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State of the art RF electronics readout for axion dark matter experiments

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Axion haloscopes are the most promising method to search for dark matter, requiring with a wide coverage from hundreds of MHz up to hundreds of GHz. The detection principle proposed by Sikivie utilizes high quality resonators under a strong magnetic field and its sensitivity is significantly improved using cryogenic low-noise amplifiers. The Center for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS) has designed readout systems based on Josephson parametric amplifiers (JPAs). These readout systems feature noise levels slightly exceeding the standard quantum noise limit. One limitation of a single JPA readout is the scanning frequency range of a single chip. At CAPP, we developed a new technique to extend the scanning range by effectively connecting several JPA chips in parallel. We present the operational principle and main parameters of this design, demonstrating that the noise temperature remains unaffected by the parallel connection. Furthermore, single photon counters can increase the sensitivity and scanning rate in axion experiments. We investigate the possibility of the use of the latest types of microwave photon counters based on biased Josephson junctions and zeptojoule nanobolometers. The detector concept can be applied to the signal variance method developed at CAPP to enhance experimental sensitivity. In this talk, we demonstrate the potential of using both readouts in axion haloscope search experiments and discuss the perspectives of the variance method approach.

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