Spectral Evolution of an Active Galactic Nucleus

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1. Introduction

- The focus is on how early-final stage AGNs develop into well-known AGNs such as radio galaxies.
- Narrow-line Seyfert 1 galaxy (NLS1) AGNs are seen as young AGNs as they have smaller supermassive black holes (SMBHs) and higher accretion rates than normal AGNs.
- For many years, it was accepted that radio-loud (RL) AGNs have jets while radio-quiet (RQ) AGNs do not.
- This classification proved false when RQ AGNs were found to have the potential to possess jets [Järvelä et al., 2021].
- The research question was, "What is the core-jet evolution of an early-stage AGN?"

2. Aims and Objectives

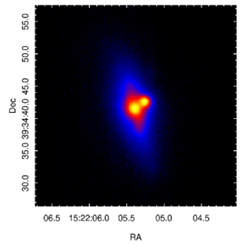
The aim was to study the core-jet evolution of the NLS1 AGN, J1522+3934, and the astrophysical processes involved with it. This was done by:

- Imaging J1522+3934 at X (8-12 GHz) and K (18-27 GHz) bands.
- Imaging J1522+3934 at sub-X and sub-K bands.
- Obtaining integrated flux densities S_ν at central frequencies ν.
- Plotting S_ν vs ν to obtain spectral indices α as $S_\nu \propto \nu^\alpha$.

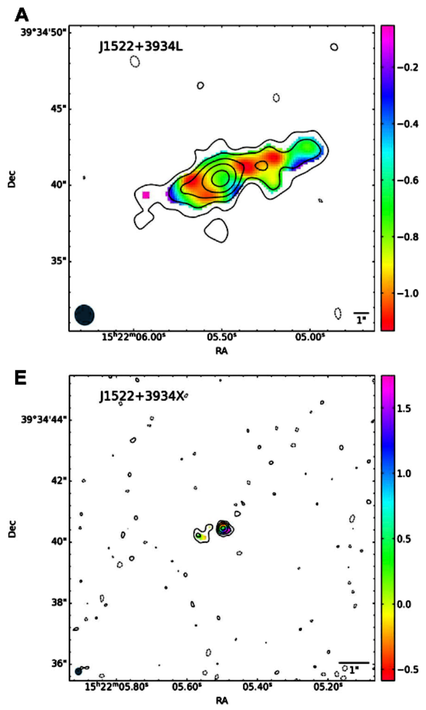
3. Methodology

The methodology involved:
Obtaining Very Large Array (VLA) data from the National Radio Astronomy Observatory (NRAO) database.
Data reduction by the Common Astronomy Software Application (CASA 6.4.1).
Performing Gaussian fits to obtain the total flux densities at central frequencies from the imview panel.

4. J1522+3934 and Spectral Index Maps

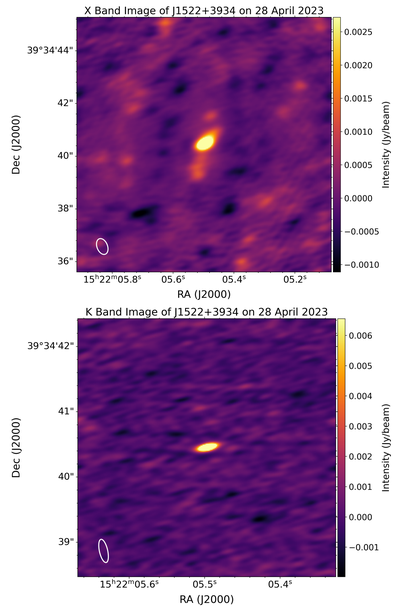


- This image above shows a J-band near-infrared (214-273 THz) band image of J1522+3934 from the Nordic Optical Telescope (NOT). This AGN was formed by the merging of an unknown active and non-active galaxy [Järvelä et al., 2018].
- The spectral index maps below show the morphology of J1522+3934. At 1.6 GHz, the morphology is extended (A). At higher resolution (9.0 GHz), J1522+3934 is compact (E) [Järvelä et al., 2021].

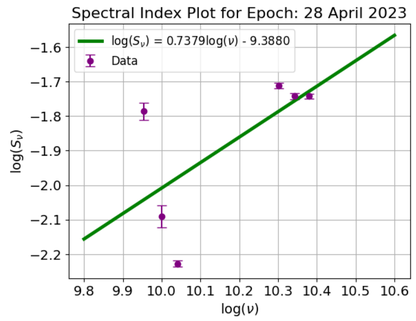


5. Results: Images and Spectral Index Plots of J1522+3934

The images of J1522+3934 at the X and K bands were found to be compact and unresolved at milli-arcsecond resolutions (19-77 mas). The images below show J1522+3934 on April 2023.



On the top: X band image (8.039-11.959 GHz). On the bottom: K band image (18.039-25.959 GHz).
The image below shows the spectral index of J1522+3934 in April 2023. The spectral transition was inverted-flat-inverted at epochs April, August, and September 2023, where the spectral indices were 0.74, 0.21, and 0.96, respectively.



6. Analysis and Conclusion

The morphology of J1522+3934 was found to be compact and unresolved at all epochs.

The spectral transition was inverted-flat-inverted as the AGN may be in its early jet-forming stage.

The jet base has absorption components that form an optically thick layer that may be the cause of the flat and inverted nature of the spectral indices [Järvelä et al., 2021].

The steepening may be a result of episodic synchrotron emission [Wang et al., 2025].

The limitations are that NLS1 AGNs and early-stage AGNs were still unresolved in the radio regime despite milli-arcsecond resolution observations.

Higher frequencies, longer bandwidths, and observations on timescales ranging from days to years may be required to notice significant changes in the core-jet evolution of an NLS1 AGN.

7. Acknowledgement

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8. Bibliography

References

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