The Tibetan Book
of the
Undivided Universe
David Bohm's Quantum Philosophy of Wholeness In the Light of Buddhist Metaphysics

Graham Smetham

First Turning
of the
Holomovement
Setting the scene for Wholeness

The work of the maverick and important physicist David Bohm has been accorded fresh impetus recently with the release of the excellent film dealing with his life and work: "Infinite Potential: The Life and Ideas of David Bohm." This film is the first of a series of films and discussions organised by the Infinite Potential organisation (www.infinitepotential.com). The description of the film portrays Bohm as:

> … the man Einstein called his "spiritual son" and the Dalai Lama his "science guru." A brilliant physicist and explorer of Consciousness, Bohm's incredible insights into the underlying nature of reality and the profound interconnectedness of the Universe and our place within it are truly transformational.

This, ultimately deserved, accolade is made by a group of physicists and philosophers who are enthusiastic about the 'later' presentation by Bohm of his 'Undivided Universe' views, presented in the final years of his life, with the collaboration of the physicist Basil Hiley. In this later and final phase of Bohm's life he was significantly impressed and influenced by what some might consider to be the 'mystical' perspective of the popular and influential 'mystic' and philosopher Jiddu Krisnamurti, whose teachings primarily derive from the doctrines of Buddhism, woven together with insights Krishnamurti gleaned from his own investigations of psychology. So, it is clear that Bohm's *later* engagement with his work in physics took place within a context of a spiritual worldview informed by Buddhist metaphysics in particular, although it cannot be asserted that Bohm's views always conformed with Buddhist doctrine. But, in this article we shall survey some significant resonances.

Bohm did not always carry out his scientific explorations in the midst a penumbra of spiritual interests, and neither does everyone appreciate his mystical engagement with physics. The science writer for the Scientific American John Horgan wrote in his 2018 article 'David Bohm, Quantum Mechanics and Enlightenment':

> Some scientists seek to clarify reality, others to mystify it. David Bohm seemed driven by both impulses. He is renowned for promoting a sensible (according to Einstein and other experts) interpretation of quantum mechanics. But Bohm also asserted that science can never fully explain the world, and his 1980 book Wholeness and the Implicate Order delved into spirituality. Bohm's interpretation of quantum mechanics has attracted increasing attention lately.[1]

It is a sometimes overlooked fact of Bohm's intellectual development that in an earlier phase of his scientific explorations, during the period that his interest in the welfare of humanity had led him to misguidedly embrace Marxism as a possible panacea for human problems, he advanced what amounted to a deterministic quantum-materialist version of quantum theory, this was his 'pilot wave' or 'ontological' interpretation,

which he proposed in his 1952 article '*A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden' Variables*'. This hard-edged pristine world of real quantum waves pushing around tiny particles of matter was proposed in order to counter and deflate what some physicists at the time considered to be a too vague, imprecise, and perhaps 'mystical' viewpoint that had been enshrined in the Copenhagen 'interpretation' by Neils Bohr and Werner Heisenberg.

This 'interpretation' was prompted by certain surprising discoveries concerning quantum behavior we shall look into later. In a lecture given at the 1928 International Physics Conference at Lake Como Bohr indicated a central aspect of the Copenhagen interpretation of quantum theory as follows:

> Now the quantum postulate implies that any observation of atomic phenomena will involve an interaction with the agency of observation not to be neglected. Accordingly, an independent reality in the ordinary physical sense can neither be ascribed to the phenomena nor to the agencies of observation.[2]

A significant feature of this formulation is that it asserts that there is no separate "independent reality in the ordinary physical sense" to either side of the interaction between observer and observed. This view seems to suggest that observing minds and the observed matter at the quantum level in some way interpenetrate and are inseparable.

Another significant aspect of the Copenhagen viewpoint is the 'Complementarity Principle' , which asserts that atomic phenomena have both wave and particle properties, and that these properties manifest in a mutually exclusive manner, they are therefore said to be 'complementary'. The behaviour of such phenomena as light and electrons depends on the experimental arrangement, it is sometimes wavelike and sometimes particle-like; but it is impossible to observe both the wave and particle aspects simultaneously. Taken together, however, they present a fuller description than either of the two taken alone. In this context Bohr referred to:

> The existence of different aspects of the description of a physical system, seemingly incompatible but both needed for a complete description of the system. In particular, the wave-particle duality.[3]

And, according to Bohr, this is:

> The phenomenon by which, in the atomic domain, objects exhibit the properties of both particle and waves, which in classical, macroscopic physics are mutually exclusive categories.[4]

And he referred to:

> The apparently incompatible sorts of information about the behavior of the object under examination which we get by different experimental

> arrangements can clearly not be brought into connection with each other in the usual way, but may, as equally essential for an exhaustive account of all experience, be regarded as 'complementary' to each other.[5]

In observations such as these Bohr seemed to be inclined to import a mystical flavour of the East into quantum physics. As Bohr himself wrote:

> For a parallel to the lesson of atomic theory regarding the limited applicability of such customary idealisations we must in fact turn … even to that kind of epistemological problems with which already thinkers like Buddha and Lao Tzu have been confronted, when trying to harmonize our position as spectators and actors in the great drama of existence.[6]

Not all physicists were happy with this state of affairs, primarily instigated by the Danish physicist Neils Bohr. Hence Adam Becker, in his excellent book on the history of quantum theory - *What is Real,* has titled his chapter on the Copenhagen hegemony: 'Something Rotten in the Eigenstate of Denmark'!

In the early 1950s Bohm was one of the physicists who disliked this move towards a more 'mystical' physics, and in the conclusion to his 1952 article he wrote (in the following quote 'Ψ-field' is the quantum wave-field):

> The usual interpretation of the quantum theory implies that we must renounce the possibility of describing an individual system in terms of a single precisely defined conceptual model. We have, however, proposed an alternative interpretation which does not imply such a renunciation, but which instead leads us to regard a quantum-mechanical system as a synthesis of a precisely definable particle and a precisely defined Ψ-field which exerts a force on the particle.[7]

Bohm's use of the term 'renounce' here is perhaps a response to Bohr's assertion concerning the fact that he thought that a "renunciation of the visualization of atomic phenomena is imposed upon us" by the nature of reality; a view which, clearly, Bohm did not share. As can be seen in Bohm's conclusion, whereas Bohr thought that that the quantum world mystically-morphed between appearances of waves or appearances of particles, but never both , Bohm asserted that both waves and particles were there at all times, the waves pushing particles around. However, as we shall see, this sparse quantum mechanistic worldview later transmuted into a glorious spiritual vision of an Undivided Universe which is enlivened by the presence of a kind of primordial consciousness projecting itself into embodied limitation.

In the book *The Undivided Universe* co-authored by Bohm and Hiley (B&H), which was in the final stages of completion when Bohm died, B&H describe Bohm's final metaphysical vision of an interconnected holistic universe:

> We may suppose that the universe, which includes the whole of existence, contains not only all the fields that are now known, but also an indefinitely

> large set of further fields that are unknown and indeed may never be known in their totality. Recalling that the essential qualities of these fields exist only in their movement we propose to call this ground the *holomovement*. It follows that ultimately everything in the explicate order of common experience arises from the holomovement. Whatever persists with a constant form is sustained as the unfoldment of a recurrent and stable pattern which is constantly being renewed by enfoldment and dissolved by unfoldment. When the renewal ceases the form vanishes.[8]

It has to be said that in this presentation B&H actually present their own vision in a way that can lead to misunderstanding, if it taken on its own without elucidation from other descriptions from Bohm's work and some other sources, such as discussions with colleagues. This is because the assertion that the holomovement is the '*ground*', and that "everything in the explicate order of common experience *arises from* the holomovement", clearly gives the impression that the explicate order, which includes the everyday world of our experience, *arises* out of the *ground* of the holomovement. This would seem to indicate that the explicate order is separate from, being projected out of, so to speak, the holomovement.

However, this is not the correct picture. When all of the various metaphors and descriptions in Bohm's writings and talks are taken into account, it is clear that the holomovement is the movement of the totality, and therefore the explicate order is an internal aspect of the holomovement. The holomovement contains both implicate orders and the explicate order. Because the contents of the explicate order, which unfold from the implicate order(s), have a greater stability, the explicate order has a degree of separation from the implicate orders. But all the orders are within the holomovement. Bohm's friend and collaborator David Peat describes this:

> Bohm believes that the Implicate Order has to be extended into a multidimensional reality; in other words, the holomovement endlessly enfolds and unfolds into infinite dimensionality. Within this milieu there are independent sub-totalities (such as physical elements and human entities) with relative autonomy. The layers of the Implicate Order can go deeper and deeper to the ultimately unknown. It is this "unknown and undescribable totality" that Bohm calls the holomovement.[9]

Thus, we see that "independent sub-totalities (such as physical elements and human entities) with relative autonomy", which are the contents of the explicate order, unfold out of the implicate orders, but the entire process remains within the holomovement.

In his book *Wholeness and the Implicate Order*, Bohm gives the following description:

> It is being suggested here, then, that what we perceive through the senses as empty space is actually the plenum, which is the ground for the existence of

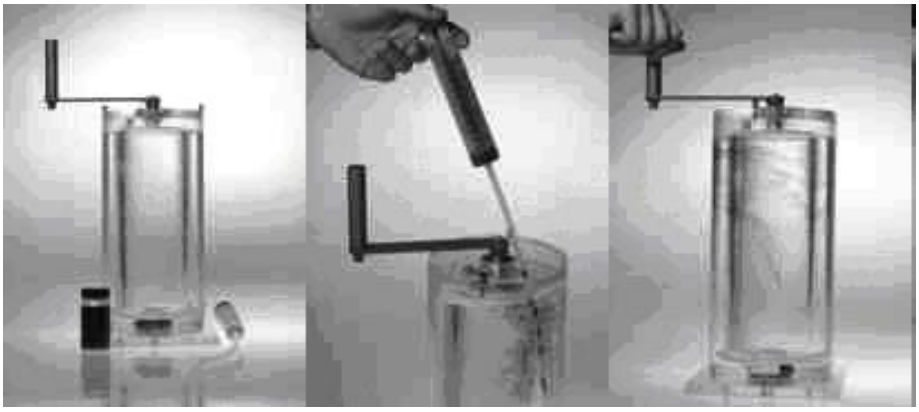
> everything, including ourselves. The things that appear to our senses are derivative forms and their true meaning can be seen only when we consider the plenum, in which they are generated and sustained, and into which they must ultimately vanish. This plenum is, however, no longer to be conceived through the idea of a simple material medium, such as an ether, which would be regarded as existing and moving only in a three dimensional space. Rather, one is to begin with the holomovement, in which there is the immense 'sea' of energy ... This sea is to be understood in terms of a multidimensional implicate order, … while the entire universe of matter as we generally observe it is to be treated as a comparatively small pattern of excitation. This excitation pattern is relatively autonomous and gives rise to approximately recurrent, stable and separable projections into a three-dimensional explicate order of manifestation, which is more or less equivalent to that of space as we commonly experience it.[10]

This entire process, including the projection of a 3-D world, takes place within the holomovement.

To illustrate his idea of the relationship between the implicate order and the manifested 'explicate' order Bohm used the example of glycerine machine, whose primary function is to illustrate laminar fluid flow:

> …two concentric glass cylinders, with a highly viscous fluid such as glycerine between them, which is arranged in such a way that the outer cylinder can be turned very slowly … A droplet of insoluble ink is placed in the fluid and the outer cylinder is turned, with the result that the droplet is drawn out into a fine thread-like form that eventually becomes invisible. When the cylinder is turned in the opposite direction the thread-like form draws back and suddenly becomes visible …[11]

The state of the apparatus when the droplet is drawn into an invisible thread is representative of the 'enfolded' implicate order. Turning the cylinder back 'unfolds' the implicate order until at a certain point the manifest 'explicate' order of the drop will become apparent. Individual drops can be enfolded by the process, each being enfolded in a closely aligned sequence so that when the cylinder is turned to unfold the enfolded drops they will manifest as if there was a single moving drop. The drop appears to be a single moving entity but this illusion is mistaken. In actuality the appearance of a single moving drop is a succession of enfolded drops which manifest sequentially from the implicate order. Note that before the drop is 'unfolded' it is in an 'enfolded' state wherein bits of it exist spread over the volume of the glycerine. This corresponds to Bohm's view that what appears to be independent 'particles' are appearances, which are enfolded in a smeared out fashion within the implicate order, in a similar way to a hologram.



The glycerine machine

A hologram is a special type of photograph that creates a complete three-dimensional image when it is illuminated in the right manner by a beam of light. All the information which produces the 3D scene is encoded into the pattern of light and dark areas on a two-dimensional piece of film. This example of a hologram is another example used by Bohm to illustrate an aspect of his ideas:

> We proposed that a new notion of order is involved here, which we called the implicate order (from a Latin root meaning 'to enfold' or 'to fold inward'). In terms of the implicate order one may say that everything is enfolded into everything. This contrasts with the explicate order now dominant in physics in which things are unfolded in the sense that each thing lies only in its own particular region of space (and time) and outside the regions belonging to other things. The value of the hologram in this context is that it may help to bring this new notion of order to our attention in a sensibly perceptible way; but of course, the hologram is only an instrument whose function is to make a static record (or 'snapshot') of this order. The actual order itself which has thus been recorded is in the complex movement of electromagnetic fields, in the form of light waves. Such movement of light waves is present everywhere and in principle enfolds the entire universe of space (and time) in each region (as can be demonstrated in any such region by placing one's eye or a telescope there, which will 'unfold' this content). … this enfoldment and unfoldment takes place not only in the movement of the electromagnetic field but also in that of other fields, such as the electronic, protonic, sound waves, etc. There is already a whole host of such fields that are known, and any number of additional ones, as yet unknown, that may be discovered later.[12]

And, in his book, co-authored with David Peat, *Science, Order, and Creativity,* Bohm added a further 'superimplicate' order to his conception to emphasize a hierarchical nature of implicate orders that he conceived of as the overall basic structure of the process of reality:

> …a generative order, in the form of the superimplicate order, lies at the foundation of physics … In the first implicate order this is basically a movement of a field, and yet, through the information in the second implicate order, the movement is organised into a particlelike behavior. … all of the so-called elementary particles can be treated in this way, as quantum mechanical fields that are organised by information in their superimplicate orders which make possible the creation, sustenance, and annihilation of particlelike manifestations. They are thus relatively constant and autonomous particlelike features of the holomovement that that emerge through the generative order.[13]

The diagram on the next page shows a schematic top-down layout of the Bohm's view of the descent (it could be around the other way, the direction is irrelevant) from the fundamental source of the manifested world, which Bohm called the superimplicate order, through movements in the first implicate order which are subsequently organized to become particles, or 'particlelike manifestations', within the second implicate order, the 'particles' then descend through further implicate orders wherein they are further organized until they finally manifest as the 'explicate' order of the everyday world. This diagram and description is very basic, Bohm actually indicates that each type of particle would have its own field. But we are concerned with basic principles here.

The philosopher Paavo Pylkkanen, in his book *Mind, Matter, and the Implicate Order*, describes Bohm's vision, which derives from quantum field theory:

> Underlying each particle is a movement in a field. This movement enfolds information about the whole universe into a small region where the field manifests itself as a particle-like entity. Because the field is also spread, in principle, throughout the universe, information about the particle-like entity can be found in every region of the universe. In this sense, the whole universe is enfolded in everything, and everything is enfolded everywhere in the whole universe. The implicate order thus prevails as the most fundamental order of the universe currently known to us.[14]

According to Bohm, the process of reality is an intimately interconnected multitudinous 'flux' of apparent fragments which unfold from a interconnected 'wholeness':

> The new form of insight can perhaps best be called Undivided Wholeness in Flowing Movement. This view implies that flow is, in some sense, prior to that of the 'things' that can be seen to form and dissolve in this flow. One can perhaps illustrate what is meant here by considering the 'stream of consciousness'. This flux of awareness is not precisely definable, and yet it is evidently prior to the definable forms of thoughts and ideas which can be seen to form and dissolve in the flux, like ripples, waves and vortices in a flowing stream. As happens with such patterns of movement

in a stream some thoughts recur and persist in a more or less stable way, while others are evanescent. The proposal for a new general form of insight is that all matter is of this nature: That is, there is a universal flux that cannot be defined explicitly but which can be known only implicitly, as indicated by the explicitly definable forms and shapes, some stable and some unstable, that can be abstracted from the universal flux. In this flow, mind and matter are not separate substances. Rather, they are different aspects of one whole and unbroken movement.[15]

----------BOHM'S HOLOMOVEMENT ----------

SUPERIMPLICATE ORDER

{HOLOGRAPHIC INFORMATION FIELD}

↓

FIRST IMPLICATE ORDER

{movements**}**

↓

SECOND IMPLICATE ORDER

{organizing**}**

↓

PARTICLES or PARTICLE-LIKE MANIFESTATIONS

↓

EXPLICATE ORDER

{EVERYDAY WORLD**}**

⟶⟶⟶⟶⟶⟶⟶⟶⟶⟶⟶

This is the 'holomovement', an vast, interconnected universal mind-like organism moving and 'unfolding' in time. The 'holomovement' is a central concept in Bohm`s overall quantum metaphysical worldview. It brings together the holistic principle of "undivided wholeness" with the view that this undivided whole is also in a state of

development, or dynamic flux, or becoming. The term 'holomovement' itself enfolds all the various levels or layers that Bohm speaks of.

As previously indicated, this Bohmian vision of the undivided wholeness of the universal holomovement was a development of a much simpler and sparser quantum worldview proposed by Bohm in 1952, in which he suggested that quantum particles were guided around the universe by 'pilot-waves'. Bohm earlier suggestion was in response to the types of explanations being used at the time, and previously, to explain strange quantum behavior. The prevailing 'interpretation' concerning the strange functioning at the quantum level, which had been revealed by investigations such as the double sit experiment, was the Copenhagen interpretation. The Copenhagen interpretation was proposed by the physicist Niels Bohr around 1920. In essence, it suggests that, before a 'measurement' is performed a quantum particle doesn't actually exist in one state or another, it is in a state of semi-existence, or indeterminate-existence, in all possible states at the same . But when a 'measurement' or an 'observation' takes place the semi-existent or indeterminate set of possible-particles is forced to adopt just one of its possible states, the others disappear, Subsequently there is just one 'real' particle.

Several significant physicists at the time found this point of view, or 'interpretation', disconcerting. Today the physicist Roger Penrose has said of such a proposal in his book *Shadows of the Mind*:

> Taken at its face value, the theory seems to lead to a philosophical standpoint that many (including myself) find deeply unsatisfying. At best, and taking its descriptions at their most literal, it provides us with a very strange view of the world indeed. At worst, and taking literally the proclamations of some of its most famous protagonists, it provides us with no view of the world at all.[16]

Bohm was one of the dissenting physicists, and he suggested that the strange behavior of subatomic particles is a result of the operation of quantum field forces acting on particles. What appeared to be strange non-classical quantum weirdness might be caused by hidden features that did not conflict with ordinary ideas of causality and reality, the quantum realm may operate more in line with mechanisms that operate above the quantum level, i.e. mechanisms within 'classical' reality. So Bohm proposed a quantum ontology (i.e. what kind of 'stuff' really exists and what is does) which involved continuously real particles being guided on the crests of quantum waves. It was this sparse quantum 'ontological interpretation' which later developed spectacularly into the grand holomovement of implicate and explicate orders within a undivided universe.

Given the fact that in his later metaphysical explorations Bohm saw connections between his perspective and 'Eastern' and 'mystical' notions, it should be no surprise that parallels and connections may be found between the his final metaphysical ideas and certain schools of Buddhist psycho-metaphysics, as well as Chinese Taoism and

Hindu Yoga. Indeed, in his later vision Bohm seems to be more in accord with Bohr's supposed 'mystical' bent to some degree. Thus, in *Science, Order, and Creativity* Bohm and Peat point out that:

> Thus, Buddhism, each person is directed through reflection and meditation, to be aware, moment to moment, of the whole train of his or her thoughts. It is stated that in this process the fundamental "groundlessness" of the self can be seen. In this way a key piece of "misinformation" can be cleared up, i.e the almost universal assumption that the self is the very ground of being. This leads to Nirvana, in which their is a blissful unification with the totality…. Approaches of this kind move in the direction of the transcendent .. of union of the individual with the ultimate totality.[17]

And they write with regard to Krishnamurti:

> His writings go extensively and deeply into the question of how, through awareness and attention to the overall movement of thought, the mind comes to a state of silence and emptiness, without any sense of division between observer and the observed.[18]

In *Wholeness and Implicate Order* Bohm wrote:

> … the easily accessible explicit content of consciousness is included within a much greater implicit (or implicate) background. This in turn evidently has to be contained in a yet greater background which may include not only neuro-physiological processes at levels of which we are not generally conscious but also a yet greater background of unknown (and indeed ultimately unknowable) depths of inwardness that may be analogous to the 'sea' of energy that fills the sensibly perceived 'empty' space.
>
> Whatever may be the nature of these inward depths of consciousness, they are the very ground, both of the explicit content and of that content which is usually called implicit. Although this ground may not appear in ordinary consciousness, it may nevertheless be present in a certain way. Just as the vast 'sea' of energy in space is present to our perception as a sense of emptiness or nothingness so the vast 'unconscious' background of explicit consciousness with all its implications is present in a similar way. That is to say, it may be sensed as an emptiness, a nothingness, within which the usual content of consciousness is only a vanishingly small set of facets.[19]

In Buddhism the term 'emptiness' is a central technical term (*sunyata*) designating the ultimate nature of the process of reality, an immaterial non-manifest 'ground' of potentiality from which both mind and matter emerge. The following description of 'emptiness' is from the *Yogacara,* the yoga-practice consciousness-only, perspective, a viewpoint which presents 'emptiness' as a positive phenomenon, the underlying field of the process of reality, and not as an mere 'absence' of dualistic features of the process of reality (as in the *Madhyamaka* Budhist school):

> That is a unique feature of the Yogacarin presentation of emptiness, because emptiness is normally understood as a complete negation or a completely negative term rather than something positive. Here, once subject and object are negated, emptiness, which is reality, is affirmed in its place. A short passage from the *Madhyantavibhanga* says, "Truly, the characteristic of emptiness is nonexistence of the duality of subject and object, and the existence of that nonexistence." "The existence of that nonexistence" is reality. Duality is removed, but emptiness itself is another kind of existence.[20]

Here a resonance with Bohm's characterisation of emptiness is clearly apparent. Bohm highlights the lack of "division between observer and the observed" which is clearly stated as the central feature of the Yogacarin view of emptiness, which is stated to be a "positive" phenomenon of non-dual awareness which manifests when "duality of subject and object" is negated. It is the still mind which manifests when all dualistic (i.e. 'observer-observed' division) movements within mind are transcended. In Bohmian terms we can think of the explicate order as having been experientially removed in order to directly perceive the implicate order(s).

