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Extragalactic Gamma-Ray Astrophysics

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During the last decades, various classes of radio-loud active galactic nuclei have been established as sources of high-energy radiation extending over a very broad range from soft gamma-rays (photon energies E˜MeV) up to very-high-energy gamma-rays (E>100 GeV). These include blazars of different types, as well as young and evolved radio galaxies. The observed gamma-ray emission from such implies efficient particle acceleration processes taking place in highly magnetized and relativistic jets produced by supermassive black holes, processes that have yet to be identified and properly understood. In addition, nearby starforming and starburst galaxies, some of which host radio-quiet Seyfert-type nuclei, have been detected in the gamma-ray range as well. In their cases, the observed gamma-ray emission is due to non-thermal activity in the interstellar medium, possibly including also a contribution from accretion disks and nuclear outflows. Finally, the high-energy emission from clusters of galaxies remains elusive, although the upper limits provided in this respect by Fermi-LAT and ground-based Cherenkov Telescopes, are at this point already very constraining. Those upper limits, along with many other results gathered on extragalactic gamma-ray sources – e.g., timing properties of gamma-ray flares in blazar sources, energetics of the extended gamma-ray lobes in radio galaxies, or spectral characteristics of starburst galaxies in gamma-rays – challenge the standard model of cosmic-ray origin and propagation, and in particular the paradigm of the shock acceleration that plays a major role in the cosmic ray production. Still, in many respect the extragalactic gamma-ray astrophysics is a relatively young field, keeping in mind that a large fraction of the gamma-ray emitters detected in the Fermi-LAT all-sky survey remains unidentified. This constitutes a space for potential new exciting discoveries with future CTA or planned MeV satellite missions, in a combination with already operating neutrino and ultra-high-energy cosmic ray experiments, as it is among such unidentified gamma-ray emitters we may expect to find new classes of extragalactic sources of high-energy emission and particles.

Presenter: STAWARZ, Lukasz (Jagiellonian University)

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