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Demonstration of fault-tolerant Steane quantum error correction

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Encoding information redundantly in quantum error correcting (QEC) codes is a way –perhaps the only way – to protect quantum information processors from the harmful effects of noise that impede large-scale computation. However, the execution of QEC itself is subject to faults which can transform and spread uncontrollably unless fault-tolerant design principles are applied as well. The consequence of this is that device capabilities, noise profile, QEC code, and correction scheme are all influencing each other.
In my talk I will present the first experimental demonstration of Steane QEC [1] which in combination with the transversal CNOT and full qubit connectivity minimizes the necessary coupling between data and auxiliary qubit register. We demonstrate the benefits of Steane error correction over previously demonstrated universal, fault-tolerant gate implementations [2] using traditional flag-based syndrome readout with three different types of codes of increasing code distances, establishing experimental Steane QEC as a competitive paradigm for fault-tolerant quantum computing.
[1] Postler, Lukas, et al. "Demonstration of fault-tolerant Steane quantum error correction." arXiv preprint arXiv:2312.09745 (2023).
[2] Postler, Lukas, et al. "Demonstration of fault-tolerant universal quantum gate operations." Nature 605.7911 (2022): 675-680.

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