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## High-Energy Neutrino and Gamma Ray Production in Clusters of Galaxies

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We estimated the contribution from clusters of galaxies to the diffuse neutrino and  $\gamma$ -ray background. Due to their unique magnetic-field configuration, CRs with energy  $\leq 10^{17}$  eV can be confined within these structures over cosmological time scales, and generate secondary particles, including neutrinos and gamma-rays, through interactions with the background gas and photons. We used 3D-MHD simulations of galaxy formation to model the turbulent intergalactic and intracluster media. We propagate CRs in these environments using multi-dimensional Monte Carlo simulations across redshifts (from  $z \sim 5$  to  $z = 0$ ), considering all relevant photohadronic, photonuclear, and hadronuclear interactions. We find that for CRs injected with a spectral index  $1.5 - 2.7$  and cutoff energy  $E_{\max} = 10^{16} - 10^{17}$  eV, clusters contribute to a substantial fraction to the diffuse fluxes observed by the IceCube and Fermi-LAT, and most of the contribution comes from clusters with  $M > 10^{14} M_{\odot}$  and redshift  $z < 0.3$ . We also estimated the contribution from Perseid-like clusters within a distance of about 75 Mpc.

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