Bull. Astr. Soc. India (2002) 30, 743–746

Observations of Associated H I Absorption in Radio Galaxies and Quasars using GMRT

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Abstract. We describe observations and preliminary results of absorption by cold hydrogen gas (H I) associated with six radio galaxies and quasars (Table 1) which may provide valuable information about their host galaxies and their surroundings. Observations were made using GMRT (Swarup et al. 1991).

1. Observations and Results

A strong absorption line has been observed in 3C268.3 which is a Compact Steep Spectrum (CSS) radio galaxy (Fig.1(a)). The optical depth of the peak absorption feature is about 0.13 and its redshift is 0.371. This feature is redshifted with respect to the [O III] emission line by about 500 km/s and seems to indicate that the H I absorption is taking place due to an infalling gas cloud. The radio galaxy 3C268.3 is a compact double radio source with a 2 arcsec separation. One of its radiolobes is coincident in projection with an optical feature (de Vries et al. in prep).

Two other CSS sources show H I absorption lines which are not coincident with the [O III] emission line that is generally used for determining the redshifts of radio galaxies. Using GMRT, Dwarkanath & Owen (2001) found H I absorption associated with the radio galaxy C153 in cluster A 2125 with an optical depth of 0.36. The H I absorption is redshifted w.r.t to the [O III] emission line by about 400 km/s. Interestingly, the H I absorption is closer to [O II] and Hα emission lines. Morganti et al. (2001) find a similar result for PKS 1549-79 in which [O III] emission line is also blue shifted w.r.t. [O II] and Hα. Since H I absorption line is closer to [O II] and Hα emission lines, they suggest that the [O III] is emitted by gas in the inner line region, which is undergoing outflow from the nucleus, whereas the [O II] and Hα are likely to be closer to the real systematic velocity of this galaxy.

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Table 1. GMRT Observations of Associated H I Absorption

Sr. No.	Source	Redshift	Time Hrs	S_{Total} (mJy)	S_{rms} (mJy)	S_{abs} (mJy)	Optical Depth
1.	0902+34 G	3.395	6	1520	~ 2	15	$\sim 1\%$
2.	4C 1235+39 G	3.220	3	1472	1.7	< 3.5	$< 0.25\%$
3.	PKS 1402+044 Q	3.193	3	1235	1.2	< 3	$< 0.3\%$
4.	PKS 1614+051 Q	3.197	2.5	832	1.1	< 2.5	$<1.3\%$
5.	3C268.3 G	0.371	1	3340	~ 6	45	1.1%
6.	PD456 Q	0.1840	6	102	0.8	< 1.6	$<1.5\%$

Poonam Chandra, Swarup & Kulkarni (in prep.) have made observations of associated H I absorption in the radio galaxy 0902+34 (z = 3.395) at 323.3 MHz. It is the highest known redshift for associated H I absorption (Fig. 1(b)) It is noteworthy that GMRT observations with 15 antennas over a duration of about 6 hours gave a similar rms noise as provided by the Westerbork Synthesis Radio Telescope (WSRT) for observations over a duration of about 144 hrs (de Bruyn et al. 1996). Further the higher angular resolution of GMRT would allow us to locate the positions of H I absorbing clouds with respect to the central component and the outer lobes of the radio galaxy. The source 0902+34 has been imaged by HST and seems to be a proto-galaxy.

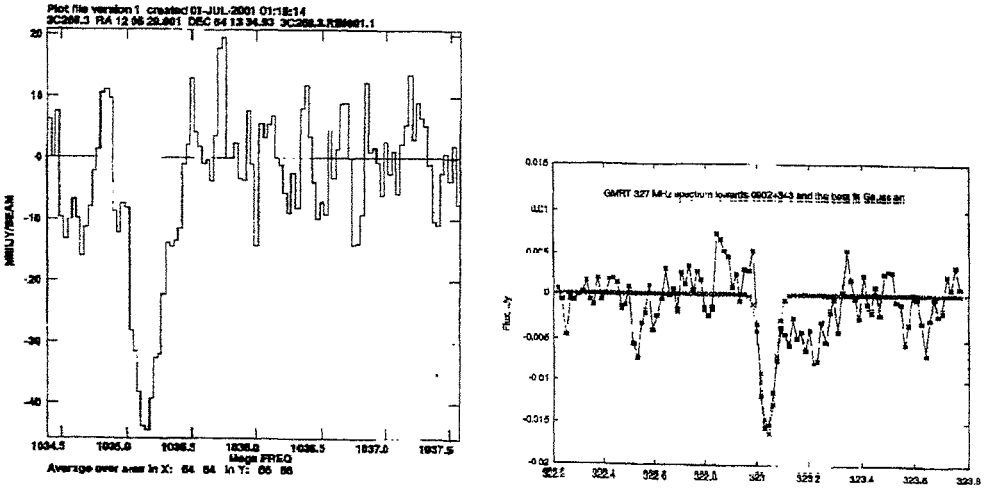

Figure 1. (a) GMRT observations of the redshift 21 cm associated H I absorption in the radio galaxy 3C268.3 at z=0.371. The H I absorption is redshifted with respect to [O III] emission line by about 500 kms^{-1}. (b) The Associated H I absorption profile in the radio galaxy 0902+343 at z=3.395 obtained by Poonam Chandra et al. (in prep) using 6 hours of GMRT.

