Probing the quantum-classical boundary with compression software

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Abstract

We recast the problem of the existence of a local-realistic description of quantum measurements using an algorithmic approach. First, we revisit the information-theoretic Bell inequality due to Braunstein and Caves [Phys. Rev. Lett. 61, 662 (1988)] that is based on Shannon entropies. Then, we ask if a similar inequality can be formulated in an algorithmic way. We assume that outcomes in a bipartite Bell scenario are locally simulated by Turing machines. In particular, each party has a universal Turing machine that outputs local measurement outcomes. These outcomes are calculated from inputs that encode information about a local measurement setting and a description of the bipartite system that was sent to both parties. In general, the system description can encode some additional information that is not available in quantum theory, i.e., local hidden variables. However, we later show that an analysis of the Kolmogorov complexity of this data allows us to derive an inequality, similar to the one due to Braunstein and Caves, that must be obeyed by any theory in which such data exists. Since the Kolmogorov complexity is in general uncomputable, we show that the inequality can be expressed in terms of compressibility of the data generated in such experiments and that quantum mechanical predictions lead to its violation if one applies known compression algorithms. Finally, we experimentally demonstrate that compressed outcomes of measurements on photonic pairs do not satisfy our inequality. We argue that our approach allows us to relax the i.i.d. assumption, namely that individual bits in the outcome bit-strings are independent identically distributed.

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Short Biography

Prof. Pawel Kurzynski taken his PhD and MSc in phisics (Adam Mickiewicz University, Poznan, Poland), focus on Quantum Walks on graphs. Then, moved to Singapore to work with Dag Kaszlikowski (CQT, NUS) on foundations of quantum theory. Currently, he is a Senior Research Fellow (CQT) and Assistant Professor (Adam Mickiewicz University, Poznan, Poland).