Suppression of coherent errors in Cross-Resonance gates via recursive DRAG

Presenter: Boxi Li
Affiliation: Forschungszentrum Jülich, PGI-8 Quantum Control
E-Mail: b.li@fz-Juelich.de
Co-Authors: Tommaso Calarco, Felix Motzoi
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Abstract: The high-precision control of quantum logical operations with high fidelity is a prerequisite to increasing circuit depths in quantum processors, implementing useful quantum algorithms, and reaching fault-tolerant scalable architectures. A ubiquitous approach used for entangling gates has been all-microwave control of superconducting qubits, primarily using the Cross-Resonance 2-qubit gate. However, fidelities have stalled around the 99% range. Here, we derive an analytical scheme for significantly improving fidelities in Cross-Resonance gates, effectively reducing coherent errors by about 3 orders of magnitude compared to existing pulse shapes. Our approach uses a simple recursive composition of DRAG pulses derived for each spurious coupling in the corresponding two-level subspace and a cancellation tone on the target qubit, without the requirement of new control hardware.

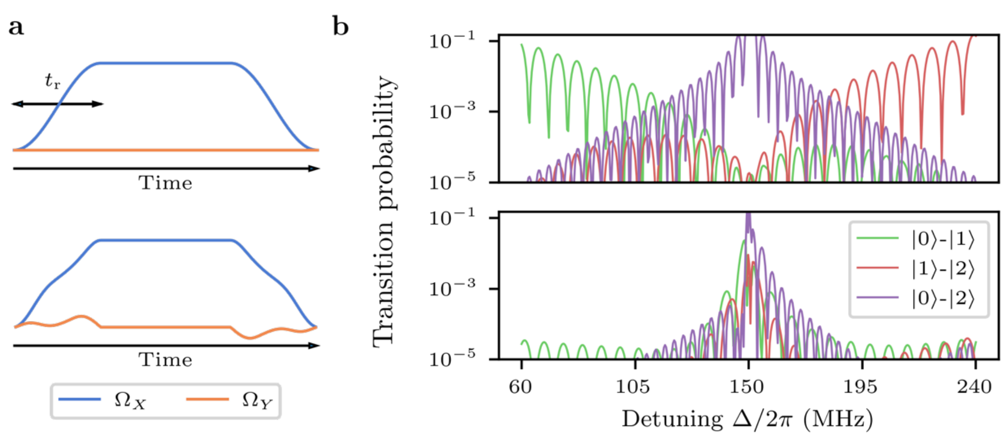

Figure 1: **(a):** Schematic illustration of a Tukey pulse shape (top) and a derived CR pulse to suppress the transition errors on the control qubit (bottom). **(b):** The probabilities of unwanted transitions among the 3 lowest levels of the control qubit introduced by two CR drives that are plotted in (a). Parameters used are $\Omega_{\text{max}}/2\pi = 30$ MHz, $\Delta/2\pi = -300$ MHz, and $t_r = 10$ ns.