Searching for Signatures of Radio Jets and Outflows from Ultraluminous Infrared Galaxies

Mousumi Das (IIA), Rubinur Khataun (IIA), K.S.Dwarkanath (RRI), Shweta Srivasava (PRL)

AGN in Ultraluminous Infrared Galaxies (ULIGRs)

ULIRGs are gas rich merger remnants that have bolometric luminosities greater than 10^{12} $L_{\odot}$. The intense luminosity is due to ongoing star formation in their disks. The UV emission heats up the dust and is re-radiated at mid and far infrared wavelengths (Sanders & Mirabel 1996). They have an $r^{1/4}$ profile which indicates that they are mergers evolving into elliptical galaxies (Genzel et al. 2001). AGN are found to reside in approximately 70% of all local ULIRGs (Nardini et al. 2010). A significant fraction also show signatures of outflows and strong winds associated with star formation (Alatalo et al. 2014; Dasrya & Combes 2013).

ABSTRACT

We present radio continuum observations of a sample of ultraluminous infrared galaxies (ULIRGs) at 1280MHz with the GMRT. ULIRGs are gas rich merger remnants that are in the process of transforming into elliptical galaxies. They are very luminous objects (L $>10^{12}$ L∗) with high star formation rates. Active Galactic Nuclei (AGN) have been detected in ULIRGs but radio jets are rare. We searched for signatures of jets or outflows from a sample of ULIRGs that show signs of AGN activity at 15GHz. Of the 18 galaxies in our sample, only two show extended emission at 1280MHz. Our results indicate that jets are rare in ULIRGs and probably form well after the ULIRG has relaxed into an elliptical galaxy. However, radio emission from outflows is more common. In this poster we present preliminary results of our study.

Sample selection, observations and data analysis

We chose an initial sample of 22 ULIRGs from the 15GHz VLA study of ULIRGs by Nagar et al. (2003). All the sample galaxies are bright IRAS sources and have spectroscopically identified AGNs. We have carried out GMRT low frequency radio continuum observations of the sources at 1280 GHz in 2007. The observations were short scans of approximately 45 minutes for each source. About 18 sources had good data. The data was analysed used AIPS. We made maps with natural weighting in order to detect sources with extended emission. We have done follow-up deep GMRT 1280MHz observations of one source that appears to have extended emission and will be observing another in the ongoing cycle.

Compact Cores

Our data quality is not very high. However, we have imaged about 10 of the 18 sources observed. The majority show compact cores similar to those displayed in the figures below. Only two are extended, IRAS 15001+1433 and IRAS23389+0300. Average beam size is 6".

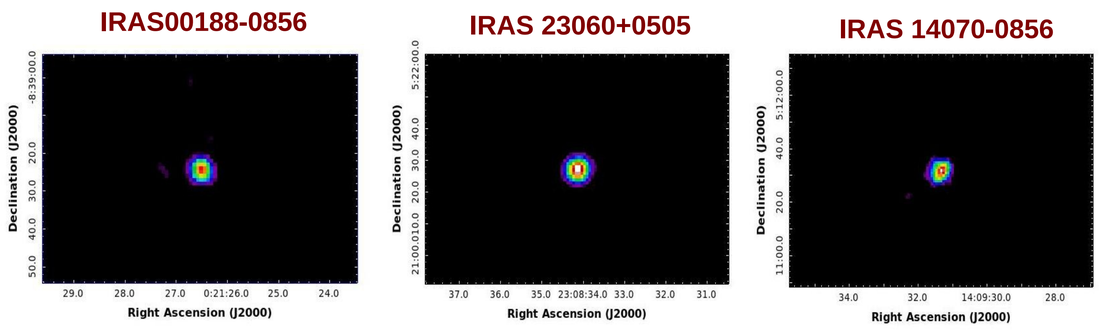

Figure 1. The figure shows the compact cores in the 1280 MHz GMRT maps. The images are made with natural weights to obtain extended features.

IRASF 15001+1433 : Signature of radio jets or outflows

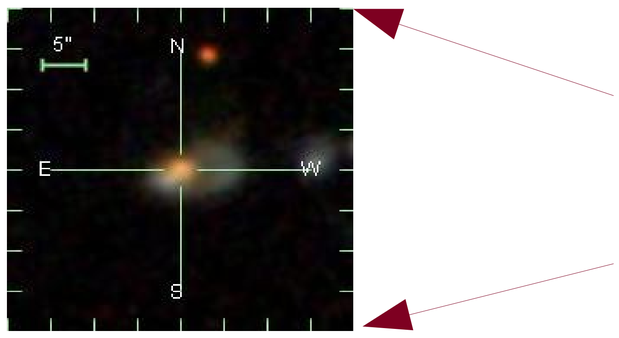

Figure 2. The SDSS image of the ULIRG IRASF15001+1433. The galaxy has a compact reddish core that hosts the AGN, but bluish extended emission indicative of star formation in the outer parts of the galaxy.

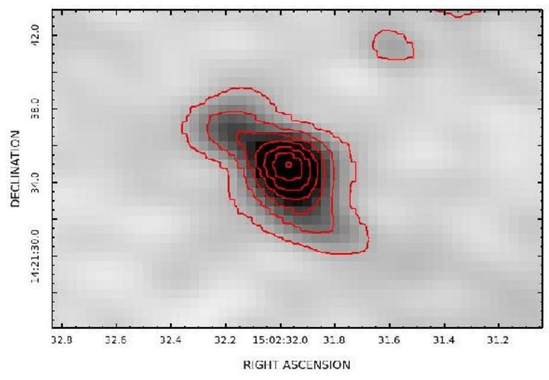

Figure 3. The GMRT 1280 MHz map of IRAS 15001+1433 made with natural weighting to obtain the extended emission. The galaxy shows extended emission out to a radius of 10.8 kpc. The beam is 8.7"x7.2". The VLA maps at 1.4 GHz and 15 GHz show compact emission only for this ULIRG.

