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dc-SQUID readout scheme with high dynamic range and intrinsic MHz frequency-domain multiplexing capability

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Direct-current superconducting quantum interference devices (dc-SQUIDs) are among the most sensitive wideband devices for measuring any physical quantity that can be naturally converted into magnetic flux. Therefore, they are ideally suited, for example, for reading out cryogenic particle detectors such as transition edge sensors or metallic magnetic calorimeters. However, SQUIDs are intrinsically non-linear devices due to their periodic flux-to-output signal characteristics. For this reason, their linear flux range is rather small and for many applications a flux-locked loop (FLL) circuit to linearize the relation between the SQUID input and output signal is employed. Despite the great success of this technique, FLL operation requires feedback wires routed to each SQUID often setting a practical limit for modern multichannel SQUID-systems.
In this contribution, we present a novel readout scheme for dc-SQUIDs that provides linearization of the SQUID output without the need for individual feedback wires. At the same time, it allows for setting up an easy-to-use MHz frequency-division SQUID multiplexer not requiring large on-chip filter elements. Moreover, it significantly increases the dynamic range of the SQUID system. Our readout scheme is based on flux ramp modulation which was originally introduced for linearizing the output signals of a microwave SQUID multiplexer. It relies on applying a sawtooth-shaped flux signal to the SQUID to perform a quasi-continuous measurement of the SQUID characteristic. If the amplitude and repetition rate of the flux ramp is appropriately chosen, the input signal is transduced into a phase shift of the SQUID output which depends linearly on the input signal. We will discuss the basic scheme of this technique as well as a comprehensive suitability study, in particular in the context of reading out our cryogenic particle detectors, demonstrating its intrinsic multiplexing capability.

Less than 5 years of experience since completion of Ph.D

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