Dark matter is the most likely source of excess of gamma rays from galactic center

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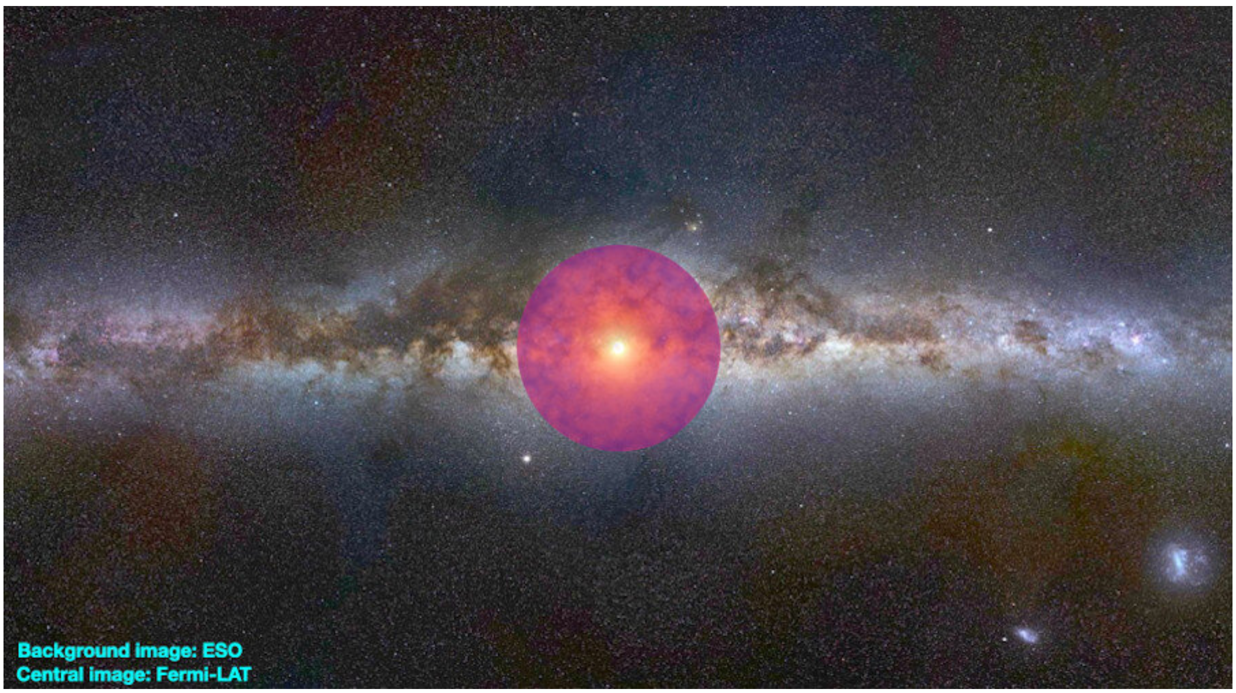

Credit: ESO/FERMI-LAT

In the recent past, space missions dedicated to the study of astrophysical signals in the high-energy spectrum revealed a series of enigmatic excesses not predicted by the theoretical models. In order to find an explanation for these anomalies, many solutions have been proposed. The most exciting hypothesis invokes the contribution of the elusive dark matter, the mysterious form of matter four times more abundant than baryonic matter, and of which scientists have so far detected only gravitational effects.

Two recent theoretical studies carried out by Mattia di Mauro, researcher of the Turin division of INFN, one of which appeared today in *Physical Review D*, confirm that this explanation is compatible with measured excesses, further demonstrating that it is not disproven by potential discrepancies between theoretical and observational data. The results obtained are based on an innovative and refined analysis comparing data acquired in the last 11 years by the main instrument aboard NASA's Fermi, the Fermi Large Area Telescope (LAT), with measurements of other astronomical anomalies recorded by the orbiting Pamela detector and by the Alpha Magnetic Spectrometer experiment (AMS-02) aboard the International Space Station. Pamela and AMS are managed by international collaborations in which INFN plays a decisive role.

Starting from 2009, the year in which Fermi measurements showed a surplus of photons with energies equal to or greater than 1 GeV (2000 times the mass of an electron) coming from the center of our galaxy, the astrophysics community has tried to explain the observations in several ways, including the possible presence of thousands of weak pulsars near the galactic center and the potential gamma-ray contribution provided by dark matter. These analyses were subject to great uncertainty since they referred to models of the so-called astrophysical gamma-ray background, produced by cosmic rays or by known sources, which, although capable of including a certain variability, are subject to great error.

In order to describe the gamma-ray excess properties more precisely and to evaluate whether it is really compatible with dark matter, the new study relied on the broadest set of data collected in the last year by the LAT, and used an analysis technique that minimizes the uncertainties of the astrophysical background by adopting multiple models. "The analysis methodology used," explains Mattia di Mauro, "has provided very relevant information about the spatial distribution of excess gamma radiation, which can explain what generates the excess of high-energy photons in the galactic center. If the excess was, for example, caused by the interaction between cosmic rays and atoms, we would expect to observe its greater spatial distribution at lower energies and its lower diffusion at higher energies due to the propagations of cosmic particles. My study, on the other hand, underlines how spatial distribution of the excess does not change as a function of energy. This aspect had never been observed before and could be explained by dark matter presence dark matter interpretation. This is because we think the particles composing the dark matter halo should have similar energies. The analysis clearly shows that the excess of gamma rays is concentrated in the galactic center, exactly what we would expect to find in the heart of the Milky Way if dark matter is in fact a new kind of particle."

A second study, which will be published in the same journal, examines the validity of the dark matter hypothesis using the predictions from a larger model that describes possible particle interactions of this elusive component of the universe. A theoretical model demonstrated how the existence of dark matter particles is not disproven by other anomalies recorded in the astrophysical background. These include the excess of positrons measured by Pamela and AMS-02, if attributed to a surplus of dark matter, and the non-detection of high-energy photons from dwarf galaxies close to ours, whose stellar motions imply the presence of high concentrations of dark matter.

Di Mauro says, "Starting from the physical model developed in this second study, after considering different results for the interaction and annihilation of dark matter particles, alternatives that would precede the production of high-energy photons, we verified which of these possibilities best accorded with the galactic center's excess gamma rays, while also considering the surplus of positrons and the non-detection of gamma rays from dwarf galaxies. This comparison has made able to derive accurate properties of the dark matter, properties compatible with the galactic center excess and the upper limits found with other particle data."

More information: Mattia Di Mauro. Characteristics of the Galactic Center excess measured with 11 years of Fermi -LAT data, *Physical Review D* (2021). DOI: 10.1103/PhysRevD.103.063029

Multimessenger constraints on the dark matter interpretation of the Fermi-LAT Galactic center excess: arxiv.org/abs/2101.11027 arXiv:2101.11027v1 [astro-ph.HE]

Provided by INFN

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