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Search for axion-like dark matter with ferromagnets

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Ultralight axion-like particles are well-motivated dark matter candidates, emerging naturally from theories of physics at ultrahigh energies. We report the results of the Search for Halo Axions with Ferromagnetic Toroids (SHAFT) - a direct search for the electromagnetic interaction of axion-like dark matter in the mass range that spans three decades from 12 peV to 12 neV [1]. The detection scheme is based on a modification of Maxwell's equations in the presence of axion-like dark matter, which mixes with a static magnetic field to produce an oscillating magnetic field. The experiment makes use of toroidal magnets with iron-nickel alloy ferromagnetic powder cores, which enhance the static magnetic field by a factor of 24. Using SQUIDs, we achieve a magnetic sensitivity of $150\,\mathrm{aT}/\sqrt{\mathrm{Hz}}$, at the level of the most sensitive magnetic field measurements demonstrated with any broadband sensor. We recorded 41 hours of data and placed new limits on the magnitude of the axion-like dark matter electromagnetic coupling constant over part of our mass range, at 20 peV reaching 4.0×10^{-11} GeV^{-1} (95\% confidence level). Our measurements are starting to explore the coupling strengths and masses of axion-like particles where mixing with photons could explain the anomalous transparency of the universe to TeV gamma-rays.

[1] Alexander V. Gramolin, Deniz Aybas, Dorian Johnson, Janos Adam & Alexander O. Sushkov, "Search for axion-like dark matter with ferromagnets", *Nature Physics* **17**, 79-84 (2021).

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