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Towards fault-tolerant quantum computation based on near-field microwaves with trapped ions

The fault-tolerant regime allows a quantum computer to perform a quantum algorithm with arbitrary precision. To do so it is necessary to perform all single-qubit and two-qubit entangling gates with a low enough infidelity. In the context of trapped-ion quantum computing, operations based on microwaves are an alternative to the more diffused laser driven operations. Due to their lower frequencies, microwave gates are not limited by the errors induced by photon scattering typical of optical gates. For surface-electrode ion traps it is possible to embed the required microwave conductors directly into the trap structure to generate the oscillating magnetic field for single-qubit and multi-qubit gates [1]. I will report the results from our experiment where we have achieved a two-qubit entangling gate infidelity in the 10-3 range [2]. I will discuss how amplitude modulation of the microwave signal has been used to increase the robustness of such gates against one of the biggest sources of infidelities, motional mode frequency fluctuations. To realize a scalable ion trap processor based on microwaves, it is possible to use a novel fabrication method developed in our group [3-4]. The use of high-fidelity operations, combined with a scalable trap structure, opens the possibility to perform large scale quantum computation in the near future.

[1] C. Ospelkaus et al., Phys. Rev. Lett. 101 090502 (2008)
[2] G. Zarantonello et al., Phys. Rev. Lett. 123 260503 (2019)
[3] A. Bautista-Salvador et al., New. J. Phys. 21 043011 (2019)
[4] H. Hahn, G. Zarantonello et al., App. Phys. B 125 154 (2019)

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