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Studying SNR-MC interactions as galactic PeVatrons in the era of CTAO and ASTRI Mini-Array

Supernova remnants (SNRs) are among the primary sources of cosmic rays (CRs) in our galaxy and observations of the *pion bump* by AGILE and Fermi-LAT support their role in CR production. Recently LHAASO detected ultra-high-energy (UHE, > 100 TeV) γ-rays from several Galactic sources, including some SNRs. However, existing theoretical models predict that they can accelerate CRs to PeV energies only within the first 100 years, whereas all known SNRs are much older. A possible explanation for their UHE emission involves runaway CRs in an environment with suppressed diffusion interacting with nearby molecular clouds (MCs). This scenario can help to understand if SNR-MC systems are critical in evaluating the maximum energies of CRs accelerated by SNRs.

LHAASO detected ˜200 TeV γ-ray emission from W51, a notable PeVatron hosting the star-forming regions W51A, W51B, and the middle-aged SNR W51C, which interacts with MCs in W51B. Potential accelerators include the SNR-MC, the candidate pulsar wind nebulae (PWNe) CXO J192318.5+140305, and several young star clusters. While the SNR-MC interaction can explain the detected pion bump and GeV-TeV γ-ray emission, it does not fully account for the UHE emission observed by LHAASO.

To better understand the different scenarios, more data above 1 TeV and a better angular resolution are needed. This will be addressed by next-generation imaging atmospheric Cherenkov telescopes, such as the Cherenkov Telescope Array Observatory (CTAO), with over 60 telescopes at La Palma (Spain) and Paranal (Chile), and the ASTRI Mini-Array at the Teide Observatory in Tenerife.

In this work, we analyze the W51C-B region to study MC interactions and potential PWNe contributions. We discuss two theoretical scenarios for UHE emission: one where the SNR shock directly interacts with the MCs producing high energy particles, and another where CRs accelerated in the early SNR phase getting trapped in nearby MCs. Finally, we will present simulations based on the Large-Sized Telescope prototype (LST-1) of the CTAO-North array, CTAO, and the ASTRI Mini-Array, highlighting their role in possibly bridging the gap between Fermi-LAT's detection and LHAASO's UHE emission, particularly in the 1-100 TeV range and in resolving the UHE emission from the interaction region.

Collaboration(s)

CTAO, ASTRI

Authors: SUNNY, Alan (IAPS-INAF and University of Rome Tor Vergata, Rome); Dr CARDILLO, Martina (IAPS-INAF); Dr TUTONE, Antonio (IASF - INAF)

Presenter: SUNNY, Alan (IAPS-INAF and University of Rome Tor Vergata, Rome)

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