Second experiment hints at seasonal dark matter signal

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Things just got a little less lonely for researchers who have been insisting for years not only that their experiment has found dark matter, but also that the dark matter signal varies with the seasons. Now a second experiment, called CoGeNT, is reporting similar findings, though both results are in conflict with two other teams' observations.

The Soudan mine is home to the CoGeNT experiment (Image: ShakataGaNai/(CC BY-SA 3.0))

No one knows what dark matter is – astronomers merely detect its gravitational pull on normal matter, which it seems to outweigh by a factor of five to one. But many researchers believe it is made of theoretical particles called WIMPs, which interact only weakly with normal matter.

Since 1998, researchers running the DAMA experiment deep inside the Gran Sasso mountain in Italy have claimed to have found evidence of WIMPs.

DAMA uses an array of sodium iodide detectors to spot the rare moments when WIMPs slam into atoms in the detectors, producing flashes of light. The number of flashes ebbs and flows with the seasons, and DAMA team members argue that this is because Earth's velocity relative to the surrounding sea of dark matter changes as the planet orbits the sun. They say their observations could be explained by a WIMP weighing a few gigaelectronvolts.

Tense situation

However two other experiments have found no sign of dark matter with their detectors. One, called XENON100, uses 100 kilograms of liquid xenon deep below Gran Sasso mountain, and the other, called CDMS II, uses ultra-pure crystals of germanium and silicon housed in a deep mine in , Minnesota.

Both experiments are so sensitive that they should have seen dark matter if the DAMA result is due

to WIMPs. "The situation has created tension," says Dan Hooper, a theorist at the University of Chicago in Illinois.

Now another dark matter experiment called CoGeNT has found a seasonal variation in its results, reports team leader Juan Collar, who presented an analysis of 442 days of observations at the American Physical Society meeting in Anaheim, California, on Monday.

"We tried like everyone else to shut down DAMA, but what happened was slightly different," Collar said during his presentation.

Germanium crystal

The CoGeNT detector is tiny compared with many other dark matter experiments. It comprises a 440-gram crystal of germanium. Still, dark matter is so abundant that 100 million particles of it are expected to pass through the CoGeNT detector every second.

About once a day, one of these will wallop a germanium nucleus, sending the nucleus careering through the crystal, where it rips electrons from neighbouring atoms. An electric field sweeps these electrons towards an electrode to produce a tiny electrical signal.

Previously, the CoGeNT team reported an excess of events when it ran its experiment in the Soudan mine for 56 days (*Physical Review Letters*, DOI: 10.1103/PhysRevLett.106.131301). Team members said the excess could be due to some kind of background noise that physicists don't understand, or potentially to WIMPs weighing 7 GeV.

'Smoking gun'?

The experiment kept running continuously until a fire in the Soudan mine on 17 March halted observations. This motivated Collar and his colleagues to look for a seasonal variation in the 442 days of observations they had already collected. "I hope this isn't the final data we have taken," says Collar, who has not yet been allowed to return to the Soudan mine to check for damage.

The CoGeNT team finds that their signal changes with the seasons in exactly the same way as the DAMA result does. And it is consistent with a low-mass dark matter particle, like that reported by DAMA.

"The annual modulation is the closest thing to a smoking gun [for dark matter]," says theorist Jonathan Feng at the University of California, Irvine, who is not part of the CoGeNT team. "This is the first evidence we've seen it somewhere other than DAMA."

Weird WIMP

But Laura Baudis at the University of Zurich in Switzerland, who reported at the meeting on Monday that XENON100 still had seen no signs of dark matter, is not sure what to make of the results: "I

need time to think about them."

Feng suggests that the discrepancy among all the experimental results may simply be due to the assumption that WIMPs interact the same way with protons and neutrons. If this is not the case, that could explain differences in the signals from xenon and germanium detectors, which each have a different ratio of protons to neutrons (arxiv.org/abs/1102.4331). "These experiments may look inconsistent, but a small theoretical tweak can bring everything in to line," he told *New Scientist*.

Both the CoGeNT and XENON100 teams are planning to enlarge their experiments. Approval has just been given to build the XENON1T experiment in the Gran Sasso mine, which will use 1 tonne of liquid xenon. And the CoGeNT team is planning to replace its single germanium crystal with four separate crystals, each weighing 1 kilogram, starting later this year.

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