Radio Observations of a Candidate Dual/Binary Active Galactic Nuclei in the Double Peaked Emission Line Galaxy 2MASX J1203

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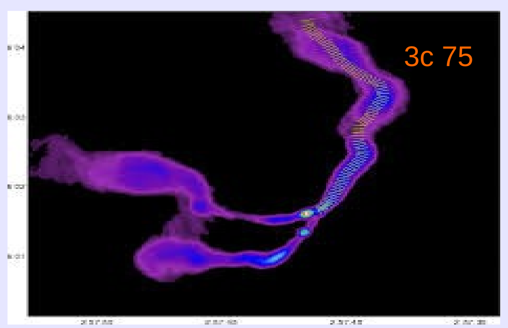
Binary/Dual AGNs

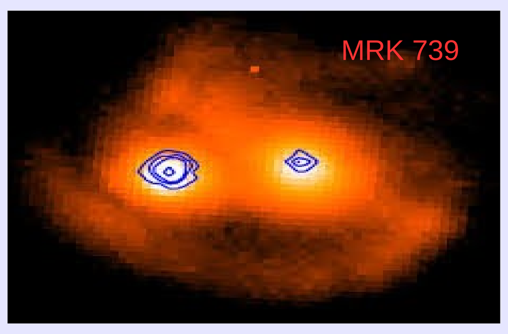
- Binary or dual active galactic nuclei (DAGN) are expected from galaxy formation theory.
- Binary/dual AGN systems can help us to understand the galaxy evolution during mergers as well as the SMBH growth.
- These systems can be detected at optical, radio and X-ray frequencies (Fig 1).
- There are few indirect signatures of dual/binary AGN: (1) Periodicity in flux variability (2) X or S-shaped radio morphology (3) Double-peaked emission lines (DPAGN) (Fig 2).
- But these signatures can be explained by some other physical processes.
- So to confirm dual AGN one needs to do high resolution direct imaging.

Direct Signatures

1. Two cores in radio image



2. Two cores in X-ray map



3. Two cores with distinct spectra in optical/IR

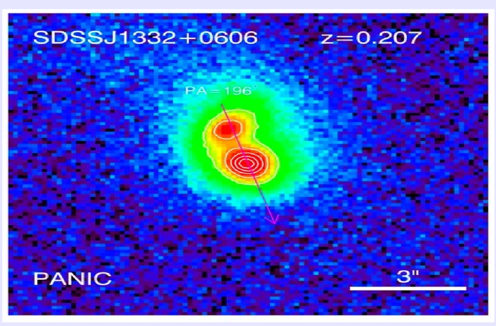
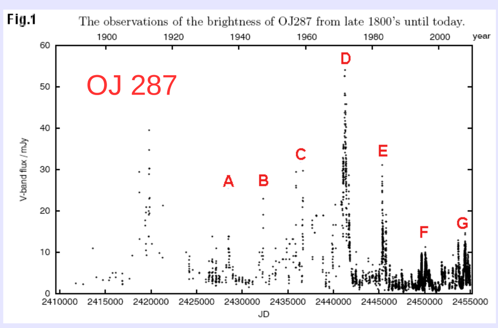


