What Is Ultimately Possible in Physics Will Be Found Within An Observer-Participant Universe Where the Photon Carries the Arrow of Time

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In considering the question about what is ultimately possible in physics one must confront three fundamental issues, which occur at the interface between the microscopic and macroscopic levels of the universe:

1) The problem of the asymmetry between the description of the microscopic and macroscopic “Arrows of Time” in the universe;
2) The problem of the asymmetry between microscopic quantum objects and macroscopic classical objects inherent in the laws of quantum physics;
3) The problem of finding a physical explanation of how living, macroscopic conscious observers emerge from the microscopic laws of quantum physics.

The origin of these three fundamental problems is the Copenhagen Interpretation of Quantum Theory, in which Neils Bohr states that it is meaningless to ascribe a complete set of objective physical attributes to a microscopic quantum object prior to the act of quantum measurement. In this picture of the universe only the probability of a quantum measurement can be predicted in a deterministic manner. These probabilities are the quantum potentia, associated with expectation values of physical operators over the quantum state vector, obey a deterministic unitary time evolution described in a time reversal conserving manner by the Schrodinger equation. However in this picture of the universe objective reality, associated with the quantum actua generated from the quantum potentia by the quantum measurement process, can not be deterministically described. This is because within it the quantum measurement process is described in a time reversal violating manner by a projection operator whose connection to the macroscopic observer cannot be physically explained. Hence, with its inherent asymmetry in the distinction between microscopic quantum systems and macroscopic observers the Copenhagen Interpretation picture of the universe is incomplete, giving rise to the three fundamental problems described above.

Progress toward unraveling the mystery underlying these three problems was made by John Wheeler, who pioneered the concept of “The Observer Participant Universe”. In Wheeler’s picture of the universe it was stated that “No elementary quantum phenomenon is a phenomenon until it is an irreversibly recorded phenomenon” and macroscopic conscious observers participate directly in the process of irreversibly actualizing the quantum potentia. However this theory was also incomplete since it offered no dynamic explanation was given about the manner in which macroscopic conscious observers irreversibly actualize microscopic elementary quantum phenomena. The logical asymmetry associated with the Copenhagen Interpretation distinction between microscopic quantum systems and macroscopic observers was still present in Wheeler's version of the observer-participant universe. In particular this logical asymmetry, between the description of the observer and the observed, also occurs within the Copenhagen Interpretation of the quantum field theoretic formulation of Quantum Electrodynamics, in which the physical world is arbitrarily divided into two complementary components: a) a microscopic quantum field theoretical world consisting of electrons, positrons and photons, and b) a macroscopic classical world of macroscopic measuring instruments in which "macroscopic conscious observers" reside.

It is clear that to resolve these three fundamental problems, and thus be able to determine what is ultimately possible in physics, we must begin the task by searching for a new paradigm of the quantum electrodynamic measurement process that puts the object and the observer on a logically symmetric quantum electrodynamic footing at the microscopic level. The new paradigm required to resolve the problems (1), (2), and (3) was found by generalizing Wheeler's concept of the observer-participant universe into a microscopic quantum operator form which is logically symmetric in regard to the definition of the "observer" and the "object".

This was accomplished by incorporating an Abelian operator gauge symmetry of microscopic operator observer-participation called "Measurement Color" [1,2,3] into the operator equations of Quantum Electrodynamics in the Heisenberg picture [4]. This was accomplished by defining an Abelian quantum field operator labeling symmetry associated with the integer indices k = 1,2, …, N (where in the limit N --> ∞) and then imposing this symmetry onto the quantum field theoretic structure of the QED formalism. The resultant Measurement Color Quantum Electrodynamics (MC-QED)[4] described the quantum measurement process in terms of myriads of electron-positron quantum fields $\psi^{(k)}$ and $\psi^{(j)}$ ($k \neq j = 1,2,\ldots, N \rightarrow \infty$) undergoing mutual microscopic observer-participant quantum measurement processes mediated by the charge-field photon quantum fields $A^{\mu(j)}$ ($j \neq k$) through which they interact.

