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Perfect state transfer, Cayley presentations, and quantum hardware

We study perfect state transfer (PST) on Cayley graphs. Bridging the classical theory of isomorphic Cayley graphs with quantum walks, we show that under mild hypotheses, Cayley graphs of groups with an abelian subgroup of index two, or of extraspecial p-groups with conjugacy-closed connection sets, are also Cayley graphs of abelian groups. Consequently, many known constructions of PST on dihedral, dicyclic, and extraspecial 2-groups are actually non-abelian presentations of abelian Cayley graphs. Conversely, we prove that for odd prime powers $q \geq 5$, the $\mathrm{SL}(2, q)$ graphs of Pantangi and Sin admit no abelian Cayley presentation, giving the first provably non-abelian infinite family of Cayley graphs with PST. We also construct an infinite family of Cayley graphs with peak state transfer.

Finally, I will briefly discuss experiments implementing continuous-time quantum walks with perfect and peak state transfer on a 156-qubit IBM Heron quantum processor.

Based on joint works with Arnbjörg Soffía Árnadóttir (arXiv:2608.20476) and Priscilla Awuah (arXiv:2610.20855).