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Quantum Sensings for the DMRadio Axion Searches

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***Abstract*–The DMRadio suite of experiments probes QCD axion masses from 20 neV to 1 µeV (5kHz-300MHz), including DMRadio-50L (5KHz-5MHz), DMRadio-m^3 (5MHz-300MHz), and DMRadio-GUT (100kHz-30MHz). To probe the most important axion models, DMRadio must measure electromagnetic signals with greater sensitivity than the Standard Quantum Limit (SQL). This sub-SQL sensitivity will be achieved through the use of the radio-frequency quantum upconverter (RQU), which consists of a superconducting resonator loaded by a flux-tunable interferometer made of three Josephson Junctions in two loops. The tunable inductance creates a parametric interaction that upconverts kHz-MHz flux signals onto microwave-frequency tones. The RQU can operate at the SQL with phase-preserving measurement and can beat the SQL with quantum backaction evasion (BAE) protocols that use phase-sensitive operation. This device architecture achieves the extremely high sensitivity to signals over a broad frequency tuning range required by the DMRadio experiments. I will present designs, modeling, and measurement data from first-generation RQUs with a three-junction interferometer. I demonstrate phase-sensitive measurements using these devices, which is the first step towards implementing BAE protocols. I also describe future impact to DMRadio-50L (5kHz-5MHz) as a testbed for developing RQU sensor technology, before its implementation in the DMRadio-GUT experiment (100kHz-30MHz).**

Keywords (Index Terms)– axion detection, RF, parametric, amplifier, quantum-limited, interferometer, superconducting

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