

Haloscope at Yale Sensitive to Axion CDM (HAYSTAC) Phase I Results and Phase II Upgrades

Wednesday, 22 August 2018 15:40 (30 minutes)

We report on the results from a search for dark matter axions with the HAYSTAC experiment using a microwave cavity detector at frequencies between 5.6-5.8 GHz. We exclude axion models with photon couplings a factor of 2.7 above the benchmark KSVZ model over the mass range $23.15 < m_a < 24.0 \mu\text{eV}$. We achieve a near-quantum-limited sensitivity by operating at a temperature $T < h\nu/2k_B$ and incorporating a Josephson parametric amplifier (JPA), with improvements in the cooling of the cavity further reducing the experiment's system noise temperature to only twice the Standard Quantum Limit at its operational frequency, an order of magnitude better than any other dark matter microwave cavity experiment to date. This result concludes the first phase of the HAYSTAC program. The second phase of the HAYSTAC program will incorporate an updated dilution refrigerator with 3X the cooling power at base temperature, updated cryogenics that improve the quality factor of the cavity by 40%, and a squeezed-vacuum state receiver that promises a 2.3X scan rate enhancement by evading the standard quantum limit for thermal noise.

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