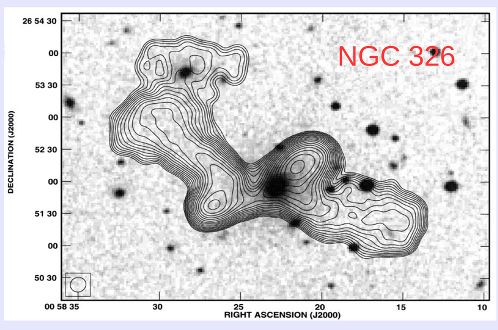
Figure 1

Indirect Signatures

1. Periodicity in flux variability



2. X- or S-shaped radio galaxies



3. Double-peaked emission line in optical Spectra ([OIII] emission lines)

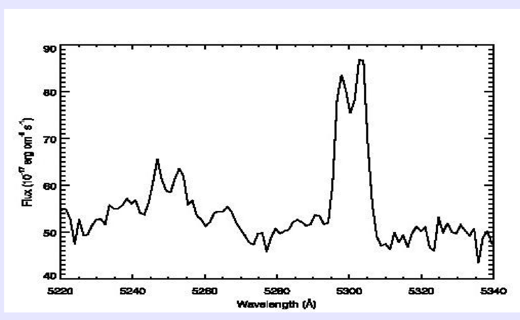


Figure 2

Target galaxy J1203

- The galaxy J1203 was part of our **larger sample of DPAGN** (Rubinur et al. 2018, 2019).
- Our 6 GHz EVLA observation showed the interesting two-sided radio structure (Fig 3a).
- Hence we studied J1203 separately with the help of archival 8.5 and 11.5 GHz EVLA data (Fig 3c, 3d).
- We have used the CASA and AIPS packages for data reduction.

