

GMRT Observations of the Group Holmberg 124

+ Preliminary results on Holm 377 and Holm 565

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Abstract: We discuss the results of a multi-frequency radio study using the Giant Metrewave Radio Telescope (GMRT) of the group Holmberg 124 which comprises galaxies: NGC 2820, NGC 2805, Mrk 108 and NGC 2814. We detect the radio continuum bridge connecting NGC 2820 with NGC 2814 and find it to have a steep spectrum with index -1.8 at frequencies below 1.4 GHz. A large asymmetrical loop is detected in the 21 cm line of HI to the north of NGC 2820. We also report detection of a dwarf galaxy with mass $\sim 10^8 M_\odot$ to the north-west of NGC 2820. We conclude that both tidal interaction and ram pressure stripping due to the motion of the galaxies in the intragroup medium have likely influenced the evolution of this group [1]. Preliminary results from a radio continuum study of Holmberg 377 and Holmberg 565 at 330 MHz using GMRT, in particular, the first positive detection of interaction between NGC 4302 and NGC 4298 are also presented.

Introduction

A multi-frequency radio study of poor groups of galaxies is essential alongwith other wave-bands such as X-rays and optical to understand the evolution of small groups of galaxies and ultimately formation of clusters and the largest structures in the universe since different wave-bands trace different constituents. While X-rays traces hot gas ($T_e = 10^6 - 10^7$ K) of the intragroup medium (IGrM) which emits through free-free emission and spectral lines, optical emission traces star forming regions in galaxies. Radio continuum, on the other hand, traces the relativistic electron plasma in a magnetic field and the HI 21cm line traces cold neutral gas. Thus, all the above diagnostics are required to obtain for understanding the evolution of the group, its member galaxies IGrM.

In this paper we discuss our results of a multi-frequency radio continuum and HI 21cm study of the group Holmberg 124 using GMRT. We detect a steep spectrum bridge connecting NGC 2820 and NGC 2814 and a large asymmetrical HI loop to the north of NGC 2820. Additionally, preliminary results from GMRT observations of Holmberg 377 and Holmberg 565 are presented [2].

Observations

Table 1 summarizes details of GMRT [3] observations on Holm 124, Holm 377 and Holm 565. Although we have completed a comprehensive multi-frequency study of Holm 124, a similar study is being undertaken for Holm 377 and Holm 565 as is evident from the blank boxes in the table. Using NVSS and FIRST data on the latter two galaxies, preliminary results are presented in this paper. Note that the angular resolution at 330 MHz obtained on the three galaxies is different and is caused by editing data for RFI. Typical dynamic range at 330 MHz ranged from 1000 to 2500.

Results and Discussion

Holmberg 124

Fig 1 presents the low resolution 330 MHz image and the high resolution 1280 MHz image of NGC 2820, NGC 2814 and Mrk 108 (the triplet). NGC 2805 is about 8' south of the triplet and is not

Table 1: GMRT Observations of Holm 124, Holm 377 and Holm 565

Members	Holmberg 124 NGC2820,NGC2814 Mrk108,NGC2805			Holmberg 377 NGC4302 NGC4298			Holmberg 565 NGC5403 UGC08919		
	Beam	PA	Rms mJy/b	Beam	PA	Rms mJy/b	Beam	PA	Rms mJy/b
1280 MHz	7" × 5"	46°	0.08	-	-	-	-	-	-
610 MHz	22" × 13"	70°	0.4	-	-	-	-	-	-
330 MHz	20" × 14"	49°	1	27" × 10"	-47°	0.8	12" × 10"	70°	0.4
240 MHz	33" × 14"	82°	1.9	-	-	-	-	-	-
HI 21 cm	16" × 15"	26°	0.2	-	-	-	-	-	-

included. The radio emission from NGC 2805 is fairly weak and shows little correlation with the optical emission. It seems to have been severely distorted. Note the bridge of emission connecting the triplet. The bridge (see Fig 1a), first detected by [4] at 1.4 GHz and which has a low surface brightness is also detected at 2σ level at 610 and 240 MHz. Using all this data we obtain a spectrum with an index of -1.8 . A radio tail extending to the south is detected in NGC 2814. The radio continuum features, we believe, are due to the tidal interaction in the group members.

