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JAGIELLONIAN UNIVERSITY
IN KRAKÓW



LOFAR

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CROSSING the SIZE LIMIT of RADIO SOURCES with LOFAR

with Dorota Koziół, Natalia Żywucka,
Arti Goyal, Marek Jamrozy and others

AGNs ZOO - hybrid radio galaxies

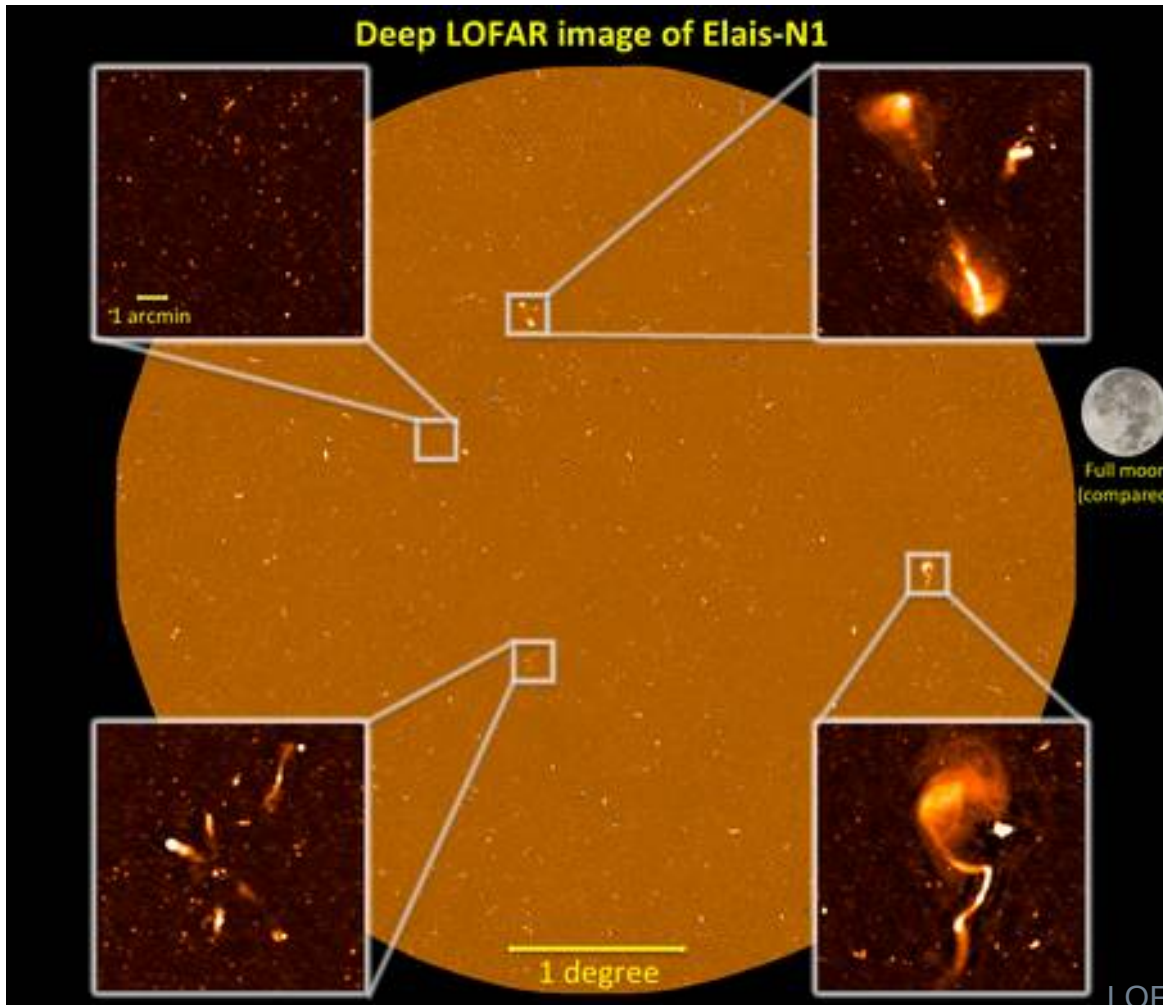
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Philip Best, Jose Sabater, and the LOFAR surveys team



Machalski+, 2008

Oei+, 2022

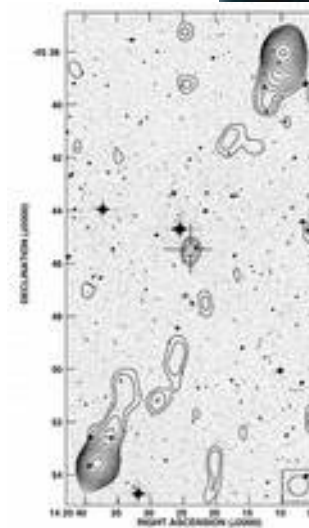


Fig. 1. VLA and GB6 survey contour map of 2542h-0740' at 1.4 GHz, overlaid on the optical SDSS field. Contours are logarithmic, with a noise of 27 μ Jy beam⁻¹. The field covered is 4 $^{\circ}$ x 10 $^{\circ}$ beam.

