Canadian Journal of Physics
Revue canadienne de physique

On Fundamental Flaws of Everett's Many Worlds Interpretation of QM, and Plausible Resolution based on Maxwell-Dirac Isomorphism

Journal:	*Canadian Journal of Physics*
Manuscript ID	Draft
Manuscript Type:	Review
Date Submitted by the Author:	n/a
Complete List of Authors:	Christianto, Victor; Institut Pertanian Malang, Forestry Smarandachey, Florentin; University of New Mexico, Mathematics and Sciences
Keyword:	quantum measurement problem, quantum physics, many worlds interpretation, scale symmetry, Maxwell-Dirac isomorphism
Is the invited manuscript for consideration in a Special Issue? :	N/A

On Fundamental Flaws of Everett's Many Worlds Interpretation of QM, and Plausible Resolution based on Maxwell-Dirac Isomorphism

Victor Christianto*,**, & Florentin Smarandache***

*Malang Institute of Agriculture (IPM), Malang – INDONESIA, email: victorchristianto@gmail.com

**URL: http://researchgate.net/profile/Victor_Christianto

*** Dept. Mathematics & Sciences, University of New Mexico, Gallup, USA. Email: smarand@unm.edu

Abstract

Despite its enormous practical success, many physicists and philosophers alike agree that the quantum theory is so full of contradictions and paradoxes which are difficult to solve consistently. Even after 90 years, the experts themselves still do not all agree what to make of it. The area of disagreement centers primarily around the problem of describing observations. Formally, the so-called quantum measurement problem can be defined as follows: the result of a measurement is a superposition of vectors, each representing the quantity being observed as having one of its possible values. The question that has to be answered is how this superposition can be reconciled with the fact that in practice we only observe one value. How is the measuring instrument prodded into making up its mind which value it has observed? Among some alternatives to resolve the above QM measurement problem, a very counterintuitive one was suggested by Hugh Everett III in his 1955 dissertation, which was subsequently called the Many-Worlds Interpretation of QM (MWI). In this paper we will not discuss all possible scenarios to solve the measurement problem, but we will only shortly discuss Everett's MWI, because it has led to spurious debates on possibility of multiverses, beyond the Universe we live in. We also discuss two alternatives against MWI proposal: (a) the so-called scale symmetry theory, (b) the Maxwell-Dirac isomorphism.

Keywords: quantum measurement problem, many-worlds interpretation, quantum metaphysics, multiverse, realism interpretation, scale symmetry, Maxwell-Dirac isomorphism.

PACS 2010: 02, 03, 41, 98

Introduction

In its simplest form the quantum theory of measurement considers a world composed of just two dynamical entities, a system and an apparatus. According to the Copenhagen interpretation of QM, at the point of time when an observer operates the apparatus to observe the system, the system's wave function collapse. But the exact mechanism of wave function collapse is unknown. Furthermore, it is difficult to model the correlation between a macroscopic observer and apparatus (governed by classical physics) with the system in question, which is supposed to be governed the Schrodinger wave function. This is known as quantum measurement problem, which baffled many physicists since the early years of QM development.

To quote De Witt's paper in Physics Today [7]:

> "At this point Bohr entered the picture and deflected Heisenberg somewhat from his original program. Bohr convinced Heisenberg and most other physicists that quantum mechanics has no meaning in the absence of a classical realm capable of unambiguously recording the results of observations. The mixture of metaphysics with physics, which this notion entailed, led to the almost universal belief that the chief issues of interpretation are epistemological rather than ontological: The quantum realm must be viewed as a kind of ghostly world whose symbols, such as the wave function, represent potentiality rather than reality."

Apparently, Everett also realized that Copenhagen interpretation is largely incomplete. In his 1955 PhD thesis, Everett essentially proposed a resolution from measurement problem by assuming a multitude of possibilities, which is why his hypothesis is called Many Worlds Interpretation.

In De Witt's words:

> "… it forces us to believe in the reality of all the simultaneous worlds represented in the superposition described by equation 5, in each of which the measurement has yielded a different outcome. Nevertheless, this is precisely what EWG would have us believe. According to them the real universe is faithfully represented by a state vector similar to that in equation 5 but of vastly greater complexity. This universe is constantly splitting into a stupendous number of branches, all

> resulting from the measurement like interactions between its myriads of components. Moreover, every quantum transition taking place on every star, in every galaxy, in every remote comer of the universe is splitting our local world on earth into myriads of copies of itself."

In other words, Everett's hypothesis called for a different picture of reality, and obviously this requires a careful consideration of the difference between physics theories and metaphysics. In the next section we will discuss several objections and critics to MWI.

Some critics to Everett's Many Worlds Interpretation

Since publication of his dissertation, Everett's MWI has caused debates especially on philosophical problems related to his proposal. Barrett has reviewed earlier discussions on this topics.[6]

While Barrau [9] has tried to argue in favor of possible experimental vindication of MWI, nonetheless there are also serious criticisms. One critics came from Adrian Kent from Princeton University, where Everett obtained his PhD.

