ATINER CONFERENCE PAPER SERIES No: PHI2013-0844

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ATINER's Conference Paper Series
PHI2013-0844

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Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN **2241-2891**
23/1/2014

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This paper should be cited as follows:

Poochigian, D. (2013) **"Bohm's Paradox and the Conscious Observer"** Athens: ATINER'S Conference Paper Series, No: **PHI2013-0844.**

Bohm's Paradox and the Conscious Observer

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Abstract

David Bohm identifies a paradox within quantum theory. Assumed by quantum theory is an observer who is both a distinguishable constituent of an indistinguishable world, and an indistinguishable constituent of a distinguishable world. Without a distinguishable observer, a distinguishable quantum world is impossible. Within a distinguishable quantum world, a distinguishable observer is impossible. Thus, a quantum world appears self-contradictory. Content in relation composes a quantum world. A distinguishable and indistinguishable quantum world having the same content and different relation, content is not paradoxical and relation is paradoxical. Non-quantum and quantum worlds being ontologically incompatible, relational identity is an inherent operational and functional constituent of the quantum world. Component of relation are the operators one and zero, and the functions injection, surjection, and bijection. Integrating the minds of distinct scientific observers is the relativistic bijective assumption of common experiential content and uncommon experiential form. Quantum operational functions smoothly transitioning quantum states from one into another, contradictory states occur consecutively, not concurrently. Doing so resolves Bohm's paradox.

Keywords:

Corresponding Author:

Bohm's Paradox

At the foundation of quantum mechanics is a paradox. While widely acknowledged among quantum theorists, David Bohm explicitly formulates it noting,

> at the quantum level of accuracy the entire universe (including, of course, all observers of it), must be regarded as forming a single indivisible unit with every object linked to its surroundings by indivisible and incompletely controllable quanta. If it were necessary to give *all* parts of the world a completely quantum-mechanical description, a person trying to apply quantum theory to the process of observation would be faced with an insoluble paradox. This would be so because he would then have to regard himself as something connected inseparably with the rest of the world. On the other hand, the very idea of making an observation implies that what is observed is totally distinct from the person observing it (Bohm 584-585).

Constitutive of this enigma is assuming investigation of the natural world constitutes statistical correlation of observational experiences. Accepting this, then to what investigation of the natural world comes is quantum theory. Statistics is ontologically presented as a quantum entanglement linking empirical observations. Composed is an unbroken continuity of combinations of initiatory and concluding observations. Concluding observation is a 'collapse' of the quantum entanglement in this otherwise unbroken continuity.

Presuming attainable is, 'As long as Natural Philosophy exists, its ultimate highest aim will always be the correlating of various physical observations into a unified system, and, where possible, into a single formula,' then everything in the universe is related (Planck 1). Accepting a relation is a quantum entanglement of quantum collapses, since a quantum entanglement of any two quantum collapses, *a* and *b*, is imaginable, then everything in the universe is related. A quantum entanglement constituting every state of being intervening *a* and *b*, it is an unbroken continuum from *a* to *b*. Now *a* and *b* are indistinguishable as autonomous objects. They are distinguishable only as states of being of a common object, *ab*. Metaphorically constituted is,

> A rhizome . . . made of plateaus. . . . We call a "plateau" any multiplicity connected to other multiplicities by superficial underground stems in such a way as to form or extend a rhizome. . . . Each plateau can be read starting anywhere and can be related to any other plateau. To attain the multiple, one must have a method that effectively constructs it (Deleuze&Guattari 21-22).

Even this 'Babylonian attitude [where] you know all of the various theorems and many of the connections in between,' is incomplete, considering every quantum entanglement is composed of an infinity of points (Feynman

Chapter 2, "The Relation of Mathematics to Physics"). Each of these points is linked to every other point in a quantum entanglement, until generating an undifferentiated line. In turn, each quantum entanglement is linked to every other quantum entanglement in a quantum entanglement, until generating an undifferentiated surface. Each undifferentiated surface is linked to every other undifferentiated surface in a quantum entanglement, until generating an undifferentiated universe.

