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Axion dark matter search results around 9.5 μeV at CAPP with a high-temperature superconducting cavity

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Superconducting radio frequency technology has played a significant role in the progress of precision measurements in particle physics experiments for decades. However, the presence of an external magnetic field could limit scientific productivity in many areas where a strong magnetic field is absolutely necessary. One specific example is a dark matter axion haloscope utilizing a microwave cavity (> 1 GHz) immersed in a high DC magnetic field (> 7 T). Having a high quality (Q) factor superconducting cavity would profoundly impact the way axion dark matter experiments are performed. Recently, the Center for Axion and Precision Physics Research (CAPP) successfully fabricated a half-million Q factor HTS cavities made of biaxially-textured GdBCO tapes. High-temperature superconducting (HTS) rare-earth barium copper oxide (ReBCO) is an excellent choice of material for realizing the high Q factor superconducting cavities for the axion search because of its characteristics such as ultra-low RF surface resistances (< 0.1 mOhm) at high magnetic fields and high depinning frequencies (> 10 GHz). The superconducting cavity was implemented in an axion detector with a quantum-noise-limited Josephson parametric amplifier (JPA) to collect axion dark matter physics data. We present the results of an axion dark matter search aiming at an axion mass range of around 9.5 μeV with KSVZ level sensitivity. This work is the first axion search result using an HTS cavity and also demonstrated the lowest total system noise (~190 mK) among published axion haloscope searches in phase-insensitive operations of JPA.

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