PROCEEDINGS OF SCIENCE

Deep radio surveys at 325 MHz of legacy fields with GMRT: Search for High-redshift Radio Galaxies revisited

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We have carried out deep radio survey of legacy deep fields like DEEP2, VIMOS4, VLACOSMOS and LBDS at 325 MHz with GMRT. The primary aim of these observations are to search for steep spectrum radio sources, which are strong candidates for high-redshift radio galaxies. Matching deep optical, IR and high frequency radio observations are available for these fields which make them the most valuable data set for studying the evolution of radio loud AGNs including low power AGNs. Here we describe goals of our programme and present preliminary results of one of the DEEP2 field, centered at RA 16h49m30s and DEC 34d56′, covering an area of 2 degree $\times$ 1.75 degree with the GMRT. The resolution is 8.5 $\times$ 5.8 arcsec and the rms noise is $\sim 90\mu$Jy/beam in most part of the image. We have catalogued about $\sim$ 1000 sources with flux density $>$ 1 mJy at 325 MHz, from this image. The GMRT 325 MHz sources were matched with FIRST, NVSS, SDSS and DEEP2 optical data. In this field, $\sim$ 120 sources have $\alpha > 1$ and majority remain un-identified with SDSS. The steep spectrum radio sources without optical counterparts are strong candidates for HzRGs and will be followed up in optical and IR for redshift estimates. One of the steep spectrum source, un-identified in SDSS, show clear FRII morphology in FIRST. Using FRI/FRII break luminosity, its redshift is expected to be $>$ 2. This deep radio data at 325 MHz will also be used to study evolution of low power radio sources, along with available deep multi-band data.

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1. Introduction

For several reasons, it is important to discover radio loud AGNs at high redshifts (Afonso et al. 2014). First, the host galaxies of high redshift radio galaxies (HzRGs) are among the most massive galaxies (eg: Best et al. 1998; Rocca-Volmerange et al. 2004), therefore, the formation and evolution of such galaxies at high-redshifts can be studied by picking them through the radio window. This will be complementary to the emerging population of Lyman Break Galaxy (LBG) population at high-redshifts, which are less massive by one to two orders of magnitude than AGN host galaxies (eg: Tilvi et al, 2013). Second, these objects are known to reside in dense environments, so are excellent tracers of protoclusters (Miley, et al. 2006, Kuiper et al. 2012). Third, the radio luminosity function of HzRGs beyond redshift of 4 is poorly constrained (Cruz et al. 2007). Fourth, since supermassive blackholes are essential ingredients of radio loud AGN, the formation of supermassive black holes at such early epochs can also be probed using these objects.

Despite several decades of efforts only one radio galaxy is known at redshift > 5 (van Breugel et al. 1999), though there are close to 50 HzRGs with z > 3 (Miley and de Breuck 2008; Ishwara-Chandra et al. 2010). Here we outline the Giant Metrewave Radio Telescope (GMRT) programme with an aim to detect more HzRG candidates that may lie at z > 5, which are 10 to 100 times less luminous than known high-redshift radio galaxies.

In order to understand whether the kown HzRGs represent typical FRII radio sources at high-redshift, or the brightest among that category, we had compiled all the known HzRGs beyond the redshift of 3. The median flux density of all known HzRGs beyond redshift of 3, is 0.5 Jy at 325 MHz (Figure 1). This is almost three orders of magnitude brighter than the FRI/FRII break. At redshift of 3, the FRI/FRII break luminosity corresponds to a flux density of ~ 2 mJy at 325 MHz (assuming a spectral index of 1 for the K-correction). The corresponding values at redshifts of 4 and 5 are ~ 1 and ~ 0.5 mJy, respectively. Comparing this to the median flux density of the presently known HzRGs, it shows that the known HzRGs represent only the tip of the iceberg, i.e; they are the brightest objects in radio, at each redshift. There are, potentially, a large number of HzRGs yet to be discovered which are ~ 100 times less radio luminous than the known HzRGs (see Fig. 1). From the radio luminosity function of HzRGs, we could expect at least a 10 fold increase in space density of the radio sources beyond the redshift of 3 at radio luminosities ~ 100 times lower than those of the known HzRGs (Waddington et al. 2001).