The following passage, taken from the commentary to the *Diamond Sutra* by the contemporary Chinese Buddhist teacher Hsing Yun, would also seem to be appropriate in this context:

> Dust clouds the metaphorical pool of enlightened awareness. … Lakshana rush into the mind and appear before it like clouds of dust-like lakshana; impure intentions are based on deluded visions of dust. Dust clouds the mind on all levels; matter is dust, illusion is dust, and thoughts and perception also are dust. Only the Tathagata sees the 'vast realm of emptiness' in which all of this floats in the clarity of perfect awareness.[21]

Here, the "metaphorical pool of enlightened awareness" represents the mind in its state of pristine unmoving consciousness which has qualities of crystal-like clarity and empty-luminosity. Such assertions of the experiential qualities of the unmoving field of consciousness are not speculative. They can be experienced as a result of correct and committed meditation practice. The term 'lakshana' means 'marks', or 'signs', but here is best rendered as 'disturbances'. Perceptions of the material world, thoughts, and intentions for impure actions within the material world all "rush into the mind" and cloud it as if with dust. Only an enlightened being, a Tathagata, one who has 'gone-beyond', has a mind which has "he clarity of perfect awareness" that is able to directly perceive the "vast realm of emptiness" within which the dualistic world floats. Here the "vast realm of emptiness" would correspond to Bohm's most subtle implicate order.

One of the Buddhist metaphysical perspectives, which is especially significant to the work of Bohm, that will be employed here is Dzogchen (rDzogs-chen), which is translated as the 'Great Perfection' or the 'Great Completion'. The great Buddhist

scholar Herbert Guenther was an expert explorer in this interface of science and Buddhist spirituality. In his book *The Teachings of Padmasambhava* Guenther referred to Bohm's work eleven times, and in the introduction to his book *Ecstatic Spontaneity: Saraha's Three Cycles of Doha* Guenther wrote the following:

> The fact is, modern physics has become ever more "mystical," not least of all because of the exposure of some of its most outstanding representatives to Eastern thought. David Bohm's association with J. Krishnamurti is well known; Erwin Schrödinger was deeply impressed by Indian philosophy; Neils Bohr chose as his emblem the Taoist ying-yang symbol; C.G. Jung's collaboration with Wolfgang Pauli led to the idea of synchronicity; and so on. Does it not seem fitting that these pioneers be called by the name that history has given to many of its great visionaries - mystics?[22]

In his book *From Reductionism to Creativity rDzogchen and the New Sciences of Mind* Guenther referred to Bohm's work in the context of the Dzogchen worldview:

> It is this ... inner dynamics of Being that eventually pushes it, figuratively speaking, over the instability threshold into its actuality so the virtually operative actuality in Being now assumes a true actuality that may be called Being's "eigenstate". This process is termed *gzhi-snang* which, borrowing a term coined by David Bohm, I render as "holomovement," which in the rDzogs-chen context means that Being in its totality (*gzhi*) lights up (*snang*), and in this lighting-up makes its presence felt. The implication is that, as paradoxical as it may sound, Being is nowhere else than in the what-is, … this means that we are the whole and yet only part of it.[23]

In this description the term 'eigenstate' is a technical term within quantum theory applying to the measurement process. Before a measurement is carried out, for example, an electron's momentum and position are both uncertain (Heisenberg's Uncertainty Principle), and it is only possible to make a precise measurement of one of these characteristics. This means that it is only possible to know the precise value of the eigenstate of position, or the eigenstate of momentum. Both of these eigenstates may take, when measured, a range of discrete values called eigenvalues, but only one of the eigenstates can be known at one time. The term "eigenstate" is derived from the German word "eigen" meaning "inherent" or "characteristic." When a measurement is performed on position, for example, this eigenstate will manifest as being in just one of its possible eigenvalues. Thus we can say that eigenstates are possible modes of manifestation from the multiple uncertainty of quantum potentiality.

In the above description by Guenther, Absolute Being is conceived of as originally 'existing' in a virtual state of non-manifestation. This state of non-manifestation contains a multitude of virtual possible manifestations, just as a state of quantum potentiality also contains a set of potential eigenstates. Thus, these virtual states of possible manifestations within Absolute Being can be compared to potential quantum

eigenstates within Unmanifest Being. In addition to this characterisation, Guenther also indicates that Absolute Being contains an internal pressure towards instability and a consequent manifestation in actuality of one of the virtual potentialities into a manifested eigenstate of actuality. This manifestation of an 'eigenstate' internal to Being, is a manifestation within the wholeness of Being, and is clearly described, paradoxically, as both containing the essential nature of the wholeness of Being at the same time as being a movement within Being as a whole.

This situation is compared by Guenther, with deep justification, to David Bohm's notion of the 'holomovement' of implicate and explicate orders, which corresponds to Guenther's metaphor of unmanifested (implicate) and manifested (explicate) 'eigenstates', within the wholeness of the overall holomovement of the process of reality. Bohm, in his important book *Wholeness and the Implicate Order*, uses his notion of the "holomovement" as his central metaphor for the way in which the Absolute Whole of the process of reality consists of an 'implicate order' lying behind (metaphorically) the 'explicate orders' of manifestation. This perspective can be compared with Guenther's Dzogchen account of Absolute Being in its modes of 'virtual actuality' and subsequent 'true actuality' of manifestation, thereby being in movement of unfolding manifestation. Thus we have the Absolute Wholeness, or 'Absolute Being' (the word 'Being' here does not denote a static 'Being'), in movement denoted by the 'holomovement'.

The following section is taken from the introduction to Guenther's book *The Teachings of Padmasambhava.* It describes a direct experiential activation of a holistic dimension of being, a dimension that can be identified with Bohm's more scientific-description approach:

> [Padmasambhava] formulated a holistic vision that transcends the traditional division between the physical and the mental, the emotional-instinctual and the spiritual, in two related disciplines that remain experiential through and through. One he referred to by the name.of ... *spyi-ti yoga* . Let us begin with the *spyi-ti* experience. This is how Padmasambhava lets the teacher "Utterly free from the.limitations set by the categories of rational thought" explicate to the "Little Man (who is the whole's) self-manifesting Light" … No less revealing is the following statement … that links this *spyi-ti* experience and teaching with the (whole's) intensity/energy of which Padmasambhava has repeatedly spoken:
>
> *spyi* means the totality of that which exists without exception, *ti* means (the whole's) intensity/energy becoming a vortex; *spyi* means (the experiencer's) spiritual-excitation-excitability, egological mentation, overall psychic background, and (its) divisive concepts, *ti* means (the whole's) intensity/energy becoming a vortex, *yo* means the totality (of all that is) being indivisible and unpremeditated, *ga* means (the whole's)

> intensity/energy from whose vortex the giving birth to thoughts/meanings arises. Therefore (this experience) outshines all other spiritual pursuits by its brilliance; Therefore the *spyi-ti* experience is completeness with respect to (the experiencer's) psychic-spiritual constitutedness.[24]

The unlimited teacher in this description are the influences of subtle implicate orders which leave traces of wholeness within the 'fragmentation', as Bohm would say, within the explicate order. The explicate order is the abode of "Little Man" who has been projected into the movement of the explicate order by the projective energies - the "self-manifesting Light" - within the "vortex", which corresponds to Bohm's holomovement, The entire energetic-vortex-holomovement gives rise to dualistic thoughts and meanings which create division within the explicate order . However, it is through the practice which manifests the "*spyi-ti* experience" that completeness can be restored.

As we have seen, in his book *Wholeness and the Implicate Order* Bohm calls the totality of all that is by the term the 'holomovement', which encompasses what he calls the 'implicate order', and the 'explicate order' which unfolds from the hidden implicate order(s) into the experience of everyday life. The holomovement is the process which he conceives of as encompassing both orders. As the holomovement progresses the implicate order explicates, or 'unfolds', the explicate order of experience into the everyday world and subsequently events within the explicate order can also enfold in some way back into the implicate order. In the following passage Bohm describes the basic overview of his vision:

> Our basic proposal was then *what is* is the holomovement, and everything is to be explained in terms of forms derived from this holomovement. Although the full set of laws governing its totality is unknown … these laws are assumed to be such that from them can be abstracted relatively autonomous or independent sub-totalities of movement … having a certain recurrence and stability of their basic patterns of order and measure. … we have contrasted implicate and explicate orders, treating them as separate and distinct but … the explicate order can be regarded as a particular or more distinguished case of a more general set of implicate orders from which the latter can be derived. What distinguishes the explicate order is that what is thus derived is a set of recurrent and relatively stable elements that are *outside* of each other.[25]

In other words, the holomovement consists of the overall implicate order, and, as the holomovement progresses, perhaps according to internal laws that we cannot know, the operation of these internal laws causes an unfoldment of a set of implicate levels within the implicate order, and this unfoldment generates, at more manifest levels, explicate levels of everyday type experience. This explicate level of the experiential world is characterized by relatively stable elements which appear to be completely separate from each other, even though at the deeper implicate level all aspects of the

holomovement are fundamentally interconnected.

In their book *The Undivided Universe* Bohm and his associate Basil Hiley give the following account, in which they take consciousness into into their picture:

> …the intuition that consciousness and quantum theory are in some sense related seems to be a good one … Our proposal in this regard is that the basic relationship of quantum theory and consciousness is that they have the implicate order in common. The essential features of the implicate order are … that the whole universe is in some way enfolded in everything and that each thing is enfolded in the whole. However, under typical conditions of ordinary experience, there is a great deal of *relative* independence of things, so they may be abstracted as separately existent, outside of each other, and only externally related. However, more fundamentally the enfoldment relationship is active and essential to what each thing is, so that it is internally related to the whole and therefore to everything else. Nevertheless, the explicate order, which dominates ordinary 'common sense' experience as well as classical physics, appears to stand by itself. But … it cannot be properly understood apart from its ground in the primary reality of the implicate order, i.e. the holomovement. All things found in the explicate order emerge from the holomovement and ultimately fall back into it. … It takes only a little reflection to see that a similar sort of description will apply even more directly and obviously to consciousness…[26]

Thus we see that there is a very significant correspondence between Guenther's description of how in the Buddhist 'Great Completion' metaphysical worldview Absolute Being is conceived of as a repository of enfolded virtually operating 'actualities' which because of inner dynamics become unstable as virtually hidden and therefore flow out into non-virtual manifestation, and Bohm and Hiley's account of how the implicate order, operating within the dynamics of the holomovement, produces an explicate descent to manifest as the explicate order of the everyday world. In both these cases the parts are said to in some sense contain the whole at the same time as also appearing to be an independent part of the whole.

When we consider the esoteric Buddhist Yogacara school, the practitioners of the yoga of meditation who considered all phenomena to derive form a deep level of Mind-Energy, we discover similar formulations:

> The metaphysical doctrine of the ancient Yoga tradition puts forth an understanding of the creation, progression and eventual destruction of the Universe that seems surprisingly modern, to the extent in which it agrees with leading edge advances in science, quantum mechanics and cosmology. Those who go deeply into this subject, will find this doctrine rooted in a profound understanding of a great mystery called PARAMĀRTHA, which in

> Indian philosophy means 'the Absolute', devoid it is said of all attributes, and essentially distinct from manifested finite Being. The manifestation (*pravrtti*) and re-absorption of the Universe, or domain of finite Being, and how the latter relates to the transcendent infinitude of the Absolute has been central to Yogacara inquiry from the beginning of its history … It is believed that by means of proliferation (*prapanca*, differentiation), the innate essence of being in three forms (*trisvabhava*) manifests or is transformed, as it were, into active mentation in the act of Creation. This is then explained as the coming into being of *alaya-vijnana*, universal or cosmic consciousness, which is a concept that has also been held in the Western philosophy by many great thinkers, from Plato, Plotinus and others…

Thus we can discern the exciting possibility of a rich, mutually enhancing and invigorating intellectual, and potentially experiential, mutual elucidation and illumination, through the exploration of these deep metaphysical accounts of the structure and process of reality.

It will be useful to begin with a deeper exploration and clarification of the work of Bohm and his later associate Basil Hiley, alongside some contrasts and elucidations with other perspectives. By understanding the viewpoints that Bohm was motivated to replace we can investigate more deeply in order to comprehend how a fully developed Bohmian perspective can actually enfold other perspectives under its holistic unity. We shall see that other quantum perspectives becomes partial viewpoints within the overall Bohmian holomovement. This seems completely in line with Bohm's motivation that various fragmentary viewpoints on the process of reality should be amenable to a higher order unity of harmonization.

According to Bohm the holomovement can be characterised, or perhaps non-characterised:

> Thus, in its totality, the holomovement, is not limited in any specifiable way at all. It is not required to conform to any particular measure. Thus, the *holomovement is undefinable and immeasurable.* To give primary significance to the undefinable and immeasurable holomovement implies that it has no meaning to talk of a *fundamental* theory, on which *all* of physics could find a permanent basis, or to which *all* the phenomena of physics could similarly be reduced.[27]

Here Bohm appears to indicate that as soon as any measurement might occur, then the holomovement would cease to be the holomovement precisely due to an enforced limitation. This does not mean, however, that nothing can be said about the holomovement. I have been surprised by interactions I have had on the Infinite Potential discussion forum where some people have asserted the complete and utter transcendent undefinablity of the holomovement, apparently not realizing that if this were really the case then Bohm himself would have been unable to say anything about it. What Bohm means with the 'undefinable' claim is that from the point of view of

the explicate order the inward workings and interconnections of the implicate order within the holomovement are undefinable, especially by the techniques of the scientific community. But clearly Bohm did take steps to 'define' what he meant by the term. A few paragraphs back from the above quote Bohm actually offered a kind of definition in the form of a metaphorical description:

> It will be useful … to consider some further examples of enfolded or *implicate* order. Thus, in a television broadcast, the visual image is translated into a time order, which is 'carried' by the radio wave. Points that are near each other in the visual image are not necessarily 'near' in the order of the radio signal. Thus, the radio wave carries the visual image in an implicate order. The function of the receiver is then to explicate this order, i.e. to 'unfold' it in the form of a new visual image.

Thus we see that, according to Bohm, the manifested everyday world of matter and consciousness is encoded, or 'enfolded', at a deeper level of the process of reality, within some kind of 'carrier' medium, this is, in Bohm's terminology an 'implicate order'. The process of the enfoldment into the carrier medium, which is not material, and unfoldment from the implicate order of the carrier medium into the 'explicate order' of the everyday world of experience makes up the overall 'holomovement'. So, we can conclude that the holomovement encompasses the coordinated movement of both the implicate and the derived explicate orders.

In the early pages of *Wholeness and the Implicate Order* Bohm wrote that:

> The new form of insight can perhaps best be called *Undivided Wholeness in Flowing Movement*. This view implies that flow is, in some sense, prior to that of the 'things' that can be seen to form and dissolve in that flow. One can perhaps illustrate what is meant here by considering the 'stream of consciousness'. This flux of awareness is not precisely definable, and yet it is evidently prior to the definable forms of thoughts and ideas which can be seen to form and dissolve in the flux, like ripples, waves and vortices in a flowing stream. As happens with such patterns of movement in a stream some thoughts recur and persist in a more or less stable way, while others are evanescent.
>
> The proposal for a new general form of insight is that all matter is of this nature: That is, there is a universal flux that cannot be defined explicitly but which can be known only implicitly, as indicated by the explicitly definable forms and shapes, some stable and some unstable, that can be abstracted from the universal flux. In this flow, mind and matter are not separate substances. Rather, they are different aspects of one whole and unbroken movement. In this way, we are able to look on all aspects of existence as not divided from each other, and thus we can bring to an end the fragmentation implicit in the current attitude toward the atomic point of view, which leads us to divide everything from everything in a thoroughgoing way. Nevertheless, we can

> comprehend that aspect of atomism which still provides a correct and valid form of insight, i.e. that in spite of the undivided wholeness in flowing movement, the various patterns that can be abstracted from it have a certain relative autonomy and stability, which is indeed provided for by the universal law of the flowing movement.[28]

Thus, again, we see how Bohm conceives of the mainstream physics as describing a limited sub-domain functioning with a relative degree of independence, but which functions within the much greater realm of interdependent unity of the holomovement. The explicate realms of matter and consciousness derive from a deeper more unified source:

> If matter and consciousness could in this way be understood together, in terms of the same general notion of order, the way would be opened to comprehending their relationship on the basis of some common ground. Thus we could come to the germ of a new notion of unbroken wholeness, in which consciousness is no longer to be fundamentally separated from matter.[29]

For Bohm, the implicate order underlies the duality of matter and individuated consciousness. It is the ground from which they both arise as manifested coordinated 'explicate' aspects of the deeper implicate order that is usually beyond the direct reach of dualistic awareness. The realms of individuated mind and the appearance of matter mutually unfold from the implicate order into what Bohm termed the 'explicate' order. Mind and matter, subject and object, are coordinated manifestations from the deeper enfolded order of the non-local 'implicate order.'

The 'non-local' nature of the implicate order, and the explicate orders which unfold from it, is one of the implicate order's essential characteristics. And it is the issue of quantum non-locality which is a significant issue for Bohm's reworking of quantum theory. The term 'non-locality' refers to the fact that, in pre-Bohmian quantum interpretations, there is a possible instantaneous 'communication' between 'entangled' particles within a quantum field, however vastly far apart their positions may be. However, in non-Bohmian views this 'spooky', as Einstein called it, possible interconnection does not manifest in the 'classical' everyday world. In Bohm's undivided universe quantum metaphysics, on the other hand, such 'spooky' interconnections are part of the everyday world. In fact they are an essential part of Bohm's worldview, Bohm and Hiley call their vision one of an 'Undivided Universe' precisely because such universal instantaneous interconnections between any two points exist in the everyday world.

Having surveyed some of the breadth and depth of Bohm's later 'mystical' phase, so to speak, it is worthwhile tracing Bohm's intellectual journey from his quantum-materialist 1952 article. What prompted Bohm to drastically rework the quantum Copenhagen worldview generally accepted at the time? Bohm and some other

physicists, notably Einstein, were worried and disturbed by the details of the transition from quantum state to everyday 'classical' particle state proposed by the Copenhagen interpretation of quantum mechanics, established primarily by Neils Bohr and Werner Heisenberg around 1925-1927. It claims that a quantum 'particle' does not actually become a real, 'classical' - everyday - 'particle' until its quantum state is measured. Prior to being measured, on this view, a particle is not really a particle at all, it is a large array of possible particles, each with differing possible positions and momentums. Such a quantum particle does not exist in one definite state or another, but in all of its possible states at the same time. It is only when we measure, or 'observe' its state that a quantum particle is forced to adopt one of its possible states, and that is the state that is observed. All the other possible states that semi-existed before the measurement disappear, and the adopted state becomes the 'real' 'classical' state of the particle. The prior state of existing in all possible states at the same time is called a 'superposition'. The mathematical description of the superposition is called a wavefunction. When a quantum object is measured, or 'observed', the wavefunction 'collapses' and the object is forced into one of the states contained in its wavefunction.

Some physicists and philosophers, such as philosopher David Mermin, seem content to leave the actual details of the mechanism by which the transition from quantum potentiality to a measured reality as unknowable:

> It is a fundamental quantum doctrine that a measurement does not, in general, reveal a preexisting value of the measured property. On the contrary, the outcome of a measurement is brought into being by the act of measurement itself, a joint manifestation of the state of the probed system and the probing apparatus. Precisely how the particular result of an individual measurement is brought into being - Heisenberg's transition from the possible to the actual - is inherently unknowable. Only the statistical distribution of many such encounters is a proper matter for scientific inquiry.[30]

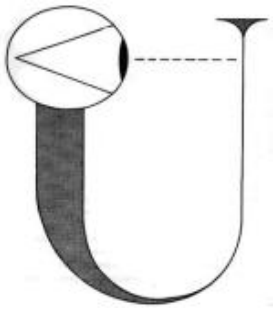
Others have suggested that in some sense the human beings doing the measurement have a role. Thus the German physicist Pascual Jordan (1902-1980) declared that:

> Observations not only disturb what has to be measured, they produce it... We compel [the electron] to assume a definite position... We ourselves produce the results of measurements.

Thus the Copenhagen view does come in different flavours, but this approach to the situation can create the impression that the consciousnesses of observers can have direct effects on quantum possibility states in order to 'create' a fully 'real' material reality. Thus, it almost seemed, to some disgruntled physicists, that reality was being magically conjured up from quantum unreality.

