

Astrowatch

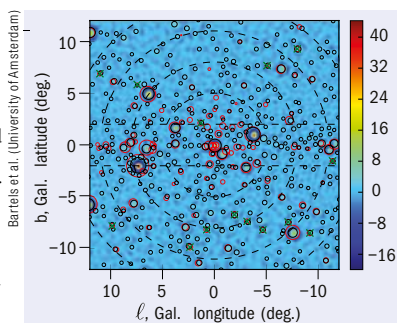
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Gamma-ray excess is not from dark matter

An excess of gamma rays at energies of a few GeV was found to be a good candidate for a dark-matter signal (*CERN Courier* April 2014 p13). Two years later, a pair of research articles refute this interpretation by showing that the excess photons detected by the Fermi Gamma-ray Space Telescope are not smoothly distributed as expected for dark-matter annihilation. Their clustering reveals instead a population of unresolved point sources, likely millisecond pulsars.

The Milky Way is thought to be embedded in a dark-matter halo with a density gradient increasing towards the galactic centre. The central region of our Galaxy is therefore a prime target to find an electromagnetic signal from dark-matter annihilation. If dark matter is made of weakly interacting massive particles (WIMPs) heavier than protons, such a signal would naturally be in the GeV energy band. A diffuse gamma-ray emission detected by the Fermi satellite and having properties compatible with a dark-matter origin created hope in recent years of finally detecting this elusive form of matter more directly than only through gravitational effects.

Two independent studies published in *Physical Review Letters* are now disproving this interpretation. Using different statistical-analysis methods, the two research teams found that the gamma rays of the excess emission at the galactic centre are not distributed as expected from dark matter. They both find evidence for



Gamma-ray map of an area (24° wide) around the galactic centre showing the wavelet transform of the Fermi data. This processing reveals many peaks circled in black. The brightest ones match the sources detected by Fermi (red circles), while the fainter ones suggest a hidden population of point sources. The colour scale encodes the signal-to-noise ratio.

a population of unresolved point sources instead of a smooth distribution.

The study, led by Richard Bartels of the University of Amsterdam, the Netherlands, uses a wavelet transformation of the Fermi gamma-ray images. The technique consists of a convolution of the photon count map with a wavelet kernel shaped like a Mexican hat, with a width tuned near the Fermi angular resolution of 0.4° in the relevant energy band of 1–4 GeV. The

intensity distribution of the derived wavelet peaks is found to be inconsistent with that expected from a truly diffuse origin of the emission. The distribution suggests instead that the entire excess emission is due to a population of mostly undetected point sources with characteristics matching those of millisecond pulsars.

These results are corroborated by another study led by Samuel Lee of the Broad Institute in Cambridge and Princeton University. This US team used a new statistical method – called a non-Poissonian template fit – to estimate the contribution of unresolved point sources to the gamma-ray excess emission at the galactic centre. The team's results predict a new population of hundreds of point sources hiding below the detection threshold of Fermi. The possibility of detecting the brightest ones in the years to come with ongoing observations would confirm this prediction.

In the coming decade, new facilities at radio frequencies will be able to detect hundreds of new millisecond pulsars in the central region of the Milky Way. This would definitively rule out the dark-matter interpretation of the GeV excess seen by Fermi. In the meantime, the quest towards identifying the nature of dark matter will go on, but little by little the possibilities are narrowing down.

● Further reading

R Bartels *et al.* 2016 *Phys. Rev. Lett.* **116** 051102.
SK Lee *et al.* 2016 *Phys. Rev. Lett.* **116** 051103.

Picture of the month

This faint dwarf galaxy called IC 1613 was discovered in 1906 in the constellation of Cetus. It is a member of the Local Group of galaxies and lies just over 2.3 million light-years away. The image, captured with the OmegaCAM camera on ESO's VLT Survey Telescope in Chile, shows many details of this irregular galaxy containing very little cosmic dust. This property allowed astronomers to use it decades ago to study precisely variable stars such as Cepheid and RR Lyrae, which have the special property that their period of brightening and dimming is linked directly to their intrinsic brightness. By measuring the period, astronomers can derive the actual luminosity of the star and hence – using the observed brightness – its distance. It is thanks to such peculiar stars that the cosmic distance ladder could be constructed. The extension of this ladder deeper and deeper into space with the use of new "standard candles" such as Type Ia supernovae led to the Nobel-prize-winning discovery of the accelerating expansion of the universe (*CERN Courier* November 2011 p5).

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