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Ultra low noise readout with Travelling wave parametric amplifiers: the DARTWARS project

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Noise at the quantum limit over a large bandwidth is a fundamental requirement in forthcoming particle physics applications operating at low temperatures, such as neutrino measurements, x-ray observations, CMB measurements, and axion dark matter detection—involving MKIDs, TESs and microwave resonant cavity detectors—as well as in quantum technology applications, as the high-fidelity readout of qubits. The readout sensitivity of these detectors is currently limited by the noise temperature and bandwidth of available cryogenic amplifiers such as HEMTs or JPAs. The DARTWARS (Detector Array Readout with Traveling Wave AmplifieRS) project has the goal of developing high-performing innovative traveling wave parametric amplifiers with high gain, high saturation power, and nearly quantum-limited noise. The practical development follows two different promising approaches, one of which is based on Josephson junctions and is presented in this contribution: the Josephson Traveling Wave Parametric Amplifier (JTWPA).

Our JTWPA is designed as a coplanar waveguide embedded with a serial array of nonhysteretic single-junction cells of rf-SQUIDs, which allow to operate both in 3-wave-mixing and 4-wave-mixing mode. To avoid the presence of additional undesired tones besides the signal and idler, two layouts are currently being studied, the resonant phase matching and the quasi-phase matching.

A preliminary characterization was performed on a prototype JTWPA with 990 cells, in a dilution refrigerator with base temperature 15 mK. The operation in 3-wave-mixing was demonstrated, although with some nonhomogeneity issues, and a gain of about 25 dB was obtained.

The next step consists in improving the homogeneity of junctions: a sample of junctions with critical current 4 μA and self-capacitance 225 fF was fabricated. Their room-temperature normal resistances were tested with a probe-station, showing a good resistance spread between 5% and 10%.

Collaboration

DARTWARS collaboration

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