

Matt Leifer

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Matt Leifer

Perimeter Institute, Waterloo, CA

The reality of the quantum state from Kochen-Specker contextuality

The stated aim of this conference is “the open exploration of the quantum state as a reality”, but, as a curmudgeon, I would prefer to first establish whether the quantum state actually needs to be real. After all, there are many advantages to viewing the quantum state as epistemic (a state of knowledge, information, or belief) instead. For example, the fact that nonorthogonal quantum states cannot be distinguished is puzzling if they represent distinct states of reality, but unsurprising if they are more analogous to overlapping probability distributions.

In this talk, I will review recent progress on rigorously establishing the reality of the quantum state. After a quick review of early results like the Pusey--Barrett--Rudolph theorem, I will focus on more recent work that does not make additional assumptions beyond our basic framework for realist theories (the ontological models framework). This framework assumes that there is some objective state of reality, and that quantum states correspond to probability distributions over them. Although it is impossible to prove that quantum states must be real in this framework without additional assumptions, it is possible to show that the amount of overlap of the probability distributions is much too small to account for the lack of distinguishability of quantum states. I will review the “overlap bounds” that have been proved along these lines and show that they can all alternatively be derived from proofs of Kochen-Specker contextuality. I will discuss experiments to test these bounds and, if time permits, show how the connection to contextuality allows for a unified treatment of experimental errors.

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