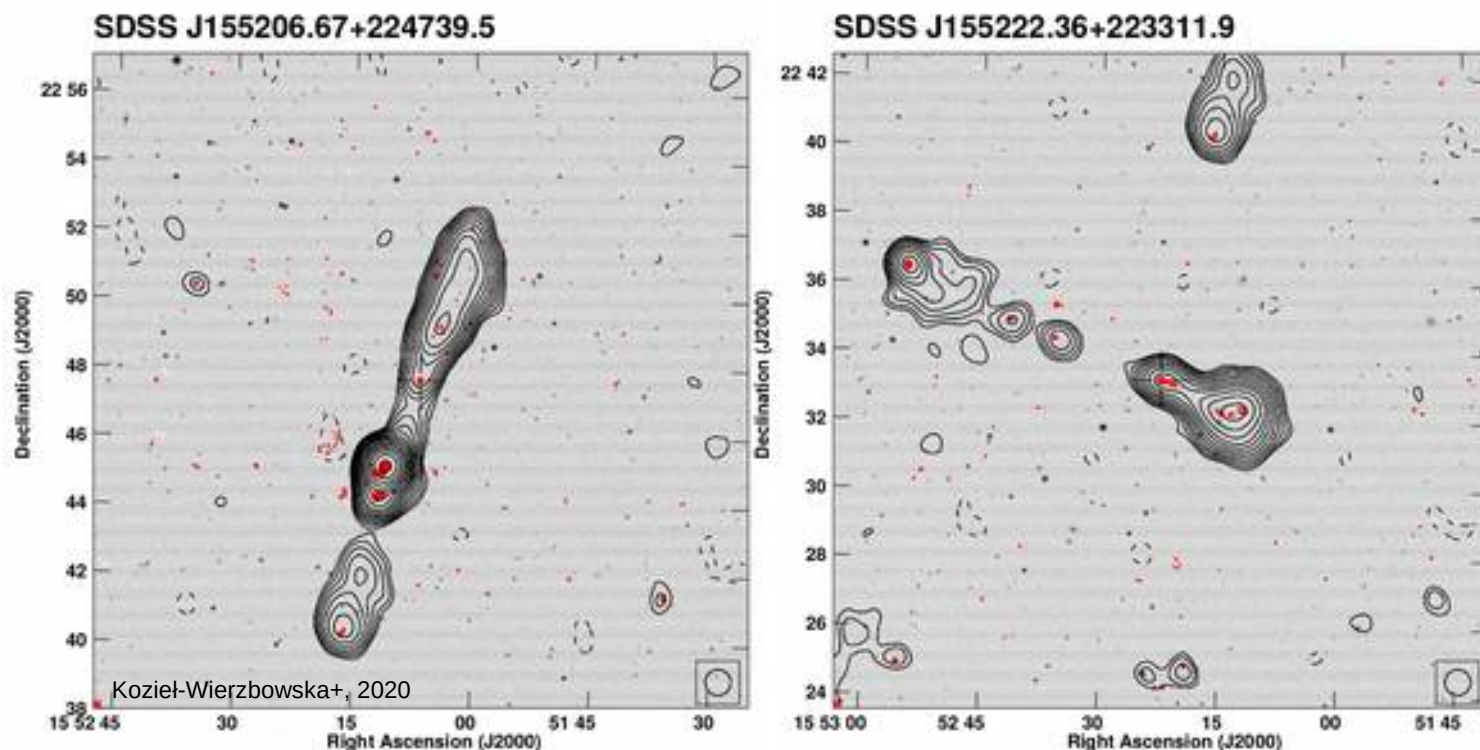
Giant sources in the ROUGE I catalog

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ROUGE I

(Kozieł-Wierzbowska+, 2020)
a catalog of radio sources
associated with optical hosts
with unresolved or extended
morphologies

- The SDSS Main Galaxy sample (Strauss+, 2002)
- the Red Galaxy Sample (Eisenstein+, 2001)
- FIRST (Becker+, 1995)
- NVSS (Condon+, 1998)

NVSS (black) & FIRST (red) contour images overload on SDSS grey-scale maps. The contours start from a 3σ confidence level and are scaled of $\sqrt{2}$. Negative 3σ contours are marked with dashed lines.

