The Physics Behind the Multimessenger Emissions of AGN: From a Radio perspective
Disentangling AGN-Starburst regions in edge-on galaxies

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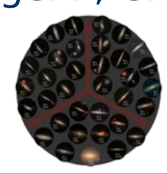


I.Continuum Halos in Nearby Galaxies – an EVLA Survey

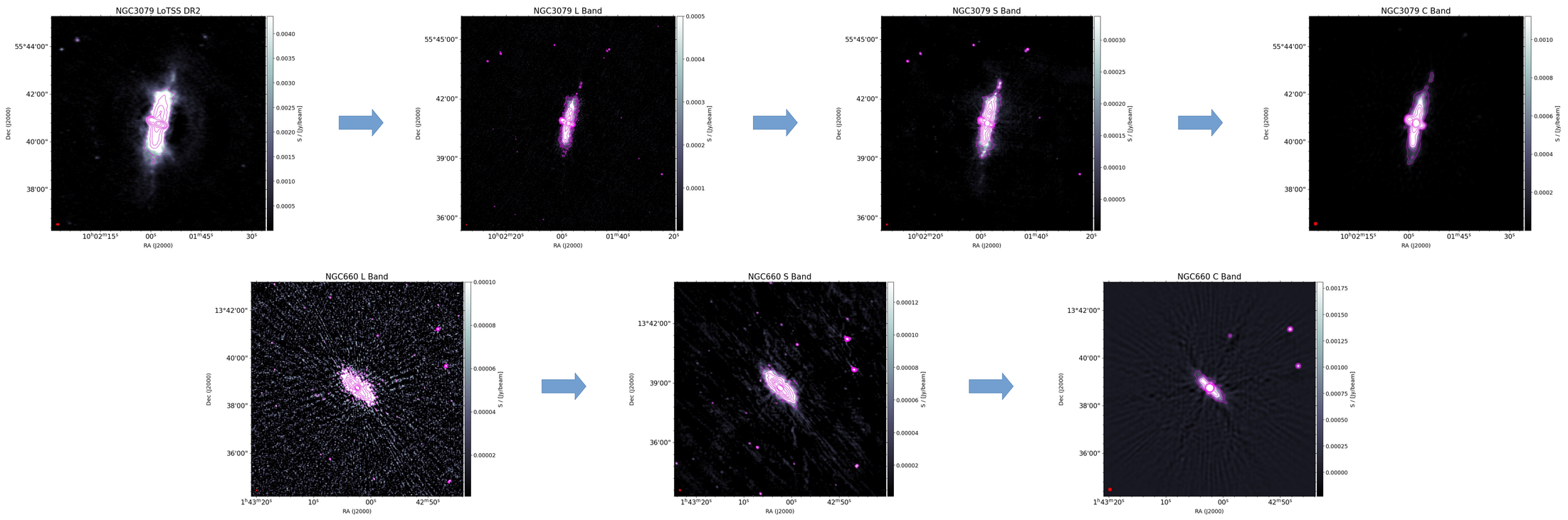
CHANG-ES is a survey that maps the radio continuum halos of a sample of 35 edge-on spiral galaxies in all polarization products in L- and C-bands. With this data, we intend to investigate physical conditions and origins of halos, characterize cosmic-ray transport, measure Faraday rotation and map the magnetic field. Recently, new S-band data has been collected (PI: Y. Stein), which is aimed to bridge the emission components originating from star-forming regions, AGN, and aged electrons in the galaxy halos.

Currently, data products and polarization products for L- and C-bands in B-, C-, and D-array configurations, are available on the official CHANG-ES website (scan QR code or access https://projects.canfar.net/changes/).