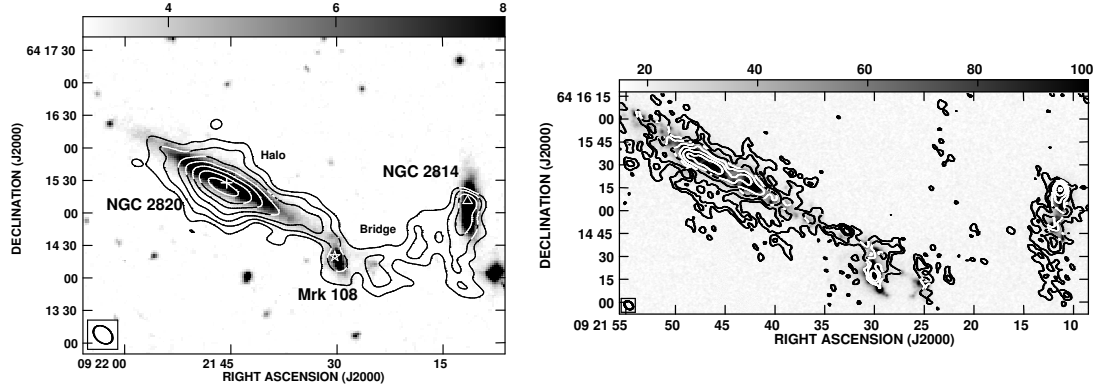


Figure 1: 330 MHz (a) and 1280 MHz (b) image of the triplet in Holmberg 124 superposed on the DSS and $H\alpha$ [5] images respectively.

The HI column density maps of the group are presented in Fig 2. Note the bridge almost connecting NGC 2820 with NGC 2814 and the streamer emerging from NGC 2814 which although positionally coincident is kinematically distinct from NGC 2814. Also note the asymmetrical HI distribution in the almost face on galaxy NGC 2805. The northern arc traced by HI in NGC 2805 coincides with an optical arc. We also report the detection of about $10^8 M_\odot$ of HI which is kinematically linked to NGC 2820, in what appears to be a dwarf galaxy, to the northeast of NGC 2820 (see Fig 2(a)). These are likely due to tidal interaction between the group members.

Additionally, we note the presence of the large HI loop to the north and the abrupt cutoff in HI to the south of NGC 2820 which is an almost edge-on galaxy. The HI loop has an extent of about 17.5 kpc along the disk and rises out to 4.9 kpc along the minor axis. From the projection of the loop, it appears to emerge from the edge-on disk at about the 25 mag-asec $^{-2}$ diameter. It is difficult to imagine such a large structure being created from tidal interaction of NGC 2820 with a small companion like NGC 2814. Moreover it is not clear how to interpret the sharp cutoff to the south in the tidal interaction scenario. We find that the ram pressure acting on the gas in NGC 2820 due to its motion in the IGrM for a typical IGrM density of $4.4 \times 10^{-4} \text{ cm}^{-3}$ is comparable to the gravitational pull on the gas. This suggests that ram pressure might be responsible for the northern HI loop and the sharp southern boundary [1]. It is likely that tidal interactions have reduced the surface density of HI in the outer parts of NGC 2820 and thus enabled ram pressure

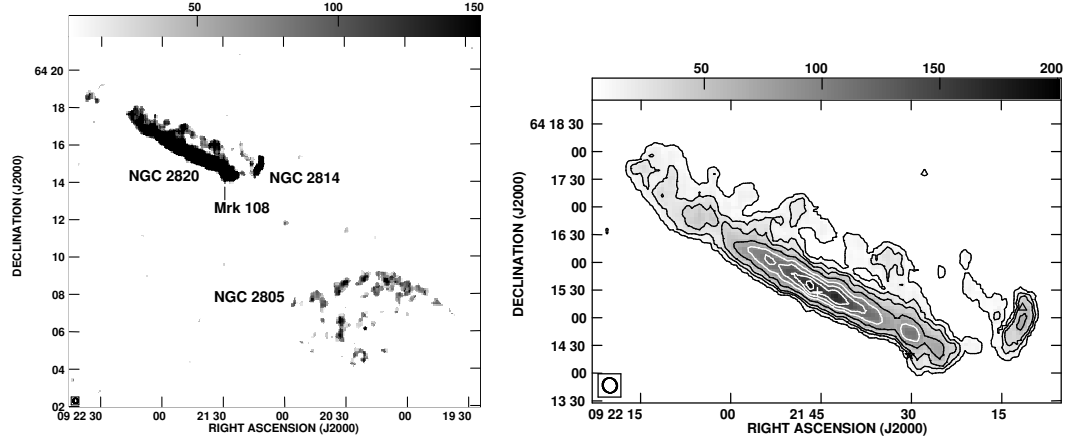


Figure 2: (a) HI Column density map of Holmberg 124. (b) blow up of the HI column density in the triplet. Note the large HI loop to the north of NGC 2820 and the streamer emerging from NGC 2814.

to strip it off. More details can be found in [1]. Unlike clusters, ram pressure is not believed to be important in groups due to lower temperatures and lower densities [6]. Thus, the afore-mentioned conclusion requires confirmation.