Giant sources in the ROUGE I catalog

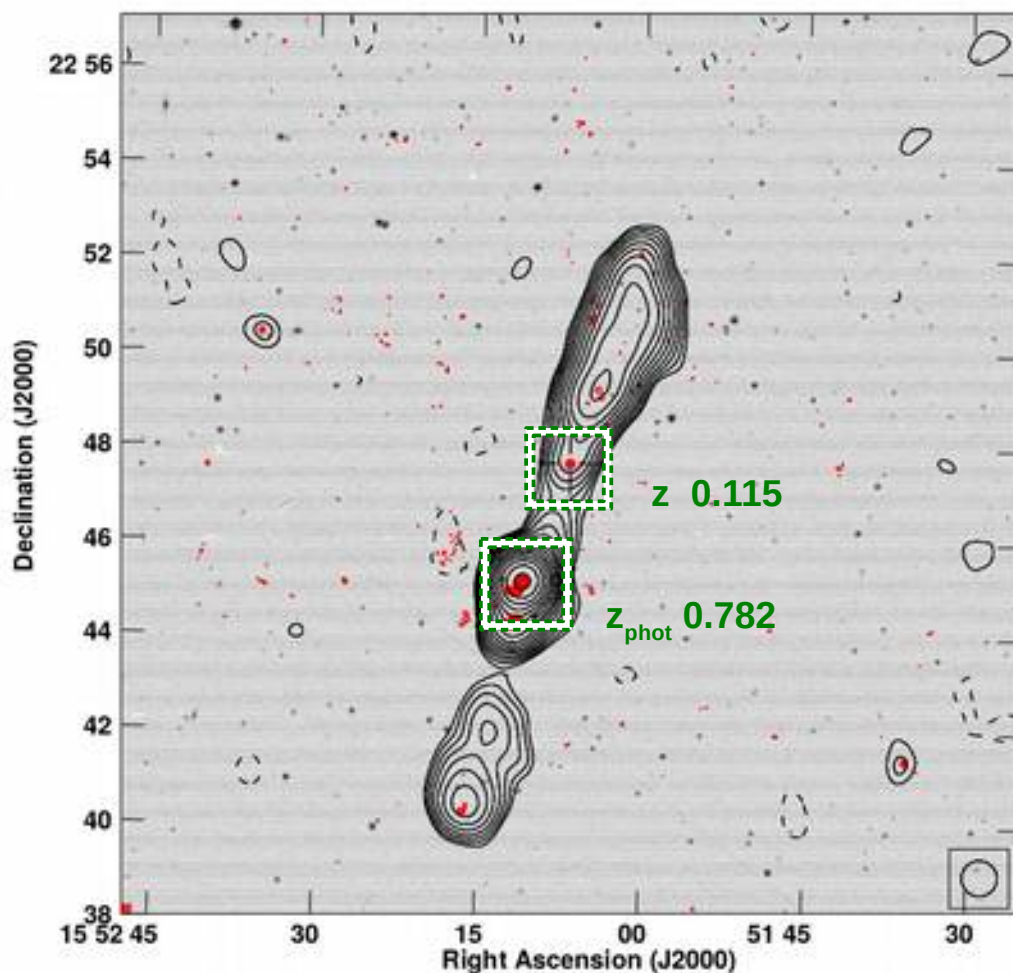
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SDSS J155206.67+224739.5



Proctor (2016):
faint elliptical galaxy,
LAS 668'

1st host) $z_{\text{phot}} = 0.782 \rightarrow 5.0$ Mpc
2nd host) $z = 0.115 \rightarrow 1.5$ Mpc

Giant sources in the ROUGE I catalog

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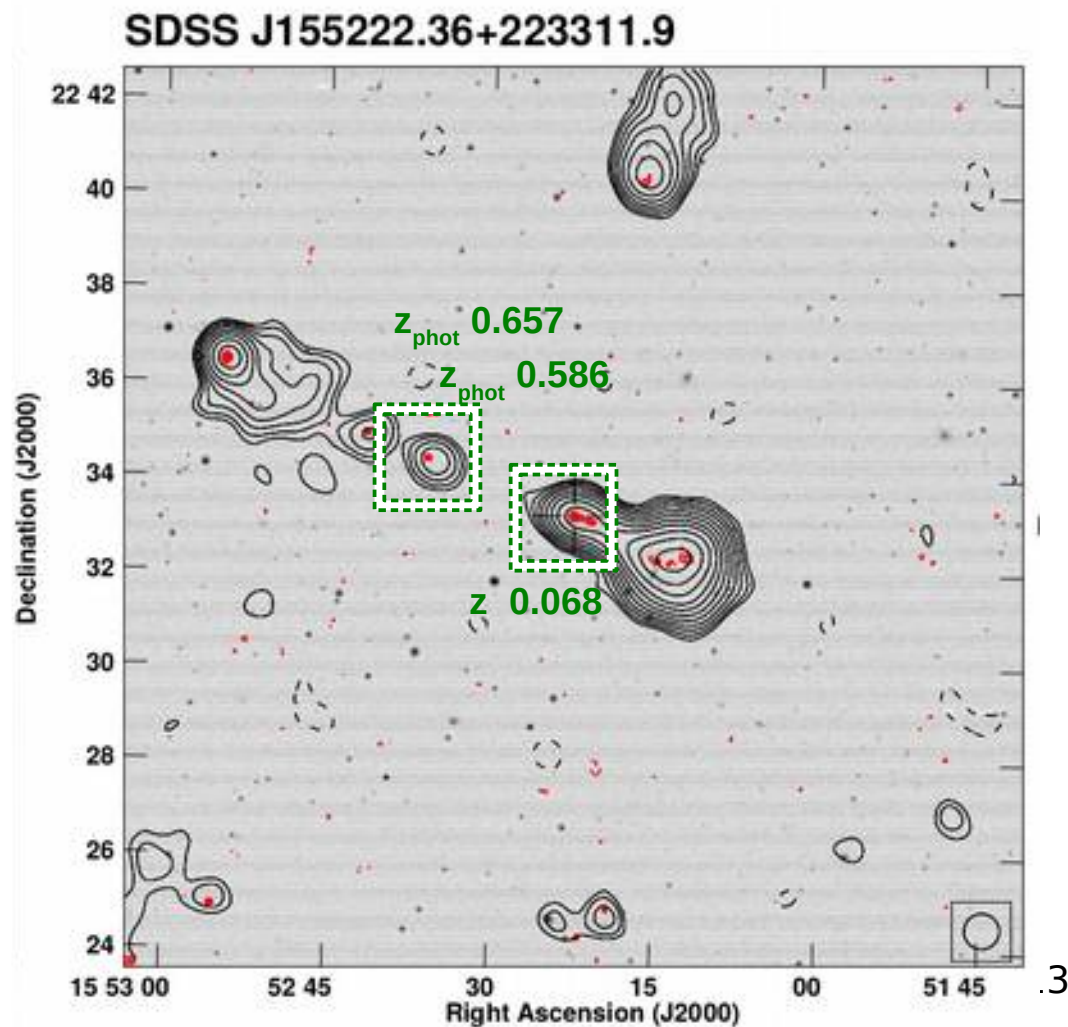
Possibly DDRG
One-sided jet-like structure
LAS 578'

