Martin Ringbauer, C. Branciard, E. G. Cavalcanti, F. Costa, R. Chaves, B. Duffus, A. Fedrizzi, C. Giarmatzi, A. G. White

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Measurements on the Reality of the Wavefunction

The quantum wavefunction is at the heart of our best description of nature, yet we don't know what this object actually represents. Does it correspond to physical reality (the psi-ontic interpretation), is a representation of knowledge or information about an underlying reality (the psi-epistemic interpretation) or is there no reality at all and the wavefunction just represents our subjective experience? The psi-epistemic viewpoint appears very compelling in that it offers intuitive and simple explanations for many puzzling quantum phenomena. Whether it is indeed compatible with quantum mechanics and the notion of objective observer-independent reality has, on the other hand, long been an open question. We have recently demonstrated experimentally that no realist psi-epistemic model can fully explain the imperfect distinguishability of non-orthogonal quantum states – one of the fundamental features of the theory. In contrast to the no-go theorems of Pusey, Barrett, Rudolph and others, our experiment requires no fundamental assumptions such as a specific structure of the underlying ontic state space. Our results thus suggest that maintaining objective observer-independent reality requires a psi-ontic interpretation. Alternatively one could give up objective reality, or reject the ontological model framework and consider more exotic alternatives, such as retrocausal influences. Indeed, Bell's famous theorem already shows that our classical notion of causality is incompatible with quantum mechanics and well-established causal discovery methods fail to produce conclusive results in the face of Bell-inequality scenarios. We explore relaxations of Bell‘s assumptions as a possible way to recover a causal explanation of Bell correlations and test hidden variable models beyond Bell‘s theorem.

M. Ringbauer, A.G. White, C. Giarmatzi, F. Costa - Centre for Engineered Quantum Systems, School of Mathematics and Physics, University of Queensland, Brisbane, Queensland 4072, Australia
M. Ringbauer, A.G. White, C. Giarmatzi - Centre for Quantum Computer and Communication Technology, School of Mathematics and Physics, University of Queensland, Brisbane, Queensland 4072, Australia
C. Branciard - Institut Néel, CNRS and Université Grenoble Alpes, 38042 Grenoble Cedex 9, France
R. Chaves - Institute for Physics, University of Freiburg, Rheinstrasse 10, D-79104 Freiburg, Germany
E.G. Cavalcanti - Centre for Quantum Dynamics, Griffith University, Brisbane, QLD 4111,

Australia
A. Fedrizzi - School of Engineering and Physical Sciences, Heriot-Watt University, EH14 4AS Edinburgh

Reference
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