Quantum Simulation of Markovian and non-Markovian channel addition on NISQ devices and in the Quantum Optics Lab

Ian J. David[1], Solomon A. Uriri[1], Filip A. Wudarski[2,3,4], Ilya Sinayskiy[1,5], Mark Tame[6], and Francesco Petruccione[1,5]

[1]*School of Chemistry and Physics, University of KwaZulu-Natal, Durban 4001, South Africa*
[2]*Quantum Artificial Intelligence Lab. (QuAIL), Exploration Technology Directorate, NASA Ames Research Center, Moffett Field, California 94035, USA*
[3]*USRA Research Institute for Advanced Computer Science (RIACS), Mountain View, California 94035, USA*
[4]*Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5/7, 87-100 Torun, Poland*
[5]*National Institute for Theoretical and Computational Sciences, KwaZulu-Natal, Durban 4001, South Africa*
[6]*Department of Physics, Stellenbosch University, Matieland 7602, South Africa*

The study of memory effects in quantum channels helps in developing characterization methods for open quantum systems and strategies for quantum error correction. Two main sets of channels exist, corresponding to system dynamics with no memory (Markovian) and with memory (non-Markovian). Interestingly, these sets have a nonconvex geometry, allowing one to form a channel with memory from the addition of memoryless channels and vice versa. Here, we use the NISQ device and photonic setup to investigate this nonconvexity by subjecting a single qubit to a convex combination of Markovian and non-Markovian channels. Our results highlight some practical considerations that may need to be taken into account when using memory criteria to study system dynamics given by the addition of Markovian and non-Markovian channels in experiments.