The significant physicist John Wheeler even suggested this can happen backwards in time. Wheeler came to this conclusion after pondering a cosmic thought experiment. In this thought experiment, simply described, a beam of light which originates in a distant quasar is bent around the two sides of an intervening galaxy on its way to earth, when it reaches earth the split beam is used in a quantum experiment, which, depending upon its setup, can produce particles or a wave interference pattern. If particles were created then Wheeler concluded that the experiment had forced the whole cosmic experimental setup to have been using particles from the moment the light left the distant quasar source centuries backwards in time. Thus the choice of whether waves of particles were travelling across the universe had been delayed until the experiment on Earth, and he nature of reality had been determined backwards in time. As we shall see later, there is a more plausible explanation for this scenario.

On the basis of this thought experiment Wheeler sometimes indulged in flights of quantum 'mystical' speculation. And in this context he became adept in the use of quantum-mystical saying and not-saying. The later John Wheeler was a great master of asserting the seemingly incredible, only to retreat to safer shores of credibility. Towards the end of his life Wheeler seemed fond of masterful quantum-mystical intellectual wheeler-dealing. For example, in his book *Geons, Black Holes & Quantum Foam: A Life in Physics*, Wheeler presented his 'Wheeler U' diagram, and explained how he envisioned sentient observation could 'collapse' the wave-function of reality backwards in time:



The Wheeler U

> My diagram of a big U (for universe) attempts to illustrate this idea. The upper right end of the U represents the Big Bang, when it all started. Moving along down the thin right and up along the thick left leg of the U symbolically traces the evolution of the universe, from small to large - time for life and mind to develop. At the upper left of the U sits, finally, the eye of the observer. By looking back, by observing what happened in the earliest days of the universe, we give reality to those days.[31]

How wonderful, how poetic! Consciousness creates reality by observations of the primordial quantum soup backwards in time. What a beautiful mystical mind, a quantum mystical poetic genius Wheeler must be!

But in the very next paragraph Wheeler takes it all back:

> The eye could as well be a piece of mica. It need not be part of an intelligent being. The point is that the universe is a grand synthesis, putting itself together all the time as a whole. Its history is not a history as we usually conceive history. It is not one thing happening after another after another. It is a totality in which what happens "now" gives reality to what happened "then," perhaps even determines what happens then.[32]

These two perspectives are not equivalent, the second assertion clearly nullifies the first. In the first depiction, which is a quantum psycho-metaphysical account which was reiterated, and also denied, much later in their book *The Grand Design* by Stephen Hawking & Leonard Mlodinow, in a chapter titled **Choosing Our Universe**, consciousness is a creative force acting backwards in time 'choosing' which quantum potentialities become manifest. But Wheeler's second observation quickly cancels-out any suggestion of quantum consciousness mystically acting backwards in time. In this sanitised second version some unspecified influence emanating from chunks of stone performs the job of lifting reality out of quantum indeterminacy. This version is still a bit mystical, but not quite as fully New-Agey, so to speak. Wheeler explained his temerity by indicating that he was under the influence of a kind of anti-quantum-consciousness scientific-academic thought police at the time:

> In these later years, I have dared to think about and write about and ask about the physical world in terms that some of my colleagues consider outside the scope of science - science as it is now accepted, defined, and practised. Is the universe a self-excited circuit, made real by observation?[33]

So it looks as if Wheeler really might have believed his fully New-Age first version, but thought it better not to antagonise his less mystically inclined colleagues! Although it should also be born in mind that in 1979, Wheeler spoke to the American Association for the Advancement of Science (AAAS), requesting that parapsychology should be expelled, as he considered it to be a pseudoscience. Perhaps it is difficult to know exactly what to make of such contrasting and seemingly contradictory attitudes, but they should be viewed against the prevailing scientific collective consciousness of the time. The physicists Bruce Rosenblum and Fred Kuttner, in their book *Quantum Enigma*, point out in regard to the attitude of mainstream physics since the 1950's that:

> In physics departments a conforming mind-set increasingly meant that an untenured faculty member might endanger a career by serious interest in the fundamentals of quantum physics. Even today it is best to explore the meaning of quantum mechanics while also working a 'day job' on a mainstream physics topic.[34]

In other words, there was an overwhelming anti-metaphysical-speculative and definitely anti-quantum-mysticism prejudice within the academic world which determined what physicists felt might be acceptable speculation within their discipline.

Wheeler's autobiography was published in 1998, but the prevalence of the anti-quantum-mystical activist subtle materialist worldview is is still operative to a large extent within certain scientific circles, and it is remarkable that Bohm was able to swim against this current at the time he was writing his later work, although it has to be said that Bohm's explorations and claims do not aspire to the magical New-Age cloud-dwelling frisson of Wheeler's audacity.

Seemingly 'mystical' speculations on the part of admired physicists such as Wheeler have had an impact on the growth industry of New-Age fantasy indulgence. A recent New-Age-quantum-intoxicated Wheeler devotee, inspired by some of Wheeler's claims, such as in the previous quote concerning backwards in time creation of reality, has been heaped with accolades from the New Age community by making ludicrous claims which take Wheeler's visions towards a quantum theatre of the absurd. In his book *The Quantum Revelation: A Radical Synthesis of Science and Spirituality*, the New Age prophet Paul Levy tells his quantum-struck readers that:

> When a physicist observes an elementary particle – which from the quantum point of view "causes" the particle to exist – it is as if the physicist is "dreaming up" the quantum entity in the same way that a dreamer dreams up their own dreamscape. At the same time (if we let our creative imagination run wild) it is as if the elementary particle is reciprocally dreaming, as it dreams up the physicist to observe it and hence, bestow upon it existence. The physicist and the subatomic particle are … mutually dreaming each other up …[35]

A less dreamy and more rational account of the vital importance of the nature of electrons for our existence is provided by physicist Sabine Hossenfelder:

> Fermions are extreme individuals. No matter how hard you try, you will not get two of them to do the same thing in the same place - there must always be a difference between them. … This is why electrons, which are fermions, sit on separate shells around the atomic nuclei. If they were bosons, …. they would instead sit together on the same shell, leaving the universe without chemistry - and without chemists, as our own existence rests on the little fermions refusal to

share space.[36]

And this is not the only extraordinary fact about electrons which accounts for the existence of physicists, chemists, people, animals and the entire universe. The physicist and science writer Michio Kaku tells us that:

> The reason why molecules are stable and the universe does not disintegrate is that electrons can be in many places at the same time. ….electrons can exist in parallel states hovering between existence and non-existence.[37]

The ability of electrons to be in two places at the same time, whilst still maintaining an identity as a single entity, is a feature of quantum behavior that is absolutely crucial for the functioning of reality. It is this feature of electron functioning that allows them to hold molecules together. So the remarkable abilities of tiny, barely existent, 'hovering between existence and non-existence' electrons are essential to the functioning of the entire universe.

The fact that the functioning of reality depends crucially on wisps of electronic almost-nothingness that refuse to be in the same place as another wisp of electronic almost-nothingness, and can be in many places at the same time, might indeed move one towards universal dream-interpretation of reality, but it does not imply that electrons go to bed at night. As Hossenfelder says: "Helium atoms don't get hungry and are just as well tempered on Monday as on Friday."[38] She might have added the fact that electrons do not dream for good measure!

Of course Paul Levy, a fully paid-up New-Age delusion-merchant, includes Bohm in his New-Age intellectual fantasy rampage, wherein electrons dream-up physicists in order for the physicists to dream-up electrons in turn, and so on. But, of course, he cannot find quotes from Bohm with the same New-Age wow-value as he can with Wheeler:

> To quote David Bohm, the "inseparable quantum interconnectedness of the whole universe is the fundamental reality." An expression of this undivided wholeness - the fundamental reality - is that consciousness is no longer separated from matter but somehow essential to it. Consciousness is not one thing and matter another thing that it interacts with; on the quantum level conciousness and matter are indistinguishable. As Bohm points out, if we don't see this "it's because we are blinding ourselves to it." [39]

Such a view can certainly derived from the insights of Bohm, as we have seen, according to Bohm the explicate realms of matter and consciousness derive from a deeper more unified source.

The quantum physicist Amit Goswami, a retired professor of theoretical physics at the University of Oregon and a self-styled pioneer of his new paradigm of science

called "science within consciousness," describes the phenomenon of the 'collapse of the wavefunction', unashamedly as the "observer effect":

> In quantum physics, objects are depicted as possibilities (a possibility wave); yet when an observer observes, the possibilities collapse into an actuality (the wave collapses into particle, for example). This is the observer effect.[40]

Fritjov Capra's famous book *The Tao of Physics* was published in 1975, he had no doubts concerning the role of consciousness at the quantum level:

> At the atomic level 'objects' can only be understood in terms of the interaction between the processes of preparation and measurement. The end of this chain of processes lies always in the consciousness of the human observer.[41]

The notable and knighted physicist Roger Penrose, in his 1994 book *Shadows of the Mind* seems to suggest that the quantum measurement scenario implied that:

> At the large end of things, the place where 'the buck stops' is provided by our *conscious perceptions*.[42]

But, in his 1989 book *The Emperor's New Mind* Penrose seemed unconvinced:

> Is the presence of a conscious being necessary for a 'measurement' *actually* to take place? I think that only a small minority of quantum physicists would affirm such a view.[43]

The fact that Penrose was motivated to consider this possibility however shows that when the evidence is looked at it is possible to come to such conclusions. As physicists Rosenblum and Kuttner say:

> Consciousness and the quantum enigma are not just two mysteries; they are *the* two mysteries; … Quantum mechanics seems to connect the two.[44]

And the significant physicist Eugene Wigner, co-recipient of the 1963 Nobel Prize for Physics was also impressed by the apparent role of consciousness:

> When the province of physical theory was extended to encompass microscopic phenomena, through the creation of quantum mechanics, the concept of consciousness came to the fore again; it was not possible to formulate the laws of quantum mechanics without reference to consciousness.[45]

These are a selection of remarks by significant physicists who have suggested at some point in time that Bohr's Copenhagen's viewpoint requires some active role for consciousness in bringing quantum semi-real wavy potentiality into the realm of the hard-core everyday world we all appear to live in.

The essential issue here is the fact that from the point of view of Bohr's Copenhagen interpretation, although Bohr himself did not claim precisely this, it seems that, to put the issue in crude terms, an essentially vast set of 'unreal' (from the point of view of the 'classical' everyday world) possible particles, hovering between existence and non-existence, transform when measured or 'observed' to become a really real particle, one of the possible particles becomes the 'real' particle, and all the other possible particles vanish. In this scenario there seems to be an essential element of subjectivity involved, it seems as if the experimenters' decisions during an experiment could determine what became 'real' and what did not. Some physicists went so far as to suggest that human and animal minds might be responsible for the 'collapse' of the wavefunction.

However, there were also physicists who were deeply sceptical of this claim. For example the important physicist John Bell, pondering upon Wheeler's claim that consciousness collapses the universal wavefunction backwards in time, made the wonderful sceptical remark:

> Was the wave function of the world waiting to jump for thousands of years until a single-celled living creature appeared? Or did it have to wait a little longer, for some better qualified system . . . with a PhD?[46]

But such sharp sarcastic comments do not cut through the views of some who do believe something like this. For example, Amit Goswami has asserted that consciousness can act backwards in time to solidify actuality from out of the quantum realm of potentiality, and this means that consciousness can actually affect the history of the universe backwards in time:

> This is what quantum physics demands. In fact, in quantum physics this is called "delayed choice." And I have added to this concept the concept of "self-reference." Actually the concept of delayed choice is very old. It is due to a very famous physicist named John Wheeler, but Wheeler did not see the entire thing correctly, in my opinion. He left out self-reference. The question always arises, "The universe is supposed to have existed for fifteen billion years, so if it takes consciousness to convert possibility into actuality, then how could the universe be around for so long?" Because there was no consciousness, no sentient being, biological being, carbon based being, in that primordial fireball which is supposed to have created the universe, the big bang. But this *other* way of looking at things says that the universe remained in possibility until there was self-referential quantum measurement—so that is the new concept. An observer's *looking* is essential in order to manifest possibility into actuality, and so only when the observer looks, only then does the entire thing become manifest—including time. So all of past time, in that respect, becomes manifest right at that moment when the first sentient being *looks*.

And even Stephen Hawking's and Leonard Mlodinow's (H&M) recent 'Theory of Everything' proposed in their book *The Grand Design,* seems to suggest something like this. According to H&M:

> 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. … 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...[47]

In the H&M quantum metaphysical scenario 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:

> 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.[48]

A hugely significant feature of the H&M presentation is the fact that the "observers are part of the system"[49] and, furthermore, "we create history by our observations, rather than history creating us."[50] So the observers, or what John 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, …. Hence histories in which the moon is not 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.[51]

And these quotes really do come from H&M's book.

A lot of people, who think they know what Stephen Hawking's views are, might be quite surprised if they read this book. I was once in a debate on a Richard Dawkins fan forum with a dyed in the wool materialist, and I used the previous H&M quotes to illustrate my point about the primacy of consciousness in the process of reality. The guy I was debating refused to believe me, saying he knew all about Stephen Hawking, who was a materialist who declared God to be unnecessary, and therefore I

must be lying. I replied I was holding the book in my hands and he could probably locate the quotes on the internet, but he still absolutely disbelieved me!

However, this episode pales into insignificance compared to an extraordinary episode which seems to suggest that Leonard Mlodinow did not have a clue about Hawking's views at the very time he was co-authoring with Hawking the book referred to above: *The Grand Design.* There is an instructive YouTube interchange between the New-Age author and celebrity Deepak Chopra and a Sam Harris / Michael Shermer team who are batting for the anti-New-Age perspective.[52]. This episode of intellectual jousting has been given the title: "Deepak Chopra destroyed by himself," which is a reasonable description. I have written about the details elsewhere, the bare bones need only concern us here. At an early point in the intellectual blood-letting Chopra declares that "Science is now in a process of overthrowing the climactic overthrow of the superstition of materialism." In terms of our gladiatorial metaphor, making such a ludicrous statement amounts to taking one's own sword and plunging it into one's own heart. The impact on Chopra's credibility is fatal.

This is not to say that the other side does not say some questionable things, it's just that they are not so obviously idiotic. After all, "overthrowing the climactic overthrow of the superstition" would surely leave one back with the original superstition, a completely pointless exercise. And it is quite clear that Chopra, in his impassioned and undisciplined lack of due attention to his words, has simply sabotaged his own statement; for he obviously meant to say that science was in the process of overthrowing the superstition of materialism. As we have seen, there is actually a great deal of evidence for the claim that consciousness plays some kind of role in the unfolding of immaterial quantum potentials into material manifestation, and there are quite a few significant quantum physicists who present such a view. But Chopra's lack of care and attention to language, lack of care and attention to the extent and significance of evidence, lack of care and attention for the required and appropriate detail and careful logical exposition, completely undermines his credibility for any non-partisan rational being.

At some point in this gladiatorial showdown of worldviews at the quantum New-Age OK Corral between Harris & Shermer verses Chopra & Jean Houston, Chopra suggests that if there are any physicists in the audience they should come up at some point and have their say. Miraculously, or perhaps he was a plant, it turns out that Leonard Mlodinow is in the audience and he is brought out of the audience to tell Chopra that he is entirely deluded about the nature of quantum physics. Furthermore, Mlodinow tells the audience that he is writing a book with Stephen Hawking at that very time. Given the date, this book must have been *The Grand Design*, the book in which, as we have just seen, Hawking & Mlodinow inform their readers that the most up to date knowledge of quantum physics indicates that observations, which of course must involve consciousness, activate immaterial quantum potentialities backwards in time. This view on the part of H&M is, at least in some degree,

consistent with some aspects of what Chopra is trying, however ineptly, to say. And yet Mlodinow now suggests that Chopra *entirely* misunderstands quantum theory. Either Mlodinow does not understand his own co-authored book, or he is engaging in a degree of intellectual fraud, deliberately misleading and lying to the audience. When one sees this level of apparent deceit and often self-deception on both sides of the debate, it can lead the faint hearted towards despair.

But it could be that physicists like Mlodinow consider the excesses of New-Age pundits such as Chopra and others to be so egregious that stern measures are required in response. The over-blown intellectual self-indulgence in the part of New-Age prophets like Chopra, which virtually becomes a parody of itself, leads physicists with a rigorous anti-quantum-mystical set of mind to lose patience, perhaps with some degree of good reason. Thus the theoretical physicist Jean Bricmont, who as we shall see is a staunch advocate of the early version of Bohm's 'ontological' quantum worldview, writes of Chopra's kind of self-indulgence, and New-Age overblown rhetoric in general :

> The mysterious character of quantum mechanics has led to numerous abuses, misinterpretations, speculations and extrapolations, perhaps more than any other scientific theory. It would take an encyclopedia to cover all of them … We have seen the two "mysteries" of quantum mechanics concern the role of the observer and actions at a distance. A third alleged "novelty" supposedly introduced by quantum mechanics is the death of determinism. Almost all the abuses or invalid extrapolations of quantum mechanics rely on one or more of these ideas.[53]

Also, Bricmont writes that: the majority of physicists:

> …do not accept the notion of a consciousness totally independent of the brain. Besides, even if one were to accept the idea that mind, independent of the body, intervenes in the collapse process, there is nothing whatsoever in quantum mechanics to suggest that our conscious choices affect the collapse of the wave function one way or another. So there is no reason to take seriously this sort of link between consciousness and quantum mechanics.[54]

And here there is an hugely important insight that reader must take account of and retain for future deployment: even if one accepts that consciousness is somehow implicated at the quantum level, this does not entail that "our conscious choices affect the collapse of the wave function one way or another."

However, this sober analysis of the quantum situation seems to have been missed by many over-enthusiastic quantum prophets such as Levy who, casting aside warnings from practising physicists without any argument as to why such warnings can be ignored with abandonment approaching contempt, rush to tell their readers that:

> One of the greatest sovereign powers that we all wield as human beings, although often unknowingly or without awareness, is the power of where to place or attention. As if we all have an unknown superhero power, the very power of creation lies invisibly enfolded within our field of attention. Quantum physics reveals to us that turning the gaze of our attention towards anything is a powerful creative act that alters, energizes, and potentiates whatever our gaze falls on. Focusing our attention is an act of creation in and of itself. Our beam of attention intersects and interacts with the multidimensional probability waves that hover in a ghostlike state of unrealized potentiality that comprise matter in its unobserved state. Once imbued with our attention, whatever we are looking at instantly materializes into a particular and perceivable.[55]

Here Levy pushes the evidence far beyond anything it can possibly support. As Bricmont says, there is no evidence that human beings can beam beams of consciousness-attention to collapse quantum wavefunctions at will, and very, very few, if any (possibly Amit Goswami might go this far beyond the evidence) would support such a view. For example the important physicist Wojciech Zurek points out that:

> …while the ultimate evidence for the choice of one alternative resides in our illusive "consciousness," there is every indication that the choice occurs much before consciousness gets involved and that, once made, the choice is irrevocable.[56]

Simply put, Zurek is pointing out that experiments at the quantum level indicate that consciousness is in some way involved in choosing quantum alternatives, but at the 'classical' everyday level the way that quantum alternatives do manifest seem quite independent of what particular beams of consciousness people might be projecting around. Even John Wheeler, who, in mystical mode, talked of consciousness collapsing wavefunctions backwards in time, would probably have steered clear of suggesting a group of dinosaur-hobbyists could collectively beam their consciousnesses back in time to determine which particular possible dinosaurs to 'create' from quantum potentiality.

It might be thought some claims by some significant physicists actually support a Levy type extreme New-Agey perspective. For example, according to Rosenblum and Kuttner, the evidence obtained from quantum level experiments shows that:

> The object was not there before you found it there. Your happening to find it there *caused* it to be there.[57]

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. Bernard d'Espagnat, tells us 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. [58]

However, the issue which must be grasped is that both these quotes refer to *quantum experiments*. There is no evidence that human beings can actually beam rays of consciousness to collapse wavefunctions in everyday life, which is the claim contained in the Levy description quoted above.

All these kinds of perspectives, however, clearly have a subjective element, either subtle or crude. At some level, they seem to suggest, consciousness intervenes to produce experienced 'reality' from the realm of quantum spread out wavy potentiality. This division into the pre-measurement situation of a quantum bundle of possible experiences, and the post-measurement situation of having experiential possession of just one element of the possible elements in the quantum bundle, leads to the idea that such a situation is one wherein the situation is one concerning mere knowledge rather than having a hard-core 'real' reality one can really get to grips with. We are in the mist of flimsy quantum epistemology and can never get our hand on a really satisfying reality which has an ontological credibility! As Bohm and Hiley write in the Introduction to *The Undivided Universe*, that, in the Copenhagen viewpoint, it seems that:

> …quantum theory is concerned only with our *knowledge* of reality … in more philosophical terms, it may be said that quantum theory is primarily directed towards *epistemology* which is the study of how we obtain our knowledge… It follows from this that quantum mechanics can say little or nothing about reality itself. In philosophical terminology, it does not give what can be called an *ontology* for a quantum system. Ontology is concerned with what is and only secondarily with how we obtain knowledge …[59]

One way of looking at this is to consider that if we accept that we only get an experienced 'reality' after a 'measurement' takes place then we really cannot say that the pre-measurement state is 'real' in the same way as the post-measurement state is 'real', so it seems that reality is measured into reality from a state of unreality. And this does not give any kind of coherent 'ontology', because it does not tell us exactly what kind of 'stuff' the world is made of. As Roger Penrose has declared:

> 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?[60]

It can easily seem, to those accustomed to believe in a really 'real' reality, that in the quantum measurement situation we come to have mere knowledge of we know not what. Werner Heisenberg, in this vein, asserted that quantum physicists: "no longer deal with the elementary particles themselves but with our knowledge of them."[61]

Physicist Henry Stapp, who was around at a time so that he was able to discuss such issues with Heisenberg, has later concluded from his discussions and his own further intellectual explorations that:

> We live in an *idealike* world, not a matterlike world.' The material aspects are exhausted in certain mathematical properties, and these mathematical features can be understood just as well (and in fact better) as characteristics of an evolving idealike structure. 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.[62]

Stapp considers that quantum discoveries have completely overturned materialist accounts of the process of reality, and also believes that quantum mechanics offers insight into the nature of free-will:

> Philosophers of mind appear to have arrived, today, at less-than-satisfactory solutions to the mind-brain and free will problems, and the difficulties seem, at least prima facie, very closely connected with their acceptance of a known-to-be-false understanding of the nature of the physical world, and of the causal role of our conscious thoughts within it.[63]

A crucial phrase here is, of course, '*known-to-be-false*'. For Stapp, it is incomprehensible that anyone in the scientific or academic community in general could embrace any kind of materialist outlook:

> …the re-bonding [between mind and matter] achieved by physicists during the first half of the twentieth century must be seen as a momentous development: a lifting of the veil. Ignoring this huge and enormously pertinent development in basic science, and proclaiming the validity of materialism on the basis of an inapplicable-in-this-context nineteenth century science is an irrational act.[64]

Indeed!