Content of the universe being undifferentiated, neither points nor quantum entanglements are discernable within it. Neither points nor quantum entanglements being discernable within the universe, then paradoxical is quantum generation of the universe. Simply enough, there are no elements by which to generate the universe. Thus, on its own assumptions, quantum theory is self-contradictory.

Everything within the universe being related, nothing within the universe is distinguishable except as a state of being of the universe at quantum collapse. Nothing being distinguishable as independent of the whole, neither observer nor observed is distinguishable. Observer and observed defining observation, when observation defines quantum collapse, then quantum collapse is impossible. Science being observation at quantum collapse, then science is impossible. Now as 'correlating of various physical observations into a unified system,' science is possible when it is impossible. This is a paradox.

Classical Solution

Bohm seeks to resolve the conundrum arguing, 'The paradox is avoided by taking note of the fact that all real observations are, in their last stages, classically describable' (Bohm 585). Doing so confronts Sir Isaac Newton's,

> Law I.
>
> *Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon. . . .*
>
> Law II
>
> *The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the straight line in which that force is impressed* (Newton 19, 20).

Concerning '*a right* [*straight*] *line*,' at the limit of a one-dimensional extension is an infinity of immediately contiguous points. Extension to any one of these points is no more necessary than extension to any other.

Excluding all points but what Newton might identify as '*uniform motion in a right line*,' this could be at a juncture of two equally offset points. Now

progress '*in a right line*' is ambiguous, constituting a diagonal movement onto one or the other offset points. Additionally, being arbitrary, neither movement is necessary.

Progressing to one or another offset point, ambiguity recurs in a new form. Is '*uniform motion in a right line*,' continuation '*in a right line*' of the diagonal away from what initially would have been '*uniform motion in a right line*?' Or is it away from continuation '*in a right line*' of the diagonal, in a diagonal returning towards what would initially be continuation '*in a right line*?'

Again, what constitutes '*in a right line*' is ambiguous. As ambiguous, extension to either point is no more necessary than extension to the other. Thus, Newton is mistaken in thinking motion in the physical world is necessary. Rather it is unnecessary, and being unnecessary, what constitutes motion in the physical world is probable. Being so, quantum theory is affirmed. Now God does play dice with the universe.

Probability being intrinsic to the geometry of the physical universe, ontologically suspect '*forces impressed upon* [*Every body*]' are redundant. However ambiguity at the limit of a one-dimensional extension of an object is resolved, ambiguity can recur at every limit of a one-dimensional extension. Being so, the path of any physical object is rendered uncertain.

Quantum Solution

Quantum theory being reaffirmed, Bohm's paradox still is not avoided. For not only is the path of any physical object uncertain, constitution of the path of any physical object is uncertain. Path of a physical object is a continuum from initial object *a* to subsequent object *b*. How is it known, though, initial object *a* is subsequent object *b*? Ernst Zermelo proposes a solution in the axiom of choice.

Among the representations of the axiom of choice is,

> AXIOM VI. Axiom of choice (*Axiom der Auswahl*): "If *T* is a set whose elements all are sets that are different from [the null set] ∅ and mutually disjoint, its union *UT* includes at least one subset S_1 having one and only one element in common with each element of *T*"' (Wikipedia 'Zermelo set theory.' Also see Barker 77; Bernays 133; Fränkel 16).

Not indicated is how it is known S_1 is the same 'element' in each of the subsets of *T*. If *T* is identified by its relations, then S_1 is *not* the same element in each of the subsets of *T* because it has different relations in different subsets.

Additionally requiring 'at least one subset S_1 having one and only one element in common with each element of *T*'' is problematic because being '*at least*' so. Since there can be more than one such subset: S_1, S_2, . . . S_n, how is S_1 distinguishable from S_2 . . . S_n? After all, each has the same properties as every other.

