Topological Codes and Computation - Syllabus
[15 lectures]
Dr Dan Browne

Prerequisites - Quantum Mechanics, Fundamentals of quantum computation (qubits, quantum gates) and quantum error correction.

Syllabus

Revision of Quantum Error Correcting Codes and the Stabilizer formalism [2-3 lectures]
Simple example - repetition code. Stabilizer code formalism. Error detection (quantum circuit) and correction in the stabiliser formalism.

Toric code [3 lectures]
Introduction - practical advantages of the topological approach to quantum codes

Elements of Topology [1-2 lectures]
Continuous deformation (homeomorphism) and topologically equivalent objects.
$\mathbb{Z}_2$ Homology

Toric code reprised [1 lecture]
Toric code in the language of homology
Toric code as the ground state of a many-body Hamiltonian. Self-correcting memories.
3-D and 4-D toric codes.

Planar code [2 lectures]

Elements of Fault tolerant quantum computation [3-4 lectures]
Preparation of logical qubit states and logical measurement. Encoded logical gates. Universal gate sets. CNOT Hadamard
State injection. Phase gate and "T-gate".
(if time) Error correction with faulty measurements. 3D lattice. Decoder. Thresholds.
(if time) Magic state distillation
(if time) Surface code computation and anionic topological computation

Experimental status and outlook [1 lecture]
Current experimental status of surface code architecture quantum computing. Outlook and challenges.