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Are TeV-PeV observations unveiling the full extent of particle escape in pulsar-powered sources ?

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Our exploration of the sky at the highest photon energies has recently benefited from a number of major advances, notably the expansion of the spectral window up to the PeV range, the probing of emissions over larger and larger angular scales, and the coverage of significant portions of the Galaxy. Such a broad view can be expected to lead to significant progress in our understanding of the life cycle of Galactic cosmic rays, from their acceleration in localized astrophysical sites to their release in the vicinity of sources and subsequent merging into a large-scale galactic population. Somewhat surprisingly, though, a large number of TeV-PeV sources display rather large angular extents and appear positionally coincident with pulsars. The physical connection seems viable from energetic, spectral or population arguments. In this contribution, I investigate the hypothesis that a number of the known TeV-PeV sources consists in pulsar-powered systems in which electron-positron pairs plays a major role.

I will introduce a framework for the dynamical and radiative evolution of a pulsar wind nebula inside a supernova remnant, incorporating particle escape across the different components of the system, from the nebula to the remnant and out to the interstellar medium. The model predicts a number of interesting features like the fact that pairs escaped into the remnant can be a significant if not dominant contribution to the emission from the system and may even dominate the pion-decay radiation from cosmic rays accelerated at the forward shock; or the possibility that in evolved systems, the TeV–PeV radiation from particles escaped into the interstellar medium can exceed by far that of the plerion. I will then explore to which extent such a description of pulsar-powered non-thermal sources is consistent with the properties of known Galactic sources, with a specific focus on the bright and very extended sources observed with LHAASO at the highest gamma-ray energies.

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