Difficulty occurs because the axiom of choice identifies S_1 by its relational properties. S_1 is distinguishable from S_2, . . . S_n, and S_2, . . . S_n from each other, only by what uniquely identifies them. This is membership in a set of one, which constitutes haecceity, the property of being oneself and nothing else.

As such, though, neither S_1 nor S_2 . . . S_n, are constituent of T'. Now there is no necessity in identity of observed object S_1 and observed object S_2. Neither is there any necessity in every subsequent transitive identity S_3 . . . S_n of S_1 and S_2.

It can be replied how element is related to element is unimportant, because in quantum theory everything is related in entanglement. All being entangled, however, how is anything distinguishable? This when science is the identity of relationship between distinguishable things.

Confusion arises because quantum theory is a contradictory axiom system composing many and one, without an axiom of resolution. Introducing an axiom of resolution by 'Explicit enumeration' provides consistency (Blanche 22). Occurring by 'Explicit enumeration,' an axiom of resolution is injected from outside the quantum world.

Metaphysical Solution

Incompleteness of quantum theory in respect to an axiom of resolution is why, 'No way is evident to apply the conventional formulation of quantum mechanics to a system that is not subject to *external* observation.' (Everett 455). Concerning the character of this requisite '*external* observation,' John von Neumann concludes,

> it is inherently entirely correct that the measurement or the related process of the subjective perception is a new entity relative to the physical environment and is not reducible to the latter. Indeed, subjective perception leads us into the intellectual inner life of the individual, which is extra-observational by its very nature (since it must be taken for granted by any conceivable observation or experiment) (von Neumann 418).

Acknowledging the 'intellectual inner life of the individual,' Erwin Schrödinger observes, 'The abrupt change by measurement . . . . is precisely the point that demands the break with naive realism' (Schrödinger "7. The Psi-function as Expectation-catalog"). So being, 'Resolution of the "Entanglement" Result [is] Dependent on the Experimenter's Intention' (Schrödinger "11. Resolution of the 'Entanglement' Result Dependent on the Experimenter's Intention"). Thus, 'Which measurements on B and in what sequence they are undertaken, is left entirely to the arbitrary choice of the experimenter' (Schrödinger "11. Resolution of the 'Entanglement' Result Dependent on the Experimenter's Intention").

Summarizing the observer's role, Hugh Everett concludes,

> Throughout all of a sequence of observation processes there is only one physical system representing the observer, yet there is no single unique *state* of the observer . . . . there is a representation in terms of a *superposition*, each element of which contains a definite observer state and a corresponding system state (Everett 459).

Here Everett is understandable as supposing a metaphysical conception of mind, rather than a physical conception of mind as brain, as in many other versions of the many minds variation of quantum theory.

Building on Everett's supposition, David Albert and Barry Loewer operationalize Everett's conception with a formal account of mind and brain (Albert&Loewer 195-213). Insofar as, 'Minds do not obey the Schrödinger evolution (in particular the superposition principle), but evolve in time in a genuinely probabilistic fashion,' minds are not axiomatic (Hemmo&Pitowsky 133-176). They are constituted of neither enumerated elements, nor enumerated sequences of elements. Insofar as minds 'evolve in a genuinely probabilistic fashion,' they evolve indeterminately.

Brains are axiomatic, containing enumerated elements and enumerated sequences of elements. Assuming a teleological axiom system, brain states do evolve in a probabilistic manner. Difference in genuine and axiomatic probability is genuine probability is unlimited, and axiomatic probability is limited. Thus, genuine probability includes all occurrent elements and sequences, while axiomatic probability excludes all unenumerated elements and sequences. Genuine and axiomatic probability are integrated by being definitional conceptions of the same elements, but are separated by being different definitional conceptions of the same elements.

