Narrowing the theoretical space in which to look for dark matter

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The CAST experiment at CERN. The CAST-CAPP resonator was placed inside one of the two bores of CAST's magnet (blue). Credit: CERN

The CAPP axion haloscope at the CAST experiment has hunted for axions from the Milky Way's "halo" of dark matter, and has narrowed down the theoretical space in which to look for these hypothetical

particles

Hypothetical particles called axions could solve two enigmas at once. They could account for dark matter, the mysterious substance that is thought to make up most of the matter in the universe, and they could also explain the puzzling symmetry properties of the strong force that holds protons and neutrons together in atomic nuclei.

But the theoretical space of possibilities for axions is vast, both in terms of their mass and the strength of their interaction with other particles. Axion searches are therefore targeting different regions of this space, each search bringing with it the possibility of discovery and its results guiding future searches.

In a new paper published in *Nature Communications*, a team of researchers working on the CAST experiment at CERN report how they have repurposed part of the experiment to target a previously uncharted region of the axion space.

CAST was originally designed to hunt for axions originating from the sun. In their new study, the CAST team placed a resonator consisting of four cavities inside one of the two bores of the experiment's magnet in order to build an axion detector that looks instead for axions from the Milky Way's "halo" of dark matter—an axion haloscope, which they named CAST-CAPP.

In a strong magnetic field, such as the one provided by CAST's magnet, axions should convert into photons. An axion haloscope's resonator is basically a radio that researchers can tune to find the frequency of these axion-converted photons. But the frequency of the axion "radio station" is not known, so the researchers must slowly scan a band of frequencies to try to identify the frequency of the axion signal.

The CAST-CAPP resonator can be tuned to pick up axion signals ranging from 4.774 to 5.434 GHz, corresponding to axion masses of between 19.74 and 22.47 microelectronvolts.

The CAST researchers scanned this 660 MHz band of frequencies in steps of 200 kHz for 4124 hours, from 12 September 2019 to 21 June 2021, and isolated known background signals such as the 5 GHz Wireless Local Area Network (WLAN), but did not pick up any signal coming from axions. However, the CAST-CAPP data places new bounds on the maximum strength of the interaction of axions with photons for axion masses of 19.74 to 22.47 microelectronvolts, narrowing down the space in which to look for axion dark matter.

The new bounds are complementary to results from previous axion searches, including those from another CAST haloscope, RADES, which took data in 2018.

The hunt for dark matter continues. Tune in to this station again to check for updates from CAST-CAPP or from other dark-matter investigations taking place at CERN, such as searches for dark matter that may be produced at the Large Hadron Collider.

More information: C. M. Adair et al, Search for Dark Matter Axions with CAST-CAPP, *Nature Communications* (2022). DOI: 10.1038/s41467-022-33913-6

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