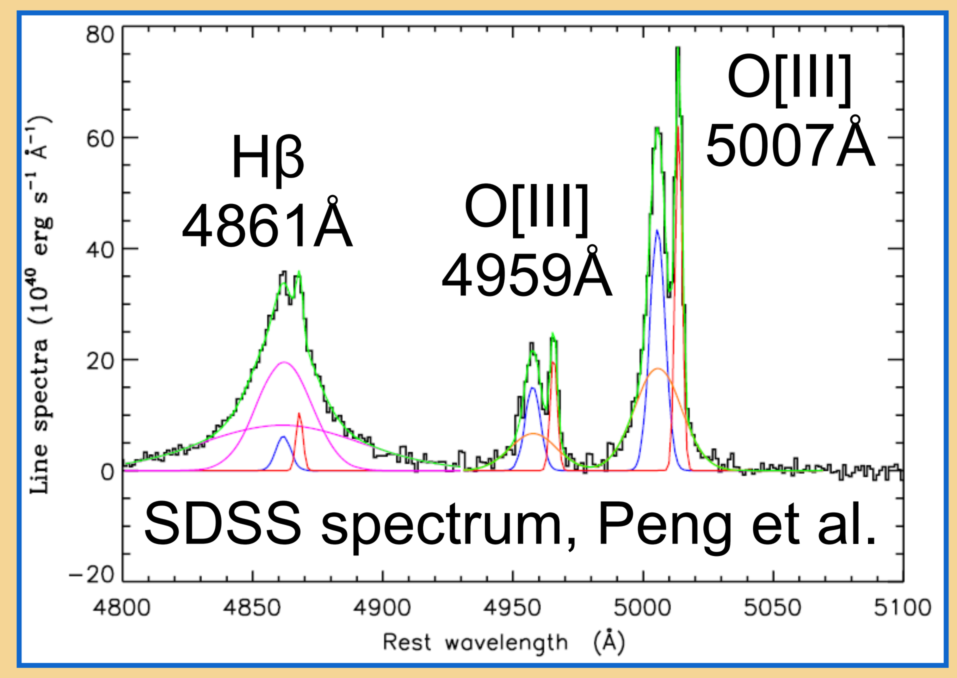
SDSS J1425+3231: the nature of a dual AGN candidate revealed