1st host) $z_{\text{phot}}=0.586 \rightarrow 3.9$ Mpc

2nd host) $z_{\text{phot}}=0.657 \rightarrow 4.9$ Mpc

3rd host) $z=0.068 \rightarrow 0.9$ Mpc

Galaxy cluster ZwCl 1550.5+2310



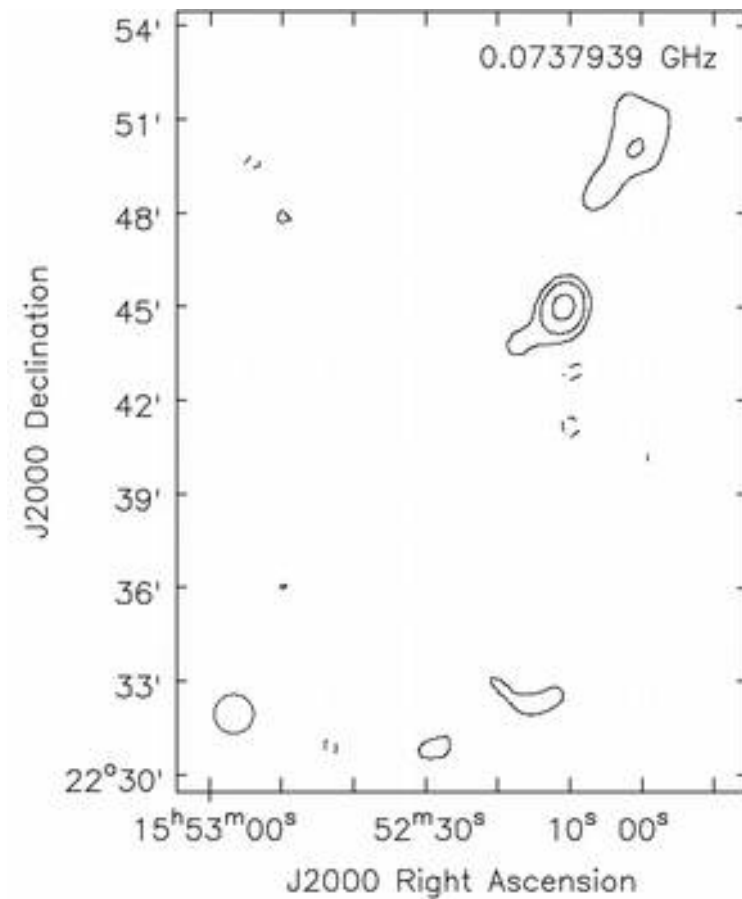
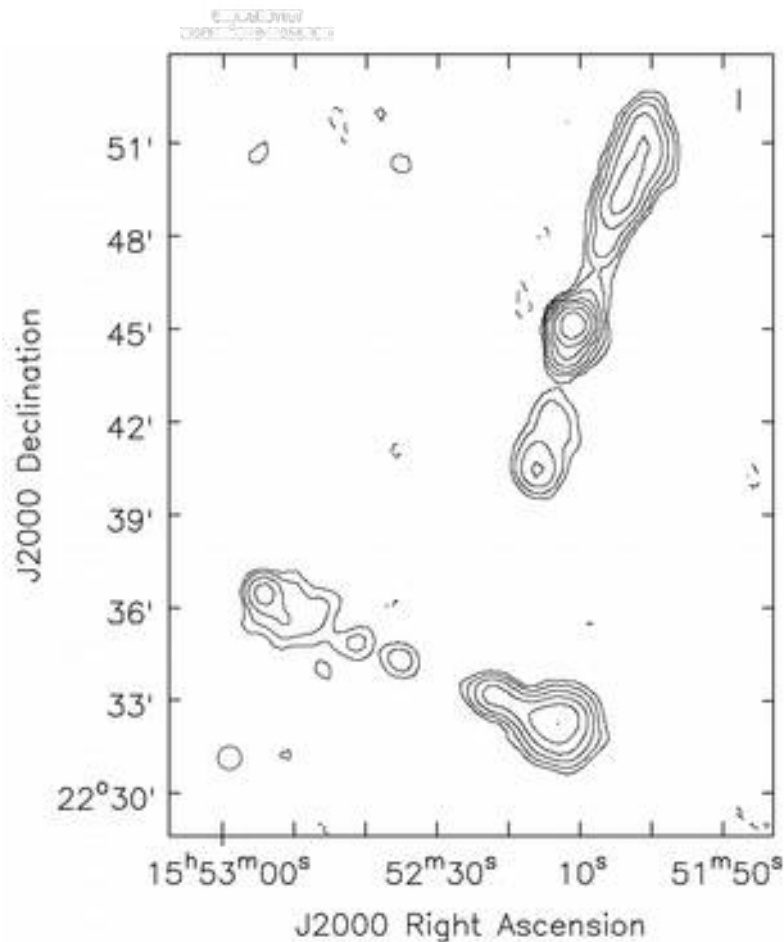
NVSS & VLASS data