In order to explain the nature of the 're-bonding' between mind and matter Stapp employs a formulation by John von Neumann (1903-1957), who was considered to be one of the world's foremost mathematicians at the time he proposed it (1925-1930), of the quantum 'measurement' process, which is the quantum process through which an actual experienced reality appears to emerge from the potentialities that are contained within the quantum wavefunction of possibilities:

Process 1: The 'free choice' of the experimental setup, Heisenberg called this phase "a choice on the part of the 'observer' constructing the measuring instruments and reading their recording." This choice is "not controlled by any known physical process, statistical or otherwise, but appears to be influenced by understandings and conscious intentions."[65] Whilst this process was originally delineated as a phase within the experimental setting, Stapp also indicates that such 'free choice' of 'probing actions' is a part of the general human condition:

> Probing actions of this kind are performed not only by scientists. Every healthy and alert infant is engaged in making willful efforts that produce experiential feedbacks … Thus both empirical science and normal human life are based on paired realities of this action-response kind…[66]

The hugely significant point in this "process 1" "free choice" is that it poses a question to which 'reality' can feedback a 'yes' or a 'no', and the fact that the choice of the question is free means that the "free choice" actually determines the nature of the possible feedbacks. Thus the "free choices" of how experiments are set up determine the nature of experienced reality for each experiment:

> …the process is active: it injects into the physical state of the system being acted upon properties that depend upon the intentional chosen action of the observing agent.[67]

Stapp calls this "process 1" 'a dynamical psychophysical bridge.'[68]

Process 2: The deterministic quantum evolution of the potentialities within the quantum wavefunction.

Process 3: is what Paul Dirac called a "choice on the part of nature." It is the 'yes' or 'no' feedback from the experimental set-up – yes reality is this way, or no reality is not this way; Stapp indicates that complex questions can be reduced to yes-no choices.

It was this situation, in which reality seemed to hang in a haze of uncertainty, or mind-like mathematical possibilities, before a 'measurement', so that quantum experiments did seem just to produce knowledge out of quantum thin air, so to speak, that provoked metaphysical dissent among some physicists. Erwin Schrödinger, the originator of the fundamental quantum wave equation, remarked concerning this state of affairs that:

> …the reigning doctrine rescues itself or us by having recourse to epistemology. We are told that no distinction is to made between the state of the natural object and what I know about it, or perhaps better, what I can know about it if I go to some trouble. Actually - so they say - there is intrinsically only awareness, observation, measurement.[69]

This is an interesting insight from the point of view of Yogacara conciousness-only Buddhism and Buddhist Dzogchen because of the notion, common to both of these, that the process of reality fundamentally derives from a deep layer of energy which is substantially of the same nature as awareness. Thus, the Dzogchen psycho-metaphysical vision of the Dzogchen philosopher-practitioner Dudjom Lingpa tells us that:

> …all sensory experiences of samsara and nirvana manifest as specific forms that come and go within the expanse of the space of supreme emptiness. The ground aspect of the dharmakaya, buddha nature, becomes evident as the

> supreme principle that pervades all of samsara and nirvana. This is the ground aspect of awareness as supreme freedom from limitations … samsara and nirvana are the phantasmagoria of a single awareness…[70]

The term 'samsara' denotes what Bohm would call the explicate order, wherein the great portion of humanity live lives of various degrees of dissatisfaction, interspersed with momentary pleasures. It also denotes the cycle of birth and death, Buddhism asserts the rebirth of streams of consciousness, although Buddhism also denies the existence of any fixed 'self' that continues from life to life. As we shall see later 'nirvana' corresponds to mental states beyond the explicate, corresponding to implicate realms of consciousness.

It is also noteworthy that this description indicates that both samsara and nirvana "manifest as specific forms that come and go within the expanse of the space of supreme emptiness." Compare this with the summary of David Bohm's article 'The Implicate Order: A New Order for Physics' which reads:

> The author suggests that emptiness is really the essence. It contains implicitly all the forms of matter. The implicate order really refers to something immensely beyond matter as we know it — beyond space and time. However, somehow the order of time and space are built in this vacuum. At present there is no law that determines the vacuum state.[71]

Bohm, of course, was not the only physicist who, at some point in his career, saw some kind of connection between quantum discoveries and Buddhism. Here is an observation made by Robert Oppenheimer, one of the physicists bearing a great responsibility for the development of the atomic bomb:

> ... discoveries in atomic physics are not in the nature of things wholly unfamiliar, wholly unheard of or new. Even in our own culture they have a history, in Buddhist and Hindu thought a more considerable and central place. What we shall find [in modern physics] is an exemplification, an encouragement, and a refinement of old wisdom.[72]

And Oppenheimer made the following observation when discussing the Heisenberg Uncertainty Principle:

> If we ask, for instance, whether the position of the electron remains the same, we must say 'no;' if we ask whether the electron's position changes with time, we must say 'no;' if we ask whether the electron is at rest, we must say 'no;' if we ask whether it is in motion, we must say 'no.' The Buddha has given such answers when interrogated as to the conditions of man's self after his death; but they are not familiar answers for the tradition of seventeenth and eighteenth-century science.[73]

And Schrödinger had a long-term interest in the Hindu Vedas.[74]

However, despite his interest in Vedic mysticism, Schrödinger, as the previous quote above (page 30) from him indicates, was dissatisfied with an awareness-based 'epistemological' view of the quantum situation. In fact, Schrödinger, said that if he were not convinced that Bohr really did believe his Copenhagen viewpoint: "I would call it intellectually wicked."[75] And Schrödinger wrote to Max Born, who was a supporter of Bohr: "Have you no anxiety about the verdict of history. Are you so convinced the human race will succumb before long to your folly?" And Einstein shared a view in alignment with Schrödinger, declaring that the Copenhagen account of quantum functioning "operates with an incomplete descriptions of physical systems."[76]

Schrödinger and Einstein were soon joined by the important quantum physicist John Bell, who expressed his "anxiety" concerning quantum "verdicts" concerning the nature of reality in observations such as:

> One wants to be able to take a realistic view of the world, to talk about the world as if it were really there, even when it is not being observed. I certainly believe in a world that was here before me, and will be there after me, and I believe you are part of it! And I believe that most physicists take this point of view when they are being pushed into corners by philosophers.[77]

The physicist Jean Bricmont, in his excellent book, in which he extols the virtues of Bohmian Mechanics, *Making Sense of Quantum Mechanics* writes:

> What we need is a theory which tells a story about what is going on on the world, even when we do not "observe" it, and which makes the same predictions as ordinary quantum mechanics , whenever we do make "observations" or experiments. If such a theory existed, then all the confusing talk about the centrality of observations would disappear and we could analyse that theory in order to see how it helps us to understand the quantum world. Amazingly, such a theory actually does it exist, and has existed ... since the the beginning of quantum mechanics …proposed by Louis de Broglie … and developed by David Bohm in 1952.[78]

And the abstract to David Bohm's 1952 paper reads:

> The usual interpretation of the quantum theory is self-consistent, but it involves an assumption that cannot be tested experimentally, viz., that the most complete possible specification of an individual system is in terms of a wave function that determines only probable results of actual measurement processes. The only way of investigating the truth of this assumption is by trying to find some other interpretation of the quantum theory in terms of at present "hidden" variables, which in principle determine the precise behavior of an individual system, but which are in practice averaged over in measurements of the types that can now be carried out. In this paper and in a subsequent paper, an interpretation of the quantum theory in terms of just

such "hidden" variables is suggested. It is shown that as long as the mathematical theory retains its present general form, this suggested interpretation leads to precisely the same results for all physical processes as does the usual interpretation. Nevertheless, the suggested interpretation provides a broader conceptual framework than the usual interpretation, because it makes possible a precise and continuous description of all processes, even at the quantum level. This broader conceptual framework allows more general mathematical formulations of the theory than those allowed by the usual interpretation. Now, the usual mathematical formulation seems to lead to insoluble difficulties into the domain of distances of the order of 10^{-13} cm or less. It is therefore entirely possible that the interpretation suggested here may be needed for the resolution of these difficulties. In any case, the mere possibility of such an interpretation proves that it is not necessary for us to give up a precise, rational, and objective description of individual systems at a quantum level of accuracy.[79]

As we can see, Bohm refers to his new approach as a type of "hidden variables" account of quantum functioning. The phrase "hidden variables" refers to the possibility that, as Einstein had claimed, the current quantum theory of the time was "incomplete," and therefore there were hidden elements, that, when found, would remove notions of observers 'creating' reality, or that reality was only subjective knowledge that was produced when minds somehow interacted with an unknowable quantum mist. The issue of the feasibility of "hidden variables" had a history of debate and controversy, these issues were encapsulated in "no hidden variables" theories, but the details need not concern us here. Bohm made the claim that his "hidden variables" approach avoided any issues that might have been thought to be problematic.

In the case of Bohm's new theory the "hidden" part is a 'pilot wave' which guides real particles, which are self-existent particles. The way in which the pilot wave behaves is such that the particles behave exactly as they appear to behave in the Copenhagen scenario, but they are continuously existent particles that do not seem to magically appear on the scene when a 'observer' gets observing! In his so very excellent pro-Bohmian Mechanics book *Quantum Sense and Nonsense,* Bricmont explains:

* It is a "hidden variables" theory.

* Its "hidden variables" are not hidden at all (hence the expression "hidden variables" is quite a misnomer in this case).

* There is no fundamental role whatsoever for the "observer" in that theory.

* The theory is not contradicted by the no hidden variables theorems. It is a sort of statistical interpretation of quantum mechanics, but a consistent one.

* The de Broglie-Bohm theory is entirely deterministic.

* It accounts for all the observations used to justify the validity of ordinary quantum mechanics.

* It allows us to understand the "active role" of the measuring devices, meaning that a measurement in general does not record some pre-existing value of the system being "measured", as the "no hidden variables" theorems imply. But it does so without making it a philosophical a priori.

* It explains to some extent where the nonlocality of the world comes form.[80]

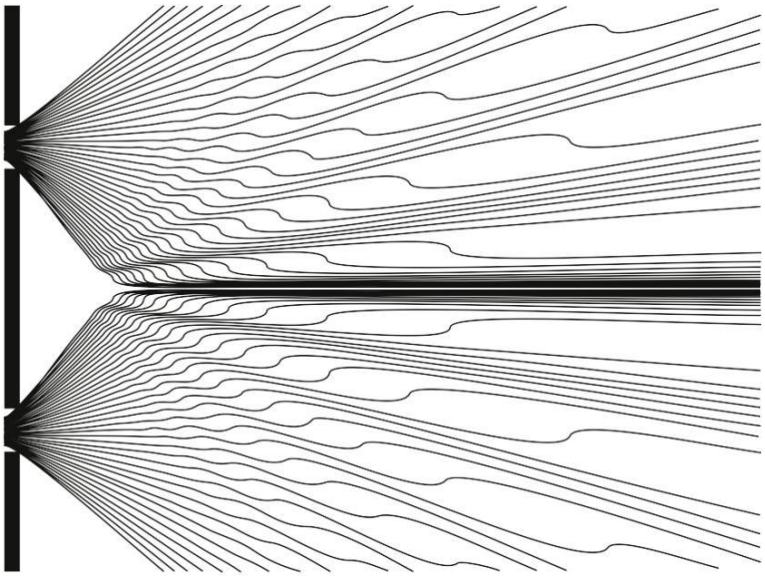
The last two points: 1) results of measurements depend on interactions, not prior independent properties, and 2) the feature of "nonlocality", Einstein's "spooky action at a distance", require further elucidation which will follow shortly.

Here are a two more useful explanatory quotes from Bricmont's excellent book, worth reading even if you are not a fan of Bohm's ideas, taken from the chapter 'The de Broglie-Bohm Theory in a Nutshell':

> The de Broglie-Bohm theory is simply a theory of matter in motion, just like Newton's theory. Of course, the way particles move is different … but there is nothing philosophically new.[81]

And:

> In the de Broglie-Bohm theory, the *complete physical state* of a particle or a system of particles is given both by its wave function, which is the same as in ordinary quantum mechanics, *and* the positions of the particles. They both change in time, in the following way:
>
> *1)* The wave function evolves according to the usual rules, *but nothing special happens to it during measurements.*
>
> 2) The motion of particles is guided by their wave function.[82]



Bohmian pilot wave guided particle paths in the two slit experiment

When John Bell read Bohm's 1952 article, 'A Suggested Interpretation of the Quantum Theory in Terms of "Hidden" Variables', he was moved to proclaim that:

> But in 1952 I saw the impossible done. It was in papers by David Bohm. Bohm showed explicitly how parameters could indeed be introduced, into non-relativistic wave mechanics, with the help of which the indeterministic description could be transformed into a deterministic one. More importantly, in my opinion, the subjectivity of the orthodox version, the necessary reference to the 'observer,' could be eliminated. But why then had Born not told me of this 'pilot wave'? If only to point out what was wrong with it? Why did von Neumann not consider it? More extraordinarily, why did people go on producing 'impossibility' proofs, after 1952, and as recently as 1978? Why is the pilot wave picture ignored in text books? Should it not be taught, not as the only way, but as an antidote to the prevailing complacency? To show us that vagueness, subjectivity, and indeterminism, are not forced on us by experimental facts, but by deliberate theoretical choice?

One can detect here that Bell was inclined to suspect that there was some kind of conspiracy on the part of some, perhaps mystically inspired or inclined, cabal of physicists to promote the Copenhagen view. Andrew Whitaker, in his book *The New Quantum Age,* comments that:

> What is exciting about the Bohm interpretation is that, totally contrary to the claims of Bohr and von Neumann, the fairly simple set of ideas produces the standard results of quantum theory … but remains entirely realist. In fact, Bohm's interpretation is also deterministic, though for Bell in particular that was rather unimportant - it was the realism that was important.[83]

And in a telephone call with BBC interviewers, prior to an interview, Bell warned, when told that he might be asked if quantum theory showed that 'reality does not exist', that: "he is an impatient, irascible sort who tolerates no nonsense."[84] This seems to suggest that Bell, like others then and now, had a a priori preference for a 'realistic' interpretation. But it is interesting to note that Einstein, who had famously also expressed a preference for a more 'realist' perspective, with remarks such as "God does not play dice!," wrote to Max Born about Bohm's proposal expressing his opinion that:

> That way seems too cheap to me. This path seems to me too easy … a physical fairy-tale for children, which has rather misled Bohm and de Broglie.[85]

It seems Einstein was a hard man to please!

We saw above that Bricmont refers to the "interactive" nature of measurement outcomes. In their book *The Undivided Universe* Bohm and Hiley explain:

> The probability of a particular result of the interaction between the instrument and the observed object is shown to be exactly the same as that assumed in the conventional interpretation. But the key new feature here is that of the *undivided wholeness* of the measuring instrument and the observed object, which is a special case of the wholeness … with quantum processes in general. …it is no longer appropriate, in measurements to a quantum level of accuracy, to say we are simply 'measuring' an intrinsic property of of the observed system. Rather what happens is that the measuring apparatus and that which is observed participate irreducibility in each other, so that the ordinary and common sense idea of measurement is no longer relevant.[86]

So, although the Bohmian approach has perhaps rescued 'reality', but it is not our good old "ordinary and common sense idea" of 'reality' we were so fond of! In Bohm's new reality the result of measurements depend upon the way in which "the measuring apparatus and that which is observed participate irreducibility in each other." In other words, quantum entities do not have their own independent properties all to themselves, so to speak, the 'real' properties that show up in measurements depend upon which other bits and pieces of the universe they are interacting with:

> The pilot wave theory is contextual. That is, it recognizes that the outcome of measurements cannot be accounted for simply by hidden variables in the observed system alone. The variables of the measuring equipment (which expression can include human observers) and the interaction between the equipment and the system all play a part in bringing about the result.[87]

So Bohm did not manage to banish all traces of quantum unconventionality!

The 'pilot wave' theory "provides a broader conceptual framework than the usual interpretation, because it makes possible a precise and continuous description of all processes, even at the quantum level." In other words, it provides a continuous mathematical description of the behavior the pilot waves which are guiding the particles, there are no sudden changes, or jumps, in ontological status, all aspects remain 'real' all the time. Physicist Henry Stapp describes Bohm's pilot wave theory:

> Bohm's model is simple and instructive. It shows that we need not cling to the idea, advanced by the founders of quantum theory, that nature cannot be described in a thoroughly comprehensible way in terms of properties that are always well defined and that evolve in accordance with well-defined deterministic ways. Bohm's model does violate one of the basic precepts of classical physics: that the force on a particle located at a point generally depends strongly upon the precise positions, *at that very instant,* of many other particles all over the universe. This instantaneous connection

> contradicts the idea of classical relativistic physics that no influence can act … faster than light.[88]

So there is a price to pay, so to speak, by adopting Bohm's method of reworking quantum mechanics into a more realistic demeanour. We now have real particles moving around, and they are not dependent on observers, or at least not on the minds of observers, and the way they move around is guided by real pilot waves. But, we also have to accept that in some circumstances, particles may instantaneously influence each other over vast cosmic distances, which is not a classical phenomenon previously considered as operating in the process of reality. Indeed, as Stapp points out, it contradicts relativity theory, which says that points in space cannot have interconnections that operate faster than the speed of light.

This non-local instantaneous interconnection between distant aspects of the Bohmian undivided universe derives from the way in which Bohmian mechanics necessarily deals with the phenomenon of quantum entanglement. Within conventional quantum mechanics, entangled particles are particles that have interacted so that they share a quantum wavefunction. They then remain interconnected so that actions performed on one particle will instantaneous affect the other, even when separated by great distances. This is the phenomenon that Einstein referred to as "spooky action at a distance." In the non-Bohmian type of physics this non-local interconnection only applies at the quantum level and disappears at the classical level, because of the way in which quantum phenomena transition to 'classical' behavior. But in Bohm's undivided universe, these "spooky" instantaneous interconnections remain operative even at the classical level. This topic will be elucidated in the next chapter.

And there is, as Stapp also points out, one other unsettling feature of Bohm's undivided universe:

> Bohm's model does however retain one feature of classical physics that can be regarded as objectionable … This is the need for an arbitrary-looking choice of initial conditions. In particular, some definite initial position for each of the particles in the universe must be chosen.[89]

So how could we account for the initial positions of all the particles at the dawn of time, given that we do not want to appeal to an independent creator God putting them all in precise places before setting the universe in motion, so to speak?

Remarkably, one possible solution derives from Buddhism, specifically a metaphysical view of the way in which universes succeed one after the other, each one inheriting the initial configuration as a karmic echo from the one that has gone before. According to the Buddhist worldview karmic causality operates at all levels of the process of reality. Many people in the West think that the mechanism of *karma-vipaka*, or action and future result, is only a moral mechanism. This, however, is not the case, *karma-vipaka*:

> …is the theory of cause and effect, or action and reaction; it is a natural law, which has nothing to do with the idea of justice or reward and punishment. Every volitional action produces its effects or results.[90]

And within Buddhist psycho-metaphysics it is understood that perceptions by sentient beings are karmically active and therefore condition future similar perceptions. The subjective structures of intentionality are embodied within the various types of sentient beings and operate to produce an intersubjectively created field of potentiality called the *alayavijnana*, the ground consciousness. And this ground consciousness produces the ground for a collectively experienced material reality:

> 'The common characteristic of the alayavijnana is the seed of the receptacle-world' means that it is the cause of perceptions which appear as the receptacle world. It is common because these perceptions appear similarly to all who experience them through the force of maturation that is in accordance with their own similar karma.[91]

The term 'karma' simply means 'action', and it refers to any action of body, speech and mind which leaves a trace within the *alayavijnana*, the ground consciousness of potentiality. These resonant traces, or seeds, will later 'mature', or be activated into experiential reality. *Karma-vipaka* is the universal law of action and maturation, cause and effect, which operates at all levels of reality, including the creation of the potentialities, or seeds, within the ground consciousness, which later mature or manifest as experiences of a supposedly external 'material' reality:

> Space, earth, wind, sun,
> The oceanside, and waterfalls
> Are aspects of the true, internal consciousness
> That appear as if being something external.[92]

The operation of karma operates on many levels of mind and the appearance of matter, and it is the collective level of mind which creates the physical environment which is inhabited by the countless beings whose collective karma created it. The Yogacara consciousness-ground-of-all perspective is quite clear that what we experience as the physical world is in fact built up through the operation of the collective karma within the fundamental consciousness-field which is the ground of reality:

> The entire world was created through latent karmic imprints. When these imprints developed and increased, they formed the earth, the stones, the mountains, and the seas. Everything was created through the development or propagation of these latent karmic potentials.' … 'How can all these external forms arise out of latent karmic imprints? All these mountains, oceans, the sun and moon are so solid and so vivid. How can they arise out of latent karmic imprints in the mind.' … 'These things arise through the power and propagation of thought.'[93]

The fact that the process of karma is responsible for the appearance of the material world is little known or understood in the West even amongst Buddhists. But this understanding of the process of reality is clearly stated within the Buddhist worldview:

> …the mind is the principle creator of everything because sentient beings accumulate predisposing potencies through their actions, and these actions are directed by mental motivation. These potencies are what create not only their own lives but also the physical world around them. All environments are formed by *karma*, that is actions and the potencies they establish. The wind, sun, earth, trees, what is enjoyed, used, and suffered - all are produced from actions.[94]

And this perspective has an uncanny resemblance to the multitudinous quantum-perception universe-creation mechanism which underpins John Wheeler's assertion that:

> Directly opposite to the concept of universe as machine built on law is the vision of *a world self-synthesized.* On this view, the notes struck out on a piano by the observer participants of all times and all places, bits though they are in and by themselves, constitute the great wide world of space and time and things.[95]

The correspondence between Wheeler's conception and the Buddhist karmic-metaphysical account of the way the universe comes into existence is striking.

