Contribution ID: **255** Type: **Contributed Oral**

Engineered Dissipation in Digitial Quantum Simulations for Complex Resource State Generation

Wednesday 3 December 2025 12:15 (15 minutes)

Quantum hardware processing power is normally optimised by minimising decoherence effects from unwanted interactions with noisy environments. Yet paradoxically, carefully tailored bath interactions can be exploited to preserve coherence rather than degrade it. Engineered dissipation, or reservoir engineering, introduces tailored couplings between a quantum system and its environment to serve as a beneficial resource for tasks of interest, such as deterministically or low-overhead autonomous preparation and stabilization of quantum states (including computationally interesting entangled or multipartite resource states, e.g., Murch 2012), and is a promising route toward always-on error correction (Kapit 2017). Recent work has shown that Floquet engineering, a technique where systems are driven under a periodic Hamiltonian to achieve new effective time dynamics, is also compatible with reservoir engineering in superconducting quantum simulators (Petiziol 2022).

In this work, we extend reservoir engineering to the domain of digital quantum simulation (DQS), which can be interpreted as discretized periodic time-evolution. We describe two proof-of-concept examples: 1) the generation and stabilization of arbitrary quantum states within a single-qubit toy-model Trotterisation, identifying parameter regimes that optimize fast driving and high-fidelity state preparation; and 2) a fully autonomous implementation of the three-qubit phase-flip error-correcting code within a DQS framework without the need for measurement-based feedback.

More generally, DQS allows arbitrary Hamiltonians to be simulated on any universal quantum processor, within the bounds of decoherence and control precision. Our illustrative examples of how to integrate DQS with reservoir engineering highlight its potential role in extending existing noisy intermediate-scale quantum (NISQ) devices to produce, stabilize, and passively correct much more complex resource states which we will explore in future work. We also discuss directions for integrating control protocols that maintain compatibility with continuous autonomous error correction.

Authors: DI LONARDO, Adrien (University of Technology Sydney); Dr PETIZIOL, Francesco (Technical University of Berlin, Germany); TRAN, Joshua (University of Technology Sydney); LANGFORD, Nathan (Centre for Quantum Software and Information, School of Mathematical and Physical Sciences, University of Technology Sydney)

Presenter: DI LONARDO, Adrien (University of Technology Sydney)

Session Classification: Quantum Science and Technology

Track Classification: Topical Groups: Quantum Science and Technology