Remarkable advances in qubit hardware have enabled landmark experiments demonstrating small-scale quantum simulations, quantum computational tasks, and error-correction protocols. Nonetheless, achieving scalable, fault-tolerant quantum error correction (FTQEC) necessary for building useful quantum technology remains a challenging task. Firstly, it is still very hard to realize scalable hardware which operates below the maximum noise-strength that the error correction codes can tolerate, called the threshold. Moreover, with the noisy hardware available today or in the near-future, the resource overheads for FTQEC is dauntingly large. In fact, the overhead can completely overwhelm the advantage of quantum algorithms over classical ones for many practical problems. While developing low-noise quantum hardware is important to ease the requirements for FTQEC, in this talk I will focus on a complementary strategy which is based on the observation that some type of errors are less contagious and easy to correct than others. I will show how the detailed noise properties of the underlying quantum hardware can be leveraged to design high-threshold and low-overhead protocols for FTQEC. I will also discuss the opportunities for practical applications in different hardware platforms, with specific focus on superconducting circuits.

Host: Steven Girvin

Quantum Error Correction for Next-Generation Qubit Technologies

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