The Buddhist metaphysical account described above is further amplified and elucidated by some teachings regarding the formation of universes from the *Kalacakra Tantra,* which describes:

> …vast world systems throughout infinite space. At any particular time, some world systems are arising, some abiding, some disintegrating, and others remaining dormant. In this view, there is no absolute beginning. There is simply the beginningless interplay of various factors that make world systems arise, abide, disintegrate and remain dormant.[96]

And, furthermore, the *Kalacakra Tantra* describes the state as it exists between the destruction of one universe and the karmic arising of the next as follows:

> During this time of emptiness the subtle particles … exist as isolated fragments and are not in any conventional sense objects of the sensory powers of the eye and so forth. They are known as *empty particles*….[97]

So, to answer Stapp's query as to how particles can start out in an appropriate configuration for the generation of a coherent universe, running according to Bohm's 1952 version of pilot wave theory; this situation can be accounted for if such 'empty' particles, or particles of quantum potentiality, are generated as karmic echoes from one disintegrated universe into the next universe. So we see that, even within the context

of Bohm's deterministic quantum materialist-mechanical 1952 attempt to banish quantum 'weirdness' from the process of reality, it is possible to find interesting modes of further development in an unexpected direction.

Bohm's 1952 deterministic realist 'pilot wave' approach had the seeds of its own necessary future development within it. This because it highlighted the very counter-intuitive notion of instantaneous connections between 'particles' across vast cosmic distances. As noted previously, in pre-Bohmian quantum theory such 'spooky' interconnections only had significance in the quantum world, they did not operate in the everyday classical 'world'. But the mathematical formulations that Bohm had to employ in his new theory meant that the 'spooky' non-local cosmic interconnections were projected into 'classical' reality. And such universal instantaneous interconnections between cosmically distant particles are not an obvious feature of the everyday world, as Hiley and Peat (H&P) tell us in their introduction to *Quantum Implications: Essays in Honour of David Bohm*:

> … this relationship may depend on the quantum states of even larger systems, ultimately going on to the universe as a whole. Within this view separation becomes a contingent rather than a necessary feature of nature. This is very different from the way we perceive the macroscopic world around us, where separation seems basic.[98]

One does not expect electrons on the other side of the universe to be disturbed when one raises an afternoon cup of tea!

So we see that in Bohm's 1952 pilot-wave quantum metaphysics a universally holistic network of interconnections is a natural and necessary result of the theoretical development. And in 1957 Bohm began to update his views in his book *Causality and Chance in Modern Physics,* abandoning his Marxist sympathies and moving in a more spiritual direction. At this time Bohm declared that communists "began to minimise the importance of spirit," and Bohm later told an interviewer that at the time, in line with his new intellectual direction, "I also read Buddhism or oriental philosophy, Indian philosophy, yoga and probably some of the Christian philosophers."[99] He also came across the works of Krishnamurti around this time.

In the preface to the new 1984 edition of *Causality and Chance in Modern Physics* Bohm explained how his attempt at formulating a fully causal, deterministic and realistic account of quantum functioning led him towards wider vistas of quantum metaphysics:

> … the development of classical physics … led to to the notion that the universe may be compared to a gigantic mechanism. … more recent developments in physics, notably relativity and quantum theory, do not fit in with such a mechanistic philosophy. Rather they very strongly suggest the need for a radically new over-all approach, going beyond mechanism. The usual interpretation of quantum theory does not give a clear idea of how far-

> reaching is this change, because it functions solely as a mathematically algorithm … an alternative interpretation is discussed, in which an electron (for example) is assumed to be a particle that is always accompanied by a new kind of wave field. …[100]

Here Bohm is referring to his 1952 pilot-wave proposal. But he now indicates that the initial pilot-wave viewpoint is of a provisional nature, awaiting important further insights:

> This interpretation in terms of particle plus field was regarded, however, as furnishing only a provisional mode of understanding the quantum theory … In these studies … it became clear that even the one-body system has a basically non-mechanical feature, in the sense that it and its environment have to understood as an *undivided whole*.[101]

And, Bohm tells that:

> The law of the whole can be shown to imply that at the ordinary level of experience … the whole falls *approximately* into a structure of relatively independent sub-wholes, interacting more or less externally and mechanically. Nevertheless, in a more accurate and more fundamental description, quantum wholeness and non-locality are seen to the the major factors.[102]

In the next chapter we shall investigate how non-local connections necessarily imply a quantum metaphysics of wholeness.

Revisioning Bohm's Pilot Ontological Theory

NonLocal Connections

Implicates Ontological

Wholeness

Erwin Schrödinger posed his famous dead and alive cat paradox in order to highlight the apparent absurdity of the quantum state of superposition, wherein many possibilities for manifestation exist at the same time, although none of them are really real, so to speak. A 'superposition' is a mathematical description of all the possibilities for manifestation which semi-exist prior to a 'measurement' taking place. Once a measurement occurs only one of the possibilities in the superposition actually makes it into full reality, and all the other disappear. He outlined his thought experiment in a letter to Einstein. Schrödinger wrote (ψ denotes the quantum wavefunction):

> Confined in a steel chamber is a Geiger counter prepared with a tiny amount of uranium, so small that in the next hour it is just as probable to expect one atomic decay as none. An amplified relay provides that the first atomic decay shatters a small bottle of prussic acid. This and – cruelly – a cat is also trapped in the steel chamber. According to the ψ-function for the total system, after an hour … the living and dead cat are smeared out in equal measures.[103]

In this thought scenario the cat's state of 'existence' depends upon the state of 'existence' of the atomic constituents in the uranium. Some of these atoms will be in a superposition of decay and non-decay. As the cat lives or dies depending upon non-decay or decay, the cat itself must hover between the state of life and the after-life at the same time. However, it is important to understand that Schrödinger did not actually believe that cats could be placed into states of being half-dead and half-alive; the description he gave was only a thought experiment that he concocted in order to illustrate what he considered to an absurdity within the Copenhagen account of quantum theory.

Einstein had also discussed the quantum phenomenon of superposition as it would appear if it manifested on the everyday macroscopic level. One of Einstein's thought experiments is called Einstein's Boxes. Physicist Travis Norsen has written about this:

> It is well known that several of quantum theory's founders were dissatisfied with the theory as interpreted by Niels Bohr and other members of the Copenhagen school. Before about 1928, for example, Louis de Broglie advocated what is now called a hidden variable theory: a pilot-wave version of quantum mechanics in which particles follow continuous trajectories, guided by a quantum wave. David Bohm's rediscovery and completion of the pilot-wave theory in 1952 led de Broglie back to these ideas; … Erwin Schrödinger was likewise doubtful that the quantum wave function could alone constitute a complete description of physical reality. His famous "cat" thought experiment was intended to demonstrate quantum theory's

> incompleteness by magnifying the allegedly real quantum indefiniteness up to the macroscopic level where it would directly conflict with experience. By far the most important critic of quantum theory, however, was Albert Einstein. [Einstein suggested] another thought experiment which, like … Schrödinger's cat, is intended to argue against the orthodox doctrine of quantum completeness. This thought experiment – "Einstein Boxes"– is due originally to Einstein, although it has also been discussed and reformulated by de Broglie, Schrödinger, Heisenberg, and others. Given its unique simplicity, clarity, and elegance, the relative obscurity of this thought experiment is unjustified. Einstein's Boxes establishes this conclusion with a more straightforward logical argument.[104]

Einstein's Boxes not only brings quantum 'weirdness' into the everyday world, within the context of a thought experiment, it also provides a simple, but dramatic, insight into the nature of the spectacular phenomenon of quantum non-locality. This is especially true of Einstein's thought experiment as presented by Louis de Broglie. As Norsen indicates:

> de Broglie's re-formulation of the thought experiment in terms of literal boxes simply exaggerates the spatial separation of two parts of the total wave function, and thus brings out more clearly the implications of the locality assumption.

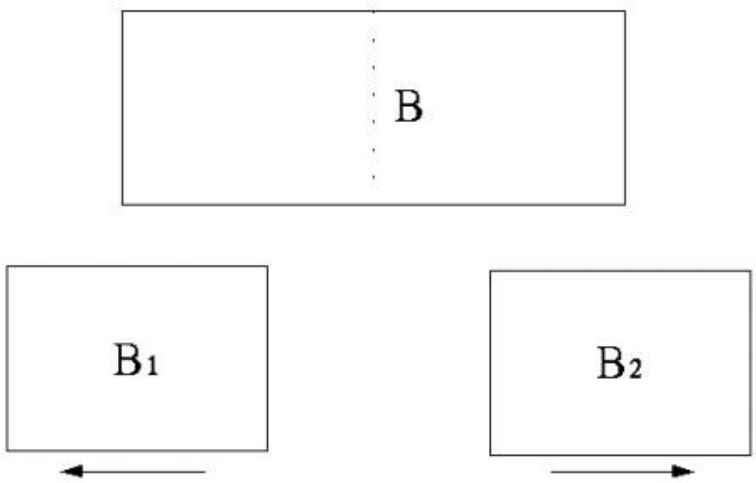


Figure 1

In his 1964 book *The Current Interpretation of Wave Mechanics: A Critical Study*[105], Louis de Broglie described Einstein's Boxes thought experiment. In the following we shall go through his description with some elucidations:

To begin the description de Broglie wrote:

> Suppose a particle is enclosed in a box B with impermeable walls. The associated wave Ψ is confined to the box and cannot leave it. The usual interpretation asserts that the particle is "potentially" present in the whole of the box B, with a probability $|\Psi|^2$ at each point. Let us suppose that by some process or other, for example, by inserting a partition into the box, the box B is divided into two separate parts B_1 and B_2 and that B_1 and B_2 are then transported to two very distant places, for example to Paris and Tokyo. [See Fig. 1.] The particle, which has not yet appeared, thus remains potentially present in the assembly of the two boxes and its wave function Ψ consists of two parts, one of which, Ψ_1, is located in B_1 and the other, Ψ_2 in B_2. …

Here de Broglie refers to an initial situation where a quantum 'particle' is constrained within a box. A quantum particle, according to the Copenhagen view, is not a classical type particle because it does not fully exist as a particle somewhere in the box. Instead 'it' is a quantum haze of potentiality spread out inside the box, and 'it' has a probability (given by the square of the wavefunction $|\Psi|^2$) of being measured into existence for each point in the box. If the box is cut in two to produce two new self-contained boxes which are separated by a large distance, each of the two boxes will now have there own wavefunctions Ψ_1 and Ψ_2 . But, although each box has its own wavefunction, there is still only one 'particle' involved, so now there are two interconnected wavefunctions, with one particle smeared out as potentiality across both wavefunctions inside the boxes, but not in-between. Next de Broglie continues:

> The probability laws of wave mechanics now tell us that if an experiment is carried out in box B_1 in Paris, which will enable the presence of the particle to be revealed in this box… According to the usual interpretation, this would have the following significance: because the particle is present in the assembly of the two boxes prior to the observable localization, it would be immediately localized in box B_1 in the case of a positive result in Paris. This does not seem to me to be acceptable. The only reasonable interpretation appears to me to be that prior to the observable localization in B1, we know that the particle was in one of the two boxes B_1 and B_2, but we do not know in which one, ….

Here de Broglie indicates that if an experiment is carried out in Paris which results in the particle being found to be in the Paris box B_1 then, instantaneously, the wavefunction of potentiality will disappear from the Tokyo box B_2, there will be no possibility of a particle being discovered in B_2. The combined wavefunction of particle-potentiality that has been hovering within the two boxes has now 'collapsed' so that there is just one particle in box B_1. Furthermore, de Broglie clearly states that he finds this situation "unacceptable." For de Broglie the particle must have been fully in one of the boxes before the measurement. He could not accept the idea of a ghost-like hovering in semi-existence within the two boxes, but not in-between, before the

measurement. Next de Broglie continues:

> We might note here how the usual interpretation leads to a paradox in the case of experiments with a negative result. Suppose that the particle is charged, and that in the box B_2 in Tokyo a device has been installed which enables the whole of the charged particle located in the box to be drained off and in so doing to establish an observable localization. Now, if nothing is observed, this negative result will signify that the particle is not in box B_2 and it is thus in box B_1 in Paris. But this can reasonably signify only one thing: the particle was already in Paris in box B_1 prior to the drainage experiment made in Tokyo in box B_2. Every other interpretation is absurd. How can we imagine that the simple fact of having observed nothing in Tokyo has been able to promote the localization of the particle at a distance of many thousands of miles away?

Here de Broglie describes the truly mind-boggling notion, which is required by the Copenhagen view, that a combined superposed quantum wavefunction for one particle spread between these two boxes, one in Paris and the other in Tokyo, may be 'measured' *negatively* at one end, in this case the Tokyo box B_2, finding no particle there, and that this negative 'measurement' within box in Tokyo will cause the 'particle' to immediately fully appear in box B_1 in Paris. Again de Broglie indicates his incredulity that anyone would think such a possibility as anything other than "absurd." How could observing "nothing" in Tokyo create the manifestation of something in Paris?

This "absurd" instantaneous quantum interconnection, which is clearly predicted by the Copenhagen quantum interpretation, is called quantum non-locality. An important aspect of this quantum phenomenon is the fact that it seems that 'entangled' particles demonstrate Einstein's non-local 'spooky' instantaneous interconnections across vast distances. Particles are said to be in a state of quantum 'entanglement' if they have been produced, or have interacted, in a manner which produces a kind of inner connection between the two particles. For example, a photon which encounters a polarizing filter will 'randomly' collapse into a definite state of polarisation and either pass through or be reflected, depending upon the alignment of polarisations. Until it encounters the filter the photon does not have a definite polarisation, instead it is in a superposition of possible polarisations. Its polarisation is randomly determined the moment it reaches the filter. Brian Greene explains this kind of entanglement:

> The astounding thing is that such a photon can have a partner photon that has sped miles away in the opposite direction and yet, when confronted with the same 50-50 probability of passing through another polarised … lens, will somehow do whatever the initial photon does. Even though each outcome is determined randomly and even though the photons are far apart in space, if one photon passes through so will the other.[106]

It is important to comprehend the unexpected nature of this phenomenon. Two 'entangled' photons move a vast distance apart and then, when one is measured into a definite polarisation, the other photon immediately responds as if it 'knows' what has happened to its partner photon. And this immediate response is not affected by any scale of distance between the two photons.

So, it seems that at the quantum level there is some kind of instantaneous communication between entangled particles. This astonishing aspect of the quantum world is quantum 'non-locality'. Greene has remarked that:

> Numerous assaults on our conception of reality are emerging from modern physics … But of those that have been experimentally verified, I find none more mind-boggling than the recent realisation that our universe is not local.[107]

In order to reinforce the 'mind-boggling' nature of the quantum phenomenon of non-locality David Lindley, in his book *Where Does the Weirdness Go*, presents the situation in terms of a pair of gloves, a analogy first employed by John Bell. Suppose someone buys a pair of gloves and then sends the left glove to someone in Hong Kong and the right to someone else in New York. This represents the 'common-sense' situation under the 'locality' view that we are familiar with from our everyday macroscopic world; the 'leftness' of the Hong Kong glove is 'local' to Hong Kong and the 'rightness' of the other glove is 'local' to New York. There can be no instantaneous interconnection between the two gloves which affects their handedness at the moment that one of the packages containing either glove is opened. But if these gloves were quantumly entangled then both gloves would be in a state of hovering between 'leftness' and 'rightness' until one of the packages containing the individual gloves was opened, at which point the gloves would magically adopt a definite 'leftness' and corresponding 'rightness.' Thus there is a non-local instantaneous interconnection between the gloves, an interconnection which defies 'common sense.' It was because of this defiance of the procedures of what one expects a really real, straight-down-the-line, no-nonsense, common-sense reality to conform to that led physicists like Einstein, de Broglie, Bell and Bohm to be suspicious!

In 1935 Einstein, together with Boris Podolsky and Nathan Rosen wrote a paper in which they argued that, contrary to the predictions of quantum physics, particles must have definite local attributes. This paper became famous as the EPR paper. EPR argued that, because the measurement outcome at one end of the entangled pair seems to determine what happens at the other side, even if the 'sides' are cosmically distant, there must be some *local* 'elements of reality', at each side, which pre-determine the measurement outcomes. Einstein, Podolsky, and Rosen formulated this view in their famous Reality Criterion:

> If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then

there exists an element of reality corresponding to that quantity.[108]

Thus Einstein and friends, like de Broglie, Bell, Bohm and some others, could not accept ideas of semi-existent smeared-out 'particles' in instantaneous communication across cosmic distances. There must be "pre-determined" "elements of reality" at either end of the quantum conundrum. But, unfortunately for Einstein and his colleagues, the EPR paper actually formed the basis for proving the opposite. In 1964, nine years after Einstein's death and nearly 30 years after the EPR paper, the physicist John Bell produced a crucial mathematical inequality which was used to experimentally test the veracity of the non-local quantum effect, and it was conclusively shown that the quantum world is non-local.

Experiments conducted by Alain Aspect and his team examined the status of Bell's inequality as applied to two entangled particles in the late 1970's and early 1980's and found that the results conclusively proved quantum non-locality. These experiments, and even more precise experiments subsequently performed, showed that there is is an intimate connection between entangled particles which operates instantaneously no matter how distant they may be. Subsequently, astounding experiments have been conducted on three entangled particles. The experiment involves measuring vertical, horizontal, and circular polarisation of the three particles. Quantum theory predicts a 'dance' of these attributes which can in no way be possible if there are locally predetermined programs, or 'local' hidden determining features, for the particle states. Physicist Michael Horne observed concerning this:

> Einstein's 'elements of reality' do not exist. No explanation of the beautiful dance among the three particles can be given in terms of an objectively real world. The particles simply do not do what they do because of how they are; they do what they do because of quantum magic.[109]

Here Horne highlights the fact that the appearance of the "objectively real world" of independent completely separate objects is, from an *ultimate* point of view, misleading. Quantum experiments now show that at a deeper quantum level there are extraordinary 'hidden' interconnections underlying the everyday world: "quantum magic!"

But not everyone was enamoured with "quantum magic." John Bell, like Einstein, was someone who was desperate for a 'realist' account of the process of reality. When confronted with evidence that the non-local EPR correlations were real and 'spooky' quantum interconnections exist, he declared:

> Most physicists were (and are) unimpressed by [EPR correlations]. That is because most physicists do not really accept, deep down, that the wavefunction is the whole story. They tend to think that the analogy of the glove left at home is a good one. If I find that I have brought only one glove, and that it is right-handed, then I predict confidently that the one still at

> home will be seen to be left handed. But suppose we had been told, on good authority, that gloves are neither right- or left-handed when not looked at. Then that, by looking at one, we could predetermine the result of looking at the other, at some remote place, would be remarkable. Finding that this is so in practice, we would very soon invent the idea that gloves are already one thing or the other even when not looked at. And we would begin to doubt the authorities that had assured us otherwise. That common-sense position was that taken by Einstein, Podolsky and Rosen, in respect of correlations in quantum mechanics. They decided that the wavefunction, making no distinction whatever between one possibility and another, could not be the whole story. And they conjectured that a more complete story would be locally causal. "However it has turned out that quantum mechanics can not be 'completed' into a locally causal theory, at least as long as one allows, as Einstein, Podolsky and Rosen did, freely operating experimenters. The analogy of the gloves is not a good one. Common sense does not work here.[110]

So, Einstein's belief in, and hope for, independent 'elements of reality,' each with their own separate independent on-board bits of information, is false. The universe seems, at least at the quantum level, more like an interconnected pattern, a pattern that contradicts the possibility of absolutely separate, independently existent elements with definite completely independent attributes. This seems to imply that if no measurements were to take place then the entire universe must become a complex web of quantum entanglement within which every particle would be non-locally connected to all other particles. As Roger Penrose tells us:

> So long as these entanglements persist, one cannot, strictly speaking, consider any object in the universe as something on its own … Why is it not necessary to consider that the universe is not just one incredibly complicated quantum entangled mess that bears no relationship to the classical-like world that we actually observe?. In practice, it is the continual use of the procedure **R** that cuts the entanglements free …[111]

Penrose uses the symbol '**U**' to denote the underlying quantum wavefunction that develops through time according to the mathematics of the wavefunction, and the symbol '**R**' to refer to the outcome when a wavefunction collapses into actuality, seemingly through the agency of measurement and perhaps consciousness.

