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The Morphology of Young and Massive Star Clusters as Galactic PeVatrons

PeVatrons constitute a fascinating class of astrophysical objects capable of accelerating particles up to PeV energies (1 PeV = 10^{15} eV). These objects are some of the most energetic astrophysical sources in the Universe, but their nature and the acceleration mechanisms are still uncertain. Among PeVatron candidates, there are supernova remnants, pulsar wind nebulae, and young and massive star clusters (YMSCs). The accelerated particles can then interact with the surrounding interstellar medium and background radiation fields to produce secondary very-high-energy gamma rays (>100 TeV), which are the principal signature of both leptonic and hadronic PeVatrons. The air shower observatory LHAASO detected >100 TeV photons from dozens of sources in the Galactic Plane proving the existence of PeVatrons within the Milky Way. The next-generation ground-based Cherenkov imaging telescopes like ASTRI-Mini Array and the Cherenkov Telescope Array (CTAO) will be able to reconstruct better the energy and direction of the secondary gamma radiation, studying the Cherenkov radiation produced by particle showers in the atmosphere.

Cygnus OB2 and Westerlund 1 are particularly interesting YMSCs, because the ASTRI-Mini Array and CTAO will be able to spatially resolve them. They will therefore be essential to perform morphological studies, which will be relevant because of the insights that they can give on acceleration mechanisms and environments. We studied these YMSCs and the surrounding regions. We modeled the secondary gamma-ray emission and simulated observations of the regions with the ASTRI Mini-Array. Finally, we studied the spatial distribution of the gamma-ray emission as a function of the distance from the centre of the source and compared it with that of other simulated extended gamma-ray sources such as TeV halos, which are thought to form around middle-aged pulsars.

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