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Constraining the Diffusion Coefficient and Cosmic-Ray Acceleration Efficiency using Gamma-ray Emission from the Star-Forming Region RCW 38

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We report a detailed study of gamma-ray emission near the young Milky Way star cluster (0.5 Myr old) in the star-forming region RCW 38. Using 15 years of data from the Fermi-LAT, we find a significant (σ>22) detection coincident with the cluster, producing a total gamma-ray luminosity of L = (2.66±0.92) x 10^34 erg s^-1 adopting a power-law spectral model (Γ=2.34±0.04) in the 0.1-500 GeV band. Using an empirical relationship and Starburst99, we estimate the total wind power to be 7×10^36 erg s^−1. This corresponds to a CR acceleration efficiency of η_CR = 0.4 for a diffusion coefficient consistent with the local interstellar medium of D = 10^28 cm^2 s^−1. Alternatively, the gamma-ray luminosity could also account for a lower acceleration efficiency of 0.1 if the diffusion coefficient in the star-forming region is smaller D = 2.5 x 10^27 cm^2 s^−1. In addition, we perform a Chandra X-ray analysis of the region to compare the hot-gas pressure from the CR pressure and find the former is four orders of magnitude greater, suggesting that the CR pressure is not dynamically important relative to the stellar wind feedback. As RCW 38 is too young for supernovae to have occurred, the high CR acceleration efficiency in RCW 38 demonstrates that stellar winds may be an important source of Galactic cosmic rays.

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