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Greater quantum efficiency through physics-aware system software

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Abstract

Quantum computing is at an inflection point, where 127-qubit machines are deployed, and 1000-qubit machines are perhaps only a few years away. These machines have the potential to fundamentally change our concept of what is computable and demonstrate practical applications in areas such as quantum chemistry, optimization, and quantum simulation.

Yet a significant resource gap remains between practical quantum algorithms and real machines. A promising approach to closing this gap is to design software that is aware of the key physical properties of emerging quantum technologies. I will illustrate this approach with some of our recent work that focuses on techniques that break traditional abstractions and inform hardware design, including compiling programs directly to analog control pulses, computing with ternary quantum bits, 2.5D architectures for surface codes, and exploiting long-distance communication and tolerating atom loss in neutral-atom machines.