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First Operation of the HAYSTAC Dark Matter Axion Experiment with a Squeezed-State Receiver

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The Haloscope At Yale Sensitive To Axion Cold dark matter (HAYSTAC) is a pathfinder and an innovation testbed for the 2.5-12 GHz (10-50 μeV) mass range. Operational since 2015, it has from the beginning utilized Josephson Parametric Amplifiers which have enabled it to achieve a system noise temperature at only 2x the Standard Quantum Limit (SQL), and thus probe in the QCD model band at masses in the 6 GHz range, despite its small volume (1.5 L). We have now implemented a receiver based on a Squeezed-vacuum State Receiver (SSR) in the 4-5 GHz range, which evades the SQL entirely. Coupled with improvements in thermal design, the scan rate has been accelerated by a factor of 5-10, and thermal improvements to be incorporated in the next run should result in another factor of 2 speedup. The status of the experiment and first results from the SSR will be discussed, demonstrating sensitivity to axions at (1.5-2)x the KSVZ model coupling. HAYSTAC is one of the first experiments in the domain of particle astrophysics and cosmology that has utilized squeezed states of vacuum in actual data production, along with LIGO.

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