Error correction for Fibonacci quasiparticle poisoning

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Abstract

Topological quantum computers encode information in global and topological properties of quantum systems that are resistant to local perturbations [1]. This makes this type of information processing very promising in the future. However, it is possible that the effects of finite temperature can introduce some inevitable errors. This event is known as quasiparticle poisoning.

We consider a quasiparticle pair creation error process where a particle and its antiparticle are created from the vacuum. One of them might interact with the anyons in our system by fusing with them. Such interaction is described by a unitary operation accounting for all the possible fusion outcomes.

We use the diagrammatic algebra for anyonic theories [2] to study different types of quasiparticle poisoning on Fibonacci anyons. We find the concrete description of the error as a quantum channel. We see that the channels are non-unitary, implying that the process is not reversible. However, the error can be corrected.

Within our set of physically available anyons we identify a qudit subspace that will serve as the code space. We explore different possible encodings that guarantee the shielding against the error or its recoverability.

We focus on the implementation of stabilizer codes [3] as one of these recoverability schemes.

References

[1] Nayak, C., Simon, S. H., Stern, A., Freedman, M., & Sarma, S. D. *Reviews of Modern Physics*, *80*(3), 1083 (2008).
[2] P. Bonderson, K. Shtengel, and J. K. Slingerland, Annals of Physics, 323(11), 2709-2755 (2008).
[3] Gottesman, D., Caltech Ph.D. thesis, https://arxiv.org/abs/quant-ph/9705052 (1997).

Figures

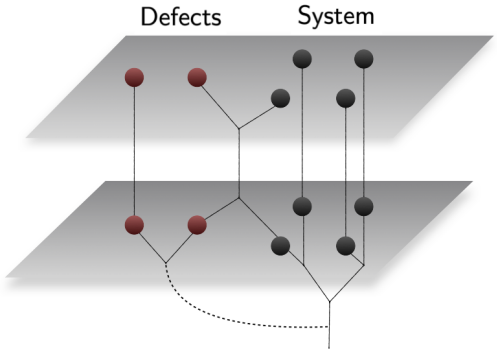

Figure 1: Illustration of the quasiparticle pair (red dots) production and poisoning process in a four-anyon (black dots) system.