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(right) L-band NVSS contours of J155210.97+224508.0

(left) VLASS (Lacy+, 2020) contours of J155235.1+223418

Contours start from a 3 σ confidence level and are scaled of $\sqrt{2}$. The negative 3 σ contours are marked with dashed lines.

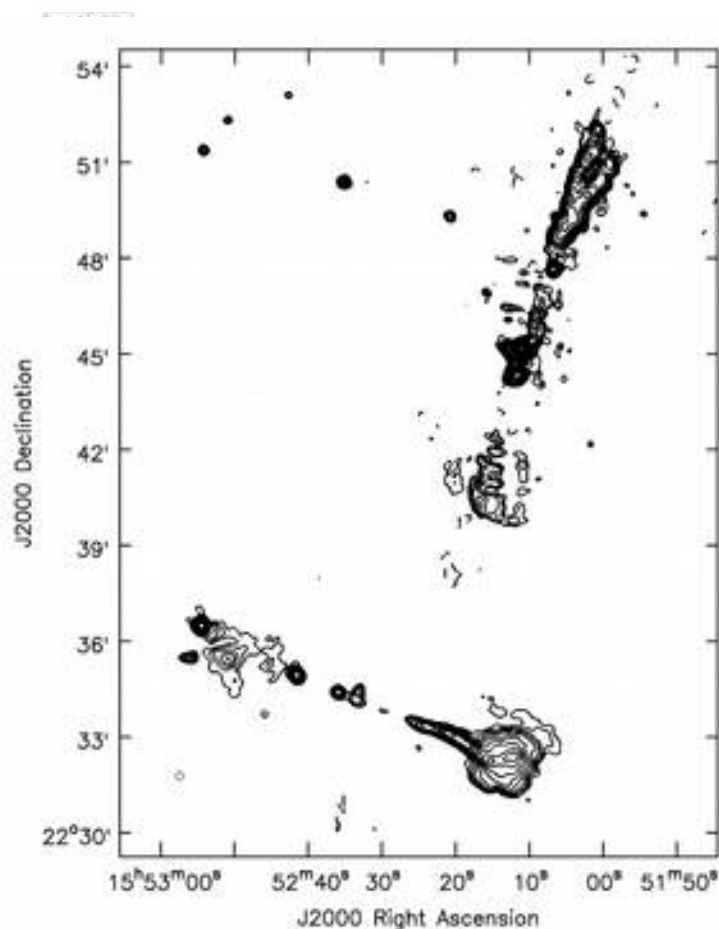
GMRT 325 MHz & ASKAP observations

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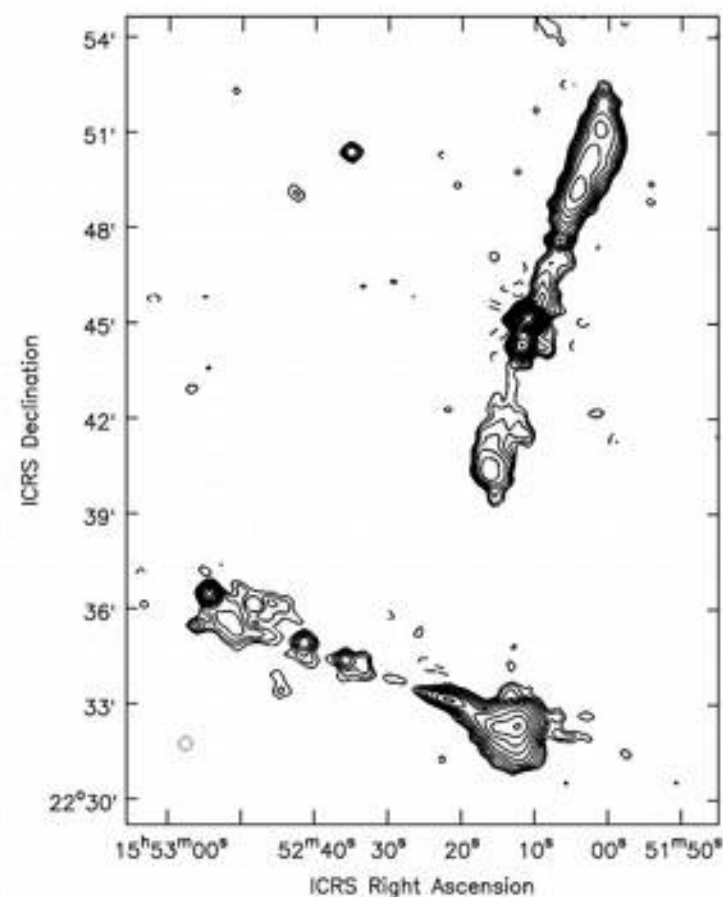


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Pajdosz-Śmierciak+, in prep. to MNRAS



