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Using symmetric qubit clusters to protect quantum computation

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We propose to use 4-level systems with an additional symmetry to encode pairs of coupled qubits. The chosen symmetry allows clusters to perform universal quantum computation on their encoded qubits, and gives full control over their energy spectrum. Each level can be dynamically decoupled from its immediate environment, modelled by its tunneling-coupling to a semi-infinite lead, turning the clusters into memory units when needed. We show that cluster quantum operations are symmetry-protected against unbiased noise, even when dynamically coupled to the leads. Finally, we discuss possible physical implementations, and a scalable scheme of resonator-coupled clusters.

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