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Revisiting the Galactic Center Excess in Gamma-rays with Multi-Messenger Observations

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The Galactic center excess (GCE) remains one of the most intriguing discoveries from the Fermi Large Area Telescope (LAT) observations. I will revisit the characteristics of the GCE by first showing a new set of high-resolution galactic diffuse gamma-ray emission templates. This diffuse emission, which accounts for the bulk of the observed gamma rays, is ultimately due to cosmic-ray interactions with the interstellar medium. Using recent high-precision cosmic-ray observations, in addition to the continuing Fermi-LAT observations and observations from lower energy photons, we constrain the properties of the galactic diffuse emission. I will describe a large set of diffuse gamma-ray emission templates which account for a very wide range of initial assumptions on the physical conditions in the inner galaxy. I will discuss the updated spectral and morphological properties of the GCE coming from this new set of templates and the implications on the interpretation of the GCE. In particular, a high-energy tail is found at higher significance than previously reported. This tail is very prominent in the northern hemisphere, and less so in the southern hemisphere. This strongly affects one prominent interpretation of the excess: known millisecond pulsars are incapable of producing this high-energy emission, even in the relatively softer southern hemisphere, and are therefore disfavored as the sole explanation of the GCE. The annihilation of dark matter particles of mass 40^{+10}_{-7} GeV (95% CL) to b quarks with a cross-section of $\sigma v = 1.4^{+0.6}_{-0.3} \times 10^{-26}$ cm^{3}s^{-1} provides a good fit to the excess especially in the relatively cleaner southern sky. Dark matter of the same mass range annihilating to b quarks or heavier dark matter particles annihilating to heavier Standard Model bosons can combine with a subdominant millisecond pulsars component to provide a good fit to the southern hemisphere emission as well, as can a broken power-law spectrum which would be related to recent cosmic-ray burst activity.

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