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On Multi-frequency Observations of Massive Merging Clusters

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Galaxy clusters are compositions of dark matter, galaxies, and hot baryonic gas. The clusters grow via major and minor merger events, which makes them the perfect laboratory for investigating various astrophysical processes connected to the hot gas in intra-cluster medium, cosmic ray particles, and large-scale magnetic fields. While X-ray observation provides us with information related to the cluster's mass, merger history, and dynamical state, radio observations complement the thermal X-ray and optical emissions and reflect the processes that result in non-thermal synchrotron radiation. With the advancement of radio interferometer techniques, many fascinating features hosted in galaxy clusters have been revealed in the past few decades. However, the details of the origin of these emissions, particle acceleration, and magnetic field amplification mechanisms are still poorly understood. The large-scale radio structures in the clusters are classified as radio halo, minihalo, relic, and phoenix. Studying these extended radio structures helps probe the fundamental physics of particle acceleration and provides insights into large-scale structure formation and evolution. These radio structures show steep spectra ($\alpha<-1$) and thus are fainter at GHz frequency and brighter at sub-GHz frequency bands. Several information related to spectral age, cluster merger dynamics, magnetic field, and particle acceleration process can be estimated by multi-frequency study of these diffuse cluster sources in detail.
Here, I will present our analysis using modern day radio telescopes like uGMRT, VLA, and MeerKAT and report some interesting results about some of the massive merging galaxy clusters. I will present the spectral nature of those cluster radio emissions through multi-frequency radio observations. I will also discuss the cluster merger and dynamical scenario by combining the radio findings with X-ray and optical studies.