Topological Quantum Error Correcting Codes: Efficient Preparation, Optimisation and Characterisation

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In recent years, topological quantum error correcting codes have become one of the most promising and actively pursued routes towards the practical realisation of fault-tolerant quantum computers. In this talk, I will show how recently developed iterative state preparation and optimisation techniques [1] as well as efficiently measurable local entanglement witnesses constitute valuable, scalable tools for the control and characterisation of correlated many-particle quantum systems. I will illustrate how these techniques have been essential in the recent realisation of a minimal topological color code with trapped ions [2], and I will comment on ongoing work on fault-tolerant coupling of logical qubits of increasing size and robustness.

[1] M. Müller et al., *Iterative Phase Optimization of Elementary Quantum Error Correcting Codes*, Phys. Rev. X **6**, 031030 (2016).

[2] D. Nigg, M. Müller et al., *Quantum computations on a topologically encoded qubit*, Science **345**, 302 (2014).