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Wideband SQUID Amplifiers for Axion Search Experiments

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It was theoretically shown that axions can be detected by converting them to microwave photons inside high-Q cavity resonators in the presence of a strong magnetic field [1]. In such experiments, very weak microwave signals should be scanned in a wide frequency range. The best semiconductor amplifiers have a lowest noise temperature plateau of about 1.1 K even at significantly lower ambient temperature. Superconducting quantum interference devices, or SQUIDs, can work as microwave amplifiers with noise temperature close to the standard quantum limit (SQL), TSQL = hf/kB ≈ 50 mK at 1 GHz [2]. Previously designed SQUID-based high-frequency amplifiers have narrow bandwidth due to a microstrip resonant input coil [3]. It requires serial replacements of SQUID preamplifiers in order to scan a wide frequency range. This procedure is complex and time consuming because of a large mass of hardware should be cooled down below 100 mK. SQUID-based microwave amplifiers with a suitable amplification should be designed with the smallest possible tunnel junction capacitance, with reasonably low SQUID loop inductance, and maximal transfer function at the working point. Sub-micron size Josephson junctions with a very small capacitance 0.04 pF were used for low-frequency SQUID current sensors [4]. We tested a few of such sensors at high frequencies and found out that they can work as both resonant and wideband microwave amplifiers. In this presentation, we report on SQUID-based wideband microwave amplifiers fabricated using sub-micron size Josephson junctions with very low capacitance. A single amplifier can be used for axion search experiments in a frequency range from about 500 MHz to approximately 5 GHz.

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