Suppressing noises with topology and dynamical decoupling

High-quality qubits are essential components of practical quantum computers. However, physical qubits inevitably interact with their environments, which causes decoherence and dissipation. To overcome this problem, one may employ an approach to isolate the qubits from their environments. Dynamical decoupling is a strong candidate, and it protects qubits by repeatedly applying some operations to average out the unwanted interactions.

To date, existing dynamical decoupling proposals mainly focus on designing decoupling operators and optimizing intervals of the application of the operators. Little work has considered the topology factors in these schemes, such as where the qubits are placed and what one can benefit from such an arrangement. Here, Zhang et al. [1] from Tsinghua University have considered the case where a set of qubits is placed on a topological non-trivial surface. Explicitly, each qubit is attached to an edge of a two-dimensional square lattice embedded in a torus. They designed novel dynamical decoupling proposals based on the topological equivalence classes of the circles on the surface. For example, by using the circles belonging to the topologically trivial equivalence class in the original and dual lattices, they developed a procedure to remove all unwanted local interactions with the environments from the dynamics of the qubits. Moreover, they also designed two 4-ordered decoupling groups, each element of which is related to a different topological equivalence class in the original or dual lattice.

One significant advantage of their proposals is that the topologically dynamical decoupling schemes can work together with quantum error correction surface codes, so as to greatly reduce the threshold required to perform faithful quantum information processing. Meanwhile, their proposals can be realized with bounded-strength Hamiltonians, and thus are experimentally feasible.

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1 J. Zhang, X.-D. Yu, G.-L. Long, and Q.-K. Xue, *Sci. China-Phys. Mech. Astron.* **62**, 120362 (2019).