Contribution ID: **157** Type: **not specified**

Quantum Magic in Discrete-Time Quantum Walk

Thursday, 28 August 2025 17:15 (3 minutes)

Quantum magic, which accounts for the non-stabilizer content of a state, is essential for universal quantum computation beyond classically simulable resources. However, the way magic builds up during structured unitary dynamics remains largely open. Here, we investigate the generation and evolution of quantum magic in discrete-time quantum walks (DTQWs)–a simple, tunable unitary model realizable on a wide range of architectures. We use Stabilizer Renyi Entropy as a measure of quantum magic and investigate single- and two-walker quantum walks on a one-dimensional lattice, considering a wide range of initial coin states. Our results reveal that DTQWs can dynamically generate significant magic, with the amount and structure dependent on the initial state of the coin. In the case of a single walker, we found a nontrivial and complementary relationship between magic and entanglement at long times. In the two-walker setting, even states close to stabilizer form can evolve into highly magical states when subjected to quantum walk protocols. The generation of magic can occur independently of entanglement growth, emphasizing its distinct role as a quantum resource. We further show that the dynamical magic generation is robust under realistic noise—specifically, decoherence in the coin degree of freedom—demonstrating that this process persists across noisy settings. Finally, we discuss an experimentally feasible scheme to measure magic using current technology. Our findings position DTQWs as accessible and controllable platforms for producing quantum magic, offering a new perspective on their role in quantum information proces

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Session Classification: Poster

Track Classification: Poster presentation