In essence, Kent's objection on MWI is because:

> "The relevance of frequency operators to MWI is examined; it is argued that frequency operator theorems of Hartle and Farhi-Goldstone-Gutmann do not in themselves provide a probability interpretation for quantum mechanics, and thus neither support existing MWI nor would be useful in constructing new MWI."[5]

Furthermore, he argues:

> "Firstly, the very failure of MWI proponents to axiomatize their proposals seems to have left the actual complexity of realistic MWI widely unappreciated. It may thus possibly be tempting for MWI advocates to assume that there is no real problem; that Everett's detractors either have not understood the motivation for, or merely have rather weak aes thetic objections to, his program. (Hence perhaps the otherwise inexplicable claim by one commentator that "Avoiding this [prediction of multiple co-existing consciousnesses for a single observer] is their [Everett's opponents'] motivation for opposing Everett in the first place.")

> Secondly, MWI seem to o□er the attractive prospect of using quantum theory to make cosmological predictions. The trouble here is that if an MWI is ultimately incoherent and ill-founded, it is not clear why one should pay attention to any quantum cosmological calculations based on it." [5, p. 27]

In answering frequent question of what are the alternatives to MWI hypothesis, Kent outlined a number of ideas, including subquantum physics. But in the following section, we will discuss two simpler alternatives which seem quite worthy for further considerations: (a) scale symmetry theory, (b) realistic approach based on Maxwell-Dirac isomorphism.

Resolution to the problem based on scale symmetry theory

In a semi-popular article in *Quanta Magazine*[10], Natalie Wolchover describes about how some theoretical physicists who feel unhappy with multiverse metaphysical problem, have come up with new theories where mass and length are no longer fundamental entities. In scale-symmetry theory, advocated earlier by Bardeen around 1995, the origin of mass can be derived without invoking Higgs mechanism.[11]

Proponents of scale symmetry theory argue that this approach has clear prospect to prove that multiverse hypothesis (MWI) is an excess baggage. In essence, they believe that the key to the correct answer to the measurement problem is not by pondering metaphysical problems such as the existence of multiple realities and multiple histories, but by examining our assumptions on mass, length, and scales. See also Hashino et al. [12].

Resolution to the problem based on realistic Maxwell-Dirac isomorphism

There is a simpler resolution to the aforementioned QM measurement problem, although it is not quite popular, i.e. by admitting that (a) Schrodinger's wave function is unphysical therefore it has no value for realistic physical systems, (b) the measurement problem is caused by confusion on the physical meaning of quantum wave function. One we accept these, then we should find the correct physical meaning of wave function, by formal connection with classical electrodynamics. In other words, contradictions and confusions can be removed once we reconcile quantum picture with classical electrodynamics picture of wave function, instead of crafting unfounded assumption of many-worlds.

There are some papers in literature which concerned with the formal connection between classical electrodynamics and wave mechanics, especially there are some existing proofs on Maxwell-Dirac isomorphism. Here the author will review two derivations of Maxwell-Dirac isomorphism i.e. by Hans Sallhofer and Volodimir Simulik. In the last section we will also discuss a third option, i.e. by exploring Maxwell-Dirac isomorphism through quaternionic language.

a. Sallhofer's method

Summing up from one of Sallhofer's papers[1], he says that under the sufficiently general assumption of periodic time dependence the following connection exists between source-free electrodynamics and wave mechanics:

$$\sigma \cdot \begin{bmatrix} rotE + \frac{\mu}{c}\frac{\partial}{\partial t}H = 0 \\ rotH - \frac{\varepsilon}{c}\frac{\partial}{\partial t}H = 0 \\ div\varepsilon E = 0 \\ div\mu H = 0 \end{bmatrix}_{divE=0} \equiv \left[(\gamma \cdot \nabla + \gamma^{(4)}\partial_4)\Psi = 0\right] \tag{1}$$

In words: Multiplication of source-free electrodynamics by the Pauli-vector yields wave mechanics.[1] In simple terms, this result can be written as follows:

$$P \cdot M = D\,, \tag{2}$$

Where:

P = Pauli vector,

M = Maxwell equations,

D = Dirac equations.

