The ASTRI Mini-Array: a breakthrough in the Cosmic Ray study

Authors: M. Cardillo for the ASTRI Project

Context

In spite of the large amount of data collected by both space and in-ground gamma-ray instruments in the last decades, the Cosmic Ray origin is still an open issue. We lack the direct proof of their acceleration; in particular, a confirmed hadronic emission detection above 100 TeV. For this reason, the coming of new Imaging Atmospheric Cherenkov Instrument as the ASTRI Mini-Array (ASTRI MA) and the Cherenkov Telescope Array Observatory (CTAO) is our hope for solving the tricky issue of CR sources. The ASTRI MA will operate with three of its nine telescopes at the end of the 2022 and it will be completed in 2024. Thanks to its unprecedent performances, it will be the first to open the road to a new era of IACTs.

Aims

Our work shows how the ASTRI MA will be able to solve some critical ambiguities in the Galactic CR context thanks to its very large Field of View, very good angular and energy resolution and unprecedent sensitivity at 10 TeV. We illustrate how ASTRI MA will extend the spectrum of some sources, solve their morphology and constrain theoretical parameters as like as the diffusion coefficient or the hadronic percentage produced in the PWN.

Methods

We simulate the ASTRI MA observations for some chosen sources important in the CR context, using different exposure times, and analyze them in order to understand what we have to expect for the future in comparison with the current data. We use optimized Instrument Response Function produced by Monte Carlo simulations and both the Scientific Tools used in CTAO, CTOOLS and Gammapy.

Results

Our results show that the ASTRI MA will be able to:

- confirm or disprove the pevatronic origin of some VHE sources, from Supernova Remnants to Galactic Center region to PWN.
- solve the morphology of extended sources, understanding their energy dependency and their possible correlation with other wavelength (SNRs, pevatron regions, TeV halos near PWN)
- understande the diffusion coefficient energy dependences near the sources solving the emission from the near MCs, trapping CRs
- disentangle leptonic and hadronic nature of VHE emission above 100 TeV detected from PWNae as the Crab Nebula
- detect Starburst galaxies at the VHE in order to confirm or disprove their hadronic nature and, consequently, their contribution to neutrino flux.