A wavefunction precisely predicts the evolution over time of the state of a quantum system, a 'state' being the, possibly infinite, collection of possibilities contained within the wavefunction. But then, as Penrose describes:

> 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.[112]

And, significantly, the new states appear as classically 'physical' states whereas prior to the measurement event the wavefunction is a purely abstract mathematical construction to which a 'classical' physical reality cannot be ascribed. Penrose adopted the symbols **U** and **R** to indicate the two processes. Adding the **M** to indicate a measurement, the situation can be represented, scanning left to right:

M **M** **M**

⇓ ⇓ ⇓

U> U> U> U> R > U > U> U> U> R > U> U> U> U> R > U> U> U>

U = Unitary continuous development of wavefunction

M = Measurement

R = Real momentary discontinuous transition to 'physically real' event.

Penrose diagram no. 1

As we have just seen, Penrose tells us that the process **R** also "cuts the entanglements free." In other words, the reason that, according to the Copenhagen view, 'spooky' entanglements do not show up in the everyday 'classical' world, assuming of course that one accepts that such entanglements do not show up in the everyday world, is that continuous measurements eliminate entanglements from the classical everyday world. This is illustrated by the diagram on the next page which replaces the symbol **U** with **E**, which stands in for 'universal **E**ntanglement'. Here we see that measurements play the role of 'cutting free' the continuous state of universal interdependent entanglement which would be in operation if the measurements did not take place.

M **M** **M**

⇓ ⇓ ⇓

E> E> E> E> R > E > E> E> E> R > E> E> E> E> R > E> E> E> E>

E = Entangled state of quantum interconnected universe

M = Measurement

R = Real momentary discontinuous transition to 'physically real' event.

Penrose diagram no. 2

But, as we know, the primary motivation for Bohm's 1952 pilot-wave proposal was precisely to show that the 'measurement' process as conceived of within the Copenhagen worldview, wherein a semi-existent stack of possibilities get reduced to one through a 'measurement' interaction, could be eliminated within a new, more 'realistic' proposal in which particles exist all the time, and are guided around by pilot waves. Therefore, there is no Copenhagen-style 'measurement' intervention and no subsequent Copenhagen-style 'reduction. In this situation Penrose diagram no. 1 becomes Penrose diagram no. 3 and Penrose diagram no. 2 becomes Penrose diagram no. 4. We are left with an undivided, continuously entangled universe!

U> U> U> U> U > U > U> U> U> U > U> U> U> U> U > U> U> U>

U = Unitary continuous development of wavefunction. An undivided universe.

Penrose diagram no. 3

E> E> E> E > E> E> E> E> E> E> E> E> E> E> E> E> E> E> E>

E = Entangled state of quantum interconnected universe. A continuously interconnected entangled universe.

Penrose diagram no. 4

So, what would a continuously entangled and entangling universe be like. Penrose gives the following account in his massive tome *Roads to Reality*:

> How are we to come to terms with quantum entanglement and to make sense of it in terms of ideas we can comprehend, so that we can manage to accept it as something that forms an important part of the workings of our actual universe? … A puzzle that must be faced is that entanglements tend to spread. It would seem that eventually every particle in the universe must be become entangled with every other. Or are they already all entangled with every other. Why do we not just experience an entangled mess with no resemblance whatsoever to the (almost) classical world we actually perceive? The Schrödinger equation evolution of system does not help with this. It tends to make things worse, with more and more parts of the universe becoming entangled with any system we start with, as time goes on. … It is my view that Nature herself is continuously enacting **R-**process effects, without any … intervention by a 'conscious observer'.[113]

So, Penrose suggests that there must be a "**R-**process" internal to the functioning of the universe which is not dependent on consciousness. The mechanism that Penrose advances as his preferred view is that of gravitational objective-reduction. The basic idea is there are gravitational aspects within quantum superposition which cause them to 'collapse' and thereby there is an objective-reduction to a classical state.

Bohm's decision to explore a new 'realistic' approach to quantum functioning was, at least in part, a result of being called by Einstein to have a discussion. Bohm had just written a textbook *Quantum Theory* which had been given good reviews. Einstein had read it and was not happy with its pro-Copenhagen perspective. After the discussion Bohm had significantly changed his viewpoint. As Adam Becker tells us in his recent book *What is Real,* Bohm recalled: "I began to wonder, does the [wave function] give a complete description of reality?" And Becker continues:

> Einstein was sure that it didn't. Bohm took that idea and ran with it. In a matter of weeks, he discovered that there was a simple way to rewrite the fundamental equations of quantum theory. The predictions and results remained the same - the new version was mathematically equivalent to the old - but the picture of the world suggested by the math, the story that it told, was radically different from the Copenhagen interpretation.[114]

And Becker describes Bohm's revelation:

> In Bohm's interpretation of quantum physics, much of the mystery of the quantum world simply falls away. Objects have definite positions at all times, whether or not anyone is looking at them. … particles are just particles, and their motions are guided by pilot waves. Particles surf along these waves …[115]

In Becker's description, it seems for all the world as if Bohm had just seen through all the Bohr-inspired mystical Eastern-mystification and obfuscation that had misled physicists previously, possibly due to hidden hypnotic powers on the part of Bohr, and had miraculously seen the true light of how quantum theory was really just like the everyday world of pots and pans and washing-machines. But this story is not just true. In this context it is extremely instructive to consider Heisenberg's response to Bohm's 1952 proposal, made in an essay 'Criticisms and Counterproposals to the Copenhagen Interpretation of Quantum Theory':

> When one analyses the papers of … [those who do not "want to change the Copenhagen interpretation so far as predictions of experimental results are concerned", but try "to change the language of this interpretation in order to get a closer resemblance to classical physics] it is important to realize from the beginning that their interpretations cannot be refuted by experiment, since they only repeat the Copenhagen interpretation in a different language. …. Along this line, for instance, Bohm has made a counter-proposal to the Copenhagen interpretation. … Bohm considers

> the particles as 'objectively real' structures, like the point masses in Newtonian mechanics. The waves in configuration space are in this interpretation 'objectively real' too, like electric fields. Configuration space is a space of many dimensions … Here we meet a first difficulty: what does it mean to call waves in configuration space 'real'? This space is a very abstract space … but things are in the ordinary three-dimensional space, not in abstract configuration space. One may call the waves in configuration space 'objective' when one wants to say that these waves do not depend upon any observer; but one can scarcely call them 'real' unless one is willing to change the meaning of the word. … This objective description … reveals itself as an 'ideological superstructure', which has little to do with immediate physical reality …[116]

It has to be said that Heisenberg has a very valid point. According to Bohm's pilot wave proposal:

> An N-particle quantum system (N > 1) is a generalisation from the one-particle case. There is only a single guiding wave field represented by the wavefunction ψ, but now ψ is defined on a 3N-dimensional configuration space.[117]

This means that for a 10 particle system, for example, any one of the particles in the system is 'guided' by a quantum pilot wave which has a configuration space of 30 dimensions. As Heisenberg points out, things in the 'real' everyday world move around in three dimensional space, and the forces upon them operate in three dimensional space, but particles in Bohm's worldview are pushed around by forces determined by 30 dimensional configuration space. So is the equal use of the term 'real' in this context, as if both situations have exactly the same degree of reality, so to speak, justified?

We have seen that according to Becker's presentation of Bohm's pilot wave view: "the mystery of the quantum world simply falls away". In his recent book *Through Two Doors at Once: the Elegant Experiment that Captures the Enigma of Our Quantum Reality* the science writer Anil Ananthaswamy provides an equally no-nonsense, down-to-earth and matter-of-fact, or perhaps fact-of-matter, account of Bohm's 1952 quantum worldview:

> Here was an alternative to the Copenhagen view of things: a deterministic theory of particles that move around because of interactions with the wavefunction, which in turn is a real thing and evolves according to the Schrödinger equation. Bohm's theory has a definite ontology: the world is made up of particles and wavefunctions, even if wavefunctions are not "physical" in the sense that particles are physical, but nonetheless are real, objective aspects of reality. A particle has a definite position at all times, which means it has a trajectory - in direct contravention of the Copenhagen view of reality. The particle is "guided" by the wavefunction, and thus not

> just be the usual forces (such as electromagnetism), but by a "quantum potential," a new force felt by the particle because of its interactions with the wavefunction… Moreover, the theory is deterministic: given a particle's position and its wavefunction, you can predict the particle's position at some later time. And even more emphatically, the particle's trajectory is objective reality - it exists independent of an observer.[118]

This description clearly emphasises the 'real', 'deterministic', 'objective' demeanour, the fact that it is "independent of an observer" and the fact that "Bohm's theory has a definite ontology", but it does not mention the fact that the nature of the so-called 'objective', 'real', 'deterministic' wavefunction is so extravagant, bizarre and complicated that, at least to some frugal minds, it pushes the meaning of the word 'real', used with the implication of more 'classical', towards the fantastic.

For example, consider the issue of "empty ghost waves", Lee Smolin, in his recent book *Einstein's Unfinished Revolution: The search for what lies beyond the quantum*, points out:

> … there are several reasons that pilot wave theory is not entirely convincing as a true nature of nature. One is the empty ghost branches, which are parts of the wave function which have flowed far (in the configuration space) from where the particle is and so likely will never again play a role in guiding the particle. These proliferate … but play no role in explaining anything we have actually observed in nature. Because the wave function never collapses, we are stuck with a world full of ghost branches. There is one distinguished branch, which is the one guiding the particle, which we may call the occupied branch. Nonetheless, the unoccupied ghost branches are real.[119]

When one comprehends the complexity, extravagance, and counter-intuitiveness of Bohmian quantum metaphysics, with vast numbers of redundant supposedly 'real' "ghost waves" zooming around all over the universe, apparently most of which have no purpose, although some occasionally are able to "recapture its particle and cease to be empty"[120], for example, Heisenberg's objections to the Bohmian quantum metaphysical worldview can be better appreciated. The point is that the everyday common-sense, kitchen-sink down-to-earth credentials of the Bohmian perspective seem to be frequently wildly over-inflated. And we still have not looked closely at the issue of Bohmian non-locality yet! But just to anticipate what is to come shortly, according to Norsen: "The pilot-wave theory is manifestly non-local in the following sense: the velocity of each particle, at a given instant, depends upon the instantaneous positions of all other particles (at least when there is entanglement)". And this non-local interdependence could involve incomprehensibly vast numbers of particles across the universe!

There are 2 main points of Heisenberg's criticism of Bohm's proposal:

1) it is essentially Copenhagen in essentials, but the equations and language have been

rearranged to conform to a 'realist' 'ideological superstructure';

2) The claim that the pilot-wave (or 'quantum potential') is 'real' in a classical everyday sort of sense is dubious.

Consider the first Heisenberg objection, which is that Bohm's proposal is not much more that the Copenhagen perspective reworked into different language and massaged equations, reworked according to a 'ideological superstructure'. The following passage from *Foundations of Quantum Mechanics: An Exploration of the Physical Meaning of Quantum Theory* by Travis Norsen is important because it begins to clarify why Heisenberg's first objection has some force:

> …probably the most important virtue of the pilot-wave theory is that we do not need to divide the world up into "quantum system" … and "classical environment" … in order to understand measurements and their outcomes. Instead, we are free (indeed, required!) to enlarge the "quantum system" …until in includes literally everything - the entire universe. This is of course in contrast to ordinary ordinary quantum mechanics which … seems to require one to introduce what Bell called a "shifty split" (i.e., an artificial division of the world into distinct "quantum" and "classical" realms, with special ad hoc exceptions to the usual dynamical rules when the two realms interact). The claim, then, is that unlike orthodox quantum mechanics, the pilot-wave theory is not afflicted with a "measurement problem".[121]

In the Copenhagen scenario as usually envisaged, the quantum and classical realms are conceived of as essentially separate, somehow the quantum realm then transmutes into the classical through the intervention of a measurement, and because of this quantum effects such as non-locality are lost in the transition. In the Copenhagen view, therefore, non-locality effects are restricted to the quantum level, and the everyday classical level remains reassuringly everyday, with no quantum intrusions, so to speak. Bell's "shifty split" acts as a kind of gatekeeper keeping quantum weirdness corralled within the quantum level. Bohm's pilot-wave quantum worldview conflates this division so that quantum functioning becomes part of the 'classical' world.

The Copenhagen division appears to be also a division in ontology, what kind of 'stuff' reality is made up from. Pre-measurement quantum 'stuff' is not 'real' 'stuff' in the way that post-measurement 'classical' stuff really is 'real' 'stuff'. Pre-measurement quantum 'stuff' is more like potential 'stuff', not fully manifested 'stuff'. And this was and is one of the central issues for some physicists. As Norsen presents his discomfort:

> …all this should make one feel very uncomfortable. To begin with, there is a kind of schizophrenic division of the world into two "realms" (the microscopic quantum part, and the macroscopic classical part) which seem to have completely different ontologies and completely different dynamical laws. And then there are apparently special dynamical rules which come

> into play when the two realms interact, during a "measurement". If you say "during measurements, quantum wave functions cease to obey Schrödinger's equation and instead collapse" that is already weird and troubling, but it becomes downright *meaningless* if you can't specify exactly what kinds of physical processes count as "measurements".[122]

So, by bringing together the two "realms" into the one classical "realm", with the quantum functioning now sitting beside and interacting with the classical functioning, and, furthermore, reworking the quantum equations with brilliant mathematical ingenuity so that some aspects of particle functioning, primarily position, can be continuously specified, Bohm produced a version of quantum-classical functioning within the classical realm wherein particles appeared to be always particles. But another crucial result of this conflation was that quantum effects such as non-locality now turned up as a significant part of what was previously a non-quantum "realm" of the classical world. But it did seem that the "measurement" problem disappeared, particles were always particles.

This feat was welcomed with joy by some, such as John Bell who exclaimed that he had seem the "impossible done". Einstein, however, was not happy with Bohm's proposal, he called it "too cheap", perhaps because the one quantum phenomenon that irritated him most was non-locality:

> It is not clear exactly what Einstein meant as "too cheap", but it seems likely that the theory did not strike him as a step in the right direction since it failed to eliminate (but in some ways exacerbated) the one feature that Einstein found most unacceptable in orthodox quantum theory: non-locality.[123]

As we shall see, Bohm quickly realised that his new formulation indicated that non-locality was a primary feature of his new quantum worldview, and this led him in new a new direction of quantum metaphysical development.

As we have seen, the primary aim of Bolm's pilot-wave endeavour was the elimination of the strange split ontology and the attendant removal of the troubled measurement 'paradox'. This, it has been claimed, was achieved. But, as we have also seen, Heisenberg considered that Bohm's achievement was in essence Copenhagen dressed in new, ideologically correct, which is to say 'realist', clothing. If Heisenberg were correct about this, then it would be reasonable to expect that the measurement conundrum had not been banished, but perhaps tucked away in one of the pockets of the new Bohmian clothing, And it is possible to make a case that this is indeed the case. In fact the measurement issue appears to have been hidden in a new feature of Bohmian Mechanical functioning called 'Contextuality'.

Whilst it is the case that particles have definite positions at all times with Bohm's pilot-wave formulation, this does not mean that all possible 'properties' which may be 'measured' have intrinsic values which manifest as the same value in different measurement situations. In his book *Making Sense of Quantum Mechanics* Jean

Bricmont explains, in the context of the quantum property 'spin':

> …the value up or down of the spin that actually results from the measurement is "contextual": that value does not depend only on the quantum state and the original particle position but on the concrete arrangement of the "measuring" device. Here the scare quotes are used because we finally see the truth of something we have emphasized several times: there is no intrinsic property of the particle that is being "measured", in general, in a "measurement". Of course, since the system is deterministic , once we fix the full initial state (the quantum state and the position) of the particle and the experimental device, the result of the experiment is predetermined. But that does not mean the spin value we "observe" is predetermined … So not only is the word "hidden variable" misleading [because the 'variables' in Bohm's proposal are not actually 'hidden'], since except when one measures positions, one does not observe or measure any intrinsic property of the system …[124]

And then Bricmont makes an admission which is interesting, given the fact that he is a hardcore and committed supporter the 'realism' of Bohmian Mechanics. This situation, Bricmont says, "vindicates in some sense Bohr's emphasis on" and he then quotes Bohr:

> …the impossibility of any sharp distinction between the behaviour of atomic objects and the interaction with the measuring instruments which serve to define the conditions under which the phenomena appear.

This clearly shows that the spectre of Copenhagen has not been fully exorcised from Bohmian Mechanics , as Heisenberg pointed out. Although, to be fair, Bricmont goes on to make the point that this situation derives from the equations of Bohmian Mechanics, whereas Bohr's view was the result, according to Bricmont, of "some more or less a prori notion", a claim which is questionable and possibly unfair!

It seems that, by brilliantly massaging equations, Bohm was able to make particles have definite positions and trajectories, but other aspects of Copenhagen quantum 'wierdness' just transform into different forms of 'weirdness'. The Cambridge University philosopher of quantum physics Jeremy Butterfield, for example, described quantum contextuality in very dramatic terms in a internet interview when he gave the analogy of trying to determine whether a car was a BMW or a Porsche, it depends upon:

> …what else you are trying to determine. … the result you get might depend on whether you are also looking at colour or age. If I want to also know the colour I might find it is a BMW, … but if I also want to know its age I could find out its a Porsche…[125]

In other words, in a situation of quantum contextuality, using a classical level analogy, if you try and determine car-type and car-colour at the same time you might end up finding a BMW, but try and find the car-type and car-age, of the same car, it might turn out to be a Porsche.

Bricmont further discusses noncontextuality:

> The statement that the measurement of an observable depends upon concrete experimental arrangement used to "measure" it is true … for all quantum mechanical "observables", other than position.[126]

And then Bricmont quotes John Bell on the problem concerning the term "measurement":

> …the word comes loaded with meaning from everyday life. Meaning which is entirely inappropriate in the quantum context. When it is said that something is 'measured' it is difficult not to think of the result as referring to some pre-existing property of the object in question. This is to disregard Bohr's insistence that in quantum phenomena the apparatus as well as the system is essentially involved.

This is a crucial point, the 'properties' in Bohm's pilot-wave worldview, other than position, are not independent elements of reality, they arise as 'contextual' results of interactions between the measured system and the measuring apparatus. Finally Bricmont quotes from Detlef Dürr and other Bohmian philosophers:

> "Properties" that are merely contextual are not properties at all, they do not exist, and their failure to do so is in the strangest sense possible.

In the light of statements like this, concerning Bohmian 'properties' other than position, it is difficult not to agree with Heisenberg that the 'realist' nature of Bohmian mechanics is over-played.

This leads us to Heisenberg's second objection, which is that the claim that the Bohmian pilot-wave scenario can be considered as fully 'real' is over-stated, if not dubious. We have already entered this territory of concern through the pursuit of Heisenberg's first claim. We see in a Norsen quote above that Norsen speaks of the fact that "it becomes downright *meaningless* if you can't specify exactly what kinds of physical processes count as 'measurements'". Florian J. Boge points out that, although the Bohmian view is presented as a no-nonsense classical-type replacement for the vague and mysterious Copenhagen account, there is much equally vague about it:

> …the wavefunction seems to play … a *physical* role, and … it somehow influences the particles, thus correlating them 'non-locally'. Given that ψ is defined on configuration space though, this does not tell us how it manages to transmit its 'non-local influence' to the particles.[127]

And:

> …we *still* do not know what the wave function 'really is', and how it 'interacts' with particles located in space(time). In fact, the accounts of what exactly the wavefunction represents differ grossly among 'Bohmians'.[128]

And science writer Jim Baggot, in his excellent book *beyond measure: modern physics, philosophy and the meaning of quantum theory*, points out:

> There are many practical objections to the de Broglie-Bohm theory. For example, the wave in the de Broglie-Bohm theory can exert a strong influence on the particle through the form of the quantum potential, but there is no reciprocal action of the particle on the wave, seemingly at odds with classical mechanics in the form of Newton's third law of motion.

Can we take this as a final nail in the quantum coffin of the view that Bohmian mechanics is a thoroughly Newtonian-type 'realistic' account of the everyday world which completely banishes any trace of quantum weirdness from our world?

The truth is that, as Heisenberg points out, Bohm's proposal provides a way to introduce a small degree of classical type functioning for positions and trajectories, thus providing an 'ideological superstructure' for a limited realist account, at the same time as importing a whole load of quantum 'weirdness' into the classical everyday world. In particular, non-locality becomes a central aspect of the new worldview. Jim Baggott writes about Bohm's theory:

> …the theory was originally developed simply to demonstrate that a causal (not necessarily entirely classical) interpretation of quantum phenomena is possible in principle. … some serious problems arise if we attempt to assign properties other than position to the Bohm 'particle', such as charge, and the the theory is not without measurement problems.[129]

One of the aims that such an 'ontological' theory, a theory which supposedly (according to some advocates) gives an (almost) 'realistic' quantum vision (which Bohm's 1952 vision does not achieve) has is the elimination of the 'collapse of the wavefunction', one of the bones of contention for many, and a central issue for the 'measurement paradox'. But, Bohm's account does not fully achieve this, it only achieves a different kind of 'collapse' scenario, tucked away off-stage so to speak. Bricmont, in a section of his *Making Sense* book titled **What About the Collapse of the Quantum State?**, declares that:

> The short answer … is that there is never any collapse of the quantum state in the de Broglie-Bohm theory, but there is an effective collapse or a collapse "in practice", which coincides with the one in ordinary quantum mechanics …[130]

So, according to Bricmont, there definitely is never any 'collapse', except there is an "effective collapse" which is a "collapse in practice"! Does that make sense?