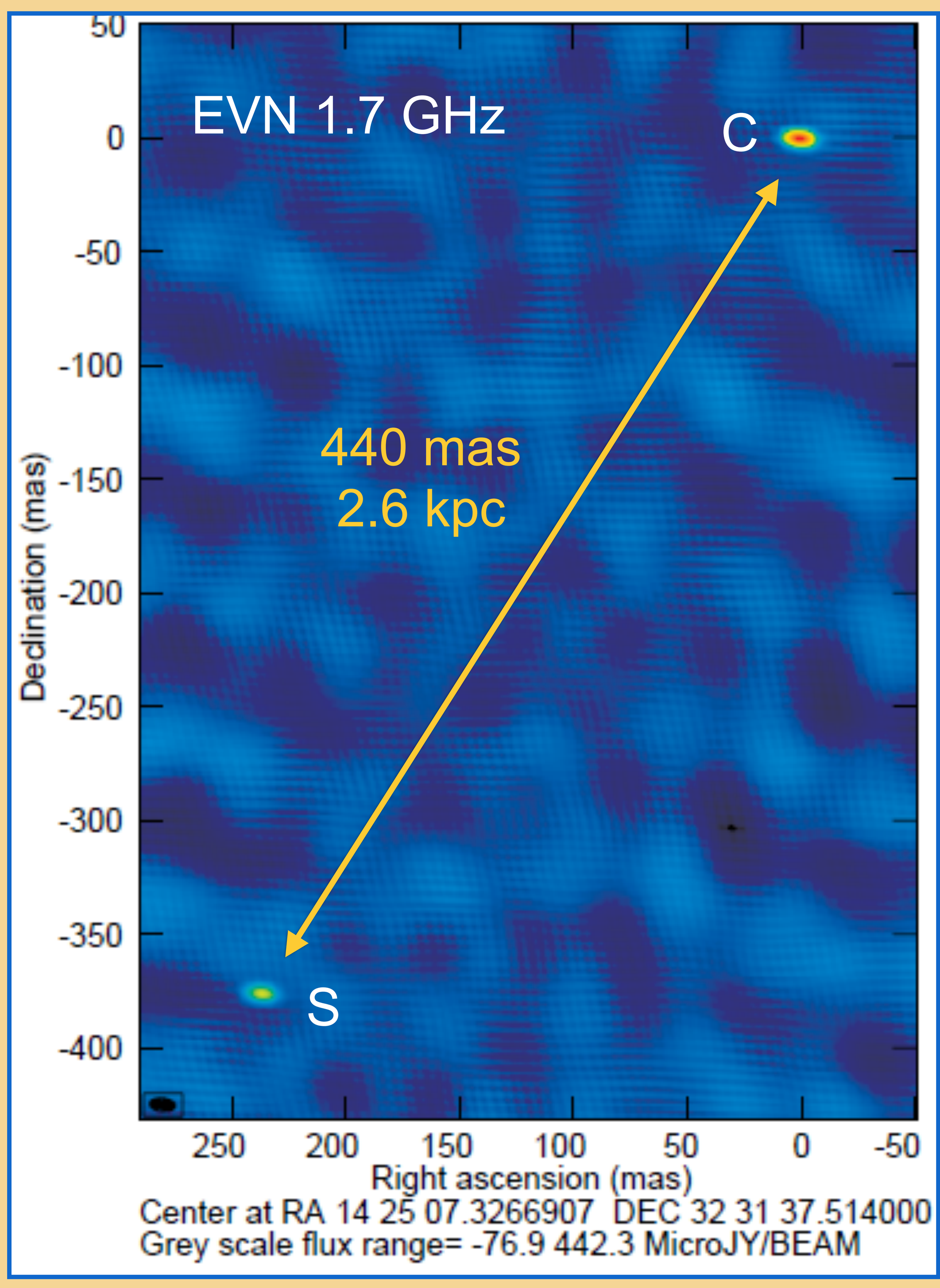
K. É. Gabányi[1,2], S. Frey[1], T. An[3], Z. Paragi[4], S. Komossa[5]

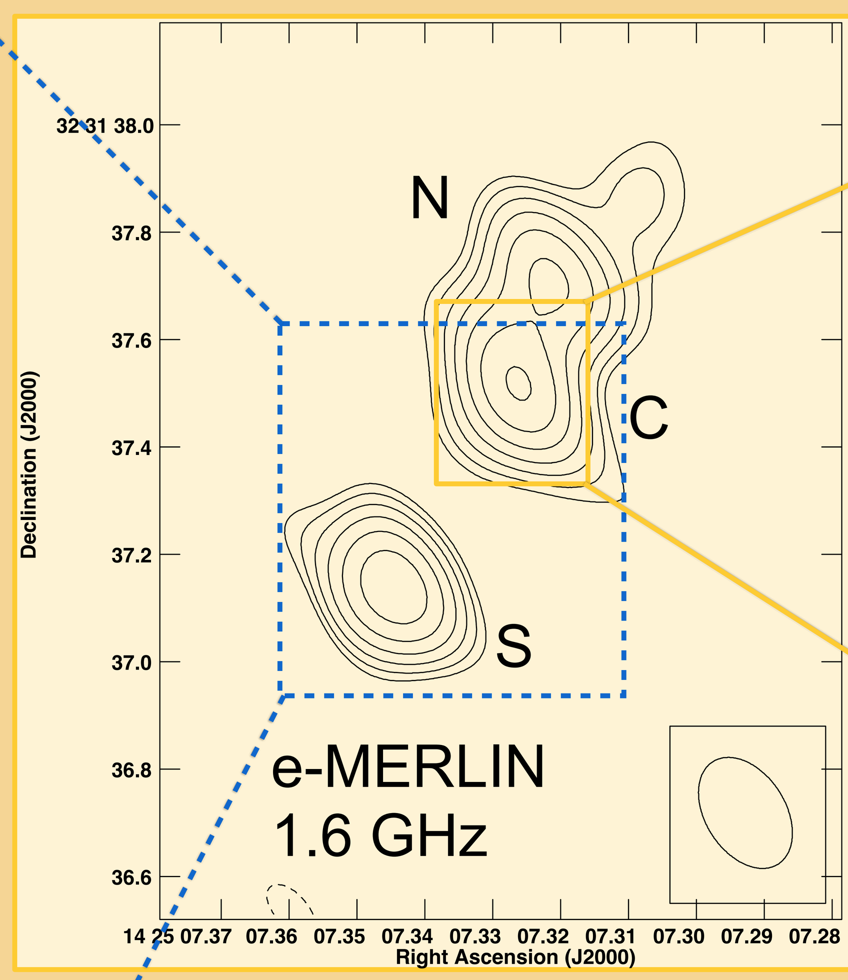
[1]Satellite Geodetic Observatory, FÖMI, Hungary, [2]MTA Research Centre for Astronomy and Earth Sciences, Hungary, [3]Shanghai Astronomical Observatory CAS, P. R. China, [4]Joint Institute for VLBI ERIC, the Netherlands, [5]Max-Planck-Institut für Radioastronomie, Germany

