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Quantum Theory and Beyond: Is Entanglement Special?

Quantum theory makes the most accurate empirical predictions and yet it lacks simple, comprehensible physical principles from which the theory can be uniquely derived. A broad class of probabilistic theories exist which all share some features with quantum theory, such as probabilistic predictions for individual outcomes (indeterminism), the impossibility of information transfer faster than speed of light (no-signaling) or the impossibility of copying of unknown states (no-cloning). A vast majority of attempts to find physical principles behind quantum theory either fall short of deriving the theory uniquely from the principles or are based on abstract mathematical assumptions that require themselves a more conclusive physical motivation. In a work (<http://arxiv.org/abs/0911.0695>) together with Borivoje Dakic we showed that classical probability theory and quantum theory can be reconstructed from three reasonable axioms: (1) (Information capacity) All systems with information carrying capacity of one bit are equivalent. (2) (Locality) The state of a composite system is completely determined by measurements on its subsystems. (3) (Reversibility) Between any two pure states there exists a reversible transformation. If one requires the transformation from the last axiom to be continuous, one separates quantum theory from the classical probabilistic one. A remarkable result following from our reconstruction is that no probability theory other than quantum theory can exhibit entanglement without contradicting one or more axioms.