Systematic efforts are needed to detect this population of radio galaxies, which are not at the brightest end of the radio luminosity function. They are well within the reach of present day radio telescopes such as GMRT. The most efficient method to find high-redshift radio galaxies is by exploiting the steep spectrum criteria (e.g: Miley and de Breuck 2008). Recently, Ker et al. (2012) have analysed the HzRG content in various radio surveys selected at low and high radio frequencies as well as the impact of different selection criteria in discovering HzRGs. It was conclusively shown that the samples selected at low radio frequencies contains much higher fraction of HzRGs as compared to sources selected at GHz frequencies. Thus, the large gap mentioned in Figure 1, can be filled by searching for steep spectrum sources using deep radio observations with GMRT at 325 MHz.

PoS(EXTRA-RADSUR2015)057

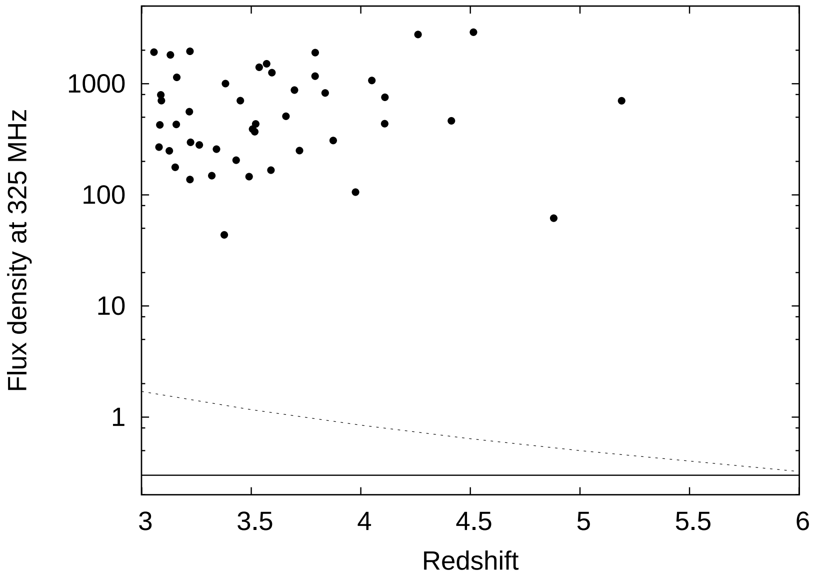

Figure 1: 325 MHz flux densities of the known HzRGs (z > 3) compiled from literature. The dotted line at the bottom is the 325 MHz flux density corresponding to the rest-frame FRI/FRII break luminosity. The solid horizontal line is the GMRT detection limit from the present 325 MHz observation. It is clear from this figure that a large number 'normal population' of FRIIs, that are 10 to 100 times less luminous than the known HzRGs are yet to be discovered.

2. GMRT Programme to search for HzRG candidates from known deep fields

We have started a programme using the GMRT to fill this gap (Figure 1), by observing several well known deep fields such as DEEP2, VIMOS4, VLACOSMOS and LBDS at 325 MHz with GMRT. Here we present results from observations of fields centered at 16h48m 34d55' and 16h51m 34d56m30$''$ around one of the DEEP2 fields (Newman et al. 2012). Each pointing was observed for $\sim$ 150 mins and the data was analysed in AIPS following standard procedures.

3. Results and Discussion

The final image at 325 MHz, of one of the DEEP2 field, centered at 16h49m30s 34d56$'$ covering an area of 2 $\times$ 1.75 degree is obtained with GMRT (Figure 2). The rms noise is $\sim 90\mu$Jy/beam in most part of the image and the resolution is 8.5 $\times$ 5.8 arcsec. We have catalogued about $\sim$ 1000 sources with flux density $>$ 1 mJy at 325 MHz, from this image. The GMRT 325 MHz sources were matched with FIRST, NVSS, SDSS and DEEP2 optical data. In this field, $\sim$ 120 sources have $\alpha > 1$ and majority remain un-identified with SDSS. The steep spectrum radio sources without optical counterparts are strong candidates for HzRGs and will be followed up in optical and IR for redshift estimates. One of the steep spectrum source, un-identified in SDSS, show clear FRII morphology in FIRST. Using FRI/FRII break luminosity, its redshift is expected to be $>$ 2. This deep radio data at 325 MHz will also be used to study evolution of low power radio sources, along with available deep multi-band data.

