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Dark matter may be destroying itself in Milky Way's core

Excess gamma-ray light at the galactic centre may indicate invisible dark-matter particles.

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Fermi zooms into the galactic centre
This animation zooms into an image of the Milky Way, shown in visible light, and superimposes a gamma-ray map of the galactic centre hinting at the presence of dark matter.

Gamma rays shining from the centre of the Milky Way could be the result of dark matter particles colliding, scientists say. If so, the signal, gleaned from NASA's Fermi space telescope, would mark the first-ever indirect detection of the particles that make dark matter, the stealthy and elusive substance that contributes most of the matter in the universe.

In theory, the amount of unseen dark matter far exceeds the regular matter in stars, galaxies and us, but it has been impossible to measure directly. Researchers have seen hints of a dark matter signal from Fermi before, but the new analysis provides the strongest case to date for a pattern that cannot be easily explained by other galactic activity. The signal, if it is from dark matter, would indicate a new type of subatomic particle, and possibly even a new force in the universe. "I would consider it currently the most exciting signal that we have that could actually be due to dark matter," physicist Rafael Lang of Purdue University, who was not involved in the study, said Saturday at the American Physical Society April meeting here.
It is still possible, however, that the intriguing light has a more mundane origin, such as spinning stars called pulsars. "I think it's a compelling possible signal of dark matter, but on its own it's not going to convince us," said Tracy Slatyer of the Massachusetts Institute of Technology, one of the co-authors of the study, which has been submitted to *Physical Review D* and posted on the arXiv online repository[1].

A leading explanation for dark matter is that it is composed of weakly interacting massive particles (WIMPs), which are theorized but have so far eluded detection. WIMPs are thought to be their own antimatter partners, and therefore would destroy one another on colliding—as matter and antimatter do. Such WIMP annihilations would produce normal matter particles that would in turn create high-energy photons, or particles of light, that we could see. Because dark matter should be densest at the Milky Way's core, that is the best place to look for annihilations.

The Fermi telescope scans the sky for high-energy gamma-ray light, and the latest analysis shows unequivocally that it sees more light at the very centre of our galaxy than expected. Whereas previous analyses were inconclusive Slatyer and her colleagues found a stark signal when they considered only the photons for which Fermi could measure a reliable path of origin on the sky, and eliminated those photons whose direction was uncertain. Within this smaller data set Fermi shows an excess of photons spread out evenly in a sphere extending at least 5,000 light-years from the Milky Way centre. They have energies between one billion and three billion electron volts (GeV), making them about a billion times more energetic than visible light. "It is quite remarkable that it is a pretty symmetric signal, and it's about 10,000 photons," beyond the expected number, says Blas Cabrera, a physicist at Stanford University who works on the Cryogenic Dark Matter Search, one of numerous belowground experiments worldwide currently searching for rare instances of dark matter particles interacting with normal matter particles directly.

If the signal truly is created by dark matter, Slatyer and her colleagues calculate that the invisible particles would weigh roughly 30 to 35 times a proton's mass, or about 30 to 35 GeV. That intrigues Cabrera, who says that such particles should have shown up already in direct detection experiments. "We are already tuned for the best sensitivity in the 30 GeV range," he says. A particle of that mass could also have shown up at the Large Hadron Collider (LHC) in Switzerland. "If this is dark matter that we're seeing in the inner galaxy, then the fact that we're not seeing it in LHC or direct detections is already telling us something pretty interesting about its interactions."

For instance, basic theories predict dark matter particles interact with normal particles by exchanging either a Z boson or a Higgs boson, which are associated, respectively, with the weak force and the mechanism that grants particles mass. But direct detection experiments should have seen these interactions already if the dark matter particle's mass is around 30 GeV. One possibility is that dark matter may be interacting via a new type of intermediary particle besides the Z or Higgs bosons, associated with an unknown fifth fundamental force. "It would be very exciting if through discovering dark matter, we also discovered a new force of nature," Slatyer says.

The Fermi signal may not be due to dark matter at all, however. The excess light could also originate in pulsars spinning so fast they make a full rotation every millisecond. The stars' magnetic fields are thought to accelerate charged particles to nearly the speed of light, which in turn emit high-energy photons in the gamma-ray wavelength. There are some issues with this explanation, however. "Millisecond pulsars produce more gamma-rays at lower energies (below about one GeV) than the observed galactic centre emission," says pulsar expert Slavko Bogdanov of Columbia University. Furthermore, Fermi observations do not identify nearly enough individual pulsars at the galactic centre to account for the light. "It would have to be a type of pulsar we don't know about," says Kevork Abazajian, an astronomer at the University of California, Irvine, who has separately investigated the Fermi signal. That is a distinct possibility, he says, "It's easier to think of a new class of pulsar than a whole new type of matter."

A more definitive test would be to see the same gamma-ray excess inside some of the couple dozen dwarf galaxies that orbit the Milky Way. These objects are thought to be especially dense in dark matter, so if dark matter annihilates, it should do so there. The known dwarf galaxies are dim and hard to study, and no clear excess light has shown up so far. New observatories coming online soon could discover new dwarfs to target, however. "If the same excess is present towards the Milky Way satellites with the expected signal strength, that would convince me we are seeing gamma rays resulting from dark matter annihilation," says Manoj Kaplinghat of U.C. Irvine who collaborates with Abazajian on an independent study of the Fermi signal. "Of course, a corroborating direct detection of dark matter in one of our underground laboratories would be a clincher."

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References

1. Daylan, T. *et al*. *available at* http://arxiv.org/abs/1402.6703 (2014).