In the context of the wavefunction 'collapse' Boge explains the situation, making reference to the Bohmian philosopher Detlef Dürr, as follows:

> A first thing to note is that "in a universe governed by Bohmian mechanics there is a priori only one wave function, namely that of the universe, and there is a priori only one system governed by Bohmian mechanics, namely the universe itself" [Dürr 2012]. To make sense of practice, however, wherein the wavefunction of the universe never occurs, Dürr et al. introduce the notion of conditional and effective wave functions, used to describe the behavior of subsystems. … The use of the conditional wave function also leads to an 'apparent collapse'.[131]

And, here we find clear signs that the seeds of Bohm's later, much more extensive and spectacular, 'wholeness and the implicate order' quantum metaphysical perspective are contained within the 1952 'ontological' 'pilot-wave' theory. In other words, Bohm's attempt to produce a more ontologically unidimensional 'realist' account of quantum functioning actually produced a more fully universal and comprehensive quantum perspective of interconnected wholeness, within which there are 'substructures' operating very much in the mode of Bohr's viewpoint, although apparently with a more 'realistic' flavour, wherein the 'observed' system and 'observing' apparatus forms a necessary whole. And these holistic substructures, functioning within the interrelated context of the holistic universe, turn out to have 'properties' that are 'contextual', and not fully self-contained and independent, precisely because of their dependence upon a universal context.

In their book *The Undivided Universe* Bohm and Hiley describe this situation:

> The probability of a particular result of the interaction between the instrument and the observed object is shown to be exactly the same as that assumed in the conventional interpretation. But the key new feature here is that of the undivided wholeness of the measuring instrument and the observed object, which is a special case of the wholeness to which we have alluded in connection with quantum processes in general. Because of this, it is no longer appropriate, in measurements to a quantum level of accuracy, to say that we are simply 'measuring' an intrinsic property of the observed system. Rather what actually happens is that the process of interaction reveals a property involving the whole context in an inseparable way.[132]

And the fact of quantum nonlocality is a central feature leading to this necessary conclusion. When the mathematical analysis of many-body systems from the Bohmian perspective is pursued it turns out that:

> … we find that this leads to further new concepts. The most important of these are nonlocality and objective wholeness, That is to say, particles may

> be strongly connected even when they are far apart, and this arises in a way which implies that the whole cannot be reduced to an analysis in terms of its constituent parts.[133]

Thus we see that the central issue of nonlocality, which came to the fore in the pilot-wave perspective, necessarily required the development of Bohm's ideas in the direction of his later perspective.

In a very real and ironic sense Bohm's attempt to break with Bohr's quantum perspective actually, through its own internal necessity, showed Bohr's Copenhagen view to be, to some extent, a necessary facet of a much more comprehensive quantum-universal interconnected metaphysical picture. In the General Introduction to the collection of essays inn honour of David Bohm *Quantum Implications* Basil Hiley and David Peat (editors) describe the development of Bohm's ideas:

> In Bohm's original perception, this notion of interconnectedness was rather vague and ill-defined but with its continual reappearance in different forms, the notion slowly took shape, ultimately leading to a very radical and novel way of looking at reality. This view eventually crystallised into what he now terms the implicate order. The first formal indication of Bohm's departure from orthodoxy can be traced to his reformulation of quantum mechanics published in *Physical Review* in 1952. But the ideas that lay behind that formulation seem to many to be totally against the spirit of his later work on the implicate order, so much so that they find it hard to see any connection at all. It is true that those papers were more intent on demonstrating that there was another logically coherent interpretation of the quantum mechanical formalism, other than the usual one. But it is the ideas implicit in this reformulation that have connections with the notion of the implicate order.[134]

The fact that many people overlook the seeds of implicit development in Bohm's 1952 approach is precisely because, as we have seen, there is a group of physicists, philosophers and science writers who wrongly promote, in lectures, technical books, and various popular books on quantum physics and metaphysics, the idea that Bohm achieved an almost Newtonian version of quantum mechanics with his 'pilot-wave' theory, thus thwarting the dangerous spread of vague Bohrian dalliance with Eastern mysticism. An excellent example we have seen above of this is Adam Becker's incorrect claim that in the pilot-wave theory "the mystery of the quantum world simply falls away".

But Bohm clearly quite quickly saw the necessary implications of his early work, and in the conclusion of the first chapter of his 1957 book *Causality and Chance in Modern Physics* Bohm wrote: "However, since the natural laws imply some kind of interconnection of all aspects of the world, as well as their approximate autonomy."[135] And on the last page we find a clear adumbration of the later notion of the 'implicate order' and the 'holomovement' and the primacy of wholeness:

> In conclusion, a consistent conception of what we mean by the absolute side of nature can be obtained if we start by considering the infinite totality of matter in the process of becoming as the basic reality. This totality is absolute in the sense that it does not depend upon anything else for its existence or for a definition of any of its characteristics. On the other hand, just what it is can be defined concretely only through the relationships among the things into which it can be analysed approximately. Each relationship has in it a certain content that is absolute …[136]

And Hiley and Peat, important developers and promoters of Bohm's later perspective, praise Bohr's original insight mightily in the following terms, which rather than denigrate Bohr, elevates him as a forerunner for Bohm's later ideas:

> Perhaps Bohr's deepest perception was not wave-particle duality, nor complementarity, but *wholeness*. Bohr writes, 'The essential wholeness of proper quantum phenomenon finds indeed logical expression in circumstances that any attempt at its well-defined subdivision would require a change in the experimental arrangement incompatible with the appearance of the phenomenon itself'. Remember of course that for Bohr the word 'phenomenon refers only to observations obtained under circumstances whose description includes an account of the whole experimental arrangement'.[137]

This is the first aspect of *wholeness*, the fact that 'measured' and the 'measurer' cannot be taken as being entirely separate entities but are themselves interconnected at a deeper level. The second aspect of *wholeness* is the fact that, by bringing the quantum level into the 'classical' world, so to speak, Bohm highlighted a subtle deep level of interdependence within all aspects of the universe. As Hiley and Peat have pointed out, it is the nonlocal nature of the Bohmian quantum worldview, the 'causal interpretation', that has caused consternation amongst some physicists:

> A particular objection appears to arise from what scientists call the nonlocal nature of this approach . This can be explained in the following way. When several particles are treated in the causal interpretation then, in addition to the conventional classical potential that acts between them, there is quantum potential which now depends *on all the particles*. Most important, this potential does not fall off with distanceringd between particles, so that even distant particles can be strongly connected. This feature, in which very distant events can have a strong influence, is what is meant by a *nonlocal* interaction and is strongly at variance with the whole spirit of classical mechanics.[138]

Here we see that because Bohm's 'causal interpretation', or 'pilot-wave theory', brings quantum features into the classical realm, then what was once just a classical realm becomes a classical plus quantum realm. So not only are there classical potentials acting on particles, there is now also quantum potentials which depend upon all other

particles, no matter how distant the particles may be.

Hiley and Peat continue:

> There is a great reluctance on the part of physicists to consider such nonlocality seriously, even though it does lie at the heart of the formal implications of quantum theory. … there does not appear to be any intrinsic reason to rule out nonlocal forces. … The quantum potential cannot be … used to carry any signal between distant effects and therefore its instantaneous connection between particles does not violate the theory of relativity.[139]

However, although the deep level of interconnected wholeness that exists at the absolute, ultimate level of the process of reality, this does not entirely invalidate the substructures which have their more 'explicate' mode of existence within the context of the undivided wholeness of the universe. It is only when these substructures are perceived of as being completely separate and fragmentary that they lose their full meaning, Within the context of the whole, functioning substructures, or 'aspects', function as parts which clearly contribute to the functioning of the whole. In *Wholeness and the Implicate Order* Bohm wrote concerning this:

> … in its totality, the holomovement is not limited in any specifiable way at all. … *the holomovement is undefinable and immeasurable*. … each theory will abstract a certain aspect that is relevant only in some context, which is indicated by some appropriate measure. In discussing how attention is to be called to such aspects, is is useful to recall that the word 'relevant' is a form obtained from the verb 'to relevate' … 'to lift up'. We can thus say in a particular context that may be under consideration, the general modes of description that belong to a given theory serve to *relevate* a certain content …[140]

And in *The Undivided Universe* we read:

> The essential features of the implicate order … that the whole universe is in some way enfolded in everything and that each thing is enfolded in the whole. However, under typical conditions of ordinary experience, there is a great deal of *relative* independence of things, so that they may be abstracted as separately existent, outside of each other, and only externally related. … the explicate order, which dominates ordinary 'common sense' experience as well as classical physics, appears to stand by itself. But actually this is only an approximation and it cannot be understood apart from its ground in the primary reality of the implicate order, i.e. the holomovement.[141]

We shall look into this aspect, the existence of "relevated" functioning substructures, which can be treated, within limits, as self-contained areas of discourse, with independent and self-enclosed modes of analysis and description, within the absolute context of wholeness, in more detail when we examine how some other quantum

interpretations can be understood as sub-aspects of the functioning of the overall holomovement.

But, in the meantime, what better way to end this chapter than to point out what a wonderful analogy the Hindu vision of Indra's Net is for Bohm's vision of an undivided wholeness constituted by mutually inter-penetrating parts. In this image the whole universe is portrayed as an interpenetrating multidimensional net of jewels, which may be thought of as representing the infinite sparks of interconnected consciousness which underlie the appearances of the phenomena world. Jewels are set at every intersection of the net and each jewel reflects the light reflected in all the jewels around it, and each of those jewels in turn reflects the light from all the jewels around them, and this multifaceted mutually reflective process is repeated infinitely. In this way, all phenomena – events, entities and sentient beings reflect and express the radiance of the entire universe. All of totality can be seen in each of its parts. This later became incorporated into the Hua-yen doctrine which views the entire cosmos as a single nexus of conditions in which everything simultaneously depends on, and is depended on by, everything else. This description is from the Avatamsaka Sutra:

> There is a wonderful net which has been hung by some cunning artificer in such a manner that it stretches out indefinitely in all directions. In accordance with the extravagant tastes of deities, the artificer has hung a single glittering jewel at the net's every node, and since the net itself is infinite in dimension, the jewels are infinite in number. There hang the jewels, glittering like stars of the first magnitude, a wonderful sight to behold. If we now arbitrarily select one of these jewels for inspection and look closely at it, we will discover that in its polished surface there are reflected all the other jewels in the net, infinite in number. Not only that, but each of the jewels reflected in this one jewel is also reflecting all the other jewels, so that the process of reflection is infinite.[142]

Bohmian Quantum Emptiness

In a talk, 'The Implicate Order: A New Order for Physics', given at a conference organized by the Center for Process Studies, David Bohm made the following comments:

> In other words, the energy in empty space is immensely greater than the energy of matter as we know it. Therefore, matter in itself is a kind of ripple in empty space. Matter is a relatively stable and autonomous ripple in the emptiness. Those of you who have studied the theory of solid states may not find this notion of emptiness entirely unfamiliar. For example, in a crystal of very dense material at absolute zero, if the crystal is of perfect order, electrons go right through it as if nothing were there. The suggestion is then that emptiness is really the essence. It contains implicitly all the forms of matter. The implicate order really refers to something immensely beyond matter as we know it -- beyond space and time. However, somehow the order of time and space are built in this vacuum.[143]

And in *Wholeness and the Implicate Order*:

> Thus, as we have seen, the easily accessible explicit content of consciousness is included within a much greater implicit (or implicate) background. This in turn evidently has to be contained in a yet greater background which may include not only neuro-physiological processes at levels of which we are not generally conscious but also a yet greater background of unknown (and indeed ultimately unknowable) depths of inwardness that may be analogous to the 'sea' of energy that fills the sensibly perceived 'empty' space. Whatever may be the nature of these inward depths of consciousness, they are the very ground, both of the explicit content and of that content which is usually called implicit. Although this ground may not appear in ordinary consciousness, it may nevertheless be present in a certain way. Just as the vast 'sea' of energy in space is present to our perception as a sense of emptiness or nothingness so the vast 'unconscious' background of explicit consciousness with all its implications is present in a similar way. That is to say, it may be sensed as an emptiness, a nothingness, within which the usual content of consciousness is only a vanishingly small set of facets.[144]

And:

> So we are led to propose further that the more comprehensive, deeper, and more inward actuality is neither mind nor body but rather a yet higher-dimensional actuality, which is their common ground and which is of a nature beyond both. Each of these is then only a relatively independent sub-totality and it is implied that this relative independence derives from the higher-dimensional ground in which mind and body are ultimately one (rather as we find that the relative independence of the manifest order derives from the ground of the implicate order).[145]

Taking these quotes together, we can make the reasonable conclusion that, from a Bohmian perspective, the explicate realms of consciousness and matter emerge or derive from a deeper, common ground which Bohm sometimes refers to as 'emptiness'. According to Bohm: "matter is a relatively stable and autonomous ripple in the emptiness", and: "emptiness is really the essence", and: "the vast 'unconscious' background of explicit consciousness … may be sensed as an emptiness".

In this chapter we shall see that several of Bohm's significant insights are remarkably consistent with some Buddhist insights contained within the Madhyamaka (Middle Way) Emptiness school of metaphysics (we shall cover Yogacara consciousness-only, and Dzogchen, in the next chapter). The *Madhyamaka* is one of the central philosophical-metaphysical schools of analaysis within Tibetan Buddhism. Its mode of analysis derives from the important second century Buddhist philosopher-practitioner Nagarjuna, who authored the remarkable book of de-constructive metaphysical analyses *Mulamadhyamakakarika*, the *Fundamental Verses on the Middle Way*. In this astonishing work Nagarjuna relentlessly deconstructs the 'things' and 'processes' of the everyday conventional reality in order to reveal their illusion-like 'empty nature'. Nagarjuna's seemingly paradoxical philosophical analysis lays bare the quantum 'empty' face of the everyday world.

As we have seen, Bohm suggested that quantum theory requires that we give up the view that objects of the everyday world and the sub-atomic constituents that are supposed to be their constituents are self-contained independent entities; they are, rather, appearances which derive from a deeper 'implicate' level which Bohm suggest in various places can be designated as 'emptiness'.

Emptiness, or *sunyata*, is a concept used by Buddhist philosophers to indicate the 'empty' inner nature of reality. Emptiness does not denote 'nothingness' but, rather, denotes 'dependent origination', the central concept of the Madhyamaka, the central 'Middle Way' doctrine of Mahayana Buddhism. In particular the central core of the doctrine of Emptiness is precisely that all phenomena lack 'inherent existence', which is to say that no phenomenon can be a completely independent, self-sufficient and self-enclosed entity or event; everything is interdependent with everything else in a web of inter-penetration. As we can see, this metaphysical perspective resonates with the Bohmian quantum worldview in a remarkable way. Bohm tells us that everyday objects and atoms appear to be independent and completely separate entities, but in reality, at a deeper level, everything is entangled with all other things in a universal web of interconnection. As Nagarjuna indicated roughly two thousand years ago:

> Whatever is dependently arisen
> Does not arise, does not cease,
> Is not permanent, is not extinct,
> Does not come, does not go
> And is neither one thing nor different things.[146]

Here Nagarjuna indicates that if we consider something to be a really independently existent separate self-enclosed entity, then it should not depend for its very existence on other entities. It should exist on its own, completely sufficient on its own substance. This would mean that it would have an immutable core of independent substantial reality, which in Madhyamaka terminology is called *svabhava*, or

'inherent existence'. It is vital to hold in mind that this paradoxical analysis applies to some self-existent entity which is considered to an 'inherently existing' thing, which is a changeless entity that is independent of all other entities:

Whatever is dependently arisen
Does not arise, does not cease,

An inherently existing entity (which is an entity with '*svabhava*' = 'inherent existence') would have to be changeless and therefore, by definition, could not 'arise' from something else simply because it cannot come into or go out of existence, this would be a change! Here we find the notion of 'dependent origination', which is the hallmark of 'emptiness' (*sunyata*). Any thing that is 'dependently originated' is 'empty' because it is dependent and therefore not self-sufficient. What is being asserted here is that if something arises dependently then it does not arise as an inherently existent entity and neither can it cease as an inherently existent entity because it has not arisen as an inherently existent entity in the first place! It is only a temporary appearance of an entity which is dependent on other causes and conditions.

Inherently existent entities cannot cease by definition. Something which arises on the basis of something else cannot be given credence as being a 'real' inherently existent thing because it has arisen in dependence on something else, so it is not self-powered, it depends on something else. It follows that this illusory 'thing', that we might think has come into inherent being has not actually arisen because it's not actually there as an inherently existent entity! It cannot, inherently, cease because there is nothing inherently existent to cease. The next line is:

Is not permanent, is not extinct,

It cannot be permanent because it appeared to arise in the first place, although it did not actually arise as an inherently existent thing, and because of this it cannot become extinct because there was never anything inherently existent to become extinct!

Does not come, does not go

Something which has not come into existence (as an inherently existent thing) can not come or go!

And is neither one thing nor different things.

It cannot be one inherently existent thing because it has arisen and so is not an inherently existent thing in the first place. It cannot be different things because the analysis would apply to each of those things in turn and, anyway, it has appeared as being in the guise of one thing. The Madhyamaka begins, then, with a complete demolition of the notion of ultimate 'things' and ultimate thinghood, which it denotes by the term 'inherent existence', intrinsic existence' or 'own-nature' (*svabhava*).

It might be thought that such a paradoxical philosophical deconstruction could not be of much relevance to modern physics. However, consider the Nagarjuna analysis in the context of the following analysis from Bohm :

> For example, any localizable structure may be described as a world tube … Inside this tube ABCD, a complex process is going on, as indicated by the many lines within the world tube. It is not possible consistently to analyse movement within this tube in terms of 'finer particles' because these, too, would have to be described as tubes, and so on ad infinitum. Moreover, each tube is brought into existence from a broader background or context, as indicated by the lines preceding AD, while eventually it dissolves back into the background, as indicated by the lines following BC. Thus, the 'object' is an abstraction of a relatively invariant form. That is to say, it is more like a pattern of movement than like a solid separate thing that exists autonomously and permanently. … Particles are then to be regarded as certain kinds of abstraction from the total field, corresponding to regions of very intense field (called singularities). As the distance from the singularity increases … the field gets weaker, until it merges imperceptibly with the fields of other singularities. But nowhere is there a break or a division. Thus, the classical idea of the separability of the world into distinct but interacting parts is no longer valid or relevant. Rather, we have to regard the universe as an undivided and unbroken whole. Division into particles, or into particles and fields, is only a crude abstraction and approximation. Thus, we come to an order that is radically different from that of Galileo and Newton – the order of undivided wholeness.[147]

As Lee Smolin says:

> Newtonian physics … gives rise to the illusion that the world is composed of objects. … But relativity and quantum theory each tell us … no, better, they scream at us, that our world is a history of processes.[148]

And Jonathan Allday, in his book *Quantum Reality: Theory and Philosophy*, points out that quantum entanglement:

> …presents us with a philosophical challenge, one that threatens to pick away at our notion of what a 'thing' is.[149]

We looked at the phenomenon of entanglement and nonlocality, with the implication of necessary universal interconnection in the previous chapter. In the Process Studies talk Bohm pointed out that:

> The original atomic theory had rigid bodies of some sort, but rigid bodies are not possible after Einstein. Let's say that a particle is made of smaller bodies -- of subparticles. Each of the subparticles, if it is extended, will meet the same problem as a rigid body. Therefore, a particle cannot be made of extended subparticles. Now then, what if it is made of particles with no extension at all, such as points whose tracks in space-time can be represented by lines? You will find that the fields around these point particles are infinite, leading to inconsistencies such as infinite mass and infinite charge and so on (especially in quantum mechanics).[150]

Quantum theory in general throws the idea of independent 'real' 'things' into question, and Bohm's version, with its emphasise on nonlocality makes this particularly pertinent. In the above quote from Bohm the reason that "rigid bodies are not possible

after Einstein" is, as Bohm explains:

> One view is that a particle is some extended structure. Now if I make a space-time diagram of a particle at rest whose boundaries are given by two lines and then suddenly accelerate it to another velocity, I see that if I push on one side of the object it immediately responds on the other side. However, in Einstein's views of relativity, this is not permitted. An impulse or a signal cannot be carried faster than the speed of light. Consequently, you cannot have a rigid or extended body in relativity.[151]

So Bohm indicates that a rigid application of Einstein's relativity theory rules out the possibility of 'rigid' extended particles. Particles can only be appearances, 'ripples in emptiness'.

This analysis, although it is clearly not exactly the same, is at least related to, and has a similar outcome, to an analysis within the Madhyamaka discourse. Some other Buddhist schools (Vaibhasika and Sautrantika) assert that the entities of the physical world are comprised of assemblies of indivisible particles. The Madhyamaka analysis, however, undermines this viewpoint. Consider an indivisible particle, it would need to be partless, otherwise it would be divisible conceptually at least, and there would need to be further reason why the parts could not be taken apart. Now consider how a 'partless particle' could be involved in the construction of the material world. A constructive partless particle might possibly be connected to six other particles which are located around the central particle in the six principle directions:

> If six particles join it simultaneously,
> This infinitesimal particle would have six parts.
> If all six together are partless,
> Then also their aggregation would be just an infinitesimal particle. [152]

If a particle is able to club together with other particles in order to produce the world of extension and experienced solidity then quite obviously it would need to connect in some way with the other particles. In other words the central particle would need to be connected to the others through its faces and this entails that any particle which can play a role in creating a world must have parts, which means that the 'partless' particles must have 'parts'!