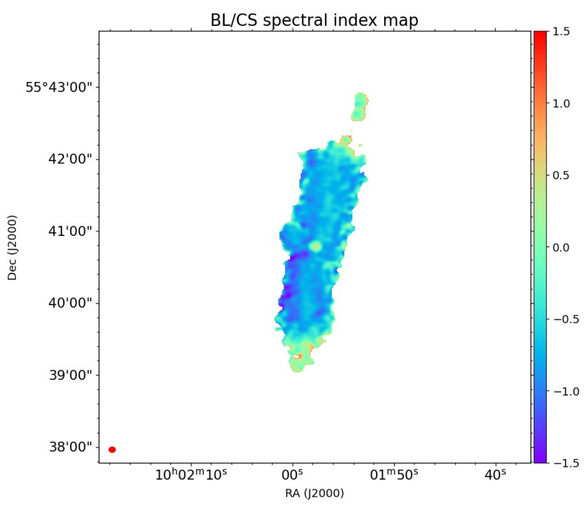
II.Sources of interest and their structures along the spectrum

Sources of interest are **NGC 3079** a Seyfert 2 galaxy, with a known AGN-starburst core, a bright AGN, and radio lobes, along with **NGC 660**, a polar ring, starburst galaxy, with a bright central source with flare activity making it an AGN or TDE candidate. Both sources additionally have measurable circular polarization, indicating a possible AGN presence.

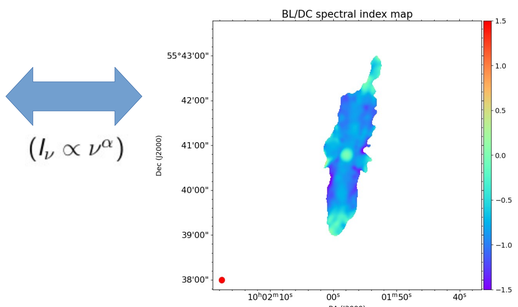
A wide spectral coverage of these galaxies, L-band to C-band for NGC 3079 and NGC 660 and with LoTSS DR2 (144MHz) for NGC 3079, enables the study of the morphology of the central source along different frequencies, thus providing with additional opportunities to constrain cosmic rays in the continuum.



i.Structures in spectral index maps

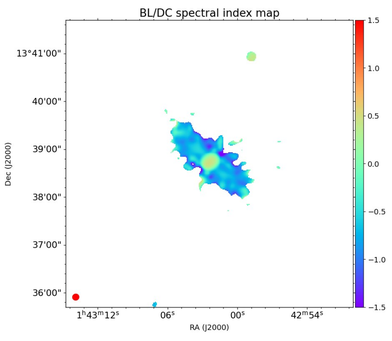


Pixel-wise spectral index maps where calculated using S-band, C-array data and L-band, B-array data with L-band, B-array data and C-band, D-array data.
Visible flattening in the central region of the galaxy indicates a possible constrain on the AGN, with the spectral index becoming steeper further out in the galaxy.
Higher resolution data from S-band allows for a more detailed view on the emission characteristics, as compared to previous maps.

