Year 2022-2023

Laboratoire : Laboratoire Leprince Ringuet
Groupe : HESS
Tuteur : Mathieu de Naurois
Address : Laboratoire Leprince-Ringuet, Ecole Polytechnique, 91128 PALAISEAU Cedex
Telephone : +33 1 69 33 55 97
e-mail : denauroi@in2p3.fr

Diffuse Very-High-Energy gamma-ray Emission in the LMC with HESS

Summary:

Diffuse emission is the most prominent observational signature from the sky at Gigaelectronvolt (GeV) energies. Galactic diffuse emission was established before individual gamma-ray sources started to emerge and is thought to be a prime source of knowledge about cosmic-ray particle interactions and radiation processes ever since. Diffuse GeV gamma-ray emission still constitutes the systematic limit of source detection near instrumental threshold. Diffuse emission is expected in the VHE domain, too: on Galactic scale primarily from hadronic particle interactions with interstellar gas and Inverse Compton scattering of high energy electrons with interstellar radiation fields, but also when encountering intense radiation fields or dense molecular clouds in the local vicinity of cosmic accelerators. Both processes are indicative for particle escape from their acceleration regions and for their propagation through their Galaxy. The Large Magellanic Clould (LMC), a satellite galaxy of the Milky Way, is one of the best target for such studies, due to its proximity and its intense stellar activity. Moreover, it is view almost face on from the earth, allowing to locate and characterize the high energy emission.

In contrast to the GeV domain the search for diffuse emission at Teraelectronvolt (TeV) energies is very challenging, largely due to the predominant isotropic background. Recent developments allowed however to make very significant progresses. In particular, a new simulation paradigm, called “RunWise simulation”, in which each and every observation is completely simulated with the actual observation conditions, allowed to get rid of the traditional background subtraction techniques and led to the first identification of large scale, diffuse emission in the LMC, however using a rather small fraction of the existing data set.

Building up on this recent success, the proposed project aims at characterizing the spatial and spectral properties of the large scale diffuse emission in the Large Magellanic Could. H.E.S.S. observations are to be compared with predictions from a model of diffuse VHE emission that is currently being developed. On the instrumental side, the investigation will push the limits of atmospheric Cherenkov imaging in sensitivity and energy through the detailed modelling of the isotropic charged particle background and the use of a complex likelihood-based template fitting technique, the latter being a novelty for investigating VHE data.

Detection and characterization of diffuse emission in the LMC and in the Milky Way would allow an indirect measurement of the Cosmic Rays density and energy distribution in the Galaxy, thus improving the global picture of production and propagation of Cosmic Rays.

References :

- M. de Naurois, The Making of Catalogues of Very-High-Energy γ-ray Sources, Universe 2021, 7(11), 421
- L. Tibaldo, D. Gaggero, P. Martin; Gamma Rays as Probes of Cosmic-Ray Propagation and Interactions in Galaxies, Universe 2021, 7(5), 141
- M. Holler, J.-P. Lenain, M. de Naurois, R. Rauth, and D.A. Sanchez, A Run-Wise Simulation and Analysis Framework for Imaging Atmospheric Cherenkov Telescope Arrays, Astroparticle Physics, 123, id. 102491
- CTA Consortium; Acharya, B. S. et al, Science with the Cherenkov Telescope Array, World Scientific Publishing
- H.E.S.S. collaboration, F. Aharonian et al., The H.E.S.S. survey of the Inner Galaxy in very high-energy gamma-rays, The Astrophysical Journal, 636 (2006)

- A. A. Abdo et al (Fermi collaboration), Fermi Large Area Telescope Measurements of the Diffuse Gamma-Ray Emission at Intermediate Galactic Latitudes, Physical Review Letters, 103 (2009)
- A. W. Strong, I. Moskalenko, O. Reimer, Diffuse Continuum Gamma Rays from the Galaxy, The Astrophysical Journal, 537 (2000)
- T. Delahaye, A. Fiasson, M. Pohl, P. Salati, The GeV-TeV Galactic gamma-ray diffuse emission. Uncertainties in the predictions of the hadronic component, Astronomy and Astrophysics, 531 (2010)
- D. Berge, S. Funk and J. Hinton, Background modelling in very-high-energy gamma-ray astronomy, Astronomy & Astrophysics, 466 (2007)
- M. de Naurois, L. Rolland, A high performance likelihood reconstruction of γ-rays for imaging atmospheric Cherenkov telescopes, Astroparticle Physics, 32 (2009)
- Diffuse Galactic gamma-ray emission with H.E.S.S H.E.S.S. collaboration, A. Abramowski et al. Phys. Rev. D 90 (2014) 122007