RADIO OBSERVATIONS OF AGN IN LOW SURFACE BRIGHTNESS GALAXIES

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Abstract

Low surface brightness (LSB) galaxies have massive HI disks, are poor in star formation and are the most dark matter dominated galaxies in our nearby universe. AGN have been detected at optical wavelengths but further studies at radio or X-ray wavelengths has not been done in detail before. We present GMRT radio observations of several giant LSB galaxies at 1.4 GHz, 610 MHz and 230 MHz. Our maps reveal radio structures such as cores and extended features resembling radio jets or lobes at lower frequencies. Followup X-ray observations have also been done with the Chandra Telescope.

1 Low Surface Brightness Galaxies

Low Surface Brightness (LSB) galaxies are rotationally dominated galaxies with large gas disks but diffuse stellar disks. They can be large spiral galaxies like Malin 1 (e.g. Braine, Herpin & Radford 2000); or they may be like the more populous dwarf spiral/irregular galaxies (e.g. Schombert, McGaugh & Eder 2001). They are extremely gas rich (HI) but generally have low metallicities which indicates that they have had very little star formation compared to HSB galaxies (McGaugh 1994). They are thus less evolved than regular HSB galaxies (van der Hulst et al. 1993). They have slowly rising rotation curves and are dark matter dominated even in the inner parts of their disks. Although these galaxies have diffuse stellar disks, many of them have prominent bulges and a relatively strong spiral structure in the disk (e.g. UGC 6614). The origin and evolution of these LSB giant galaxies is still unclear. One picture suggests that they form in low density environments (Hoffman et al. 1992); an alternative scenario by Knezek (1993) suggests that they form dissipatively from large dark matter halos.

2 AGN in LSB Galaxies

Several giant LSB galaxies that have prominent bulges have been found to host active galactic nuclei (AGN) (Schombert 1998; Sprayberry et al. 1995). The nuclear activity is due to the accretion of mass onto a supermassive black hole in the galactic center. The presence of AGN activity is somewhat suprising as AGN in spirals are ususally associated with bright galaxies (Ho, Filipenko & Sargent 1997). The AGN behaviour in LSBs was found to be similar in the optical for both high and low surface brightness galaxies. This is suprising as they are very different in other respects (e.g. star formation rates, morphologies, mass to light ratios, gas mass fractions and disk dynamics). This leads to an interesting conjecture that AGN activity is decoupled from the global disk properties of galaxies and depends mainly on the properties of the nucleus or stellar bulge.

3 GMRT Radio Observations

To fully understand the evolution of LSB galaxies and their AGN activity we need to observe their emission at different wavelengths. We have observed a sample of 9 giant LSB galaxies at 1.4 GHz, 610 MHz and 325 or 230 MHz with the GMRT. The observations are complete and we are analysing the data (Das et al. 2007). In this poster we present preliminary results for a sample of four prominent LSB giants: UGC1922, UGC 2936, UGC 6614 and F568-6 (Malin-2). For the first two galaxies we have observations at all 3 frequencies with the

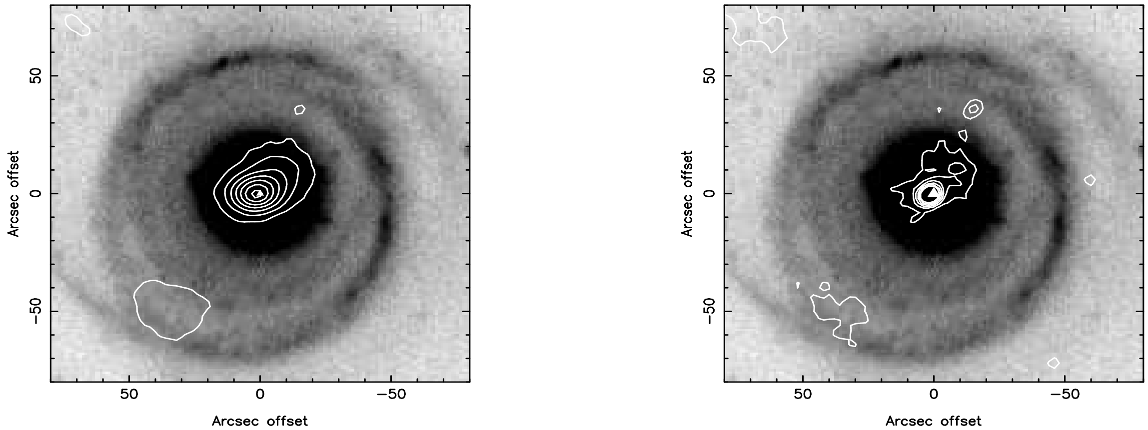

Figure 1: Figure 1a: Contours of GMRT 610 MHz radio continuum emission from the LSB galaxy UGC 6614 overlaid on the R band image of the galaxy. Natural weighting was used to obtain the extended emission; the beam is $15'' \times 12.5''$ and the contours are 4, 6, 8, 10, 12, 14 and 16 times the noise which is 0.3 mJy/bm. Figure 1b: Contours of GMRT 610 MHz high resolution radio continuum emission overlaid on the R band image of the galaxy. The beam is $7'' \times 6''$ and the contours are 3, 5, 7, 9, 11, 13, 15 times the noise which is 0.15 mJy/bm.

GMRT, whereas for the latter two galaxies we have 610 MHz and 230 MHz GMRT observations; we used VLA archival data for the 1.4 GHz maps.

All the galaxies have extended radio continuum morphology. Figure 1a and b show the 610 MHz low and high resolution maps for continuum emission from the the galaxy UGC 6614. The emission is extended in both maps and more so on one side. In the uniform weighted map, the emission resembles a one sided radio jet or lobe. The peak flux is 5mJy beam^{-1} where the beam is $13''$. This galaxy has been observed at millimeter wavelengths as well (Das et al. 2006). The flux is similar suggesting that the source has a flat spectrum core between 610 MHz, 1.4 GHz and 110 GHz. The compact structure suggests an AGN in early or mid stage of evolution; this is not suprising as LSB galaxies themsleves are poorly evolved as well. UGC 6614 is also one of the few galaxies that have been observed in X-ray. The XMM archival data indicate that the AGN is bright in X-ray. Using the radio-X-ray fundamental plane relation, the black hole mass of the AGN is 3.5×10^7 which puts it in the supermassive black hole (SMBH) domain. It is interesting to see that even such poorly evolved systems as LSB galaxies host AGN activity and a SMBH.

4 Conclusions

We have observed the radio continuum emission from a sample of giant low surface brightness galaxies using the GMRT at frequencies 1.4 GHz, 610 MHz and 325/230 MHz. The emission is mainly associated with AGN activity in the galaxies. The emission is extended in most cases and especially at lower frequencies such as 610 MHz. The extended emission is possibly radio lobes or jets associated with the AGN in these galaxies. The radio power is large compared to Seyfert galaxies but not as powerful as that seen in large elliptical galaxies.

5 References

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