New data still have scientists in dark over dark matter

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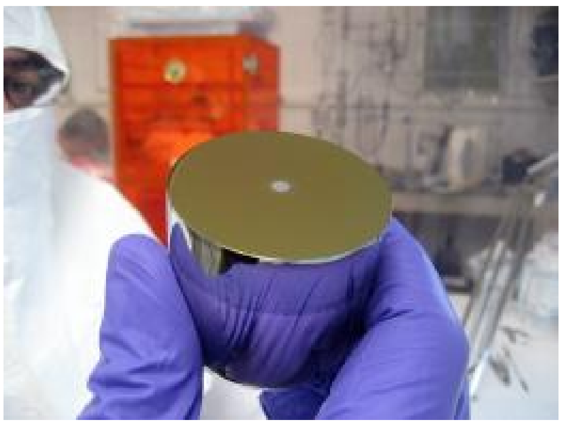

Juan Collar, associate professor in physics, holds one of the early germanium detector prototypes similar to the one being used in the Coherent Germanium Neutrino Technology (CoGeNT) experiment, situated nearly half a mile deep in the Soudan Mine in Minnesota. Such underground locations help screen out false dark-matter signals from other natural sources of radiation. Detectors of this kind are used because of their sensitivity to weak levels of radiation. Courtesy of CoGeNT Collaboration

(PhysOrg.com) -- A dark-matter experiment deep in the Soudan mine of Minnesota now has detected a seasonal signal variation similar to one an Italian experiment has been reporting for more than a decade.

The new seasonal variation, recorded by the Coherent Germanium Neutrino Technology (CoGeNT) experiment, is exactly what theoreticians had predicted if dark matter turned out to be what physicists call Weakly Interacting Massive Particles (WIMPs).

“We cannot call this a WIMP signal. It’s just what you might expect from it,” said Juan Collar, associate professor in physics at the University of Chicago. Collar and John Orrell of Pacific Northwest National Laboratory, who lead the CoGeNT collaboration, are submitting their results in two papers to *Physical Review Letters*.

WIMPS might have caused the signal variation, but it also might be a random fluctuation, a false reading sparked by the experimental apparatus itself or even some exotic new phenomenon in atomic physics, Collar said.

Dark matter accounts for nearly 90 percent of all matter in the universe, yet its identity remains one of the biggest mysteries of modern science. Although dark matter is invisible to telescopes, astronomers know it is there from the gravitational influence it exerts over galaxies.

Theorists had predicted that dark matter experiments would detect an annual modulation because of the relative motion of the Earth and sun with respect to the plane of the Milky Way galaxy.

University of Chicago physicist Juan Collar (left) and University of Washington graduate student Mike Marino inspect the CoGeNT experiment at the Soudan Mine in Minnesota. CoGeNT has detected a seasonal signal variation during its first year of operation. This is what scientists would expect if dark matter is made of Weakly Interacting Massive Particles (WIMPs), but the CoGeNT collaboration considers the results to be inconclusive. Courtesy of CoGeNT Collaboration

The sun moves in the plane of the galaxy on the outskirts of one of its spiral arms at a speed of 220 kilometers per second (136 miles per second). The Earth orbits the sun at 15 kilometers per second (18.5 miles per second). During winter, Earth moves in roughly the opposite direction of the sun's movement through the galaxy, but during summer, their motion becomes nearly aligned in the same direction. This alignment increases Earth's net velocity through a galactic halo of dark matter particles, whose existence scientists have inferred from numerous astronomical observations.

Like a cloud of gnats

WIMPs would be moving in random directions in this halo, at velocities similar to the sun's. "You find yourself in a situation similar to a car moving through a cloud of gnats," Collar explained. "The faster the car goes, the more gnats will hit the front windshield."

CoGeNT seems to have detected an average of one WIMP particle interaction per day throughout its 15 months of operation, with a seasonal variation of approximately 16 percent. Energy measurements are consistent with a WIMP mass of approximately 6 to 10 times the mass of a proton.

These results could be consistent with those of the Italian DArk MAtter (DAMA) experiment, which has detected a seasonal modulation for years. "We are in the very unfortunate situation where you cannot tell if we are barely excluding DAMA or barely in agreement. We have to clarify that," Collar said.

In particle physics, he further cautioned, agreement between two or three experiments doesn't necessarily mean much. The pentaquark is a case in point. Early this century, approximately 10 experiments found hints of evidence for the pentaquark, a particle consisting of five quarks, when no other known particle had more than three. But as time went on, new experiments were unable to see it.

"It's just incredible," said UChicago physics Professor Jonathan Rosner. "People still speculate on whether it's real."

Collar and his colleagues have calculated the probability that their finding is a fluke to be five-tenths of a percent, or 2.8 sigma in particle physics parlance.

“It’s not an exact science yet, unfortunately,” Collar said. “But with the information we have, the usual set of assumptions that we make about the halo and these particles, their behavior in this halo, things seem to be what you would expect.”

Other dark-matter experiments, including Xenon100, have not detected the seasonal signal that CoGeNT and DAMA have reported.

“If you really wanted to see an effect, you could argue that the Xenon100 people don’t have the sensitivity to Juan’s result,” said Rosner, who is not a member of the CoGeNT collaboration. “On the other hand, they’ve done a number of studies of what their sensitivity is at low energies and they believe they’re excluding this result.”

Interrupted by fire

CoGeNT operated from December 2009 until interrupted by a fire in the Soudan mine in March 2011. Fifteen months of data collection is a relatively brief period for a dark-matter experiment. In fact, Collar and his colleagues decided to examine the data now only because the fire had stopped the experiment, at least temporarily.

The fire did not directly affect the experiment, but the CoGeNT team has not been able to examine the detector because of clean-up efforts. The detector may no longer work, or if it does work, it may now have different properties.

“This effect that we’re seeing is touch-and-go. It’s something where you have to keep the detector exquisitely stable,” Collar said. If a single key characteristic of the detector has changed, such as its electronic noise, "We may be unable to look for this modulation with it from now on."

The putative mass of the WIMP particles that CoGeNT possibly has detected ranges from six to 10 billion electron volts, or approximately seven times the mass of a proton. "To look for WIMPs 10 times heavier is hard enough. If they're this light, it becomes a nightmare," Collar said.

More information:
The papers are available at:

arxiv.org/abs/1106.0650
arxiv.org/abs/1106.0653

Provided by University of Chicago

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