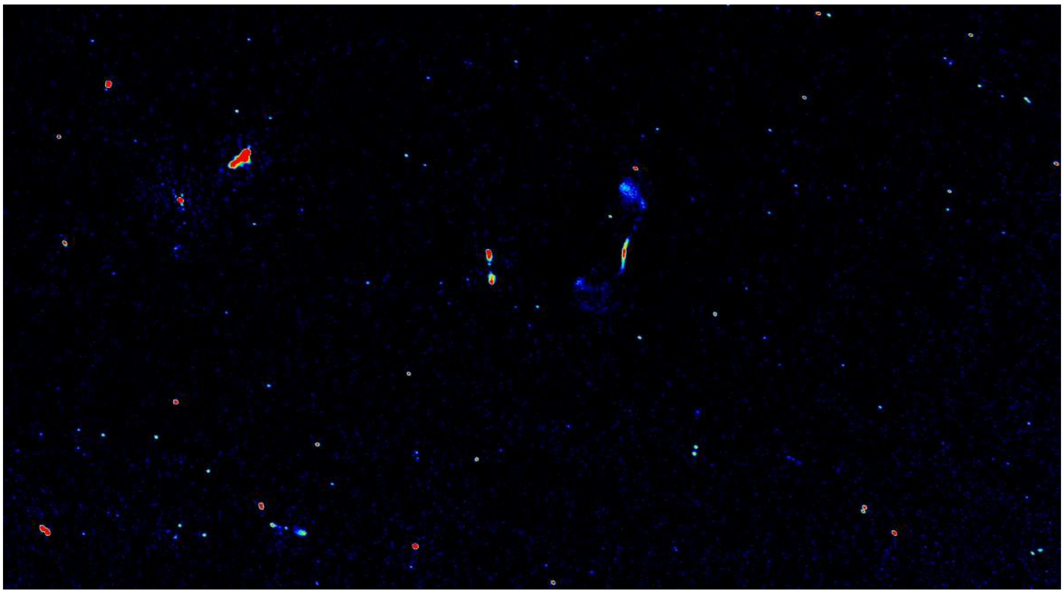

Figure 2: A portion of the GMRT 325 MHz image of the DEEP2 field ($40' \times 25'$). The rms noise is $\sim 90\mu$Jy/beam with resolution of 8.5×5.8 arcsec

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References

[1] Abazajian et al. 2009, ApJS, 182, 543

[2] Afonso, J., et al. 2015, AASKA14, 1063

[3] Becker, R. H., White, R. L., Helfand, D. J., 1995, ApJ, 450, 559

[4] Best P. N., Longair M. S., Röttgering H. J. A., 1998, MNRAS, 295 549

[5] Cruz, M. J., et al. 2007, MNRAS, 375, 1349

[6] Ishwara-Chandra, C. H., et al. 2010, MNRAS, 405, 436

[7] Ker, L. M., et al. 2012, MNRAS, 420, 2644

[8] Kuiper, E., et al. 2012, MNRAS, 425, 801

[9] Miley, G, K., de Breuck C., 2008, A&ARv, 15, 67

[10] Miley, G. K., et al., 2006, ApJL, 650, 29

[11] Newman, J. A. et al. 2012 (arXiv1203.3192)

[12] Rocca-Volmerange, et al. 2004, A&A, 415, 931

[13] Tilvi et al. 2013, ApJ, 768, 56

[14] van Breugel, W., et al. 1999, ApJL, 518, 61

[15] Waddington, I., et al. 2001, MNRAS, 328, 882