ICRC
The Astroparticle Physics Conference
34th International Cosmic Ray Conference
July 30 - August 6, 2015
The Hague, The Netherlands

Contribution ID: **1380** Type: **Invited Review talk**

Cosmic particle acceleration after a decade of VHE gamma-ray observations

Friday 31 July 2015 09:00 (45 minutes)

Gamma-rays observations are believed to play a crucial role in the solution to the long standing problem of origin of cosmic rays (CRs). The results obtained over the last decade with the space and ground based detectors have demonstrated the great potential of gamma-ray astronomy, in particular in the context of the search and identification of major contributors to the flux of galactic and extragalactic CRs.

Presently, more than 150 objects are reported as VHE gamma-ray emitters. These may be categorised into ten (or so) source populations, including Supernova Remnants (SNRs) and Active Galactic Nuclei (AGN) which have been predicted, within the frameworks of different astrophysical scenarios and conceptual/theoretical schemes, as the most likely factories of production of galactic and extragalactic CRs, respectively. However, the attempts of interpretation of these results generally reveal quite large uncertainties in estimates of the principal model parameters. This prevents us from clear-cut statements, e.g. regarding the contribution of SNRs to the bulk of galactic cosmic rays, in particular at PeV energies (the domain of the "knee"in the CR spectrum). I will briefly discuss the progress regarding the recent "hunt"for the PeVatrons, and highlight some regions in our Galaxy, including the Galactic Center, which may accommodate proton PeVatrons. If confirmed, this would be a major milestone towards the understanding the origin of galactic CRs.

At the same time, the recent gamma-ray observations demonstrate that particle acceleration is a widely spread phenomenon taking place with remarkable diversity, with regards the acceleration mechanisms, type of sources, scales of available energy, etc. In specific environments, e.g. in Pulsar Wind Nebulae (PWN) and in blazars, the particle acceleration can proceed with unusually high efficiency in the sense of both the total energy released in an ensemble of nonthermal particles and the maximum energy achieved by individual particles. In some cases these machines seem to operate at an acceleration rate close to the theoretical limit set by the classical electrodynamics.

Thus, there are many reasons to believe that the spectral, spatial and temporal studies of these extreme accelerators with the next generation gamma-ray instruments like CTA, will result in discoveries the significance of which could go beyond the traditional topics related to the origin of CRs.

Collaboration

– not specified –

Registration number following "ICRC2015-I/"

1076

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Session Classification: Invited Review Talks

Track Classification: GA-EX