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High energy emission of cosmic messengers from galaxy clusters

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We explore the high-energy emission of cosmic messengers from galaxy clusters hosting active galactic nuclei (AGNs) such as Perseus. The main objective is to distinguish the emission from the central source, such as NGC 1275, from the diffuse emission. Due to high magnetic field and large size of clusters, CRs with energy $\leq 10^{18}$ eV can be confined within these structures over cosmological time scales, and generate secondaries, including neutrinos and gamma-rays, through interactions with the background gas and photons. We employ three-dimensional cosmological magnetohydrodynamical simulations of structure formation to model the turbulent intracluster medium (ICM). To study the propagation of CRs in intracluster medium (ICM) and intergalactic medium, multi-dimensional Monte Carlo simulations are conducted, considering all relevant photohadronic, photonuclear, and hadronuclear interactions. By comparing our results with the existing upper limits from IceCube and LHAASO as well as the sensitivity of CTA, we predict that these observatories could potentially establish a new class of astrophysical sources capable of emitting high-energy multi-messenger signals. In addition, we computed the contribution from clusters across redshifts to the diffuse neutrino and gamma-ray background.

Primary author(s) : HUSSAIN, Saqib (University of Nova Gorica); ZAHARIJAS, Gabrijela (Center for Astrophysics and Cosmology, University of Nova Gorica)

Presenter(s) : HUSSAIN, Saqib (University of Nova Gorica)

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