Consciousness

Reducing mind to brain engenders its own paradoxes, psychological materialism suffering from unresolvable difficulties. Denying consciousness, psychological eliminativism is self-contradictory, claiming awareness of there being no awareness. Accepting consciousness, psychological reductivism and property dualism are circular, consciousness a Frankenstein monster creating the matter that is consciousness' own creator.

John R. Searle (Searle 133-176) and David Chalmers (Chalmers 243-244, 255) seek to evade this circle by viewing one side of it from the other side. Searle criticizes Chalmers by explaining consciousness from the perspective of a constituent of consciousness, the propositional attitude of a real autonomous material world. Chalmers criticizes Searle by explaining a constituent of consciousness, the propositional attitude of a real autonomous material world, from the perspective of consciousness. Resolution is accepting the circularity. Each perspective incomplete because explained by the other, both perspectives are complete when understood as mutually explaining each other.

In dispute is the reality of relationship. Causality being a relationship, matter can cause mind only if relationship is real, existing independently of mind. Relationship being unreal, mind constitutes matter as mind's own cause. Accepting the latter, reality is pan-psychic, relationship imposed by mind. Accepting the former, reality is not pan-psychic, relationship received by mind. Science seeks a correspondence between hypothetical appearance and actual reality.

Escape from this conclusion might be sought by arguing consciousness is hypothetical, a propositional attitude, not an observable entity, because all could be real as well as apparent. Consciousness as hypothetical is self-contradictory, though. Being analytic, consciousness as hypothetical presupposes consciousness as manifesting appearance.

Consciousness either is or is not, it is not hypothetical, not something which might or might not be. Because so, matter as the source of consciousness is circular. Since this sourcing is unobservable, it is hypothetical. Being hypothetical, its supposition is a creation of consciousness. Now consciousness as the created is the creator of its own creator.

More generally, neither body nor mind being occurrent in experience, when same experience can be the product of body or mind, body and mind are ascribed abstractions. Experience is real when ascribed to body, and ideal when ascribed to mind. Ascription being constituent of consciousness, consciousness is actual, and body and mind are nominal.

Psycho-Physical Parallelism

Insofar as it,

> is a fundamental requirement of the scientific viewpoint – the so-called principle of the psycho-physical parallelism – that it must be possible so to describe the extra-physical process of the subjective perception as if it were in reality in the physical world,

then mind as an autonomous axiom system must compose physical objects (von Neumann 419). So being, mind cannot avoid Bohm's paradox. Insofar as, 'no definition of what an "observer" is[, is] available, in terms of an atomic scale description, even in principle,' a unified system of physical observations is unattainable (Price 'Q31 What is the Copenhagen interpretation?').

Only by introducing metaphysical mental operators, the 'intellectual inner life of the individual,' is Bohm's paradox avoided. This is, 'to [*not*] describe the extra-physical process of the subjective perception as if it were in reality in the physical world.' Assuming, 'the entire universe . . . must be regarded as forming a single indivisible unit with every object linked to its surroundings by indivisible and incompletely controllable quanta,' then the axiom system depicting the observer must be 'connected inseparably with' the axiom system

depicting the observed. As such, neither is distinguishable from the other, Albert and Loewer's many minds variation of quantum theory failing.

Escape from this conundrum is possible only when embracing 'the extra-physical process of the subjective perception,' (von Neumann 419) and abandoning proceeding 'as if it were in reality in the physical world.' Certainly, doing so renders 'Natural Philosophy' incomplete, and thus incapable of achieving 'a unified system.' Not doing so, though, renders 'Natural Philosophy' self-contradictory.

Embracing 'the extra-physical process of the subjective perception,' however, is challengeable on the ground of incomparability. Insofar as consciousness is metaphysical, and matter is physical, they are ontologically incommensurable. This constitutes 'the hard problem,' which is the foundation of psycho-physical parallelism. Relation is possible, however, considering although ontologically incommensurable, consciousness and matter are epistemologically commensurable.

