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A study of super-luminous stars with the Fermi Large Area Telescope

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The γ-ray emission from stars is induced by the interaction of cosmic rays with stellar atmospheres and photon fields. This emission is expected to come in two main components: a stellar disk emission, where γ-rays are mainly produced in atmospheric showers generated by hadronic cosmic rays, and an extended halo emission, where the high density of soft photons in the surroundings of stars create a suitable environment for γ-ray production via inverse Compton (IC) scattering by cosmic-ray electrons. Besides the Sun, no other disk or halo from single stars has ever been detected in γ-rays. However, by assuming a cosmic-ray spectrum similar to that observed on Earth, the predicted γ-ray emission of super-luminous stars, like e.g. Betelgeuse and Rigel, could be high enough to be detected by the Fermi Large Area Telescope (LAT) after its first decade of operations. In this work, we use 12 years of Fermi-LAT observations along with IC models to study 9 super-luminous nearby stars, both individually and via stacking analysis. Our results show no significant γ-ray emission, but allow us to restrict the stellar γ-ray fluxes to be on average $< 3.3 \times 10^{-11}$ ph cm^{-2} s^{-1} at a 3σ confidence level, which translates to an average local density of electrons in the surroundings of our targets to be less than twice of that observed for the Solar System.

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