MAGNETIC FLUX SENSOR BASED ON A SUPERCONDUCTING CIRCUIT

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Many important quantum algorithms, like Shor's factorization algorithm [1] and Lloyd's algorithm [2] for solving a system of linear equations, employ phase estimation algorithms. The latter allow for a fast extraction of information stored in a quantum state of a system. Besides its applicability in quantum computing and quantum information processing, phase estimation is at the core of quantum metrological measurements. In this kind of measurements one estimates an unknown parameter λ, which in a most common situation determines the energy states of the system. The energy states can be measured through an estimation of a phase $\phi = E(\lambda)\tau/\hbar$ accumulated by the system during its time evolution τ. Fast estimation of the phase can be realized in a coherent quantum system, where the phase precision is limited by the Heisenberg relation $\Delta E \geq 2\pi\hbar/\tau$, whereas in a standard classical measurement the precision is restricted by a shot noise limit $\sim\ 1/\sqrt{\tau}$. This opens a resource to make the phase estimation faster.

Nowadays the Heisenberg limit can be reached with the use of two major classes of phase estimation algorithms: first one suggested by Kitaev [3] and another one originated from the quantum Fourier transform.

Here we show how to implement suitably modified Kitaev- and Fourier algorithms on a transmon type qubit in a superconducting quantum circuit architecture, and use it as a Heisenberg limited sensor of magnetic flux. Our experiment paves the way for the use of superconducting qubits as metrological devices.

[1] P.W. Shor, "Algorithms for quantum computation: discrete logarithms and factorizing", *Proceedings of the 35th Annual Symposium on Foundations of Computer Science (IEEE Computer Science Press, 1994), pp. 124-134*

[2] A.W. Harrow, A. Hassidim, and S. Lloyd, "Quantum algorithm for solving linear systems of equations", *Phys.Rev.Lett.* **15**, *150502 (2009)*

[3] A.Yu. Kitaev, "Quantum measurements and the Abelian stabilizer problem", *arXiv:quant-ph/9511026 (1995)*