

Dark Matter and Gamma Rays

Dr. Jonathan Cornell is a postdoctoral fellow at the McGill Space Institute, who works with Prof. Jim Cline. He recently completed a project to develop a theoretical model that describes the excess GeV gamma rays that come from the galactic centre.

What question were you trying to answer?

One possible explanation for the excess of high energy gamma rays observed in the centre of our Milky Way galaxy by the Fermi-Large Area Telescope (LAT) is that these gamma rays are the product of the annihilation of dark matter particles.

However, many people argue that this explanation is not viable because a similar excess would be expected from dark matter annihilation in dwarf spheroidal galaxies [low-luminosity galaxies that are companions to the Milky Way], and the Fermi-LAT has not observed this.

This leads to the question: Is it possible to construct a dark matter model in which the dark matter annihilates at a much greater rate in the galactic centre than in dwarf spheroidals?

Why did you find this question interesting?

One of the most significant mysteries remaining in particle physics is the nature of dark matter, which up until now we have only seen interact via its gravitational interactions with normal matter.

The gamma ray signal from the galactic centre is one of the most promising possible signals of dark matter interactions beyond the gravitational, so it is important to try to understand what dark matter models explain this.

What does doing your research look like?

As theorists our research is done with computers and old fashioned pencil and paper.

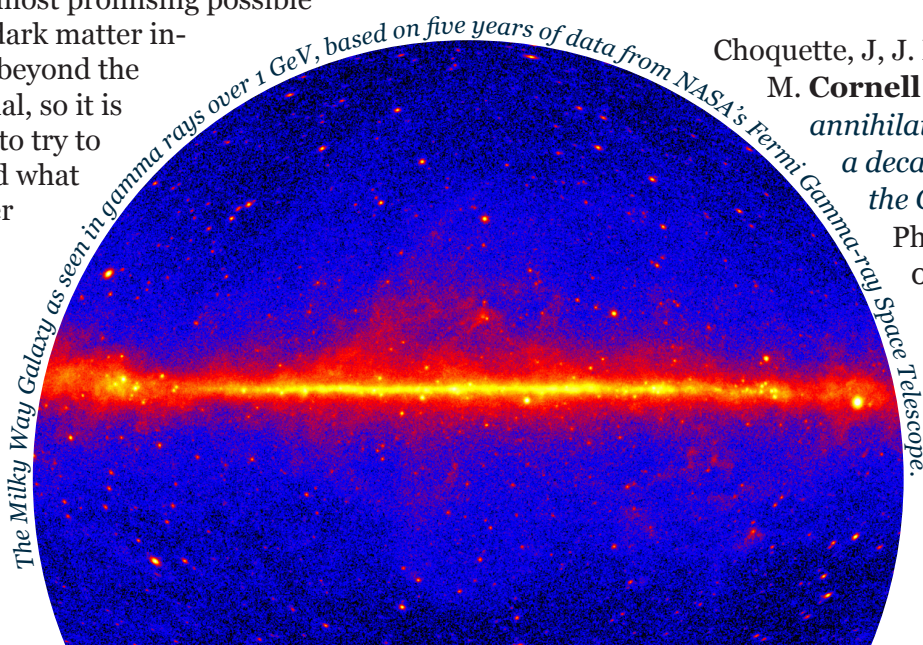
What did you find?

Since dark matter is moving much faster in the Galactic centre than in dwarf spheroidal galaxies, we developed a model in which the dark matter annihilation rate is dependent on its velocity, leading to an enhanced gamma ray signal in the Galactic centre.

To make this model work, we had to develop a new method for how the dark matter is made in the early universe.

Why this is important

The project pushes back against one of the major criticisms of a dark matter interpretation of the Galactic centre gamma-ray excess: namely, that at this point we should have expected to see a similar signal from dwarf spheroidal galaxies. It does so in a simple way, by positing a p-wave dark matter annihilation cross section. People usually discard such models because this cross section would be quite large in the early universe, leading to dark matter freezing out at late times with a relic density that is much too small. However, we show that this problem can be overcome by introducing another particle species in the dark sector which freezes out with the right relic density and then decays to the dark matter.



Choquette, J, J. M. **Cline**, and J. M. **Cornell** (2016), *p -wave annihilating dark matter from a decaying predecessor and the Galactic Center excess*, Phys. Rev. D 94 (1), 015018