The Problem with “The Measurement Problem”.

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The Problem with “The Measurement Problem”.

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Abstract

This paper argues that the “Measurement Problem” is foundationally moot, using the abstraction of “Color Guessing Game”. It has been reasoned that the preferred question to ask is, once taken the measurement, what is the certainty that the measured physical state of quantum system is the original intended state governed by absolute laws of nature. The certainty of the measured state $|\phi_k\rangle$ of the physical system with wave function $|\psi\rangle = \sum_i c_i |\phi_i\rangle$ being the original intended state is given by $P(|\phi_k\rangle)_{certainty} = \frac{|c_k|^2}{\sum_i |c_i|^2} \cdot [\frac{|c_k|^2}{\sum_j |c_j|^2}]_{measurement}$, given that the measurement probe’s wave function interaction with $|\psi\rangle$ is unknown. It has been argued that measured state’s interactions with other quantum system corresponds to classical reality, which can be changed by the act of measurement.

Keywords

Measurement Problem; Quantum foundations; Quantum Information; Quantum Wavefunctions;
Nature of Reality

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1. Introduction

Measurement Problem in Quantum Mechanics is of significance importance, as its insolvability has given rise to various well posed interpretations of Quantum Mechanics. The most widely held interpretations is Copenhagen interpretation^{1, 2, 3}, which takes the stance of wave-function collapse. Everett's Many-World interpretation argues that the collapse never occurs and there is no measurement problem⁴. Likewise, several other theories have been presented, such as De Broglie-Bohm theory⁵, Ghirardi-Rimini-Weber theory^{6, 7} and Quantum Decoherence phenomena^{8, 9}. Furthermore, Ali has argued using an "Observer's Dilemma" thought experiment that quantum mechanics is an "observably complete" theory and deals with observable nature of reality, which can be probabilistic in nature¹⁰. On the contrary, the absolute nature of reality is deterministic and is governed by the absolute laws of nature, which can be beyond human measurement capabilities.

Using this premise, a "Color Guessing Game" has been used as an abstraction to argue that "Measurement Problem" is fundamentally flawed, when dealing with observable nature of reality. The right question is once taken the measurement of the state, what is the certainty that the measured physical state was in fact intended by the absolute laws of nature, which is always deterministic. Section 3 presents the uncertainty in the measurement of the physical state, and the limits of this certainty. Based on this foundation, section 4 presents the logical qualitative correspondence from quantum to Classical reality, using extension of color guessing game abstraction.

2. Color Guessing Game

“You are a contestant of a Color Guessing Game. There is a box containing a single colored dice. You are given six possible colors to guess from (Red, Orange, Yellow, White, Blue, and Green). Furthermore, you are given six possible positions to see the color from (Up, Down, Front, Back, Left, Right).

Condition: Once you have chosen the position, to see the color, the game’s host may or may not change the original color to any other color. For example, the original color was green and you chose to see from Right Position. The host can change the color into Red.

In order to win the Jackpot you have to answer two questions correctly.

1. What is the Color of the Dice when you see it from your position?
2. What was the Original Color of the Dice?”

2.1.Certainty of Winning

You have arbitrarily chosen the position to be “Front” and the color to be “White”. Furthermore, you have guess the Original color to be “White” as well. The Probability of color being “White” is one out of six i.e. $P(W) = \frac{1}{6}$. Furthermore, the probability of original color being “White” based on the chosen position is $P(W_{Org}) = \frac{1}{36}$. In this scenario, the possible ways of interacting with the dice color, based on which position you look is 6. Once you see the color, regardless of the position, you may or may not have changed the color, however, the color you see is the color of the dice now. The certainty that it was the original color of the dice is $\frac{1}{36}$.

3. Abstraction to Quantum Systems

In this section, the “color guessing game” is abstracted to quantum system. Consider an arbitrary quantum system with the wave function $|\psi\rangle = \sum_i c_i |\phi_i\rangle$, where c_i is the probability amplitude of the state ϕ_i . Since Quantum mechanics is deemed observably complete, and $|\psi\rangle$ is the information one has of the system, where all possible states are possible unless one makes the measurement. This scenario is fundamentally similar to a dice being of any six color, unless one looks at it. The probability of measuring an arbitrary chosen state $|\phi_k\rangle$ for a given quantum system is given by equation 1.

$$P(|\phi_k\rangle) = \frac{|c_k|^2}{\sum_i |c_i|^2} \quad (1)$$

Furthermore, the process of taking measurement adds further uncertainty, as it was the case in the position of looking at the dice. Let the measurement probe be given by wave function $|\psi_M\rangle = \sum_M c_M |\phi_M\rangle$. The measurement wave function may or may not interact with the wave function $|\psi\rangle$ of the quantum system. In this article, we have assumed that the interaction of measurement probe is unknown. To serve this purpose, once the measurement is made, the state turns out to be $|\phi_k\rangle$. The question now becomes about the certainty the measured state $|\phi_k\rangle$ was the original state, intended by the absolute laws of nature. This is similar to asking the question of how certain are you that the original color of the Dice was “White”. Since the interaction of measurement probe is unknown, the certainty that $|\phi_k\rangle$ was the original state of the quantum system is given by equation 2.

