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The Two Bell's Theorems of John Bell and Causal Emergence

"Bell's theorem" can refer to two different theorems that John Bell proved, the first in 1964 and the second in 1976. His 1964 theorem is the incompatibility of quantum phenomena with the joint assumptions of Locality and Predetermination. His 1976 theorem is their incompatibility with the single property of Local Causality. This is contrary to Bell's own later assertions, that his 1964 theorem began with the assumption of Local Causality, even if not by that name. Although the two Bell's theorems are logically equivalent, their assumptions are not. Hence, the earlier and later theorems suggest quite different conclusions, embraced by operationalists and realists, respectively. Here we show how those amount to different assumptions about causation, and propose an unifying version of Bell's theorem in which each camp could reject one assumption, happy that the remaining assumptions reflect its weltanschauung. Formulating Bell's theorem in terms of causation is fruitful not just for attempting to reconcile the two camps, but also for better describing the ontology of different quantum interpretations and for more deeply understanding the implications of Bell's marvellous work. I'll conclude with some open questions and a puzzle regarding the emergence of agent-centric causal concepts in quantum theory.

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