Abstract
Superconducting quantum-limited parametric amplifiers (QPA), ideal for linear detection of weak signals, have become indispensable components for microwave quantum systems. The state-of-art QPA’s exploit the strong nonlinearity of a Josephson junction. However, the junction based QPA is sensitive to magnetic fields, necessitating the use of a magnetic shield in operation. Therefore they are incompatible with quantum systems that operate with magnetic fields. In this work, we present a quantum-limited amplifier made from NbN thin films. The nonlinearity originates from the kinetic inductance of the NbN nanobridge. We show that when operated in either phase-sensitive or phase-preserving mode, the added noise of our amplifier approaches the quantum limit.

Device Fabrication
KPA, which stands for Kinetic-inductance Parametric Amplifier, is a novel superconducting parametric amplifier suitable for environment with external magnetic field.

Design
KPA is designed as a nanowire shunted by an interdigital capacitor, forming a LC resonator. The nanowire has high-kinetic inductance, which provides the anharmonicity to the resonator.

Characterization
This particular device has a resonance frequency at 7.55 GHz, with an external coupling rate of 75 MHz to the coaxial cable.

Measurement scheme and results

Measurement Scheme

Phase sensitive and preserving amplification

Added noise calibration

An additional pair of interdigital capacitor couples the resonator to the microwave transmission line capacitively.

Outlook
For the next step, we installed a magnetic coil in the dilution refrigerator, which cools the device to 8 mK, to enable superconductivity, and suppress thermal excitations. A pair of drives, each blue or red-detuned from the resonance by 102 MHz, is applied to the KPA device. The reflection gain responses are measured using a weak coherent probing signal.

Phase preserving (top figure) is operated when the probe frequency is detuned from the mean of the two drive frequencies, while phase sensitive (bottom figure) is when the probe frequency is equal to the mean. Here a 45 dB gain is recorded.

Acknowledgements
The work is supported by ARO grant W911NF-18-1-0020, and Office of Naval Research N00014-20-1-2126. The authors thank Professor Michel Devoret, Gangqiang Liu for insightful discussions. The authors thank Michael Rooks, Yong Sun, Kelly Woods, Sean Rinehart for support in nano-fabrications.

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