Highlights

RESEARCH AREA 3 - Quantum Science and technologies - 2024

Investigating pump harmonics generation in a SNAIL-based traveling wave parametric amplifier

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JTWPA devices have been successfully implemented as quantum-noise-limited amplifiers and they recently became key tools in quantum science and technology in the microwave regime, for example for the readout of solid-state qubits and for the generation of microwave squeezed states. However, JTWPAs' broadband nature comes with the disadvantage of admitting the activation of spurious nonlinear processes, such as harmonics generation, that can potentially degrade amplification performance. Understanding the origine of such spurious modes is a key open problem in current research with these devices.

Here we provide an answer to such open problem by reporting for the first time a detailed experimental investigation of the dominant pump harmonics in a prototypical JTWPA characterized by a superconducting nonlinear asymmetric inductive element (SNAIL)-based unit cell (Fig 1).

By comparing experimental results (Fig 2) with transient numerical simulations, we demonstrate the impact of Josephson junctions' fabrication imperfections on the generation of pump's harmonics and on gain performance.

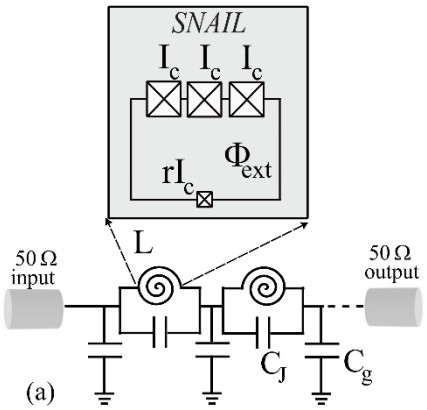

Fig. 1: Sketch of the device (a). Cg is the capacitance to ground, CJ the Josephson capacitance and L the inductance per unit cell. The SNAIL are shown with opposite orientation for adjacent cells indicating the alternated flux polarity. The inset sketches the SNAIL element which includes three large JJs with critical current Ic and one small JJ with critical current r Ic.

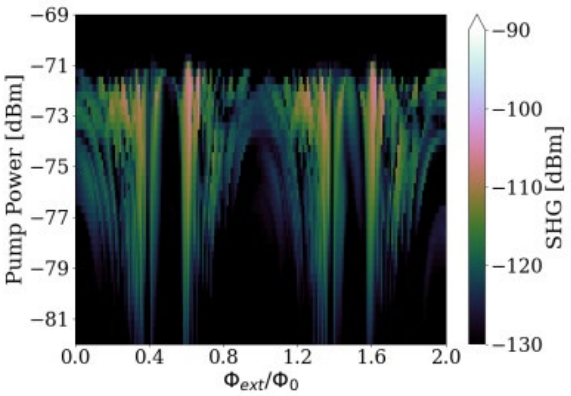

Fig. 2: Experimental study of harmonics generation. Second Harmonic Generation (SHG) of the pump measured with a Spectrum Analyzer as a function of pump power and applied flux. Pump frequency fp = 4GHz, signal frequency fs = 3.9GHz, signal power at device input Ps = −110dBm.

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