Status and Latest Results from LHAASO on Υ-ray and Cosmic Ray Physics

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The LHAASO collaboration has more than 280 members from 32 institutes in 5 countries. The commission of LHAASO in 2021 opened the epoch of ultra-high-energy (UHE) gamma-ray astronomy and paved the way to address the origin of cosmic rays up to hundreds of PeV. Located at Daocheng, Sichuan, on the eastern edge of the Tibetan plateau with an elevation of 4410 meters above the sea level (Figure 1), LHAASO's KM2A and WCDA arrays have achieved a duty cycle better than 99% and 98%, respectively, and the WFCTA has collected more than 2100 hours of high-quality data.

With a large FOV and high sensitivity, LHAASO-KM2A and WCDA have shown their superiority in UHE and very-high-energy (VHE) gamma-ray sky survey with the release of the first LHAASO catalog [1]. 90 sources with an extension less than 2 ° were detected with a significance greater than 5 σ (TS>37). Among these sources, 69 were detected by WCDA, 75 by KM2A and 54 by both arrays (Figure 2). The mean spectral index of KM2A sources is about 3.5 while those for WCDA sources is 2.5. 43 UHE sources were detected above 100 TeV with a significance greater than 4 σ . There are 82 sources within the Galactic latitude of 12 °, and 4 high latitude AGNs. 32 of these sources haven't been detected previously in the TeV range (Figure 2). Half of these sources can be associated with pulsar wind nebulae or supernova remnants (SNRs), 1 with AGN, 8 have GeV counterparts, 7 have no counterpart. Diffuse gamma-ray emission from the Galactic plane was also measured from 10 TeV to 1PeV [2]. The brightest gamma-ray burst 221009A was also fully covered by LHAASO [3]. Some preliminary results on cosmic ray spectra, composition, and anisotropy are also available. These results together will advance our understanding of the origin of cosmic ray significantly.

In particular, more than 7 SNRs have been detected by LHAASO (Figure 3). There are also a few UHE sources likely associated with SNRs. The spectra of some of these sources extend beyond 100 TeV, implying that they are indeed PeVatrons. However, their soft UHE spectra means that both leptonic and hadronic processes can account for the observed UHE emission. Detailed multiwavelength studies are needed to quantify their contribution to PeV cosmic rays [4]. More exciting developments can be anticipated in the coming few years.

References

[1] LHAASO collaboration, The First LHAASO Catalog of Gamma-Ray Sources, arXiv:2305.17030
[2] LHAASO collaboration, Measurement of ultra-high-energy diffuse gamma-ray emission of the Galactic plane from 10 TeV to 1 PeV with LHAASO-KM2A, arXiv:2305.05372
[3] LHAASO collaboration, A tera-electronvolt afterglow from a narrow jet in an extremely bright gamma-ray burst 221009A, DOI: 10.1126/science.adg9328
[4] Liu, S. et al. The origin of galactic cosmic rays, Reviews of Modern Plasma Physics, Volume 6, Issue 1, article id.19

Figure 1: Bird view of the LHAASO in 2021

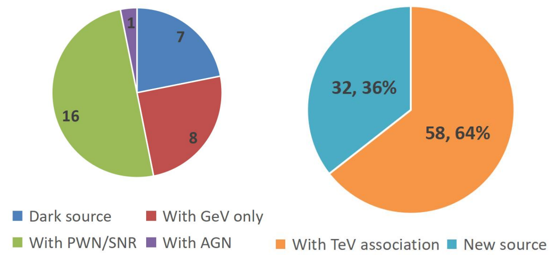

Figure 2: The first LHAASO catalogue with 90 sources (right) and 32 new sources (left)

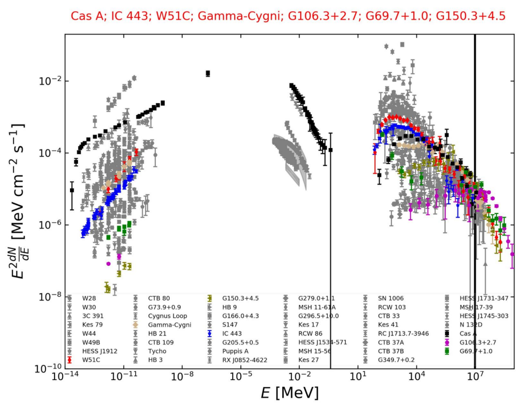

Figure 3: The spectra of 46 SNRs normalized at 1TeV