ALMOST QUANTUM THEORY: CLASSICAL THEORIES WITH A STATISTICAL RESTRICTION

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Abstract

It is common to assert that the discovery of quantum theory overthrew our classical conception of nature. But what, precisely, was overthrown? In this talk, I demonstrate that a large part of quantum theory can be obtained from a single innovation relative to classical theories, namely, that there is a fundamental restriction on the sorts of statistical distributions over classical states that can be prepared. For both discrete and continuous-variable systems, one can formalize such a restriction using a classical version of complementarity (variables which do not commute according to the Poisson bracket cannot be jointly known) or of Heisenberg's uncertainty principle (products of variances in such variables are non-vanishing) together with a principle of entropy maximization. The toy theories that result from imposing this restriction are found to have a rich structure closely paralleling that of quantum theory and containing analogues of a wide variety of quantum phenomena such as collapse, coherent superposition, entanglement, interference, teleportation, no-cloning, and many others. The diversity and quality of these analogies provides compelling evidence for the view that quantum states are not states of reality – as many interpretations assume – but rather states of incomplete knowledge. I will also discuss the quantum phenomena that are not captured by this principle. Many on this list are found to be instances of a single phenomenon, called contextuality, which I will explain briefly. I will end with a few speculations on what conceptual innovations might underlie the latter set and what might be the origin of the statistical restriction.

References:

[1] R. W. Spekkens, Phys. Rev. A **75**, 032110 (2007)