

Astrowatch

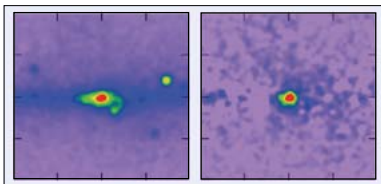
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Fermi gamma-rays match dark-matter signal

A new analysis of observations of the galactic centre by the Fermi Gamma-ray Space Telescope strengthens the case for a signal from annihilating dark matter. The authors claim that the excess emission has a spectral shape, spatial extent and normalization in good agreement with predictions of simple models of dark-matter annihilation.

Although still elusive in particle-physics experiments, dark matter is a reality for astronomers. Its presence is implied by the fluctuations in the cosmic microwave background as measured by the Planck mission (*CERN Courier* May 2013 p12). It is essential for the formation of the first stars and galaxies, and it provides the additional gravitational pull to hold clusters of galaxies together. Nonetheless, dark matter is only detected indirectly, via its effect on ordinary matter, or at most through its gravitational lensing effect on background galaxies observed through a massive galaxy cluster (*CERN Courier* July/August 2013 p14). Weakly interacting massive particles (WIMPs) are a prime candidate for cold dark matter in the universe. With a mass above about 1 GeV and interacting only through the weak nuclear force and gravity, they can remain invisible because of their lack of electromagnetic interactions. However, the annihilation of WIMPs could potentially produce gamma rays, cosmic rays and neutrinos. Theoretical candidates for WIMPs include the lightest supersymmetric particle, neutralinos and sterile neutrinos.

As with all galaxies, the Milky Way is



Gamma-ray emission in the 1–3.16 GeV energy band of the central $10^\circ \times 10^\circ$ area of the Milky Way before (left) and after (right) subtracting all known contributions, leaving an unexpected excess that can be attributed to dark matter annihilation. (Image credit: T Daylan et al., Fermi Space Telescope, NASA.)

thought to be surrounded by a spherical halo of dark matter. The density gradient towards the galactic centre makes the latter the best place to search for a gamma-ray signal associated with dark-matter annihilation. The Fermi satellite is well suited for this search at energies between 100 MeV and 300 GeV (*CERN Courier* November 2008 p13). In the past few years, the analysis of Fermi's observations of the central region of the Galaxy by different groups has detected a significant excess with a maximum emission at around 1–3 GeV.

A new analysis by a US team led by Tansu Daylan from Harvard University is now attracting attention. The team used a more restrictive selection of gamma rays, including only those with a small positional uncertainty. This allows the researchers to produce gamma-ray maps

at higher resolution, enabling an easier separation of the putative spherically-symmetric dark-matter signal from the contribution of the Galaxy's diffuse emission and the "bubbles" found by Fermi (*CERN Courier* January/February 2011 p11). The team finds an excess emission out to angles of around 10° from the centre of the Galaxy, with no significant deviation from spherical symmetry. The excess has a high significance and a best-fit spatial distribution following a generalized Navarro-Frenk-White halo profile, with an inner slope of $\gamma = 1.26$. Such a broad distribution disfavors the proposed alternative that this emission originates from a population of thousands of millisecond pulsars.

The derived spectrum associated with this excess is well fitted by dark-matter particles with mass 31–40 GeV annihilating to b quarks. The new study disfavors the previously considered 7–10 GeV mass window in which the dark matter annihilates significantly to τ leptons. The annihilation cross-section required to account for the signal is also found to be in good agreement with predictions for dark matter in the form of a simple thermal relic. While this analysis does not provide a discovery of dark-matter annihilation, it is nevertheless a compelling case for this process that will have to be confirmed by corroborating observations in dwarf galaxies around the Milky Way.

● **Further reading**
T Daylan *et al.* 2014 arXiv:1402.6703.

Picture of the month

This new image by the Hubble Space Telescope shows the spiral galaxy ESO 137-001, framed against a bright background as it moves through the heart of the Norma cluster of galaxies. The image captures not only the galaxy and its backdrop in stunning detail, but also something more dramatic – intense blue streaks streaming outwards from the galaxy, seen shining brightly in ultraviolet light. These streaks are hot young stars, encased in wispy streams of gas that are being torn away from the galaxy by its surroundings as it moves through space. This violent galactic disrobing is the result of a process known as ram pressure stripping – a drag force felt by an object moving through a fluid. The fluid in question here is superheated gas, which lurks at the centre of galaxy clusters and emits X-rays (Picture of the month, *CERN Courier* November 2008 p11). (Image credit: NASA, ESA. Acknowledgements: Ming Sun (UAH), and Serge Meunier.)



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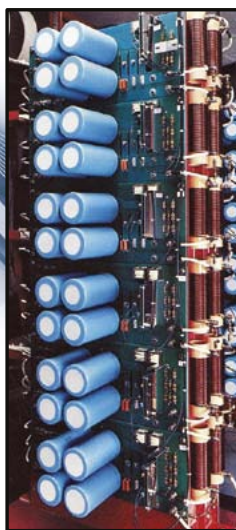
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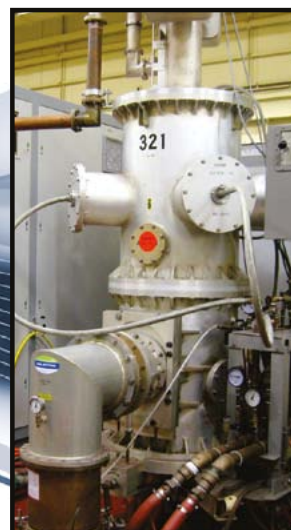
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