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Fault-tolerant quantum computation with asymmetric Bacon-Shor codes[1] PETER BROOKS, JOHN PRESKILL, California Institute of Technology — Bacon-Shor codes are quantum subsystem codes which are constructed by combining together two quantum repetition codes, one protecting against Z (phase) errors and the other protecting against X (bit flip) errors. In many situations, for example flux qubits, the noise is biased such that faults that produce Z errors are much more common than faults that produce X errors; in these cases it is natural to consider an asymmetric Bacon-Shor code where the code protecting against Z errors is longer than the code protecting against X errors. This work describes fault-tolerant constructions for gadgets that achieve universal fault-tolerant quantum computation using asymmetric Bacon-Shor codes. Gadgets take advantage of the Bacon-Shor structure by breaking up into parallel smaller gadgets that act on a single row or column, with majority voting of the separate results. For a bias of $\epsilon/\epsilon' = 10^4$, we prove a threshold around 2.5×10^{-3}. The effective error strength is shown to decrease rapidly (faster than polynomial) with decreasing ϵ. Therefore it may be practical to use Bacon-Shor codes directly with no additional concatenation. This could greatly reduce the resource overhead required for fault-tolerant computation with biased noise.

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