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Developing a theoretical model for the gamma-ray emission from the Sun

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Despite its very close proximity to Earth, there are still many unsolved puzzles about the Sun. One such example of significant recent interest relates to the gamma-ray emission (in the GeV-TeV range) from the solar disk. A major contribution to the solar emission in this energy range is believed to be caused by the interaction of galactic cosmic rays (GCRs) with the solar atmosphere: the interaction of a GCR proton with a solar atmosphere proton produces a neutral pion that decays in outgoing gamma-rays. Indeed, the only existing theoretical model, dating back to 1991, is in tension with the Fermi-LAT observed spectrum (at energy > 0.1 GeV) which is about 30 times brighter and harder than predicted. The main goal of our work is to develop a theoretical model that explains the mechanism behind gamma-ray emission. Here we investigate the transport of GeV-TeV GCRs through the static magnetic arcade of an active region within 0.3 solar radii from the top of the photosphere; a magnetic turbulent component is overlapped to the arcade magnetic field. We performed test-particle (protons) simulations with the PLUTO code by injecting GCRs at different heights from the top of the photosphere and comparing the time of the interaction GCR/atmosphere proton with the characteristic time of the trapping that results from the combination of magnetic field arcade geometry and turbulence. We find that the effect of the magnetic turbulence in the solar atmosphere cannot be neglected.

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