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Scalable architecture for quantum information processing with superconducting qubits based on spin-dependent forces PIERRE-MARIE BILLANGEON, YASUNOBU NAKAMURA, RCAST, The University of Tokyo/CEMS, RIKEN — We introduce a circuit implementing longitudinal spin-dependent forces with superconducting qubits, similarly to ion trap experiments. Our strategy is adapted to fixed frequency qubits, thus avoiding issues inherent to approaches based on tunable-gap qubits such as the presence of fixed quadratic couplings and an extra sensitivity to dephasing. We describe how to implement high-fidelity and fast controlled phase gates in one step. We also present a readout scheme based on a selective light-amplification mechanism induced by the simultaneous application of a spin-dependent force and a linear drive of the resonator. This method takes advantage of the nonlinearity in the bosonic contribution to the tunable interaction. We estimate the backaction on the qubit relaxation rate of a source of flux noise coupled to the circuit mediating the interaction. Our scheme can be readily adapted to transmon qubits and three-junction flux qubits. The absence of static interactions between atomic and photonic degrees of freedom naturally circumvents issues such as residual interactions, restrictions associated to the justification of the rotating wave approximation and correlated noise. This scheme can be scaled up to devise a large-scale quantum register.

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