Advanced experimental setup expands the hunt for hidden dark matter particles

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Final assembly of germanium radiation detectors for the Majorana Demonstrator in 2015. These detectors produced a low-background, “quiet” data set that researchers used to search for signs of dark matter and other physics beyond the Standard Model. Credit: Matthew Kapust, Sanford Underground Research Facility.

Scientific evidence for dark matter comes from observing how it influences the motion of stars and galaxies. Scientists believe that dark matter may consist of particles. To search for these particles and their billiard ball-like collisions, researchers have used some of the largest, most sensitive experiments ever built.

However, these experiments have yet to see signals of dark matter. Scientists predict that dark matter particles would be very weakly interacting. This means detectors on Earth should be able to sense a "wind" in dark matter particles as the Earth moves through dark matter and collides with a small number of the particles.

Another possibility is that when a rare collision happens, the dark matter may be totally absorbed, generating a tiny jolt of energy. The Majorana Demonstrator is a radiation detector that is very sensitive to this type of interaction. The experiment is deep underground and shielded from ambient radiation such as cosmic rays, and its detectors are extremely sensitive to small jolts of energy.

These features allowed scientists to perform a search five to 10 times more sensitive than similar detectors. The researchers did not detect the expected signal from dark matter. This allows scientists to update the limits on the possible mass of dark matter in several different models. These results are likely to remain the best limits for some time using this particular detector technology.

Understanding the nature and origin of dark matter would completely revolutionize scientists' understanding of the universe. Many theoretical models of dark matter predict that its signals can be detected using low-background radiation detectors.

By looking for specific types of dark matter and finding no signal, scientists operating the Majorana Demonstrator experiment have significantly narrowed the characteristics of potential dark matter particles. Although their study published in the journal *Physical Review Letters* did not directly detect dark matter, it used an approach that can help guide future experiments.

In this research, researchers used an advanced experimental setup with high-purity germanium detectors to search for several types of dark matter, finding no significant signal predicted by several theoretical models. The experiment was conducted at the Sanford Underground Research Facility. A range of universities and laboratories collaborated to conduct the experiment, making a broad, interdisciplinary effort.

The scientific focus was on searching for distinct types of elusive dark matter candidates, including sterile neutrinos and bosonic and fermionic dark matter. If dark matter is ever detected, it would provide dramatic insight into the composition of the universe and physics beyond the Standard Model.

The research also reinforces the Majorana Demonstrator experiment's incredible sensitivity and broad reach to multiple fields of physics. Several important research projects have all used the same underlying Majorana Demonstrator data set.

More information: I. J. Arnquist et al, Exotic Dark Matter Search with the Majorana Demonstrator, *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.041001

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