Contribution ID: **936** Type: **Talk**

GeV-TeV Connections in Massive Galaxies: Pulsar-Driven Emission and Prospects for Evolutionary Insights

Tuesday 22 July 2025 14:05 (15 minutes)

The dominant mechanisms underlying the high-energy gamma-ray emission from galaxies vary with galaxy types. In starburst galaxies, a substantial component arises from neutral pion decays. These are driven by interactions of hadronic cosmic rays (CRs) accelerated in strong shocks associated with the star formation process and its end-products. Leptonic gamma-rays may also originate from electrons directly energized by shocks within the interstellar medium of galaxies, from charged pion decays in hadronic interactions, or from pulsars and their surrounding halos. In more quiescent galaxies like the Milky Way, pulsars and their halos represent a major gamma-ray source class. These sources can contribute significantly to the high-energy galactic emission, with recycled millisecond pulsars predominantly located in globular clusters (GCs) being particularly important. Recent detections of very high-energy (VHE) emission from Galactic GCs suggests they may also contribute to the TeV gamma-ray flux from evolved galaxies. We consider a scenario where the VHE emission from GCs is driven by electrons accelerated in pulsar wind termination shocks, which undergo inverse Compton scattering as they propagate into GC magnetotails. We find that the high energy emission from these GCs could dominate the GeV and TeV flux from massive, quiescent galaxies, and show that the relationship between the GeV and TeV GC emission depends on the global galactic properties. In this contribution, we will demonstrate how GeV-TeV connections in massive galaxies can reveal new information about their formation history, and discuss how this can help to refine our understanding of how massive galaxies evolve.

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Session Classification: GA

Track Classification: Gamma-Ray Astrophysics