Evaluating WIMP Dark Matter Candidacy with Distant Astrophysical Phenomena

Abstract

Dark matter is an integral factor in the distribution of macro-scale galactic superstructures, as well as galaxy formation and evolution, though the properties of this matter remain largely unknown. Weakly interacting massive particles (WIMPs), a group of theoretical particles, serve as a primary candidate for dark matter. The Dirac nature of these proposed particles predicts the production of high-energy photons (***γ***-rays) resulting from the collision and subsequent annihilation of two WIMPs, which scientists have analyzed to predict the WIMP dark matter content of regions within the universe. This study presents the usage of a lightly-explored class of objects—distant galactic sources—for dark matter content surveys, compared to local galaxies, which have been the focus of previous research within the field. Photon event data between 500 MeV and 500 GeV collected over fourteen years by the Fermi Large Array Telescope from twelve galactic sources further than 5 MLY away from Earth was analyzed using FermiPy and probed for dark matter content. Using a combined Bayesian likelihood analysis, the 95% confidence level upper limit of the thermally averaged WIMP annihilation cross section was calculated for dark matter masses between 10 GeV and 5 TeV. No statistically significant ***γ***-ray signal from dark matter annihilation was detected from these sources, and the derived dark matter interaction rate was compared to that of previous studies to constrain the dark matter mass. Further analysis into the WIMP dark matter content within distant astrophysical sources must be conducted to present more robust limits on WIMP dark matter.