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Observability of young star clusters in gamma rays: the role of Wolf-Rayet stellar winds

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Stellar wind termination shocks are considered potential sites for efficient particle acceleration, allowing an explanation for the overabundance of Ne^{22} observed in cosmic rays (CRs) through Wolf-Rayet stars (WRs) and providing a minor but necessary contribution to the observed flux of Galactic CRs. However, only a few powerful star clusters such as Westerlund 1 and Cygnus OB2 have been firmly detected in high energy gamma rays (TeV-PeV), as well as very young star clusters embedded in parent dense molecular cloud at lower energies (around GeV). This lack of detection is limiting our ability to test the different scenarios of cosmic-ray acceleration in stellar clusters. Therefore, identifying the most promising clusters in terms of observability (so the most powerful and nearest ones) is now crucial to refine our understanding of particle acceleration and transport in these environments.

Recent attempts to catalog star clusters have leveraged Gaia data to identify individual stars across the Galaxy. By summing the kinetic power of detected stars and extrapolating from initial mass functions (IMFs), total cluster luminosities can be estimated. However, this approach has two key limitations. First, it relies on extensive modeling to infer the full stellar population and to pass from bolometric to kinetic luminosity. Second, it is hindered by Gaia's limitations in measuring the magnitudes of the most luminous stars, leading to incomplete or inaccurate luminosity estimates for massive clusters.

We propose a more direct and robust method to identify the most powerful stellar clusters: focusing exclusively on detected Wolf-Rayet stars. These stars dominate the kinetic power output of clusters, with a single WR star sometimes matching or exceeding the luminosity of an entire OB star cluster. By summing the contributions of WR stars within each cluster, we obtain a reliable and nearly complete sample of the most powerful YMSCs, without the need for IMF extrapolations. This approach provides a targeted list of the most promising clusters in terms of observability and typically offers a solid foundation for investigating their role in cosmic-ray acceleration up to PeV energies. We also explore potential coincidences between these WRs or clusters and gamma-ray sources detected by HESS, LHAASO, or Fermi-LAT, to assess possible associations.

Collaboration(s)

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