They are so insofar as consciousness is intensional. This is when constituent of consciousness is a sense of identity with an object. So occurring, mind as consciousness identifies with body when as constituent of mind as consciousness is identity with body. Metaphorically, consciousness is like a transparency overlaying matter, and thus ordering matter, while not interacting with matter.

Micro Functional Operators

This ordering proceeds by distributing ambiguous members of a set. Such members being identifiable, together they constitute the subset of all mutually ambiguous constituents of the set. These elements being mutually identifiable as constituent of this subset, their membership in this subset is unambiguous. Limitless application of inclusive disjunction to the subset of all ambiguous members of two sets defines mathematical one ('1'). Limitless application of exclusive disjunction to the set of all ambiguous members of two sets defines mathematical zero ('0').

Resolving disjunctions inclusively or exclusively, constitutes a quantum wave function collapse. Effectively, the set of all ambiguous constituents of sets is a quantum wave function. Inclusive and/or exclusive distribution of the constituents of the ambiguous subset wave function eliminates it, constituting its 'collapse' into unambiguous sets. Quantum wave collapse is logical, then, not ontological.

Distribution of the constituents of the ambiguous set either extends or contracts the membership of the respective sets of which its contents are ambiguous constituents. This extension and contraction is generated respectively by one and zero. One identifies an absolute fullness between two things. Zero identifies an absolute emptiness between two things. One and zero are generated by logical operators, which are states of being. The fullness of

one and the emptiness of zero being unobserved, both are imaginative states of consciousness.

An initial state can be extended or unextended. If extended, an infinite number of states are identifiable as extension of it. Since all of these states are so, extension to one is no more necessary than to another. Such a state constitutes entropy. Necessity of extension to one state than to another state is provided by axiomatic limits. All states inside the limits constitute extension, and all states outside the limits do not constitute extension.

If no more than one state is inside the limits, extension is necessary, not probable. This constitutes Newton's '*uniform motion in a right line*.' If more than one state is inside the limits, extension is probable, not necessary. This constitutes Heisenberg's 'probability of transition from this state to another' (Heisenberg 291).

Range of states inside the limits constitutes a quantum superposition. Extension of state to state inside the limits constitutes a force. Insofar as axiomatic limits are explicitly enumerated, a constitutive mind external to the quantum world is necessary.

Macro Functional Operators

Extension from state to state proceeds by recursion or iteration. A set whose members are identified by similarity to a constant archetype is a recursive set. A set whose members are identified by similarity to inconstant archetypes is an iterative set.

Recursion identifies a set containing no constituent concurrently constituent of another set. Constituents of the set *are not* concurrently constituents of a subset or subsets identified by differential archetypes. Iteration identifies a set containing constituents concurrently constituent of another set. Constituents of an iterative set *are* concurrently constituents of a subset or subsets identified by differential archetypes.

Extension from state to state by recursion and/or iteration will compose one of three macro functions. It is by means of these functions that 'every object [is] linked to its surroundings by indivisible and incompletely controllable quanta.' Borrowing from mathematics, these functions compose injection, surjection, and bijection.

Injection constitutes a Hilbert space, a substantively and formally unaltered element in different spaces, represented by $a=a$. Injection is constant content and form. At every point of injective extension, the element will be like at every other point of the extension. Being so, extension of injective element is by recursion.

Surjection constitutes a transmutative space, a substantively altered element in different spaces, represented by $a=b$. Surjection is at least inconstant content, and at most inconstant form. At every point of surjective extension, the whole will be unlike at every other point of the extension. Being so, extension of surjective whole is by iteration.

Bijection constitutes a transfigurative space, a substantively unaltered and formally altered element in different spaces, represented by $a_1 = a_2$. Bijection is constant content and inconstant form. At every point of bijective extension, each element will be like at every other point of the extension, and the whole will be unlike at every other point of the extension. Continuity of bijective part is by injection, and identity of each whole is by surjection. Being so, extension of bijective part is by recursion, and extension of bijective whole is by iteration.