No H I absorption has been detected by the authors from the GMRT observations of 1235+34 (4C+39-37): Galaxy at z =3.220; PKS 1402+044: QSO at z=3.193; PKS

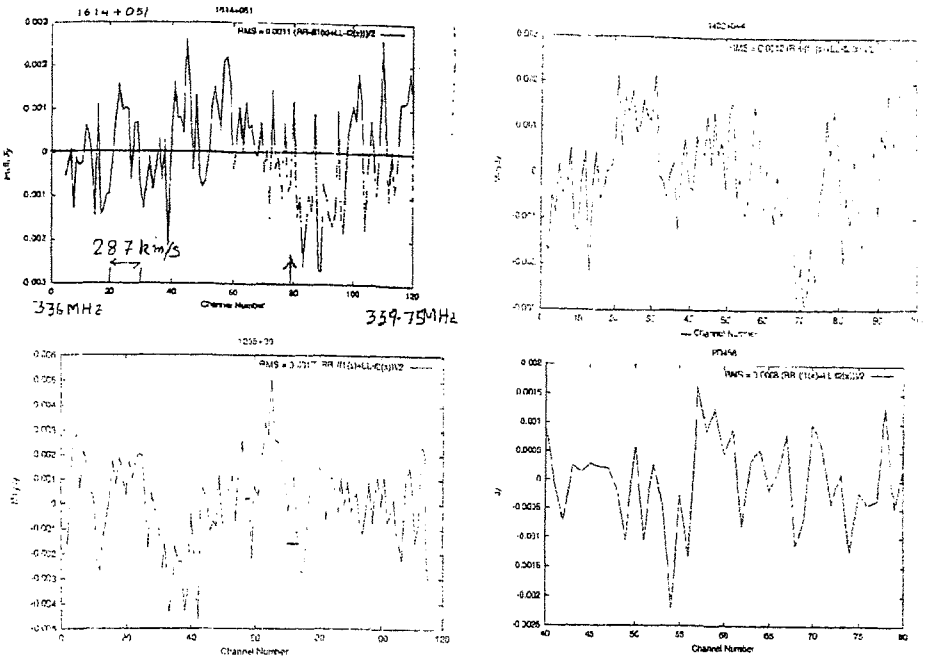

Figure 2. Upper limits on the associated H I absorption in 4 high redshift radio sources obtained by Swarup & Sarkar using GMRT. The frequency of associated H I absorption according to the redshift of the object is expected in channel Nos. 79, 56, 46 and 53 for sources 1614+051, 1502+044, 1235+39 and PD456 respectively.

1614+051: QSO at z=3.197 and PD456:QSO at z=0.1840 (Fig.2). The rms noise for the observed channel bandwidth of about 31 KHz was about 1 mJy for about 3 hour observations with GMRT, which is close to the expected value.

Associated H I absorption has been detected for over 70 radio galaxies and quasars by several workers using VLA, AT and WSRT. It is generally found that a large fraction of the Compact Symmetric Objects (CSOs) and Gigahertz Peak Spectrum sources (GPSs). with size less than about 1 kpc are found to show associated H I absorption with column densities of about $10^{20} - 10^{22}$ cm^2 for assumed spin temperature of about 100 K. The absorption seems to arise in these sources mostly from nuclear "disks" or "tori", as well in the gas enveloping either jets or hot spots in a few cases. H I absorption has also been seen from several radio galaxies and in a large fraction of red quasars (e.g. Carilli et al. 1998; Ishwar Chandra et al. this issue).

A systematic programme for observing H I associated absorption from a large sample of sources including the known high redshift gravitationaly lensed quasars has been initiated at NCRA. NCRA group is also planning to search for emissions from protoclusters at high redshifts. Our present observations indicate that by observing with GMRT for

several days, it should be possible to detect emission from H I condensates or filaments with a mass of few times $10^{12} M_{\odot}$ at a redshift of about 3.5 and 5.

Acknowledgements

We thank the staff of the GMRT that made these observations possible. GMRT is run by the National Centre for Radio Astrophysics of the Tata Institute of Fundamental Research.

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