Results

Radio Observations: S-shaped core-jet morphology

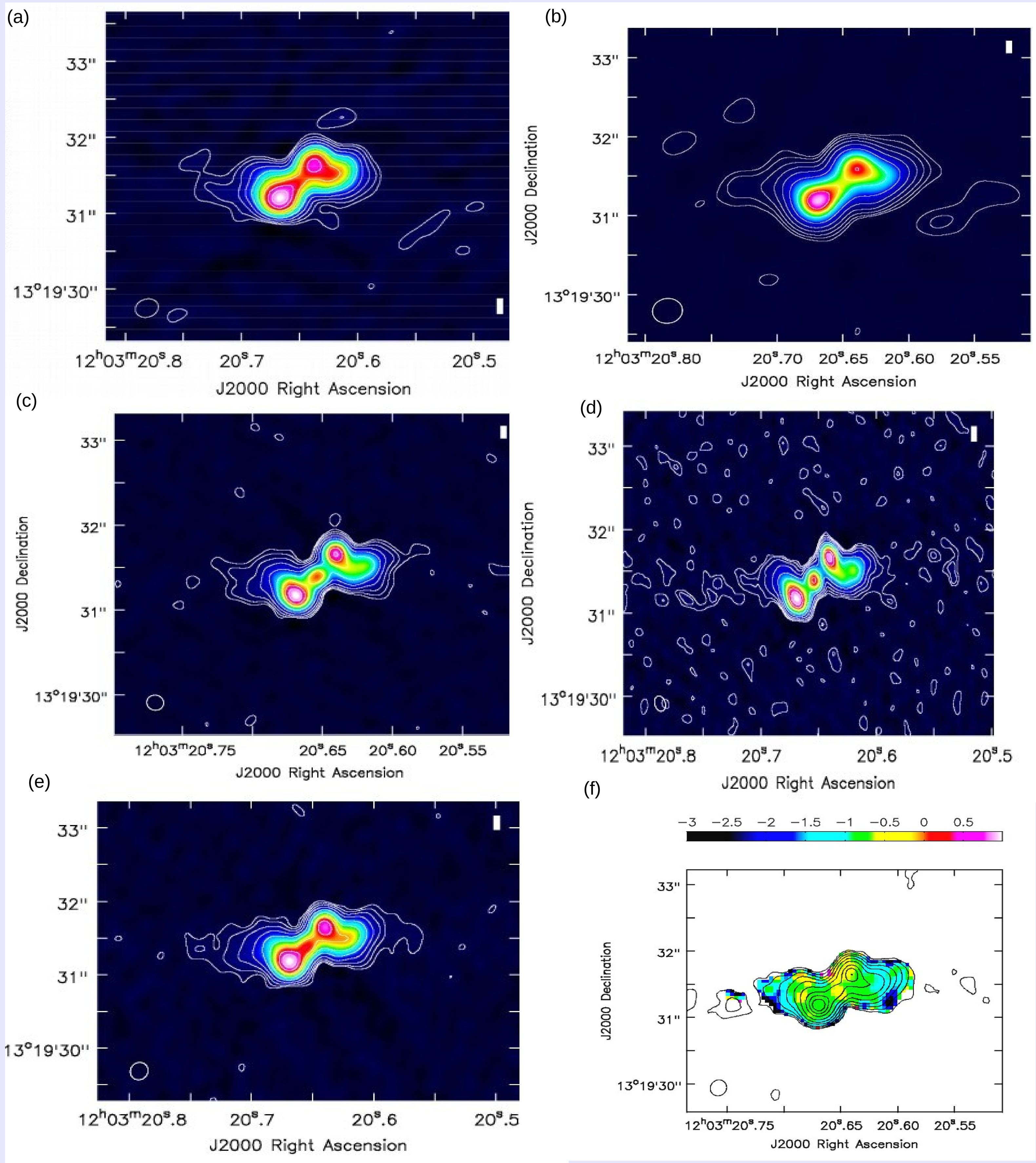


Figure 3

Fig (a) and fig (b) 6 and 15 GHz EVLA images of J1203 with conttours. These show S-shaped structure with two hotspots at 0.54" separation.

Fig (c) and (d) show the 8.5 GHz and 11.5 GHz images. The contour levels correspond to 0.60, 1.25, 2.5, 5, 10, 20, 40, 60, 80 % of peak flux density respectively .

Fig (e) shows the 8.5 GHz image with natural weighting. The core is not resolved here but it shows full extent of the jet i.e ~3.5 kpc.

Fig (f) shows the spectral index (α) image using 8.5 and 11.5 GHz image. Core shows flat α and jets have steep α.

Modeling the S-shaped structure using jet precession: Matching with Electron Lifetime

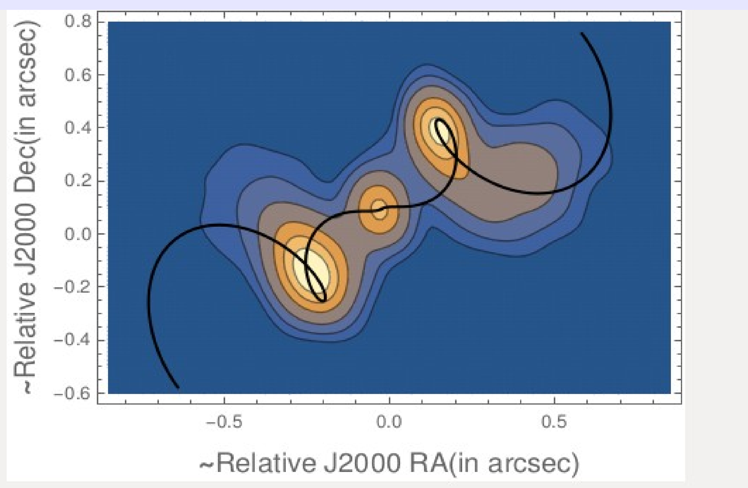


Figure 4

1. We have modelled the S-shaped radio structure using the Hjelming & Jhonstone (1981) jet precession model with jet advance velocity= 0.023C, period~ 10^5 yrs (Fig 4).

2. The lifetime of electrons calculated from equi-partition theorem is t ~10^5 yrs. This timescale matches the time, the precessing jet was "on" in this Seyfert galaxy, providing support to the precession model.

What causes the precession in Radio Sources?

(i) Binary black holes: We have calculated mass of the system. The esimated mass is $(1.56 \pm 0.26) \times 10^8 M_\odot$. We have used the mass to estimate the separation of binary SMBHs corresponding to the precession timescale: this turns out to be 0.02 pc.

(ii) Warped accretion disks: We have used the period-luminosity relation from LU (1990) to calculate the period: $10^5 - 10^9$ yrs.

(iii) Dual AGN: A close pass of the secondary SMBH in the past.

Summary

1. J1203 has an S-shaped core- jet structure of total size ~3.5 kpc with core size ~116 pc.

2. The S-shaped helical radio structure is due to jet precession of period 10^5 yrs .

3. We concluded that the jet precession caused either by a binary/dual SMBH system, a single SMBH with a tilted accretion disk or a dual AGN system where a close pass of the secondary SMBH in the past has given rise to jet precession.

(Rubinur k. et al 2017, MNRAS, 465, 4772)

4. Recently, high-resolution 3D-MHD simulations are performed to model the observed S-morphology of 2MASX J1203 (Ravi et al. 2021, to be submitted in MNRAS letter)

References

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