Within the microscopic observer-participant operator structure of the MC-QED formalism the local, time-symmetric free photon operator $A_\mu^{(0)}$ was dynamically excluded since it could not be given a Measurement Color description. Instead the photon operator was described by the nonlocal Measurement Color Symmetric "Total Coupled Radiation" charge-field photon operator $A_\mu^{(TCRF)} = \sum_{(k)} A_\mu^{(k)}(-) \neq 0$ which carried a <u>negative time parity under the Wigner Time Reversal operator</u>.

Then by applying the same time-symmetric Asymptotic Conditions to the MC-QED operator equations of motion as is done for the case of standard QED, it was found that the physical requirement of a stable vacuum state dynamically required the MC-QED Heisenberg operator equations to contain a causal retarded quantum electrodynamic arrow of time whose existence was independent of any external thermodynamic or cosmological assumptions[5]. Hence in MC-QED the resolution of problem (1) was found as being due to fact that within the formalism the photon operator carries the arrow of time. This surprising result can be better understood in a broader context by noting the fact in MC-QED the physical requirement of a stable vacuum state generates a spontaneous symmetry breaking of both the T and the CPT symmetry. Spontaneous symmetry breaking of the T and the CPT symmetry occurs in MC-QED because the photon carries the arrow of time in the formalism. In this manner the requirement of a stable vacuum state dynamically selects the operator solutions to the MC-QED formalism that contain a causal, retarded, quantum electrodynamic arrow of time, independent of any external thermodynamic or cosmological assumptions.

Note that since the microscopic observer-participant paradigm of Measurement Color with its dynamically generated microscopic dynamic arrow of time is a general concept, its application is not limited only to the case of Quantum Electrodynamics. Hence Measurement Color generalizations of higher symmetry quantum gauge particle field theories like the Standard Model should be attainable within which the gauge bosons as well as the photon carry the Arrow of Time.

Having resolved problem (1) in the context of MC-QED we next apply the new paradigm to the resolution of problem (2). We begin by first recognizing that the origin of problem (2) lies in the nature of Copenhagen Interpretation of QED. This is because within this formalism macroscopic bodies, associated with macroscopic measuring instruments and macroscopic conscious observers, are assumed to obey a strict form of "Macroscopic Realism" on a complementary classical level of physics external to the microscopic quantum electrodynamic system. Macroscopic bodies that satisfy the strict form of Macroscopic Realism are assumed have the property that they are at all times in a macroscopically distinct state which can be observed without affecting their subsequent behavior.

However, because its Measurement Color symmetry implies that the photon operator carries the arrow of time, it has been shown[4] that strict Macroscopic Realism is not valid for MC-QED . This fact has a profound effect on the nature of the time evolution of the state vector in the Schrodinger Picture of the MC-QED formalism. In particular this causes the Hamiltonian operator in the Schrodinger Picture of MC-QED to contain a quantum evolution component and a time reversal violating retarded quantum measurement interaction component. The time reversal violating quantum measurement interaction part of the Hamiltonian operator contains components which have causal retarded light travel times, connected to the values of the physical sizes and/or spatial separations associated with the physical aggregate of Measurement Color symmetric fermionic states into which the fermionic sector of state vector is expanded. For the retarded light travel time intervals in between the preparation and the measurement, the expectation values of the time-reversal violating retarded quantum measurement interaction operator will be negligible compared to the expectation values of the quantum evolution operator which generates the "quantum potentia" of what may occur.

On the other hand for the retarded light travel time intervals corresponding to the preparation and/or the measurement, the expectation values of the time-reversal violating retarded quantum measurement interaction operator will be dominant compared to the expectation values of the quantum evolution operator and this will cause the "quantum potentia" to be converted into the "quantum actua" of observer-participant measurement events.