Holmberg 377

The radio continuum emission at 330 MHz recorded from this interacting pair of galaxies, namely NGC 4302 and NGC 4298 is shown in Fig 3. The first positive detection of a radio continuum bridge connecting the two galaxies which shows that they are interacting is reported. Note how it seems to emerge from close to the centre of NGC 4302, move upwards and fall into NGC 4298. NVSS data of much lower resolution also appears to show the presence of a bridge. The morphology of the bridge is interesting. Using our data at 0.33 GHz and NVSS at 1.4 GHz, we derive a spectral index of -1.4 for the bridge. It is steep, but not as steep as the bridge we found in Holm 124. No

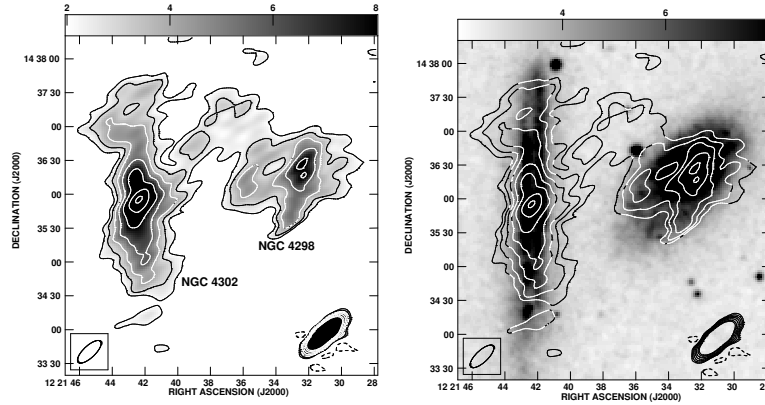


Figure 3: (a) The GMRT 330 MHz image of NGC 4302 and NGC 4298 at an angular resolution of $27'' \times 10''$. Note the bridge connecting the two galaxies. (b) The 330 MHz contours superposed on the DSS grey scale. Note that the radio disk seems to show a warp.

$H\alpha$ emission [7] is seen from the bridge indicating that no star formation is going on there. Low resolution X-ray images of this region from Einstein Observatory show emission centred on NGC 4298 and extending out to NGC 4302 [8] along the bridge which also seems to turn towards the north.

Holmberg 565

The radio continuum emission at 330 MHz recorded from Holm 565 is shown in Fig 4. Note that no

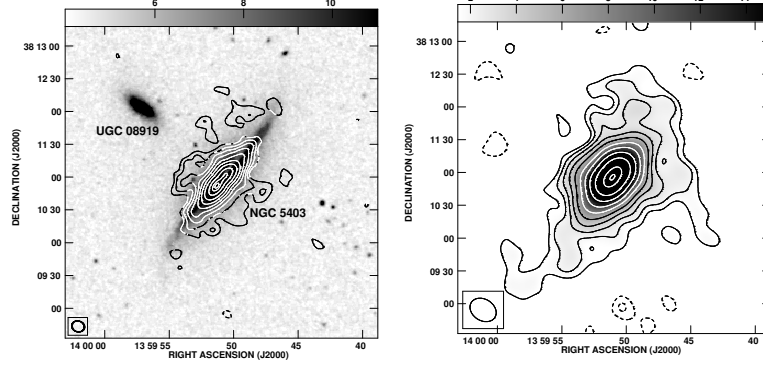


Figure 4: (a) High resolution ($12'' \times 10''$ at PA= 70°) GMRT 330 MHz contours superposed on the DSS image of Holmberg 565. No radio emission is detected from UGC 08919. (b) Low resolution ($26'' \times 20''$ at PA= 58°) GMRT 330 MHz image. Note the extended low surface brightness asymmetric halo around NGC 5403.

radio emission is seen from UGC 08919 whose morphological type is uncertain. The halo emission seen in the outer parts of NGC 5403 which is classified as a SBb galaxy, is asymmetric with large finger-like extensions to the south-west and south. Work on the latter two groups is continuing [2].

Summary and Conclusions

We have presented our GMRT results on the poor group Holm 124 which we believe shows multiple signatures of tidal interaction and ram pressure stripping on the morphology of its member galaxies. The radio continuum bridge has a very steep spectrum with an index of -1.8 . The first positive detection of a radio continuum bridge connecting the galaxies NGC 4302 & NGC 4298 in Holm 377 which has a spectral index of -1.4 is reported [2]. An asymmetric halo surrounds the disk of NGC 5403 in Holm 565 at 330 MHz. Work on the latter two groups is continuing.

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