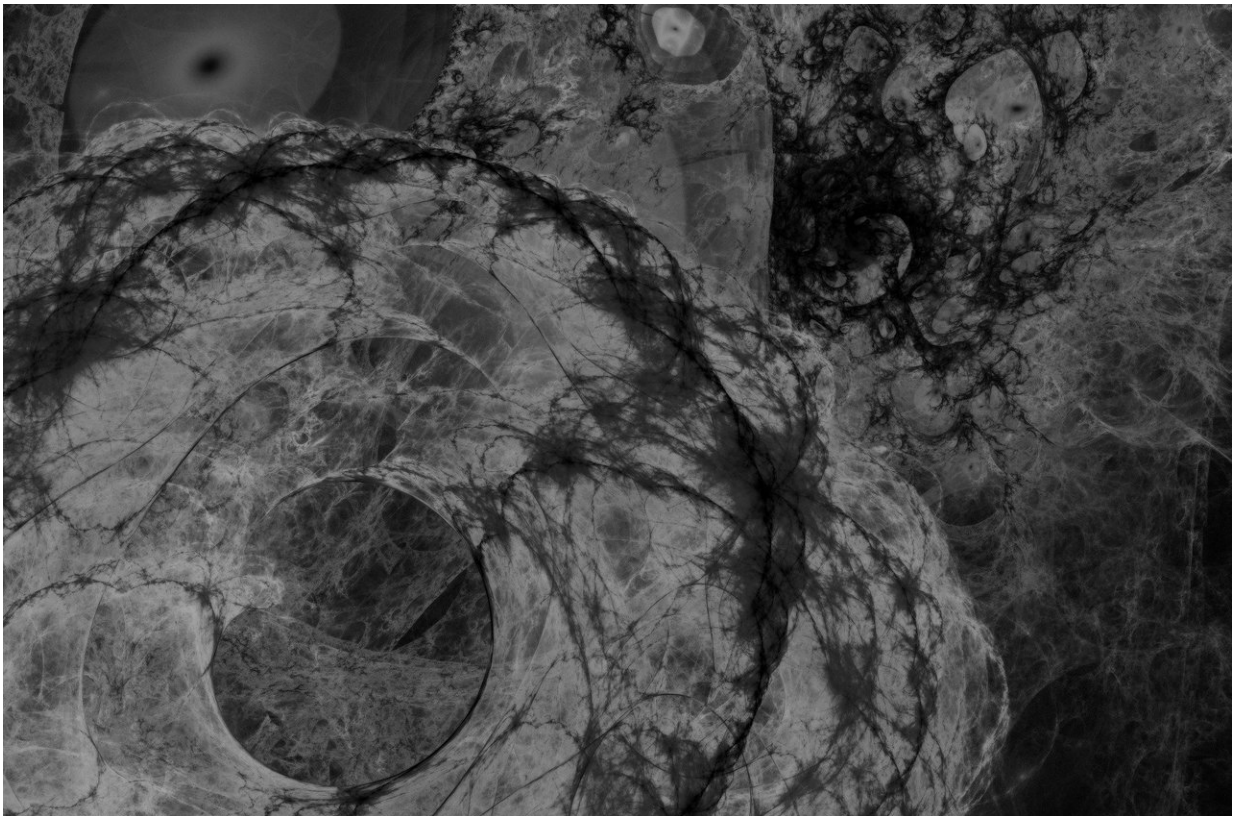


Have we detected dark energy? Scientists say it's a possibility

September 15 2021



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A new study, led by researchers at the University of Cambridge and reported in the journal *Physical Review D*, suggests that some unexplained results from the XENON1T experiment in Italy may have

been caused by dark energy, and not the dark matter the experiment was designed to detect.

They constructed a physical model to help explain the results, which may have originated from [dark energy](#) particles produced in a region of the Sun with strong magnetic fields, although future experiments will be required to confirm this explanation. The researchers say their study could be an important step toward the direct detection of dark energy.

