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Restless Tuneup of High-Fidelity Qubit Gates[1] M.A. ROL, C.C. BULTINK, QuTech and Kavli Institute of Nanoscience, Delft Univ. Tech., T.E. O'BRIEN, Instituut-Lorentz for Theoretical Physics, , S.R. DE JONG, QuTech and Kavli Institute of Nanoscience, Delft Univ. Tech., L.S. THEIS, Theoretical Physics, Saarland Univ. , X. FU, F. LUTHI, R.F.L. VERMEULEN, J.C. DE STERKE, A. BRUNO, QuTech and Kavli Institute of Nanoscience, Delft Univ. Tech., D. DEURLOO , Netherlands Organization for Applied Scientific Research (TNO) and QuTech, Delft Univ. Tech. , R.N. SCHOUTEN, QuTech and Kavli Institute of Nanoscience, Delft Univ. Tech., F.K. WILHELM, Theoretical Physics, Saarland Univ., L. DICARLO, QuTech and Kavli Institute of Nanoscience, Delft Univ. Tech. — We present a tuneup protocol for qubit gates with tenfold speedup over traditional methods reliant on qubit initialization by energy relax- ation. This speedup is achieved by constructing a cost function for Nelder-Mead optimization from real-time correlation of non-demolition measurements interleaving gate operations without pause. Applying the protocol on a transmon qubit achieves 0.999 average Clifford fidelity in one minute, as independently verified using randomized benchmarking and gate set tomography. The adjustable sensitivity of the cost function allows detecting fractional reductions in gate error with constant signal- to-noise ratio. The restless concept here demonstrated can be readily extended to the tuneup of two-qubit gates and measurement operations.

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