Open Journal of Mathematics and Physics | Volume 4, Article 269, ISSN: 2674-5747
https://doi.org/10.31219/osf.io/chmqy | published: 20 Jun 2022 | https://ojmp.org
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[white paper]
Diamond Open Access
[awaiting peer review]

The inner structure of time

Open Mathematics Collaboration*†

June 20, 2022

Abstract

Based on the idea that time is computation, we discuss one interpretation regarding the inner structure of time that explains quantum superposition.

keywords: time, quantum superposition, graph

The most updated version of this white paper is available at
https://osf.io/chmqy/download
https://zenodo.org/record/6672667

Introduction

1. This `white paper` is the *evolution* of [1, 2], inspired by [3].

2. According to the *Wolfram Model* [3–6],

`time = computation.`

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Notation

3. $R_i :=$ binary relation

4. $(a, b) :=$ ordered pair

5. $r :=$ rule that transforms R_i into R_j

6. $\subset\ :=$ proper subset relation

Spin up/down

7. Let $R_1 = \{(1, 0)\}$ and $R_2 = \{(0, 1)\}$.

8. $r : R_1 \to R_2$

9. In the light of (2), in a physical system governed by r, **time** *is the edge of the graph* of Fig. 1, where each arrow represents one unit of time.

10. Classical time evolution $t_0 \to t_1 \to t_2 \to \ldots$ then reads

$$(1, 0) \to (0, 1) \to (1, 0) \to \ldots$$

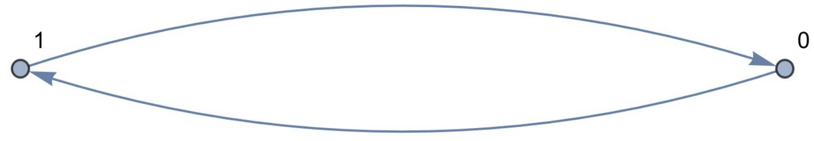

Figure 1: Graph representing the spin flip.

11. Assign the following meaning to the vertices:

$$\texttt{1} := |1\rangle := \text{spin up},$$
$$\texttt{0} := |0\rangle := \text{spin down}.$$

12. Thus, it is quite logical to assign (8) to describe the qubit

$$|\psi\rangle = \frac{1}{\sqrt{2}} (|1\rangle + |0\rangle) .$$

13. A measurement of this quantum system occuring at time t_n results in the collapsed state $|1\rangle$ or $|0\rangle$.

14. Considering that the "length" of time is the same for each quantum computational calculation in (10), (13) yields a probability 1/2 for the collapse of each state.

Time composition

15. Note that there are two arrows in the spin up/down system since

$$(1, 0) \equiv (1 \to 0).$$

16. Then the rule (8) is given by

$$r : (1 \overset{\tau}{\to} 0) \overset{t}{\to} (0 \overset{\tau}{\to} 1).$$

17. $t :=$ classical time

18. $\tau :=$ quantum time required to flip the spin of the quantum particle

19. Consider the following experiment

$$(1 \overset{\tau_0}{\to} 0) \overset{t_0}{\to} (0 \overset{\tau_1}{\to} 1) \overset{t_1}{\to} (0 \overset{\tau_2}{\to} 1) \overset{t_2}{\to} ...,$$

where $|\tau_0| < t_0 < |\tau_1| < t_1 < |\tau_2| < t_2 < ...$

20. If the observer measures the spin of the particle at t such that $t_0 < t < |\tau_1|$, then the spin collapses to $|0\rangle$.

21. If the observer measures the spin of the particle at t such that $|\tau_1| < t < t_1$, then the spin collapses to $|1\rangle$.

Final Remarks

22. In summary,

    (i) `classical time` := map between relations,

    (ii) `quantum time` := arrow within a graph.

23. *Is time a composite dimension?*

24. $\tau \in t$?

25. $\tau \subset \mathbb{C}$?

Open Invitation

Review, *add* content, and `co-author` this white paper [7, 8].
Join the **Open Mathematics Collaboration**.
Send your contribution to `mplobo@uft.edu.br`.

Open Science

The **latex file** for this *white paper* together with other *supplementary files* are available in [9, 10].

How to cite this paper?

`https://doi.org/10.31219/osf.io/chmqy`
`https://zenodo.org/record/6672667`

Acknowledgements

+ **Center for Open Science**
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+ **The Wolfram Physics Project**
  `https://www.wolframphysics.org`

Agreement

The author agrees with [8].

License

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