Identification of Four Miscellaneous Radio Sources from LoTSS DR1

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Abstract

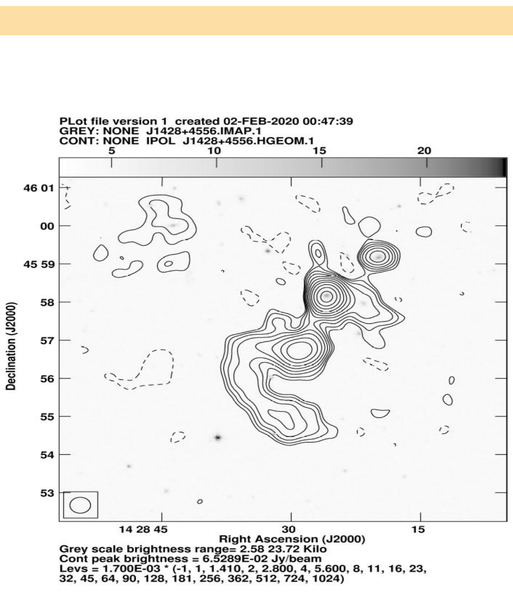
We underlook a search for Miscellaneous Radio Galaxies (MRGs) by using Low Frequency Array (LOFAR) telescope at 144 MHz frequency. The morphological structures of MRGs are different from known structures. We are interested to study of these type sources because of their unique and peculiar morphology. Here, we report four MRGs from LOFAR Two Metre Sky Survey first data release (LoTSS DR1) which cover a 424 square degree region. The MRSs are identified by manual visual search (MVS) from LoTSS DR1 data catalogue. We also check their radio morphology from other surveys like VLA Faint Images of the Radio Sky at Twenty-Centimeters (VLA FIRST) and Westerbork Northern Sky Survey (WENSS) at 1400 MHz and 325 Mhz frequencies, respectively. Based on optical counterparts from Sloan Digital Sky Survey (SDSS), we have estimated different physical parameters like spectral index, radio luminosity, radio power of these MRGs. We also try to find out the associate galaxy clusters corresponding to these MRGs..

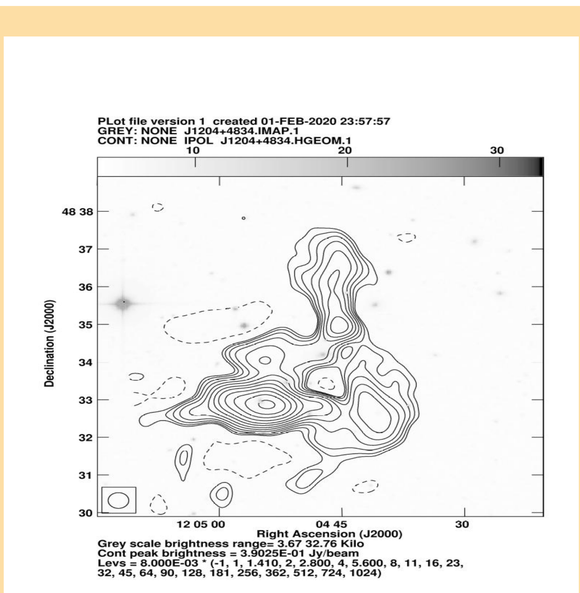
Introduction

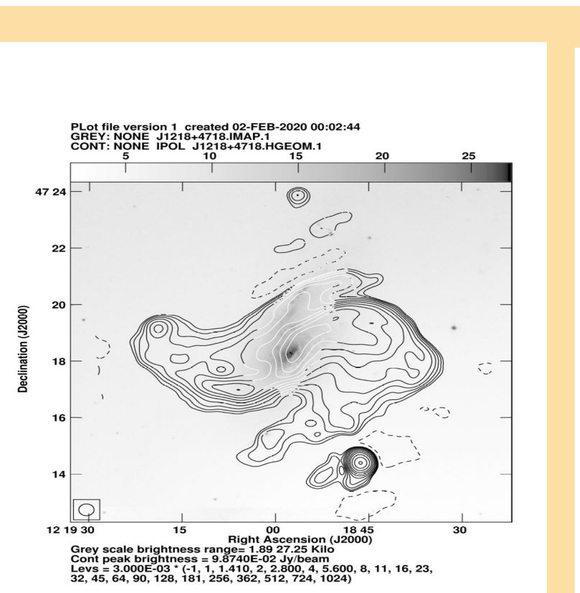
The astrophysical jets are the extended and collimated outflows of the highly-ionized plasma which is powered by the central black hole. This narrow collimated jet usually connects the core to the extended components and the outer lobes of a radio source. Jets are the signatures of the beams carrying energy from the core to the outer lobes. It is widely believed that these sources are harbouring an active galactic nucleus (AGN) at their center. Based on the radio luminosity or brightness distribution radio galaxies are categorized into two major classes, one is Fanaroff-Riley class I (FR-I) and another is Fanaroff-Riley class II (FR-II) type (Fanaroff & Riley 1974). There is some subclass of radio sources which exhibit some special morphology depending upon the orientation of the jet. For example, 'X'-shaped or 'winged' radio source (Leahy & Parma 1992; Cheung 2007; Bera et al. 2019), where a set of additional jets are aligned with a certain angle, in addition to the two regular jets and givesan overall 'X'-shape.