It has also been shown [(4)] that for a sufficiently large aggregate of atomic systems, described by the by the bare state component of MC-QED Hamiltonian and assumed to exist in an "environment" associated with the retarded quantum measurement interaction component of the Hamiltonian, the effects of the retarded quantum measurement interaction will generate time reversal violating decoherence effects on the reduced density matrix in a manner which can give these large aggregates of atomic systems apparently classical properties. Hence in contradistinction the Copenhagen Interpretation of QED with its strict form of "Macroscopic Realism", MC-QED obeys a dynamic form of Macroscopic Realism in which the classical level of physics emerges dynamically in the context of local intrinsically time reversal violating quantum decoherence effects which can project out individual states since they are generated by the time reversal violating quantum measurement interaction in the formalism. This is in contrast to the time reversal symmetric case of QED where the local quantum decoherence[(6)] effects only appear to be irreversible. This occurs in the time symmetric description of decoherence in QED because a local observer does not have access to the entire wave function and, while interference effects appear to be eliminated, individual states have not been projected out. Hence we conclude that the resolution to problem (2) can be found in the MC-QED formalism because the intrinsically time reversal violating quantum decoherence effects inherent within it imply that MC-QED does not require an independent external complementary classical level of physics obeying strict Macroscopic Realism in order to obtain a physical interpretation.

This resolution of problem (2) in MC-QED immediately leads to two possible ways to resolve the question stated in problem (3) about finding a physical explanation of how living, macroscopic conscious observers emerge from the microscopic laws of quantum physics. The first way to resolve problem (3) is a global one which can be found by noting the fact that MC-QED describes the universe in terms of myriads of microscopic, time reversal violating, observer-participant quantum field theoretic interactions which span both the classical and the quantum world. On the other hand living, macroscopic conscious observers also appear to have physical properties which simultaneously span both the classical and the quantum world. Because of this similarity it follows that the MC-QED formalism has the capability of being able to explain how macroscopic conscious observer-participant entities emerge in a microscopic observer-participant universe. Since this occurs a Measurement Color quantum field theoretic manner, it implies that a global quantum holographic description of consciousness may exist which connects the "minds of macroscopic conscious observers" to the "mind of the universe" as a whole.

The second way to resolve problem (3) is a local one which can be found by extending the Measurement Color paradigm into the recently developed quantum field theoretic domain of consciousness research called Quantum Brain Dynamics QBD[(7,8)]. If QBD can be consistently generalized into a (MC-QBD) formalism it may be possible to find a local cybernetic description of how macroscopic conscious observer-participant entities emerge in a microscopic observer-participant universe.

In conclusion we have argued that the challenge of determining what is ultimately possible in physics will require the resolution of three fundamental issues : (1) the origin of the arrow of time in the universe; (2) the nature of objective existence in the context quantum reality, and (3) the spontaneous emergence of macroscopic conscious minds in the universe. In response to this challenge we have shown how the resolution of these three fundamental issues may be found within the paradigm of an observer-participant universe where the photon carries the Arrow of Time.

REFERENCES

1. Leiter, D., Found. Phys. **14**, 857, (1983).
2. Leiter, D., Nuovo Cimento **44**, 665, (1985).
3. Leiter, D., Nucl. Phys. B. Proc. Suppl. **6**, 337, (1989)
4. Leiter, D., *On the Origin of the Classical and Quantum Electrodynamic Arrows of Time*, ArXiv:0902.4667, (2009)
5. Zeh, D.Z., *The Physical Basis of The Direction In Time*, Springer-Verlag, New York), (2007)
6. Schlosshauer, M, *Decoherence and the Quantum-to-Classical Transition,* Springer-Verlag, Berlin Heidelberg, (2007)
7. Jibu, M.& Yasue, K., *Quantum Brain Dynamics and Consciousness: Advances in Consciousness Research* - John Benjamins, (1995)
8. Vitiello, G., *My Double Unveiled; Advances in Consciousness* - John Benjamins, (2001)