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Detection of hidden photon dark matter using the direct excitation of transmon qubits

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We propose a new dark matter detection method utilizing the excitation of superconducting qubits [1]. Assuming the hidden photon dark matter of a mass of $O(10)$ μeV, the classical wave-matter oscillation induces an effective ac electric field via the small kinetic mixing with the ordinary photon. This serves as a coherent drive field for a qubit when it is resonant, evolving it from the ground state towards the first-excited state. We evaluate the rate of such evolution and observable excitations in the measurements, as well as the search sensitivity to the hidden photon dark matter. For a selected mass, one can reach $\epsilon \sim 10^{-12} - 10^{-13}$ (where ϵ is the kinetic mixing parameter of the hidden photon) with a few tens of seconds using a single standard transmon qubit. While the absolute expected sensitivity does not surpass the conventional haloscope experiments, it has a significant advantage in the frequency tunability using the SQUID-based qubit, with which a mass scan over 1-10 GHz can be achieved. The volume-independent nature of the sensitivity is also promising for searches in the high frequency regime ($>$10 GHz). The sensitivity scalability along the number of qubits also makes it a promising scheme in accord to the rapid evolution of the superconducting quantum computer technology.

[1] arXiv: 2212.03884

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