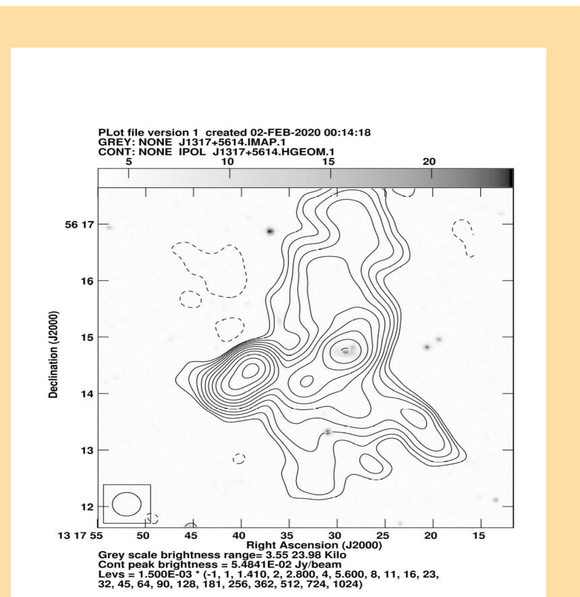
There is another class called head-tail radio sources (Rudnick & Owen 1976; Sasmal et al. 2020), where two jets are bent in the same direction in a rich cluster medium environment. There are a new group of double radio sources called HYbrid MOrphology Radio Sources (HYMORS) (Gopal-Krishna & Wiita 2000). The two lobes of these type of radio sources exhibit different FR morphological types. These HYMORS have FR-I morphology in one side of the AGN and FR-II morphology in another side. Hybrid radio morphology can be associated with galaxies, quasars and BL Lac objects.

Sample Images of Miscellaneous Radio Galaxies









Sample Selection and Result

First we select those sources which have anguler size greater than 10 ″ by our self made data reduction algorithm. Then we check manually each of the 18,580 data field we achievedafter data sorting. We used the position of optical counterpart as the position of the radio sources in Table-1 and for those sources the optical counter part or catalogued coun-terpart was not available, we used the best guess radio morphology based position. LoTSS is a 120-168 MHz survey that is being conducted with the high-band antennas (HBA) of LOFAR and will eventually cover the whole northern sky. Hardcastle et al. (2016) have already demonstrated the potential of LoTSS deep observations for discovering GRGs and found seven in the Herschel ATLAS North Galactic Pole survey area (142 sq.deg .). Here, we focus on theLoTSS first data release (LoTSS DR1) (Shimwell et al.2019). The LoTSS DR1 spans (J2000.0 epoch) right ascension 10h45m to 15h30m and declination 45 ◦ 00 0 to 57 ◦ 00 0 (HETDEX:Hobby-Eberly Telescope Dark Energy Experiment Spring field region) covering an area of 424 sq.deg with a median noise level across the mosaic of 71 µJy beam −1 and ∼6 arc sec resolution. Our search of LoTSS DR1 has enabled us to construct a catalog of 4 MRGs. With the high sensitivity of LoTSS, we are able to detect GRGs as faint as ∼ 2.5 mJy in total flux at 144 MHz. Using the available optical data and radio data, we have computed the radio powers, spectral indices and classified the morphological types for the sample of 4 MRGs. The details study of indivudual sources are discussed in the paper.

Discussion and Conclusion

Here we present peculiar radio sources as we found from LOFAR survey at 144 MHz. We think according to morphology each of the sources are unique and peculiar itself and from a typical double lobed radio galaxy. The mechanism behind such unique structure of the radio sources should be different. For a radio source its morphology depends on the jet structure; actually the jet structure/morphology defines the overall structure/morphology of the respective radio source. The jets on the both side of the central AGN may be the same or sometimes they are different. There is also an another fact we should include is the jet-inter cluster medium (ICM) or jet-inter galactic medium (IGM) interection. The jets interact with the ICM/IGM and thus change their shape, form and direction. Now the ICM/IGM on the opposite side of the AGN may not be the same always and hence each interaction results different scenerio. (Some jet interaction and other reasons with citations.) Any of these above described reasons may be the cause behaind such miscllaneous radio morphology.

References

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