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Notice for the PhD Viva Voce Examination

Mr Sudheesh T P, Registration Number: 1942089, PhD Scholar at the Department of Physics and Electronics, School of Sciences, CHRIST (Deemed to be University), will defend his PhD thesis at the public viva-voce examination on Monday, 05 October 2026, at 10.00 am in Room No. 044, Ground Floor, R & D Block, CHRIST (Deemed to be University), Bengaluru - 560029, Karnataka, India.

Title of the Thesis	:	**Morphological and Environmental Investigations of Bent Radio Sources Using uGMRT**
Discipline	:	**Physics**
External Examiner - I	:	**Dr C D Ravikumar** Professor Department of Physics University of Calicut Kerala - 673635
External Examiner - II	:	**Dr Madhav Khushalrao Patil** Professor Faculty of Science and Technology Swami Ramanand Teerth Marathwada University, Nanded Vishnupuri, Nanded, Maharashtra - 431606
Supervisor	:	**Dr Jithesh V** Associate Professor Department of Physics and Electronics School of Sciences CHRIST (Deemed to be University) Bengaluru - 560029, Karnataka
Co-Supervisor	:	**Dr Ruta Kale** Associate Professor National Centre for Radio Astrophysics - Tata Institute of Fundamental Research Pune, Maharashtra - 411007

The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva–voce examination.

Place: Bengaluru
Date: 12 September 2026

Registrar (Academics)

ABSTRACT

Bent-tail (BT) or twisted-tail radio galaxies are generally regarded as a category of radio galaxies, which are often identified by bent radio jets. Depending upon the extent of bending, bent-tail sources are further classified as wide-angle tail (WAT) sources, head-tail (HT) sources, narrow-angle tail (NAT) sources and so on. These radio sources are generally considered to be powerful tracers of dense environments and environmental dynamics. Their characteristic jet bending often reflects the interaction of radio jets emitting from the host galaxy with the surrounding environmental medium. However, outliers to this common consensus have been observed, which raises a query on the co-evolution of these bent-tail sources and their environments. This thesis investigates the correlations between host parameters, radio properties, morphology, and environment of bent-tail radio galaxies using high-sensitive upgraded Giant Metrewave Radio Telescope (uGMRT) data supplemented by multi-wavelength datasets, aiming to understand how these factors collectively influence bent-tail morphology and evolution.

In our first study, we have used the data from the Galaxy Evolution and Magnetisation in the Saraswati Supercluster (GEMSS) survey. From the survey data, extended radio sources of various morphologies were visually identified, their radio cores were determined using Very Large Array (VLA) Faint Images of the Radio Sky at Twenty-Centimeters (FIRST), Very Large Array Sky Survey (VLASS), and GEMSS data, and host associations were determined from Sloan Digital Sky Survey (SDSS), Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), Spitzer, and Wide-field Infrared Survey Explorer (WISE) images. 63 extended radio sources with various morphologies were confirmed. For each source, the projected linear extent, integrated flux density, radio power, and magnetic field strengths were estimated. The distribution and correlation of various radio parameters shows the capability of GEMSS in detecting extended radio sources of various morphologies across different redshifts, size and radio power. A cluster association study revealed that 18 of the 63 sources are associated with galaxy clusters, of which 14 exhibit bent-tail morphologies, consistent with previous findings that bent-tail galaxies preferentially reside in dense environments. Among the 9 WAT sources associated with clusters, 8 lie near the cluster centres, reaffirming the central tendency of WATs. Environmental richness values for 21 bent-tail sources were estimated. The values indicate that approximately 76% of the bent-tail sources reside in dense environments. Relative velocity estimates and positional offsets from cluster centres show that neither environmental density nor relative velocity alone determines bending. Rather, it depends on multiple factors including local environmental medium conditions and radio source location.

In the second study, we carried out deep, multi-frequency uGMRT observations on the radio source J2349-0003, to study morphology-environment interactions. J2349-0003 is a non-cluster source exhibiting episodic activity for the active galactic nuclei (AGN), and lobe misalignment. High resolution uGMRT maps at Bands 3 and 4 reveal two pairs of lobes, confirming it as a candidate double-double radio galaxy (DDRG). Its large projected linear size and moderate power imply a sparse ambient environment, suggesting that small scale dynamics on galaxy scales or host properties govern its asymmetries. Spectral age analysis indicates two episodes of AGN activity separated by a short quiescent phase, with relatively older plasma in the northern lobes possibly resulting from environmental asymmetry or recent particle injection in the southern lobes. The observed misalignment could be attributed to galaxy interactions or processes such as galaxy mergers.

The subsequent study focuses on the peculiar bent-tail galaxy J1051+5523, from a cluster environment. J1051+5523 is a WAT radio galaxy in a low-mass cluster (2.03×10^{14} M), exhibiting an asymmetric axe-like morphology. Deep ⊙ uGMRT maps shows multiple kinks in the southern jet and a sharp bent in the northern jet. The source has an estimated radio power of 2.91×10^{25} W Hz^{-1} at 150 MHz, placing it near the FR I–FR II transition region. Spectral index map indicates recent particle injection or ongoing particle acceleration, with relatively less steep lobes. The relative velocity of the host galaxy within the limits of uncertainty, is observed to be insufficient to generate the observed morphology. Thus, the observed morphology likely results from the combined effects of mild relative velocity and buoyant forces within the cluster.

Our studies demonstrate that the morphology of bent-tail radio galaxies arises from a complex interplay between host galaxy and environmental properties. The high sensitivity of uGMRT has enabled the detection of diffuse low frequency emission and detailed investigation of bent-tail evolution across different environments. In the future, our works will be extended to the analysis of a larger sample with deeper multi-frequency and X-ray data to better quantify environmental densities, and polarization studies will be used to further probe jet-intracluster medium (ICM) interactions and magnetic field configurations in bent-tail systems.

Keywords: radiation mechanisms: non-thermal – galaxies: active – galaxies: clusters: intracluster medium – radio continuum: galaxies

Publications:

1. **Sudheesh T. P.**, Kale R., Jithesh V., Ishwara-Chandra C. H., Jacob J., "A multi-frequency study of the candidate double–double radio galaxy J2349-0003 with a possible misalignment", 2025, Journal of Astrophysics and Astronomy, 46, 74, DOI: 10.1007/s12036-025-10102-7
2. **Sudheesh T. P.**, Kale R., Jithesh V., Santra R., Ishwara-Chandra C. H., Jacob J., "Investigation of the Axe-shaped Radio Galaxy J1051+5523 with uGMRT", 2025, MNRAS, 543, 2046, DOI: 10.1093/mnras/staf1604