

Peer Review

Review of: "The Measurement of Superpositions"

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This article is an attempt to apply Cantorian Set Theory to metrology. The author argues that the same foundation for metrology can be applied to classical and quantum physics.

The author has clearly put a lot of thought into the paper and refers to Suppes's work, which is a great place to start for an axiomatisation of measurement and scientific theories.

I struggled with the clarity of the ideas. I do not understand what Goedel's theorem or Russell's paradox have to do with measurement (as Goedel's theorem relates to provability in formal systems). For measurement, you can use the field of rational numbers or the completed order field of real numbers. You do not need Cantorian set theory for that other than in the definition of the set of rational numbers or the set of real numbers. If the author is concerned about finite cardinals and ordinals, then a reasonable foundation is Zermelo-Fraenkel set theory for finite sets, usually called ZF-.

I am also not convinced that you can solve the measurement problem in quantum mechanics by saying that it is classical error (or a common-mode error shared with classical physics). One puzzling thing is why the author thinks that measures should be positive whole numbers or, in general, transfinite cardinal numbers. I agree that you need to define a unit and that subsequent measurements will exhibit errors. So, for example, if you were to define 1 meter as the length of a particular meter rod (which is not the current definition), then you would indeed deviate from 1 metre almost every time you take out your ruler or tape. But measurement in quantum mechanics (and arguably elsewhere too) has some conditions imposed on it, even if it is not defined. Foremost among these is the requirement that the measurement is stable: repeating a measurement twice should not change the result. Physicists call this projection, and mathematicians call it idempotency. Projection is key to what measurements are in quantum mechanics, but it is referred to but not examined in this article. What is unique to quantum mechanics is that observable quantities are represented by operators rather than by real numbers, and the projections are

projection operators rather than reading a number off an axis. Heisenberg's uncertainty principle comes about because, in general, order matters when applying operators.

I don't think this paper is publishable without a clearer articulation of the central thesis and arguments for why quantum mechanics and classical mechanics need the same metrology, and what Cantorian set theory has to do with measurement.

A couple of more specific observations. I assume that $1/m$ is a rational number, which has not been motivated by the focus on cardinals and ordinals. A cardinal is not a limit in general; it is simply a set that represents the property of two sets being in a bijective correspondence. If you care about order, then the elements of the set are presented, and you end up with an ordinal instead. What, for example, Russell's paradox shows is that there is no such thing as a set of all sets; it is a proper class instead, which can be axiomatised (for example, in von Neumann-Bernays-Goedel set theory or the stronger Morse-Kelley set theory).

Declarations

Potential competing interests: No potential competing interests to declare.