GMRT 325 MHz (left; the project code 32_117) & ASKAP 889 MHz (right; McConnell+, 2020) contour images of J155210.97+224508.0 and J155235.1+223418ASKAP. The contours start from a 3σ confidence level and are scaled of $\sqrt{2}$. Negative 3σ contours are marked with dashed lines.

LOFAR data

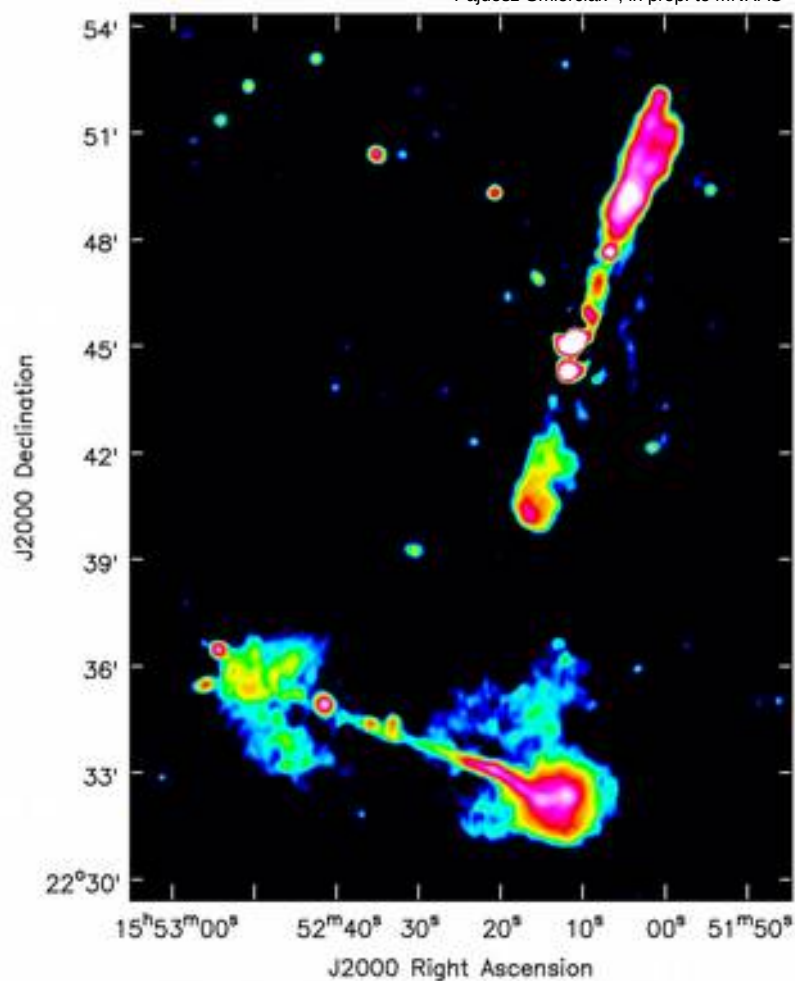
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LOFAR 144 MHz colorscale image of two GRGs candidates:
J155210.97+224508.0 and **J155235.1+223418**.
The fluxscale starts below the 0.06 Jy level to present very faint structures.