Hierarchical structure formation models predict that galaxies and their central supermassive black holes form and grow via merging events that may increase activity and/or star formation in the host galaxies. Simulations suggest that simultaneous activity of the black holes may be expected at kpc-scale separations [5]; also the number of luminous dual AGN increases with decreasing separation [4,6]. Direct observations of the tightest **AGN pairs** are only feasible in the most nearby Universe with the current optical and X-ray instrumentation. However, cosmological simulation of Volonteri et al. [6] shows that less dual AGN are expected at lower redshifts. Very long baseline interferometry (VLBI) provides the highest achievable angular resolution, however only ≈10% of AGN are radio emitters. Moreover, VLBI instruments are not ideal for large surveys due to the limited field of view. Currently there is no known efficient selection method to find convincing dual AGN candidates. Searching for double-peaked narrow optical emission lines emerging from the two separate narrow-line regions (NLR) of dual AGN was proposed as such a selection method (e.g. [7]). However, the double-peaked spectral lines can also arise from peculiar kinematics or jet–cloud interactions in the NLR (e.g. [9]), and the survey of Fu et al. [2] showed that only 1% of such sources can be real dual AGN.

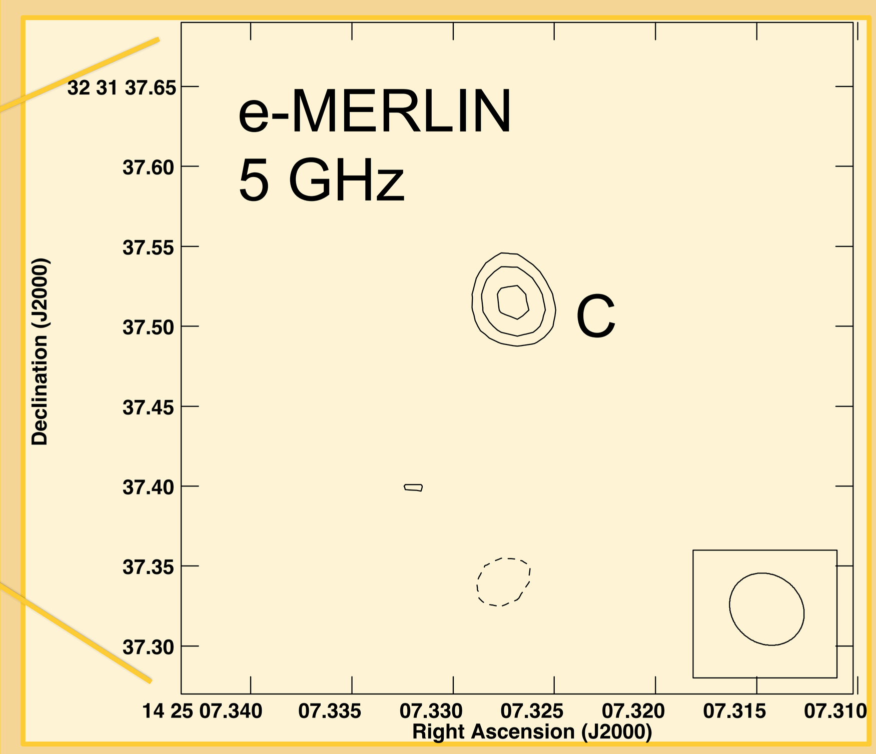
SDSS J1425+3231 (z=0.478) was reported as a promising dual AGN candidate by Peng et al. [3] based on its double-peaked narrow optical emission lines. Frey et al. [1] found two compact radio emitting features at a projected separation of ~2.6 kpc at 1.7 GHz in an **e-EVN** observation. At 5 GHz, only the brighter one (component C) was detected with EVN; its spectral index is α=–0.23 (F~ν^{α}). The other, S, has a steep spectrum, α<–0.9. Their brightness temperatures (10^7–10^8 K) indicate synchrotron origin of the radio emission. We observed the source with **e-MERLIN** at 1.6 and 5 GHz. At 1.6 GHz, three components were detected, C and S, and a northern one, N. The sum of the components' flux densities at 1.6-GHz with e-MERLIN is in good agreement with the FIRST [8] 1.4-GHz flux density, indicating that we recovered all arcsec-scale radio emission in the source. At 5 GHz, only component C could be detected.