We can also say: Wave mechanics is a solution-transform of electrodynamics. Here one has to bear in mind that the well-known circulatory structure of the wave functions, manifest in Dirac's hydrogen solution, is not introduced just by the Pauli-vector.[1]

b. Simulik's method

Simulik described another derivation of Maxwell-Dirac isomorphism. In one of his papers[2], he wrote a theorem suggesting that the Maxwell equations of source-free electrodynamics which can be written as follows:

$$\begin{aligned} rotE + \frac{\mu}{c}\frac{\partial}{\partial t}H &= 0 \\ rotH - \frac{\varepsilon}{c}\frac{\partial}{\partial t}H &= 0 \\ divE &= 0 \\ divH &= 0 \end{aligned} \tag{3}$$

Are equivalent to the Dirac-like equation [2]:

$$\left[\gamma.\nabla - \begin{pmatrix} \varepsilon 1 & 0 \\ 0 & \mu 1 \end{pmatrix} \frac{1}{c}\frac{\partial}{\partial t}\right]\Psi^{c1} = 1, \tag{4}$$

Where in the usual representation

$$\gamma = \begin{pmatrix} 0 & \sigma \\ \sigma & 0 \end{pmatrix}, \tag{5}$$

And σ are the well-known Pauli matrices.

c. Maxwell-Dirac isomorphism through Quaternionic language

Recognizing that the Maxwell's equations were originally formulated in terms of quaternionic language, some authors investigate formal correspondence between Maxwell and Dirac equations. To name a few who worked on this problem: Kravchenko and Arbab. These authors have arrived to a similar conclusion, although with a different procedures based on Gersten decomposition of Dirac equation.[4]

It seems that the above arguments of Maxwell-Dirac isomorphism can be an alternative to the problematic MWI hypothesis. This MD isomorphism can also be extended further to classical description of boson mass which was usually called Higgs boson[3], so it may be a simpler option compared to scale symmetry theory.

Concluding remarks

Despite its enormous practical success, many physicists and philosophers alike agree that the quantum theory is so full of contradictions and paradoxes which are difficult to solve consistently. Even after 90 years, the experts themselves still do not all agree what to make of it. In this paper, we review QM measurement problem which has paved a way to Many-Worlds Interpretation of QM. Nonetheless, it is clear that Everett's hypothesis called for a different picture of reality, and obviously this requires a careful consideration of the difference between physics theories and metaphysics.

In the meantime, the problem of the formal connection between electrodynamics and wave mechanics has attracted the attention of a number of authors, especially there are some existing proofs on Maxwell-Dirac isomorphism. Here the author reviews two derivations of Maxwell-Dirac isomorphism i.e. by Hans Sallhofer and Volodimir Simulik and also quaternion language.

It seems that the above arguments of Maxwell-Dirac isomorphism can be an alternative to the problematic MWI hypothesis. This MD isomorphism can also be extended further to classical description of boson mass which was usually called Higgs boson[3], so it may be a simpler option compared to scale symmetry theory.

This paper was inspired by an old question: Is there a consistent and realistic description of wave function, both classically and quantum mechanically?

It can be expected that the above discussions will shed some lights on such an old problem especially in the context of physical meaning of quantum wave function. This is reserved for further investigations.

Acknowledgement

Special thanks to Prof. Thee Houw Liong for bringing up this MWI and QM measurement problem in a recent discussion.

References:

[1] Hans Sallhofer. Elementary Derivation of the Dirac equation. X. *Z. Naturforsch*. 41a, 468-470 (1986). [1a] See also his series of papers on classical description of hydrogen.
[2] Volodimir Simulik. Some Algebraic Properties of Maxwell-Dirac Isomorphism. *Z. Naturforsch*. 49a, 1074-1076 (1994)
[3] Bo Lehnert. Minimum mass of a composite boson. *J. Modern Physics,* 5, 2016, 2074-2079.
[4] Victor Christianto & Florentin Smarandache. A derivation of Maxwell equations in Quaternion Space. *Progress in Physics* vol. 2, April 2010. url: http://www.ptep-online.com
[5] Adrian Kent. Against Many Worlds Interpretation. *Int. J. Mod. Phys*. A 5 1745-1762 (1990). See also arXiv:gr-qc/9703089
[6] Jeffrey A. Barrett. Everett's pure wave mechanics and the notion of the worlds. *Eur. Jnl. Phil. Sci.* (2011), 1:277-302
[7] Bryce De Witt. Quantum Mechanics and Reality. *Physics Today,* Vol. 23 no. 9 (1970)
[8] Hugh Everett III. The Many-Worlds Interpretation of Quantum Theory. Princeton PhD dissertation, 1955. Also published later in 1973 by *Princeton University Press.*
[9] Aureliu Barrau. Testing the Everett Interpretation of Quantum Mechanics with Cosmology. arXiv: 1415:7352 (2014)
[10] Natalie Wolchover. At Multiverse Impasse, a New Theory of Scale. *Quanta Magazine.* August 18, 2014
[11] William A Bardeen. On Naturalness in Standard Model. Fermilab-Conf-95-391-T. 1995
[12] Katsuya Hashino et al. Discriminative phenomenological features of scale invariant models for electroweak symmetry breaking. *Phys. Lett.* B 752 (2016)

Document history: version 1.0: March 8th, 2018, pk. 21:42

VC & FS