LOFAR - ASKAP spectral index

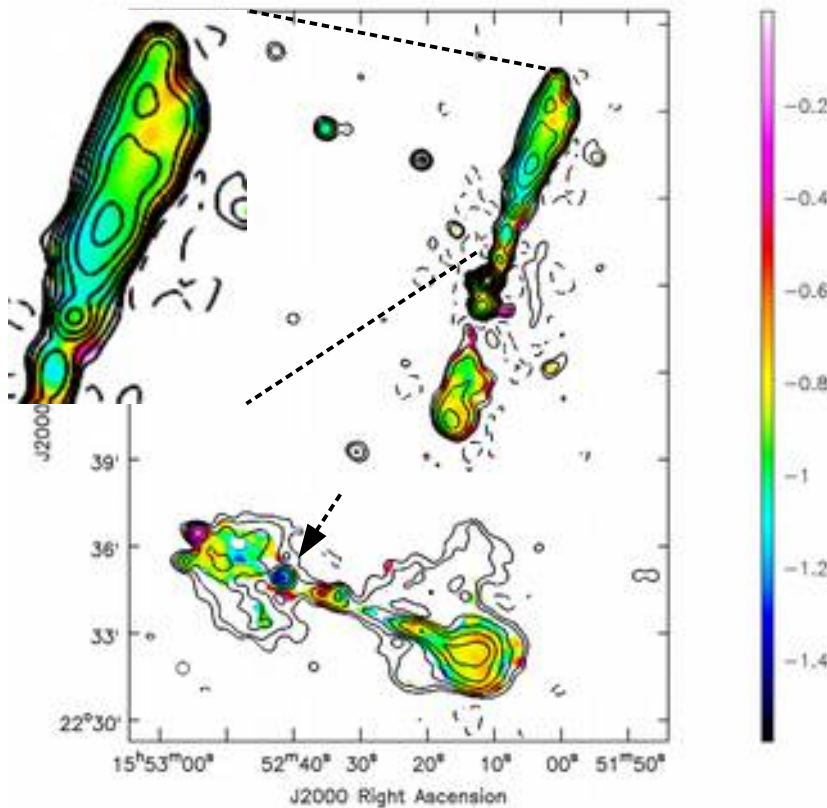
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α_{MEAN}	
N lobe	-0.90 (0.18)
S lobe	-0.77 (0.18)
E lobe	-0.91 (0.14)
W lobe	-0.84 (0.15)

- α_{MAX}
- J155210.97+224508.0 N lobe: -1.4.
- spectral index values divide N lobe area into 2 vertical areas
 - the bridge possesses value of α similar to the southern part of the N lobe

- J155235.1+223418 W lobe: -1.5
- one point-like component located at RA=15 52 41.53, Dec=22 34 55.39 with steep $\alpha_{\text{MEAN}} \cong -1.1$

Central regions of both sources possess $\alpha_{\text{MEAN}} \cong -0.8$, typical for synchrotron emission

[S~v $^\alpha$]

LOFAR-ASKAP spectral index image of J155210.97+224508.0 and J155235.1+223418 with LOFAR convolved (25" x25") contour plot. The contours start from a 3 σ confidence level and are scaled of $\sqrt{2}$. Negative 3 σ contours are marked with dashed line.

