Ultrafast intercore computation between distant solid-state QPUs

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Abstract: Modular solid-state hardware combines quantum gates with communication between different QPUs softening upscaling problems. Ultrastrongly coupled QPUs and virtual interconnects may alloew to achieve ultrafast intercore communication with rates comparable to intracore gates.

Modular hardware platform integrate interconnected quantum different QPUs onto a customized circuit. Interest in exploiting such on-chip structures of dense architectures of solid-state qubits stems from their potentiality in softening problems faced with upscaling [1], such as correlated decoherence, complexity of control, crosstalk and reliability of the components, or providing infrastructures for power supply and cooling. They should combine quantum gates with quantum communication between different cores. Despite the lessons of classical computing, a very mature technology in which links are inevitably slower over each scale of distance, we propose an interlink structure performing communication tasks with rates and fidelities comparable with those expected for short-range, intracore operations [2]. To this end we exploit a multiqubit structure where solid-state artifical atoms are ultrastrongly coupled to quantized harmonic modes modelling the interconnects. However, faster dynamics has a cost in terms of fidelity since interaction do not conserve the number of excitations inducing errors in quantum operations [3]. We propose a protocol based on adiabatic coherent transport using the interconnect as a virtual quantum bus [4,5] showing that unrecoverable errors due to the dynamical Casimir effect are suppressed. Further errors are to the renormalization of the low-energy effective Hamiltonian describing the computational space. We show that these errors are correctable by local operations solving the tradeoff between ultrastrong coupling and adiabatic control to achieve robust unltrafast communication for intercore operation as state transfer and swapping, entanglement sharing and multipartite entanglement generation [2].

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