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Radio Constraints on Multi-Messenger High-Energy Emission from Galaxy Clusters

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Galaxy clusters can work as gigantic reservoirs of cosmic rays, and they are considered to be possible sources of the IceCube neutrinos.
Some clusters are found with extended radio emission called radio halos, which provides crucial information about the non-thermal components in the intra-cluster medium. We study the high-energy emission from the galaxy clusters considering the constraints from the observations of the radio halos.
It has been believed that the radio emission is powered by the turbulent re-acceleration of relativistic electrons because radio halos are preferentially found in merging systems.
Concerning the origin of cosmic-ray electrons, we compare two scenarios, 'secondary' and 'primary' scenarios, where electrons are mainly produced through the pp collision in the secondary scenario.
We model the evolution of the spectrum and cosmic-ray distribution in a specific cluster, the Coma cluster, by solving the Fokker-Planck equation, considering the re-acceleration and spatial diffusion.
On the other hand, the occurrence of radio halos is modeled with the Monte Carlo merger tree and constrained by the observed statistical properties.

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Summary

Both secondary and primary scenarios seem to be compatible with current multi-wavelength observations, although the required injection profile of cosmic-rays and the lifetime of the radio haloes are considerably different. We roughly estimated the neutrino background intensity and find that galaxy clusters can make a sizable contribution to the IceCube data even in the primary scenario. Future high-sensitivity observation in radio and gamma-ray bands would be crucial to distinguish those two scenarios.

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