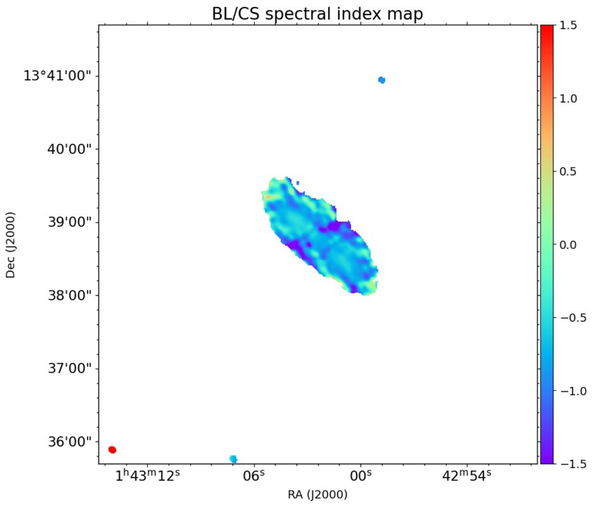


$(I_\nu \propto \nu^\alpha)$

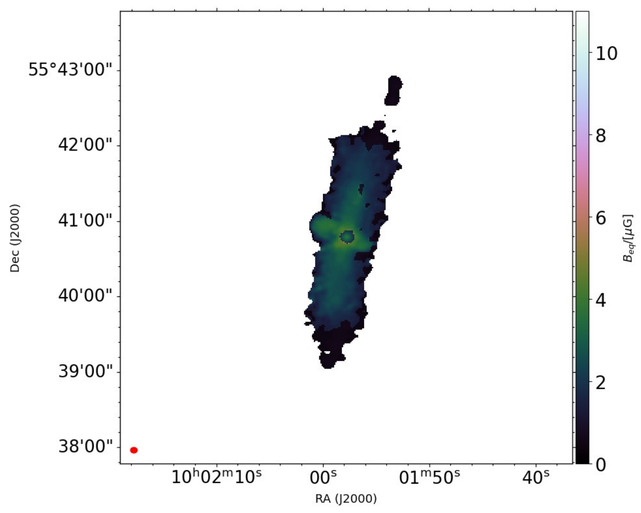
No visible core structure in BL/CS spectral index map, with the spectral index predominantly steep.
A different structure is visible in the spectral index map BL/DC, with a core structure being clearly discernible. This indicates flux changes over the epochs and hints at a TDE candidate.



$(I_\nu \propto \nu^\alpha)$



ii.Structures in magnetic field strength maps (2-zone implementation)



The magnetic field strength was calculated using the equipartition assumption as in Beck & Krause (2005), which diverges for spectral indices larger than -0.54.
All such spectral indices were clipped as in Heesen et al. (2022).
To capture AGN and starburst physics, two different K factors (proton-to-electron number density ratio) were used.

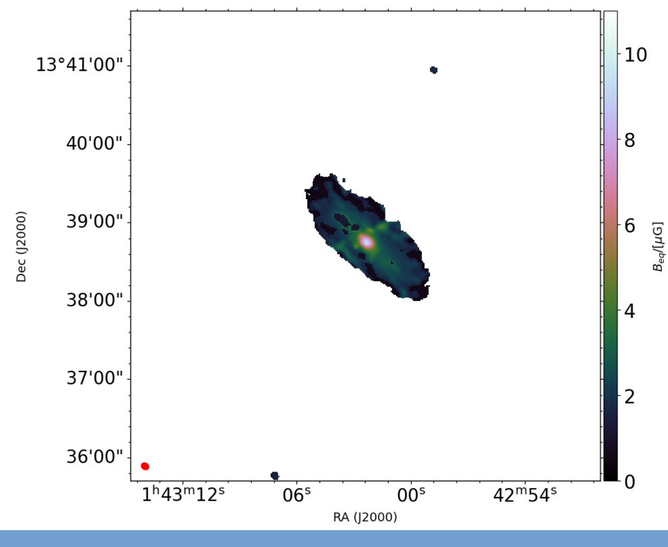
K=1: along the AGN

K=100: along the galaxy disk

This approach shows underestimated magnetic field values for NGC 3079 especially along the galaxy disk.

This approach yielded no additional information regarding the magnetic field strength at the core of the galaxy for NGC 660.

The *K* (proton-to-electron number density ratio) factors were chosen to create a stark difference as extreme cases. A more careful consideration is needed regarding this choice in a future revisit to this 2-zone approach.



III.Next steps: incorporating new data and new avenues

i. Combine with higher resolution observation (LOFAR, ALMA, VLBI) to better constrain core structures.

ii. Use machine learning algorithms to discern galactic structures in continuum bands.

iii.Understand magnetic field structure of these galaxies in S-band frequencies through rotation measure synthesis (C-band already available, L-band affected by Faraday depolarization).

iv. Conduct similar analysis for other edge-on sources showing circular polarization.