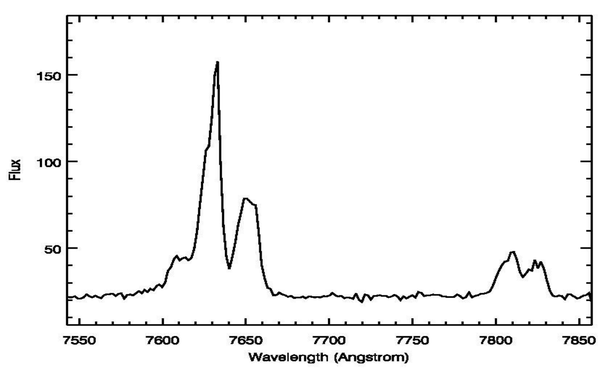

Figure 4. The SDSS spectrum of IRASF15001+1433, showing the double peaked Halpha and [SII] emission lines that are indicative of outflows from the AGN.

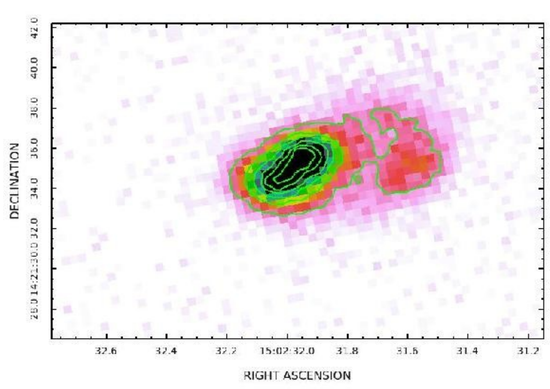

Figure 5. The SDSS g band image of the galaxy showing clearly the extended emission that is associated with star formation.

IRASF 23389+0300 : One sided extended emission

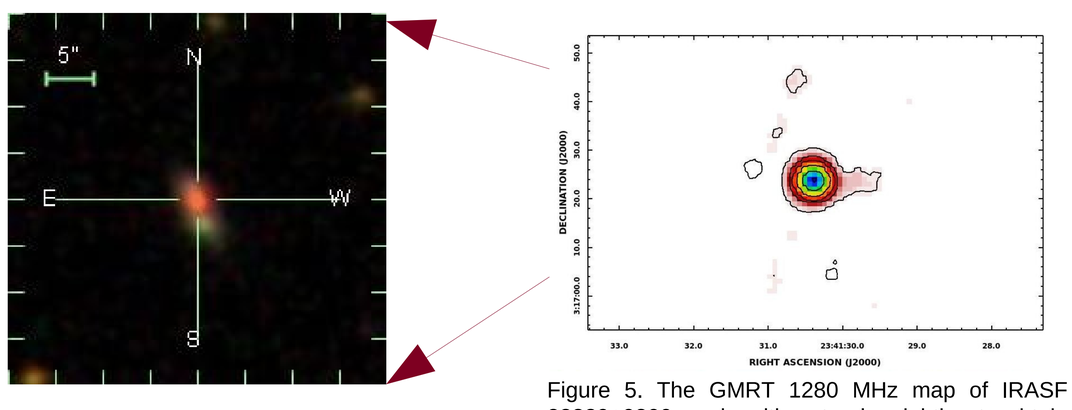

Figure 4. The SDSS image of IRASF 23389+0300. The emission is very compact and red. There is not much blue emission even though the IR emission is very high. Suggests that the star formation is heavily enshrouded in dust.

Figure 5. The GMRT 1280 MHz map of IRASF 23389+0300 made with natural weighting to obtain the extended emission. The image has a beam of 5"×5". Contours are overlaid. Note the extended emission on one side of the core which could be due to a jet or outflows.

Preliminary Results

There is only one detection of radio jets in ULIRGS (Norris et al. 2013). Thereis also one detection of radio jets in submillimeter galaxies (Sajina et al. 2007). There are however many studies of AGN outflows and starburst winds from ULIRGs. Preliminary results from our study show that extended radio emission is rare in ULIRGS. This suggests that AGN in ULIRGs are still evolving and it is not clear that they will evolve into the powerful radio loud galaxies that we observe at higher redshifts.

SUMMARY

1. We have started a study of low frequency radio emission from ULIRGs. As a first step we carried out 1280 MHz scans of 22 ULIRGs using the GMRT in 2007. The data quality was not very good. However about 18 sources have data good enough to image.
2. Preliminary analysis shows that most ULIRGs have compact radio cores. Of the 12 galaxies we have analysed only two show signatures of extended emission.
3. The extended radio emission can be due to radio jets or AGN outflows/winds. Alternatively it can be due to the intense star formation taking place in these merger remnants, many of which may have dual AGN (e.g. NGC6240).
4. The ULIRGs IRAS15001+1433 and IRASF 23389+0300 show extended emission. The first shows double sided extended emission at 1280MHz and could represent radio jets. The second ULIRG h emission. However, at higher frequencies it appears to have double cores.
5. We are observing three ULIRGS with the GMRT in 2015. We are doing deep observations of IRAS15001+1433 and IRASF 23389+0300 at 1280 MHz as well as another ULIRG that has low frequency emission in the TGSS and VLSSR surveys.
6. Follow-up VLA observations at higher resolutions will be done to resolve the dual AGN (if present) and radio jets.

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