which are in accord with observations. Hawking and Mlodinow point out that:

… situations in which … very different theories accurately describe the same phenomenon - are consistent with model-dependent realism. Each theory can describe and explain certain properties and neither theory can be said to be better or more real than the other. Regarding the laws that govern the universe what we can say is this: there seems to be no single mathematical model or theory that can describe every aspect of the universe…[40]

It seems, then, that unadulterated really 'real' reality so to speak is forever beyond conceptual reach. It is, as Bernard d'Espagnat puts it, a 'veiled reality,'[41] a reality which reveals aspects of its nature through different 'measuring' interactions with conceptual systems of consciousness but never reveals its full nature to conceptual understanding.

Hawking and Mlodinow, however, do present a spectacular account of the nature, functioning and development of what we take to be 'reality'. They describe the fact that in the double slit experiment when 'which way' information is collected, information which tells the experimenters which path any apparent 'particle' has apparently traveled, the interference pattern disappears, *a result which shows that conscious intervention has a determining effect on the experimental outcome*. They present their conclusion is as follows:

Quantum physics tells us that no matter how thorough our observation of the present, the (unobserved) past, like the future, is indefinite and exists only as a spectrum of possibilities. The universe, according to quantum physics, has no single past, or history. The fact that the past takes no definite form means that observations you make on a system in the present affect its past.[42]

And they press the point home with a description of the Wheeler cosmic delayed choice double-slit thought experiment which indicates that observation has a backwards in time quantum effect, an experiment which was subsequently performed on a terrestrial scale by Zeilinger and his team. H & M conclude:

…the universe doesn't have just a single history, but every possible history, each with its own probability; and our observations of its current state affect its past and determine the different histories of the universe, just as the observations of the particles in the double-slit experiment affect the particles' past.[43]

And so we come to the astonishing proposal. From the timeless point of creation a spontaneous universal creative act projects all possible futures into a universal possibility or potentiality space. At the point of creation everything that possibly can happen becomes potential, so at the point of creation all possible future histories of the universe come into being as potentialities, although not yet experienced realities:

In this view, the universe appeared spontaneously, starting off in every possible way. Most of these correspond to other universes …. Some people make a great mystery of this idea, sometimes called the multiverse concept, but these are just different expressions of the Feynman sum over histories.[44]

Clearly the H-M-TOE (Hawking-Mlodinow Theory of Everything) corresponds in a fashion to the multiverse scenario, except that the usual multiverse vision claims that, as in the title of Cox & Forshaw's book, 'everything that can happen does happen', whereas in the H-M-TOE all possibilities are projected as potentialities into the future, the spontaneous creative burst creating the multiverse of possible worlds.

A hugely significant feature of the H-M-TOE presentation is the fact that the 'observers are part of the system'[45] and whereas in the usual multiverse scenario, the many-worlds theory, helpless observers are haplessly and unknowingly rent asunder to occupy an exponentially increasing vast number of new 'parallel worlds,' in the H-M-TOE observers have serious work to do:

The histories that contribute to the Feynman sum don't have an independent existence, but depend on what is being measured. We create history by our observations, rather than history creating us.[46]

In other words the observers, or what Wheeler called 'observer-participants,' are able to weed out possible universes, and thereby select those which remain in the possibility mix, even backwards in time. Thus one of the central chapters in *The Grand Design* is entitled 'Choosing Our Universe':

The idea that the universe does not have a unique observer-independent history might seem to conflict with certain facts that we know. There might be one history in which the moon is made of Roquefort cheese. But we have observed that the moon is not made of cheese, which is bad news for mice. Hence histories in which the moon is made of cheese do not contribute to the current state of our universe, though they might contribute to others. This might sound like science fiction but it isn't.[47]

It is quite clear that we are being told that the reason why the moon is not made of Roquefort cheese is because the observer participants of this particular universe have observed that the moon is not made of cheese. The observations made by the observer-participants have filtered out, *backwards in time*, the possibility of a cheese moon and also, at the same time, have determined the possibilities that are projected into the future. And, as Hawking and Mlodinow say, this is not science fiction (although I seriously doubt whether there really was ever, in any universe, the possibility of the moon being made of cheese; might it be possible to push the metaphors of popular science towards the realms of impossibility?).

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