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Cosmic-Ray Induced Gamma-Ray Emission From Starburst Galaxies

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In star-forming galaxies, gamma rays are mainly produced through the collision of high-energy protons in cosmic rays and protons in the interstellar medium (ISM) (i.e. cosmic ray-induced π0 γ-radiation). For a "normal"star-forming galaxy like the Milky Way, most cosmic rays escape the Galaxy before such collisions, but in starburst galaxies with dense gas and huge star formation rate, most cosmic rays do suffer these interactions. We construct a "thick-target"model for starburst galaxies, in which cosmic rays are accelerated by supernovae, and escape is neglected. This model gives an upper limit to the gamma-ray emission and tests the calorimetry relation between gamma rays and cosmic rays for starbursts. Only two free parameters are involved in the model: cosmic-ray proton acceleration energy rate from supernova and the proton injection spectral index. We apply the model to five observed starburst galaxies: M82, NGC 253, NGC 1068, NGC 4945 and Circinus, and find the calorimetric relation holds for most of the starbursts, but for Circinus, other gamma-ray sources must be presented to explain for its GeV excess. The pionic gamma-ray emission is calculated from 10 MeV to 10 TeV, which covers the Fermi Gamma-ray Space Telescope (Fermi) energy range. We also apply the model to the extragalactic gamma-ray background emission(EGB) by assuming all star-forming galaxies are calorimetric, finding that star-forming galaxies cannot make the entire signal, other gamma-ray sources must also exist.

Collaboration

– not specified –

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