



Contribution ID: 24

Type: **not specified**

Wide-Band Haloscope Read-Out Using Flux-Driven Josephson Parametric Amplifier

Monday, 3 July 2023 17:29 (3 minutes)

This article presents the development of a broadband haloscope read-out based on a flux-driven Josephson Parametric Amplifier (JPA). While the JPA offers extremely low noise close to the quantum noise limit, initial devices had a tunable frequency range of 30 MHz, which required frequent warm-up and replacement. This results in a significant loss of time and the use of large amounts of liquid helium. To match the haloscope resonator's 200-300 MHz frequency range, we devised methods to extend the JPA's bandwidth to 300 MHz. These methods involve improvements to the JPA design by optimizing the inductance and critical current of the Josephson junction, as well as the creation of new JPA designs. In addition, we tested the implementation of multiple JPAs in a single read-out line. We tested using a switch to multiplex multiple amplifiers, and combining the amplifiers by connecting them in parallel, in series, and series-parallel combinations. This made it possible to achieve a bandwidth of up to 300 MHz without increasing the added noise due to the amplifiers. This article presents design details and test techniques for these multi-channel circuits.

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Session Classification: Poster Session