Peak: 0.84 mJy/beam. Lowest contour is 0.1 mJy/beam (3.5σ), further contours increase by a factor of √2.



Peak: 0.15 mJy/beam. Lowest contour: 0.07 mJy/beam (3.5σ), further contours increase by a factor of √2.

Instrument	Freq. (GHz)	Comp.	Flux density (μJy)
VLA-B [8]	1.4		3280
e-EVN [1]	1.7	C	456
		S	228
	5	C	354
		S	< 85
e-MERLIN	1.6	C	712
		S	1122
		N	1835
	5	C	319
		N, S	< 100

Components C and S have higher **flux densities** in the e-MERLIN data at 1.6 GHz than in the e-EVN at 1.7 GHz. This can indicate that at the lower frequency, e-MERLIN picked up the large-scale structure resolved out in the e-EVN observation and/or can be caused by variability. However, the large FWHM size of component S (104±6 mas) shows that resolution effect is more likely in that case. At 5 GHz, the flux densities of the only detected component (C) agree within the uncertainties in the e-MERLIN and e-EVN observations. In the e-MERLIN observation, component N (204±12 mas) and S have significantly **larger FWHM sizes** than component C (33±2 mas). This suggests that C is the core component while N and S are more likely extended jet- and lobe-like features, respectively. However, the detection of component S in the high resolution e-EVN observation shows that it contains a compact radio emitting feature as well. There are two **scenarios** that can explain the radio structure of J1425+3231:

(i) There is **a single low-power, radio-emitting nucleus** in the source at the position of component C, the synchrotron emitting jet base. A jet-like feature (N) is seen to the north, and a lobe (S) could be imaged with e-MERLIN at 1.6 GHz. The latter component contains a compact hotspot, which was detected with the e-EVN. In this scenario, the double-peaked optical spectral lines are related to the outflows driven by the bi-polar jets and not to a dual AGN.

(ii) There are **two low-power radio-emitting nuclei** in the source, at the positions of components C and S. Their compact cores were detected in the e-EVN observation at 1.7 GHz. One of them (C) has a jet-like extension towards north (N). The large-scale structure of the secondary nucleus (S) was detected with e-MERLIN.

Option (ii) is less likely since S was not detected in any of the higher-frequency radio observations, indicating a very steep radio spectrum, which is at odds with its identification as an AGN core.

References

[1] Frey S., et al., 2012, MNRAS, **425**, 1185
[2] Fu H., et al., ApJ, **733**, 103
[3] Peng Z.-X., et al., 2011, RAA, **11**, 141
[4] Steinborn L.K., et al, 2015, MNRAS, **458**, 1013
[5] van Wassenhove S., et al., 2012, ApJ, **748**, L7
[6] Volonteri M., et al., 2016, MNRAS, **460**, 2979
[7] Wang J.-M., et al., 2009, ApJ, **705**, L76
[8] White R.L., et al., 1997, ApJ, **475**, 479
[9] Xu D. & Komossa S., 2009, ApJL, **705**, L20

Acknowledgements

The EVN is a joint facility of European, Chinese, South African, and other radio astronomy institutes funded by their national research councils. e-MERLIN is a National Facility operated by the University of Manchester at Jodrell Bank Observatory on behalf of STFC. The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc. This research was supported by the National Research, Development and Innovation Office (OTKA NN110333), and by the China-Hungary Collaboration and Exchange Programme by the International Cooperation Bureau of the Chinese Academy of Sciences.