The world cannot be constructed from ultimate entities devoid of parts, because, if these particles were devoid of parts then the world would simply collapse because it is impossible to produce extension from an extensionless entity:

> If you insist that this is truly so
> (Though it must also face the other particles),
> How is it that earth and water
> And all other things extend – or maybe they do not?[153]

And so:

> If you say that sides that face
> The different particles are different,
> How come the finest particle is one:
> A single entity devoid of parts?[154]

Furthermore, if the world really is substantial then it must be constructed from an ultimate substance, or substances, and this must imply the existence of an ultimate particles of some sort. If this is the case then when we repeatedly divide up particles, we are supposed arrive at a final particle which is the fundamental building block. If we find that particles are infinitely divisible into their parts then we can only stop when we reach a partless particle. But if this particle is truly partless then, as we have seen, it could not take part in the construction of the world because in order for a partless particle to connect to another partless particle it is necessary for one part of a partless particle to connect to a part of another partless particle!

So particles must be infinitely divisible, each particle itself having parts. This means that each particle cannot be an inherently existent fully substantial indivisible entity because each particle is made up of its parts. This lack of inherent existence cascades down through the levels of assumed particles, arising from division, without end demonstrating that there is simply nothing that can be found at the base which can provide a solid foundation:

> The particle, it's proved, does not exist inherently.
> And therefore it is clear that … substance and the rest,
> The many things proposed by ours and other schools,
> Have no intrinsic being.[155]

This is called the reasoning of freedom from unity and multiplicity which is said to open the door of emptiness. If it is not possible to demonstrate an ultimately unitary particle which exists independently, with no dependence upon its parts, then there can be no inherent unity. If there is no unitary entity to enter into the construction of a multiplicity there can be no inherent multiplicity either. Thus, we see that the Madhyamaka analysis completely undermines the idea of fully independent and substantial atomic entities making up fully independent and substantial entities in an external material world.

This Madhyamaka analysis completely accords with Bohm's conclusions:

> A particle is not a substance. A substance would be self-generated and self-maintained. But subsistence merely means that it depends on something else to be maintained. Democritus's original idea was that the atoms were substances -- self-maintaining and eternal. But now we are saying that particles are subsistants and not substances. This fits the facts of modern physics, because as I have just said, all particles can be created and destroyed and transformed, and so on. Therefore, there is no sign that they are independent substances. We will say that particles are orders in the holomovement, which have the character of subsistence, a certain repetitiveness, stability, and so on.[156]

The observation by Bohm that a "substance would be self-generated and self-maintained" projects us immediately into the world of the Madhyamaka analysis, because this is a significant part the definition of an inherently existent substance used by the Madhyamaka. It is also part of the deconstruction of the possibility of such a 'substance' actually to exist in reality. This Madhyamaka deconstruction uses the 'Diamond Slivers' reasoning, which is given this appellation because like a diamond it is indestructible and is able to cut through wrong views concerning the nature of reality. This reasoning focuses on the possible modes of ultimate production for any

entity, and it has the familiar logical structure of the Madhyamaka tetralemma:

> Neither from itself nor from another,
> Nor from both,
> Nor without a cause,
> Does anything whatever, anywhere arise.[157]

The refutation of production from self is aimed at a school of philosophy extant at the time (2nd century) which claimed that all phenomena were actually manifestations of a permanent primal cosmic substance. Therefore any entity, such as a sprout, was asserted to be produced from its own nature. This viewpoint, production from own-nature, however, produces some rather absurd consequences. When reading through these absurd consequences it should be kept in mind that these logical detonations are also used as meditation topics for direct experience of emptiness. Directly seeing the impossibility of real substantial substances, so to speak, transforms perception of reality.

If an entity which already exists reproduces itself (Bohm's "self-generated"), the reproduction is pointless because the entity already exists. Furthermore if self-production were an inherent feature of an entity then once it had reproduced itself it would necessarily have to do so again because self-production would be an inherent feature of the entity. This must lead to an infinite, never ending, sequence of reproductions. A seed, therefore, would never get around to producing a sprout because it would be too busy reproducing itself! Also, obviously, if the seed and its sprout, the cause and the effect, were the same and yet the one produces the other then the seed and the sprout should appear to be exactly the same which is absurd. Effects are usually apprehended when the cause has ceased, but if the effect and the cause are identical then the effect should cease as soon as the cause does. And so on.

The assertion that entities are produced from causes which are 'other' is the more usual view, a view which is derived from observation of the processes of the 'common-sense,' conventional, everyday world. The idea that this view is impossible, then, can come as quite a shock. But the reasoning is unimpeachable:

> If something can arise from something other than itself,
> Well then, deep darkness can arise from tongues of flame,
> And anything could issue forth from anything.
> For 'nonproducer,' like 'producer,' is an 'other.'[158]

It is essential to bear in mind all the time when following Madhyamaka reasoning that the entities involved must always be viewed through the lens of 'inherent existence'. From this perspective it is not possible to have gradations of 'otherness'. Something is either an 'other' or it is not. There are no in between states of 'otherness'; this is a consequence of the lens of inherent existence and is entailed if we consider that things are inherently existent. So if we say that production is from something 'other' than what is produced, a rice seed being 'other' to a rice plant for instance, then the producer, or the cause, and another entity which we think is a non-producer in this case, a barley seed for instance, must actually be equal in otherness. The barley seed and the rice seed must be considered to be equally 'other' to a rice plant. So, if both a barley seed and a rice seed are equal in otherness, both of these, or neither, must be capable of producing the rice plant. If both are capable then anything can indeed issue forth from anything. The assertion of production from both self and other is refuted

by employing both of the above refutations. Finally, if things arise without any cause, then things should be produced randomly which would essentially be the same as anything arising from anything. This, however, is not observed in the world.

The 'diamond slivers' and the partless-particle reasonings, then, deconstruct any notion that there are inherently real substantial causal processes involving definite entities to be found in reality. This is not to say, however, that the appearance of such processes does not occur because, quite obviously, they do. But these appearances are conventional manifestations within a seeming, illusion-like reality. This is not to say that the Madhyamaka denies the appearance of the everyday world, which it terms 'conventional reality' (*saṁvṛti satya*). The everyday world does appear, very convincingly, to be made up of fully independent material entities. Of particular relevance in this context is the doctrine of the two levels of reality, or the two truths. The two truths are the conventional truth (*saṁvṛti satya*) of everyday reality and the ultimate truth (*paramārtha satya*) of the deeper nature of reality, which according to Madhyamaka is 'emptiness' (*sunyata*). These two levels of reality are denoted as the 'conventional', or the 'seeming', and the 'ultimate'. For ordinary beings the appearance of macroscopic reality is a 'seeming' reality that obscures the actual ultimate nature in which all phenomena are 'empty', indeterminate and illusion-like. This division of reality into two levels maps directly onto the dichotomy between the quantum level and the experiential macroscopic level of the everyday world.

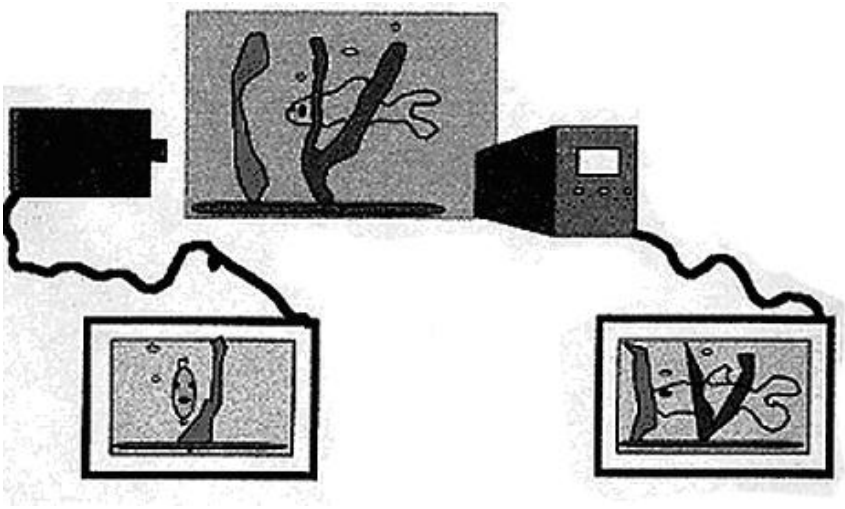
The profound understanding that all phenomena have no determinate core of substantial reality is repeatedly demonstrated within the Madhyamaka analysis. The seeming reality of the everyday world is taken as the ground from which the analysis begins; a thorough analysis, however, reveals repeated signs that point towards the ultimate nature:

> These phenomena are like bubbles of foam …'
> Like illusions, like lightening in the sky,
> Like water-moons; like mirages.[159]

This is not to say, of course, that there is absolutely nothing; but rather there is nothing substantial to be found in the manifestation of the seeming play of appearances, appearances which arise from the deeper level of 'emptiness'.

This view of the situation clearly has a great deal in common with Bohm's notion of the 'implicate order', the realm more akin to 'emptiness', which is not 'nothingness' but is more like an indeterminate pool of potentiality. The 'explicate order' of the conventional everyday world manifests from this pool of empty potentiality. As Bohm tells us:

> …one finds, through a study of quantum theory, that the analysis of a total system into a set of independently existing but interacting 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 experiments, 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.[160]



Bohm's fish-tank analogy

In order to illustrate his view he described the device shown in the above figure. We imagine a fish tank, containing a fish, with transparent sides which has two cameras aimed at it. The cameras are arranged as shown; one is aimed at the side at right angles to the side that the other is aimed at. The cameras are connected to two different displays both of which are in another room. Bohm points out that, although the images shown by the screens will be different to each other, they will also be related. For example if the fish is looking straight out of one, it will be side on in the other and if the fish turns to look straight out of the side it was previously side on to, it will obviously now appear side on in the screen that it was previously staring out of. The images on the two screens will clearly be precisely correlated, in a manner analogous to the spins of entangled particles:

> What we are proposing here is that the quantum property of a non-local, non-causal relationship of distant elements may be understood through an extension of the notion described above. That is to say, we may regard each of the 'particles' constituting a system as a projection of a 'higher-dimensional' reality…[161]

Bohm also considered that the way that all phenomena were linked together within the higher dimension, which he called the 'implicate order,' was analogous to a hologram, in which the 'whole' is written into each and every part. Bohm, then, maintained that a radical new view of the way that the elements of physics were considered to relate to each other was necessary; a perspective that emphasised the 'undivided wholeness' which underpins all the manifested phenomena of the experienced universe.

In *Wholeness and the Implicate Order* Bohm described part of his vision as follows:

> It is being suggested here, then, that what we perceive through the senses as empty space is actually the plenum, which is the ground for the existence of everything, including ourselves. The things that appear to our senses are derivative forms and their true meaning can be seen only when we consider the plenum, in which they are generated and sustained, and into which they

must ultimately vanish.[162]

What Bohm calls the 'plenum' here is equivalent to the Buddhist Madhyamaka notion of 'emptiness'. The term *sunyata*, which is usually translated as 'emptiness', does seem, because of this translation, as being nothing more than a 'void', which is in fact another possible translation. However, the original meaning of the term *sunya,* which is the Indian origin of the concept of zero, is 'the swollen', in the sense of an egg of potentiality which is about to burst into manifestation. The term 'emptiness' indicates the absence of any manifested thing, but the term also indicates the ground of all possible manifestations. As Nagarjuna pointed out:

> For those for whom emptiness is possible,
> Everything is possible,
> For those for whom emptiness is not possible,
> Nothing is possible.[163]

Bohm continues his description:

> This plenum is, however, no longer to be conceived through the idea of a simple material medium, such as an ether, which would be regarded as existing and moving only in a three dimensional space. Rather, one is to begin with the holomovement, in which there is the immense 'sea' of energy ... This sea is to be understood in terms of a multidimensional implicate order, … while the entire universe of matter as we generally observe it is to be treated as a comparatively small pattern of excitation. This excitation pattern is relatively autonomous and gives rise to approximately recurrent, stable and separable projections into a three-dimensional explicate order of manifestation, which is more or less equivalent to that of space as we commonly experience it.[164]

Here we see that Bohm's holomovement is a movement of an "immense sea of energy" which is a " multidimensional implicate order". This is the 'plenum' which can be equated with the Madhyamaka universal ground of *sunyata*, which is emptiness. Out of this ground of empty potentiality the explicated "patterns of excitation" manifested as the experienced everyday world of the explicate order. Bohm later described this structure as follows:

> What is basic to the law of the holomovement is … the possibility of abstraction of a set of relatively autonomous sub-totalities. … This operation will in general have these three key features:
>
> 1 A set of implicate orders.
>
> 2 A special distinguished case of the above set, which constitutes an explicate order of manifestation.
>
> 3 A general relationship (or law) expressing a force of necessity which binds together a certain set of the elements of the implicate order in such a way that they contribute to a common explicate end …[165]

Furthermore:

> Matter is a relatively stable and autonomous ripple in the emptiness. Those of you who have studied the theory of solid states may not find this notion of emptiness entirely unfamiliar. For example, in a crystal of very dense material at absolute zero, if the crystal is of perfect order, electrons go right

> through it as if nothing were there. The suggestion is then that emptiness is really the essence. It contains implicitly all the forms of matter The implicate order really refers to something immensely beyond matter as we know it -- beyond space and time.

In the next chapter we will explore the mechanisms that operate within emptiness to determine how “elements of the implicate order” come to produce a manifested explicate order.

[1] https://blogs.scientificamerican.com/cross-check/david-bohm-quantum-mechanics-and-enlightenment/
[2] Becker A. p39 & https://arxiv.org/ftp/arxiv/papers/1603/1603.00353.pdf
[3] http://philsci-archive.pitt.edu/1559/1/CosKraPL.pdf
[4] http://philsci-archive.pitt.edu/1559/1/CosKraPL.pdf
[5] http://philsci-archive.pitt.edu/1559/1/CosKraPL.pdf
[6] N. Bohr, Speech on quantum theory at Celebrazionne del Secondo Centenario della Nascita di Luigi Galvani, Bologna, Italy, October 1937.
[7] Bohm 1952 article
[8] UU 357
[9] https://www.scienceandnonduality.com/article/david-bohm-implicate-order-and-holomovement
[10] WIO 243
[11] Bohm, David (2002) p227
[12] WIO ?
[13] SOC, 190
[14] MMIO, 20-21
[15] WIO 14
[16] Penrose, Roger (1995) p237
[17] SOC, 258-9
[18] SOC, 259
[19] WIO, 267
[20] Kyabgon, Traleg (2010) 109
[21] Hsing Yun, Master & Tom Graham (trans)(2010) p113
[22] ES xiv
[23] G 1989 p190
[24] Padma, 13
[25] *Wholeness* p226
[26] UU 382
[27] Wholeness p190-191
[28] *Wholeness* p14
[29] Bohm, David (2002) p250
[30] N. D. Mermin. Hidden variables and the two theorems of John Bell. *Reviews of Modern Physics*, 65:803–815, 1993.
[31] GBHQ 338
[32] Ibid.
[33] GBHQ 355
[34] Rosenblum, Bruce and Kuttner, Fred (2006) p139
[35] QR 109
[36] SH 11
[37] Kaku, Michio (2006) p148
[38] SH 9
[39] QR 93
[40] Goswami, Amit (2008) p22
[41] Capra, Fritjov (1975) p152
[42] Penrose, Roger (1995) p309
[43] Al-Khalili, Jim (2003) p294
[44] Rosenblum, Bruce and Kuttner, Fred (2006) p179
[45] Quoted in Stapp, Henry (2007) p162
[46] Ghirardi, G. (2005) p403
[47] Hawking, Stephen & Mlodinow, Leonard (2010), 82-83

[48] Hawking, Stephen & Mlodinow, Leonard (2010), 136
[49] Hawking, Stephen & Mlodinow, Leonard (2010), 135
[50] Hawking, Stephen & Mlodinow, Leonard (2010),140
[51] Ibid.
[52] https://www.youtube.com/watch?v=hU6TkfCGlX8
[53] QS&NS 209
[54] QS&NS 225
[55] QR, 293
[56] Zurek Wojciech H.(2002). ' Decoherence and the Transition from Quantum to Classical – *Revisited*' in *Los Alamos Science* Number 27 2002
[57] Rosenblum, Bruce and Kuttner, Fred (2006) p75
[58] d'Espagnat, Bernard, 'The Quantum Theory and Reality' *Scientific American*, Nov. 197
[59] UU, 2
[60] Penrose, Roger (1995) p313
[61] Quoted in MSQM 16
[62] Stapp, Henry (2004) p223
[63] Stapp, Henry: 'Philosophy of Mind and the Problem of Free Will in the Light of Quantum Mechanics' p19
[64] Stapp, Henry: 'Quantum Interactive Dualism' p18
[65] Stapp, Henry: 'The Effect of Mind upon Brain' p12
[66] Stapp, Henry (2004) p241
[67] Stapp, Henry (2004) p241
[68] Stapp, Henry (2004) p241
[69] Quoted in MSQM 12
[70] Lingpa, Dudjom (2002) p127-129
[71] https://www.religion-online.org/article/the-implicate-order-a-new-order-for-physics/
[72] Oppenheimer, Robert (1954) p8-9
[73] Oppenheimer, Robert (1954) pp 8-9
[74] https://www.telegraph.co.uk/culture/books/bookreviews/9188438/Erwin-Schrodinger-and-the-Quantum-Revolution-by-John-Gribbin-review.html
[75] Quoted in MSQM 12
[76] Quoted in MSQM 12
[77] Quoted in MSQM 12
[78] MSQM 16
[79] https://journals.aps.org/pr/abstract/10.1103/PhysRev.85.166
[80] QSNS 139
[81] QSNS 140
[82] QSNS 140
[83] NQA 93
[84] MSQM 13
[85] Smolin 110-111
[86] UU 6
[87] https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/theoretical-physics/msc/dissertations/2009/Richard-Havery-Dissertation.pdf
[88] MMQM 191
[89] MMQM 191
[90] Rahula, Walpola (1974) p32
[91] Waldron, William S. (2003) p165
[92] Brunnhölzl, Karl (2007) p85
[93] Thrangu Rinpoche, Kenchen (2001) p28-29
[94] Hopkins, Jeffrey (1996) p375
[95] Barrow, John D., Davies, Paul C. W., Harper, Charles L. (eds) (2004) p577 – Wheeler, J A (1999) 'Information, physics, quantum: the search for links.' In *Feynman and Computation: Exploring the Limits of Computers*, ed A. J. G. Hey, p309 (314). Cambridge, MA: Perseus

Books.
[96] SNBN 144
[97] Khendrup Norsang Gyatso (2004) p78
[98] Qunatum Implications 15
[99] Freire 127-128
[100] Causality and Chance ix
[101] Causality and Chance x
[102] Causality and Chance x
[103] Lockwood, Michael (2005) p304
[104] https://khaledbp.files.wordpress.com/2015/09/einstein_s-boxes.pdf
[105] L. de Broglie, The Current Interpretation of Wave Mechanics: A Critical Study (Elsevier Publishing Company, 1964).
[106] Greene, Brian (2004) p83
[107] Greene, Brian (2004) p81
[108] Einstein, Podolsky, Rosen 1935, p. 777
[109] Aczel, Amir D. (2002) p203
[110] https://khaledbp.files.wordpress.com/2015/09/einstein_s-boxes.pdf
[111] Penrose, Roger (1995) 300
[112] Penrose, Roger (1999) 293
[113] Penrose, Roger (2004) 591-593
[114] Becker 97
[115] Becker 98
[116] Norsen 206-207 (quoted in)
[117] Riggs P. J. - https://casinoqmc.net/local_papers/riggs_2008.pdf
[118] Two Doors 154
[119] Smolin 201
[120] TQW 166
[121] Norsen 188
[122] Norsen 63
[123] Norsen 206
[124] Bricmont 148
[125] Jeremy Butterfield: What is contextuality?
[126] Bricmont 151
[127] QMBOE 224
[128] QMBOE 225
[129] Beyond Measure 217
[130] Bricmont 152
[131] QMBOE 224-225
[132] UU 6
[133] UU 6
[134] Hiley & Peat 2
[135] CCMS 33
[136] CCMS 170
[137] Hiley & Peat 10
[138] SOC 91
[139] SOC 91-92
[140] Wholeness 191
[141] UU 382
[142] Avatamsaka Sutra
[143] https://www.religion-online.org/article/the-implicate-order-a-new-order-for-physics/
[144] Wholeness 267
[145] Wholeness 265
[146] Garfield, Jay (1995) p2

[147] Wholeness 157-158
[148] Smolin, Lee (2002)
[149] Allday, Jonathan (2009) p408
[150] https://www.religion-online.org/article/the-implicate-order-a-new-order-for-physics/
[151] https://www.religion-online.org/article/the-implicate-order-a-new-order-for-physics/
[152] Brunnhölzl, Karl (2004) p762
[153] Shantarakshita (2005 - Padmakara Translation Group) p53
[154] Shantarakshita (2005 - Padmakara Translation Group) p53
[155] Shantarakshita (2005 - Padmakara Translation Group) p53
[156] https://www.religion-online.org/article/the-implicate-order-a-new-order-for-physics/
[157] Garfield, Jay (1995) p3
[158] Chandrakirti and Jamgon Mipham (2002) p70
[159] Khenpo Tsultrum Gyamtso (2003) p59
[160] Bohm, D (2002) p237
[161] Bohm, D (2002) p238
[162] Wholeness 243
[163] Brunnhölzl, Karl (2004) p214
[164] Wholeness 243
[165] Wholeness 247-248