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Axioms of space?

Open Mathematics Collaboration*†

July 18, 2019

Abstract

Here, we propose the discussion of which axioms nature really follow in the very quantum realm of spacetime.

keywords: axioms, geometry, spacetime, quantum gravity

Is space discretized?

1. The mathematical point has no extension whatsoever.

2. According to some theories of physics, such as the Standard Model, the elementary particle is a point, with zero volume [1].

3. Loop quantum gravity, however, states that space is discretized [2].

4. One main argument found in [3], attributed to Democritus, is that one cannot construct something with extension from something with no size.

5. The conclusion is that space has a granular structure [3].

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6. Let's analyze two axioms from pure mathematics, more specifically, from Euclidean geometry.

7. "An axiom or postulate is a statement that is taken to be true, to serve as a premise or starting point for further reasoning and arguments." [4]

8. "Euclid originally defined the point as 'that which has no part'". [4]

9. "The geometric points do not have any length, area, volume or any other dimensional attribute" [4].

10. A line is an infinite set of points of a specific form.

11. From (9) and (10), we conclude that it is possible to construct objects with sizes (lines) from points (zero volume).

12. The mathematical theory of measures [5] can help us clarify what might be going on in the more fundamental scales of spacetime, namely, the Planck scale.

13. The main point here is that, although points have no sizes, lines are made up of infinite points and do have a size.

14. How can we reconcile (4) and (13)?

15. There are two ways I can foresee.

16. One is that the nature of spacetime do not follow the axiomatic notion of a point.

17. Alternatively, one can say that space is not discretized.

18. If I had to bet, I would definitely choose (16).

19. A more profound study can be accomplished within the mathematical theories of measures [5].

Unity of spacetime

20. According to the special theory of relativity, spacetime is unified by the equation $\tau^2 = t^2 - x^2$ [6].

21. How can we extract the axioms of space from (20)?

Birth of time

22. **Conjecture**: *Space is a quantum field, and time emerges from the processes of the field.*

23. (22) needs to be proved mathematically.

24. Define the mathematical relations of (22).

25. Search for pure mathematical theorems that might connect (22) with (24).

Final Remarks

The mathematical **theories of measures** may shed some light on which are the true **axioms of space**.

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