Many Minds

Resolving the quantum paradox with consciousness can be challenged as puzzling. Science is defined by conscious observation by an observer, and verification of conscious observation by an observer by conscious observation of other observers. Conscious observation by an observer is privileged, however. Being privileged, it is unknowable by another observer. Yet, experience is as if content of another consciousness is knowable, and therefore can be verified by conscious observation of other observers.

Although not posing a logical contradiction, posed is a practical inconsistency. Resolution of this inconsistency of observational verification lies in bijection. Presupposed by the conscious observer is observation is shared by other conscious observers, all of whom together compose the community of scientists. Presumed is an a priori axiom of science.

Rendering an infinitude of particulars comprehensible is a finitude of particulars constituted by a limit of the world. Beyond this limit is the observer whereby Bohm's person observing is identified by disassociation from a limited world. Alternately, a person observed is identified as an autonomous world constituted by a limit within the encompassing limited world.

This limit is identified by the absolute emptiness between two things established by application of the exclusive disjunction of zero. Identifying the person observed is the individual's limits whereby,

> among the attributes an object must have are not only those which it shares with objects of its kind (Aristotelian essentialism), but those which are partially definitive of the special character of the individual and distinguish it from some objects of the same kind (Marcus 191).

Generalized ex post facto, the attributes shared by persons constituent of an encompassing world as a kind composes the self-determined limit of their mutual world.

Content of this mutual world presents a conservation of energy limiting the possible states of constituents of their world. Understood as component of each constituent of the whole, a complete translation of the shared attributes of any one constituent of a world can be made to any other constituent of the world.

Distinguishing individual constituents is the potential and kinetic status, as well as sequencing, of the attributes. Now each constituent is distinguishable as a different state of the constant attributes.

Assuming humans fundamentally do not agree is as analytic as assuming they fundamentally do agree. Modeled by this latter is anthropological culture. Deviance can be accommodated by evolutionary biology. Constituent of universal values is a set of tolerated anomalous values, providing a pool of value for adaptation to environmental alteration. Focusing on the aberrant, a stable science is inexplicable. Only by focusing on the common is a stable science explicable.

Bijective observation as defining of membership in the scientific community is for this reason an axiom of critical realist science. Not only is it a requirement of a complete quantum theory, it is foundational to Albert Einstein's relativity theory. Only by supposing many metaphysical minds linked in observational community is science possible.

Conclusion

Schrödinger's 'break with naive realism' clarifies the observer's status in quantum theory. Separated from the physical world, the observer no longer suffers the indistinguishability of the quantum paradox. So being, 'Resolution of the 'Entanglement' Result [is] Dependent on the Experimenter's Intention' (Schrödinger "11. Resolution of the 'Entanglement' Result Dependent on the Experimenter's Intention."). Extending the observer's role, Hugh Everett concludes,

> When dealing with a system representing an observer quantum mechanically we . . . . denote . . . by appending the . . . . memory configurations which are in correspondence with the past experience of the observer (Everett 457).

Contracting the observers' role, because unbound by naive realism, quantum observers share observations.

Despite this is the 'fundamental requirement of the scientific viewpoint . . . . to describe the extra-physical process of the subjective perception as if it were in reality in the physical world.' Although a pragmatic axiomatic qualification–'*as if* it were in reality in the physical world'–this 'fundamental requirement' subsequently becomes converted into 'reality in the physical world.' Facilitating this evolution is the cognitive scientific reidentification of mind as brain.

Engendered by this reidentification is indistinguishability of the human observer from the rest of nature. Insofar as this is presumed constituent of quantum theory, however, quantum theory is paradoxical. Observation, and analysis and classification of observed, being constituent of consciousness, they are impossible on this assumption, when these activities are intrinsic to

science. Descended from Cartesian dualism, science must preserve the mind/ body distinction if it is to escape a self-defeating paradox.

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