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Enhancing Microwave Photon Counting: Superconducting Qubits and Traveling Wave Amplifiers in Quantum Sensing

Quantum Sensing is a rapidly expanding field with applications in Fundamental Physics, including Dark Matter (DM) search. Recent progress in superconducting qubits has enabled enhanced sensitivity and reduced dark count rates in microwave photon detection experiments. The INFN Qub-IT project aims to develop an itinerant qubit-based single-photon counter able to exploit Quantum Non-Demolition techniques in the search for axion-like DM. The design of Qub-IT's superconducting qubits have been optimized through in-depth simulations and will be fabricated at the Bruno Kessler Foundation (FBK) and the Institute of Photonics and Nanotechnology (CNR-IFN).
Qub-IT will benefit from the use of Travelling Wave Parametric Amplifiers (TWPAs) developed within the DARTWARS project. Such devices will offer broadband amplification with quantum or near-quantum limited noise, crucial for high-fidelity and multiplexed qubit readout. To achieve efficient readout we rely on RF engineering and Qibo, a full-stack open source software under development by the University of Milan and the Technology Innovation Institute in Abu Dhabi. This collaboration aims to advance microwave single-photon detection and broaden the qubit readout capabilities in Quantum Sensing.

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