$$P(|\phi_k\rangle)_{certainty} = \frac{|c_k|^2}{\sum_i |c_i|^2} \cdot \left[\frac{|c_k|^2}{\sum_j |c_j|^2} \right]_{measurement} \quad (2)$$

$\left[\frac{|c_k|^2}{\sum_j |c_j|^2} \right]_{measurement}$ is the uncertainty caused by the measurement probe, and $|c_j|^2$ are the probabilities of the possible states caused by the interaction with the measurement probe wave function. Based on

the information one has, one can say with certainty given by equation 2 that the measured state was the intended original state of the quantum system by the absolute nature of reality.

3.1.Limits of Certainty

The limits of certainty depends on the interaction of measurement probe with the quantum system. In this article the information of interaction between two wave functions $|\psi\rangle$ and $|\psi_M\rangle$ is unknown. So, the equation 2 gives the lower limit of the certainty i.e. the least certainty that quantum system had originally $|\phi_k\rangle$ state. However, if one has the information about the interactions between two systems, the certainty of the measured state is increased, as $[\frac{|c_k|^2}{\sum_j |c_j|^2}]_{measurement}$ tends towards 1, as the interaction information starts to increase. If one has complete information of the interaction, the upper limit of certainty is given by equation 3, since $[\frac{|c_k|^2}{\sum_j |c_j|^2}]_{measurement} = 1$

$$P(|\phi_k\rangle)_{certainty} = \frac{|c_k|^2}{\sum_i |c_i|^2} \quad (3)$$

Based on the probabilistic nature of quantum mechanics, the most certain one can be that the measured state was the original intended state by the absolute laws of nature depends on the probabilities of the possible states, provided that all the information is available about interactions.

3.2.Measurement Problem

The measurement problem of how or whether the wave function collapse occurs is akin to asking whether the dice in the “color guessing game” of section 2 was of six colors in the first place. It was stipulated that the dice was of single color. Likewise, it has been argued that Absolute Nature of Reality is deterministic governed by absolute laws of nature¹⁰, which can be beyond the measurement capabilities of humans, and quantum mechanics is deemed complete¹¹. The wave functions of quantum mechanics arises from observable completeness. Based on this premise, one can argue that

the measurement problem is rendered moot, since absolute laws of nature and nature of reality is beyond human observation capabilities at the present moment. Nonetheless, the act of measurement makes the physical state uniquely deterministic, which can be observed. The question that takes preference is how certain one is, based on the information that the measured state is the original intended state by the absolute laws of nature. The act of measurement can change the state of the quantum system based on the interaction of the wave functions of the measurement probe and the quantum system.

4. Correspondence between Quantum and Classical Reality

This section presents argumentative arguments, based on the premises established previously for the correspondence between quantum and classical reality. Consider, four box with dices in the color guessing game. Three of the boxes are opened and has red dices. The fourth box is closed and you have to guess the color, based on the rules of section 2. Furthermore, you are asked to apply cumulative law to the colors of each dice. Before measurement, the cumulative sum is three red + the guessed color of the fourth dice. You decide to guess White and Position right to see the fourth dice. The fourth color turned out to be White. The cumulative sum of colors is three reds and one white. There is an uncertainty that the white color was originally white or not, nonetheless, that is the reality now. Likewise, if you guess two colors, the uncertainty will increase, but the seen colors will be used to calculate cumulative sums.

If one abstracts this scenario to quantum mechanics, the measured physical state is the state of the quantum system, despite being uncertain that whether it was the original intended state by the absolute laws of nature. Consider an electron which has a wave function $|\psi_e\rangle = \sum_i c_i |\phi_i\rangle$, and once measured its physical state turns out to be $|\phi_k\rangle$. The certainty that $|\phi_k\rangle$ was the original intended state by the

absolute laws is given by equation 2, provided that the interaction between measurement probe and electron is unknown. It is possible that you have altered the original intended state by absolute laws, but nonetheless, the electron if interacts with certain other arbitrary particles using certain law, will interact with state $|\phi_k\rangle$. The interaction of different quantum systems with measured physical states will corresponds to the classical reality as we experience it. It will be different if the act of measurement has altered the quantum state originally intended by the absolute laws of nature, or the classical reality is same as governed by absolute laws of nature, if the measurement process doesn't alters the original state. The classical reality is just the manifestation of physical states of the system, governed by absolute laws of nature, which can be altered by the act of measurement, if the physical states of the systems are altered once measuring the states.

5. Conclusion

To concluded, it has been argued that “Measurement Problem” is fundamentally moot, and the preferred logical question is to ask, “Once taken the measurement, what is the certainty that the measured state is the original intended state as governed by absolute laws of nature?” The interaction between the measured state of a system and other quantum systems gives rise to the classical reality we experience. The act of measurement can alter the states of the physical system and hence the classical reality.

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