The University of Texas at San Antonio

UTSA Physics and Astronomy

Alternative robust ways of witnessing nonclassicality in the simplest scenario

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Dr. Massy Khoshbin

In the foundations of quantum theory, we often ask the question "What is quantum about an experiment?" To this end, we run experiments and see if the operational statistics obtained can be modeled by a classical system or not (thus deeming a theory classical or nonclassical). One of the leading notions of nonclassicality in quantum foundations is preparation contextuality. In this work, we relate notions of nonclassicality in what is known as the simplest non-trivial scenario (a prepare and measure scenario composed of four preparations and two binary-outcome tomographically complete measurements). Specifically, we relate the established method developed by Pusey that detects preparation contextuality, that is not suitable in experiments where the operational equivalences to be tested are specified in advance, with a novel approach based on the notion of bounded ontological distinctness for preparations, defined by Chaturvedi and Saha. In our approach, bounded ontological distinctness is tested for two particular preparations that are relevant in certain information processing tasks in that they are associated with the even- and odd-parity of the bits to communicate. When there exists an ontological model where this distance is preserved we talk of parity preservation. Our results highlight that, below a certain noise threshold, all the different methods to witness nonclassicality agree. Consequently, an experimenter can choose the most suitable method based on their specific needs. As an application of our findings, we treat the case of 2-bit parity-oblivious multiplexing in the presence of noise, establishing a condition in which a quantum advantage in the protocol is still powered by preparation contextuality.

BIO: Dr. Massy Khoshbin earned a Ph.D. in Mathematics from UC Santa Barbara in 2024 under the supervision of Dr. David Morrison. Her Ph.D. research was in quantum theory, focusing on quantum information processing in the presence of noise, quantum contextuality, and generalized stabilizer subtheory. She holds a B.A. in Mathematics from UC San Diego, where her undergraduate research included quantum computation, Grover's search algorithm, and computational complexity. Dr. Khoshbin recently joined the faculty at the UTSA Math Department. Her research interests lie at the intersection of quantum foundations, quantum computation, and quantum information theory. She has previously collaborated with members of Microsoft Research Station Q on topics related to topological quantum computation.

Faculty Host: Dr. Jose Morales

Email: Jose.Morales@utsa.edu

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