JVLA S- & C-band observations

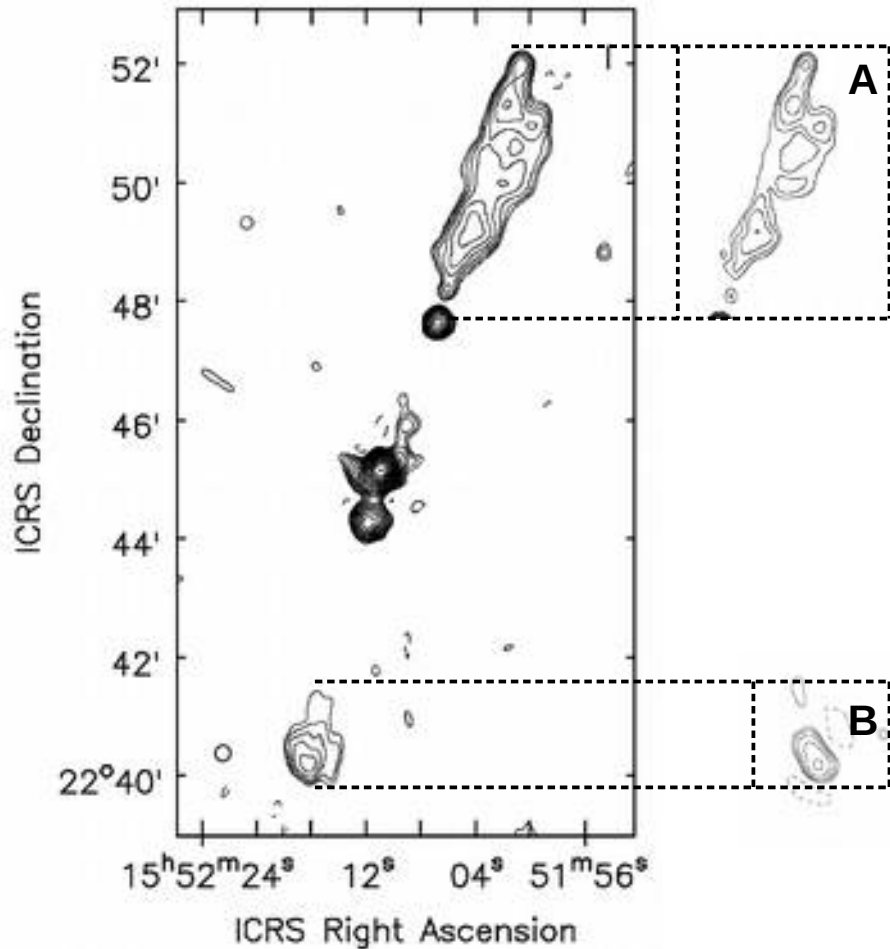
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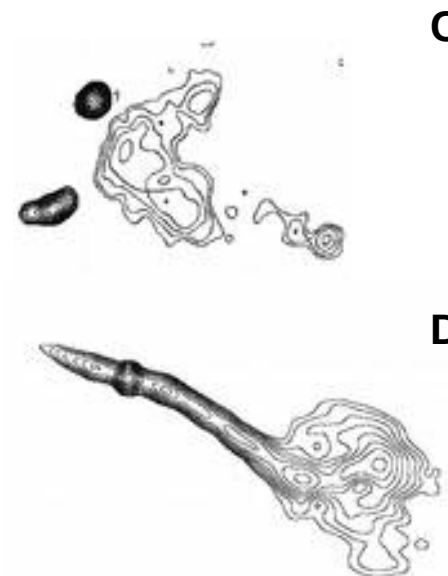


S-band JVLA data of J155210.97+224508.0 tapered at 5 k λ (**big panel**).

C-band JVLA C-config. data of:

- A) the northern lobe of J155210.97+224508.0
- B) the southern lobe of J155210.97+224508.0
- C) the eastern lobe of J155235.1+223418
- D) the western lobe of J155235.1+223418

The contours start from a 3σ confidence level and are scaled of $\sqrt{2}$. Negative 3σ contours are marked with dashed lines.



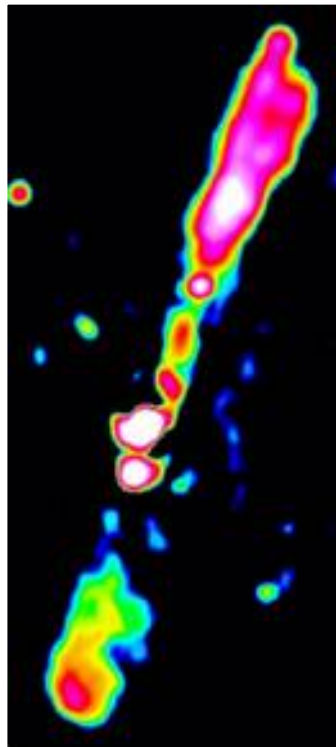
Spectral modeling

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Spectral (synchrotron) modeling parameters derived for different components of J155210.97+224508.0 & J155235.1+223418
SYNAGE (Murgia 1996) for JP (Jaffe & Perola 1973) & CI (Pacholczyk 1970) models

STRUCTURE	z	AGE [Myr]	MODEL
total	0,782	90-160	JP
total	0,115	700-740	JP
S lobe	0,782	25-45	JP
S lobe	0,115	200-210	JP
N lobe	0,782	130-230	JP
N lobe	0,115	1020-1070	JP
N lobe w/bridge	0,782	120-200	JP
N lobe w/bridge	0,115	910-950	JP

Conclusions, future work



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- **the dedicated HBA LOFAR observations** revealed extended lobes of both radio galaxies with high resolution ($13.''80 \times 5.''31$) and sensitivity (0.2 mJy/beam) with **backflow** signatures and **bridge-like structure**
- these extended lobes are also detectable with the JVLA S-, and C-band observations
- the total extension (assuming the probable hosts) is **5 or 1.5 Mpc for J155210.97+224508.0** and (unfortunately) most likely **0.9 Mpc for J155235.1+223418**
- spectral index map revealed i.a. similarity of the bridge and the N lobe of J155210.97+224508.0
- SED model fits were done for different sources' areas: **assymetry in synchrotron ages** for the lobes pair of both sources (for J155210.97+224508.0 more reasonable seems $z=0.782$)
- J155235.1+223418 morphology could be affected by the galaxy cluster environment
restarting source?
- J155210.97+224508.0 – assymetry or two separate sources aligned with each other?

- SED model fits for different regions within J155210.97+224508.0 lobes to check the above hypotesis
- probably dynamical modeling to evaluate and compare the dynamical ages and physical parameters



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THANK YOU!