URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

A deep uGMRT study of the steep spectrum radio halo in A521

Ramananda Santra*(1) and Ruta Kale(1)
(1) National Centre for Radio Astrophysics, T. I. F. R. , Pune, India; e-mail:rsantra@ncra.tifr.res.in

Diffuse radio emission from galaxy clusters known as radio halos and relics, which are not associated with individual galaxies, are the signposts of the dynamical processes in the Intracluster medium (ICM). Radio halos are the Mpc-scale centrally located diffuse sources, having spectral indices (α) between -1.0 to -1.5 (S$\propto \nu^{\alpha}$) and are co-spatial with the ICM thermal emission [1]. The turbulent re-acceleration model is mostly favored for the origin of radio halo, due to the direct observational evidence of its predictions. The turbulent re-acceleration model predicts radio halos, with very steeper spectra (<-1.5) compared to the typical observed spectrum of giant radio halos. These sources known as Ultra Steep Spectrum Radio Halos (USSRH) are expected to be originated as a consequence of the less energetic mergers [2]. Low frequency telescopes such as the Upgraded GMRT (uGMRT) allow a multi-frequency follow-up that is crucial to understand their origin.

Here we present an overview of the detailed analysis of the radio halo, the prototypical ultra-steep spectrum radio halo in the cluster Abell 521, using the uGMRT [3]. This cluster also hosts a relic [4]. Radio observations over 300-800 MHz allow us to study the system in unprecedented detail than before. We have used online RFI filtering [5] in these observations and study the effect of RFI filter at both the bands 3 and 4. Our radio images using the CAPTURE pipeline have confirmed the presence of a second relic (discovery reported by MeerKAT), R2 (Fig. 1) situated diametrically opposite to the previous one. We have also detected a faint extension of 1 Mpc, R1-TL (Fig. 1), of the previous relic at both 400 and 650 MHz. The integrated radio halo emission is well fitted with a single power law, having a spectral index = -1.86 $\pm$ 0.12. Resolved spectral index map also reveals significant fluctuations over the extent of the halo. We discuss the radio properties of the cluster in the context of the ongoing complex merger in the system and the models for radio halo generation. We also discuss the role of online RFI filtering and the data analysis pipeline in obtaining deep images with the uGMRT.

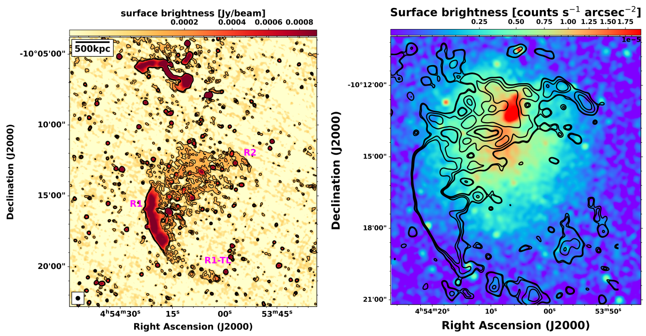

Figure 1. *Left:* uGMRT 400 MHz image at $10'' \times 10''$ is shown with different extended sources labeled in magenta. The contours levels are at $3\sigma_{\rm rms} \times$ [1,2,3..], with $\sigma_{\rm rms}$ = 31 μJybeam^{-1}. *Right:* The Chandra X-ray surface brightness map (color) overlaid with 650 MHz uGMRT radio emission (contour) is shown. The contour levels start with The contours are at $3\sigma_{\rm rms} \times$ [1,2,3..], with $\sigma_{\rm rms}$ = 29 μJybeam^{-1}. The beam size of the radio image is $22'' \times 22''$.

References

[1] Van Weeren, R. J., de Gasperin, F., Akamatsu, H., et al. 2019, Space Sci. Rev., **215, 16**.

[2] Cassano, R. & Brunetti, G. 2005, MNRAS, **357, 1313**.

[3] Santra, R., et al. 2023, in prep.

[4] Brunetti, G., Giacintucci, S., Cassano, R., et al. 2008, Nature, **455, 944**.

[5] Buch, Kale, et al 2022JAI....1150008B.