Everything our eyes can see in the skies and in our everyday world—from tiny moons to massive galaxies, from ants to blue whales—makes up less than five percent of the universe. The rest is dark. About 27% is dark matter—the invisible force holding galaxies and the cosmic web together—while 68% is dark energy, which causes the universe to expand at an accelerated rate.

"Despite both components being invisible, we know a lot more about dark matter, since its existence was suggested as early as the 1920s, while dark energy wasn't discovered until 1998," said Dr. Sunny Vagnozzi from Cambridge's Kavli Institute for Cosmology, the paper's first author. "Large-scale experiments like XENON1T have been designed to directly detect dark matter, by searching for signs of dark matter 'hitting' ordinary matter, but dark energy is even more elusive."

To detect dark energy, scientists generally look for gravitational interactions: the way gravity pulls objects around. And on the largest scales, the gravitational effect of dark energy is repulsive, pulling things away from each other and making the Universe's expansion accelerate.

About a year ago, the XENON1T experiment reported an unexpected signal, or excess, over the expected background. "These sorts of excesses are often flukes, but once in a while they can also lead to fundamental discoveries," said Dr. Luca Visinelli, a researcher at Frascati National

Laboratories in Italy, a co-author of the study. "We explored a model in which this signal could be attributable to dark energy, rather than the dark matter the experiment was originally devised to detect."

At the time, the most popular explanation for the excess were axions—hypothetical, extremely light particles—produced in the Sun. However, this explanation does not stand up to observations, since the amount of axions that would be required to explain the XENON1T signal would drastically alter the evolution of stars much heavier than the Sun, in conflict with what we observe.

We are far from fully understanding what dark energy is, but most physical models for dark energy would lead to the existence of a so-called fifth force. There are four fundamental forces in the universe, and anything that can't be explained by one of these forces is sometimes referred to as the result of an unknown fifth force.

However, we know that Einstein's theory of gravity works extremely well in the local universe. Therefore, any fifth force associated to dark energy is unwanted and must be 'hidden' or 'screened' when it comes to small scales, and can only operate on the largest scales where Einstein's theory of gravity fails to explain the acceleration of the Universe. To hide the fifth force, many models for dark energy are equipped with so-called screening mechanisms, which dynamically hide the fifth force.

Vagnozzi and his co-authors constructed a physical model, which used a type of screening mechanism known as chameleon screening, to show that dark energy particles produced in the Sun's strong magnetic fields could explain the XENON1T excess.

"Our chameleon screening shuts down the production of dark energy particles in very dense objects, avoiding the problems faced by solar axions," said Vagnozzi. "It also allows us to decouple what happens in

the local very dense Universe from what happens on the largest scales, where the density is extremely low."

The researchers used their model to show what would happen in the detector if the dark energy was produced in a particular region of the Sun, called the tachocline, where the magnetic fields are particularly strong.

"It was really surprising that this excess could in principle have been caused by dark energy rather than dark matter," said Vagnozzi. "When things click together like that, it's really special."

Their calculations suggest that experiments like XENON1T, which are designed to detect dark matter, could also be used to detect dark energy. However, the original excess still needs to be convincingly confirmed. "We first need to know that this wasn't simply a fluke," said Visinelli. "If XENON1T actually saw something, you'd expect to see a similar excess again in future experiments, but this time with a much stronger signal."

If the excess was the result of dark energy, upcoming upgrades to the XENON1T experiment, as well as experiments pursuing similar goals such as LUX-Zeplin and PandaX-xT, mean that it could be possible to directly detect dark energy within the next decade.

More information: Sunny Vagnozzi et al, Direct detection of dark energy: The XENON1T excess and future prospects, *Physical Review D* (2021). [DOI: 10.1103/PhysRevD.104.063023](https://doi.org/10.1103/PhysRevD.104.063023)

Provided by University of Cambridge

Citation: Have we detected dark energy? Scientists say it's a possibility (2021, September 15)

retrieved 28 April 2024 from

<https://phys.org/news/2021-09-dark-energy-scientists-possibility.html>

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