RUHR-UNIVERSITÄT BOCHUM

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RUB

A puzzling double Odd Radio Circle observed with Apertif and LOFAR

LOFAR Family Meeting

FACULTY FOR PHYSICS AND ASTRONOMY
Chair for Astronomy

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What is an ORC?

Classification:

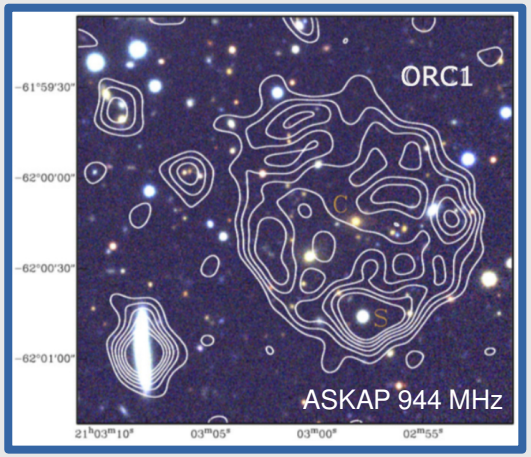
- Circles of diffuse radio emission
- No corresponding diffuse emission in the optical, IR, UV or X-ray
- Single and double sources
- Often a central radio source with a possible optical/IR counterpart

Scenarios discussed so far for their origin:

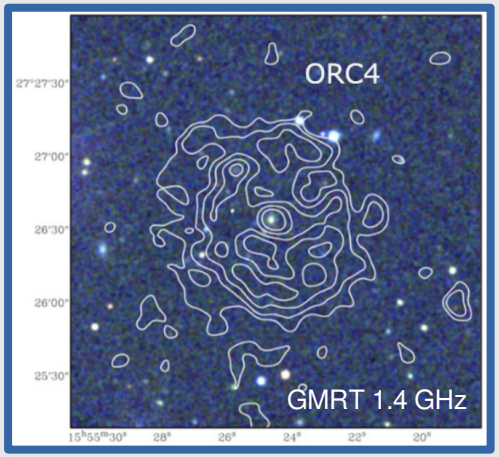
- Giant cluster haloes (Norris et al. 2021)
- Galaxy mergers (Dolag et al. 2022)
- Edge-on and end-on viewed radio lobes (Norris et al. 2021/2022)
- Supernova remnants (Filipović et al. 2022)
- Cataclysmic one-time events such as black hole mergers and Tidal Disruption Events (Filipović et al. 2022, Arias et al. 2022, Omar 2022)

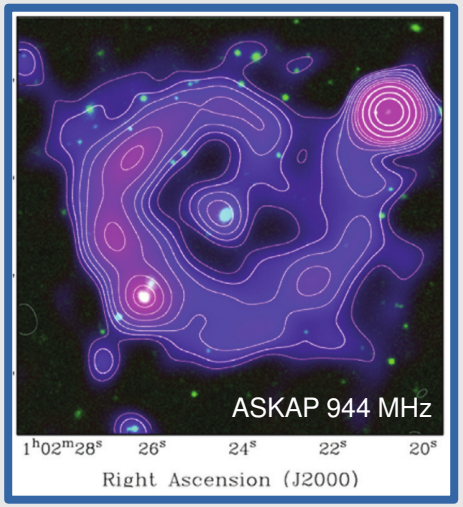
How do ORCs look?

A compilation of all known ORCs (so far)

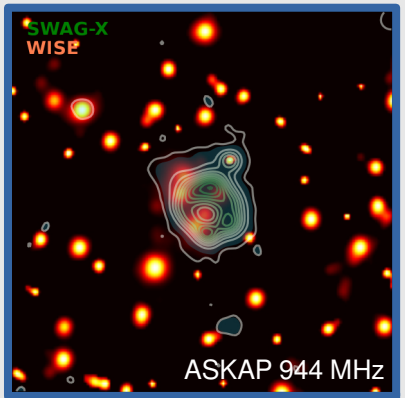


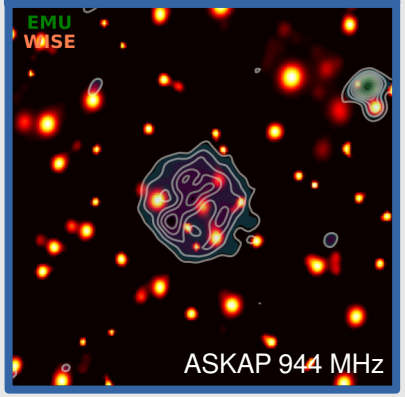
Norris et al. 2022



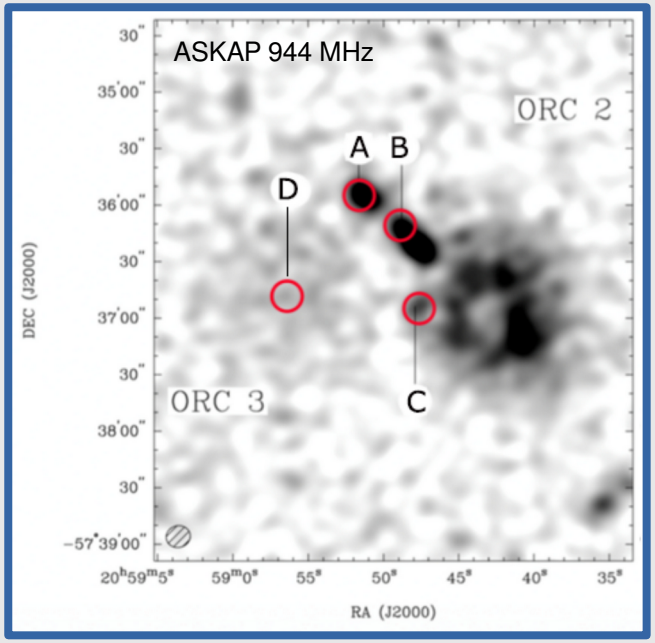


Koribalski et al. 2021

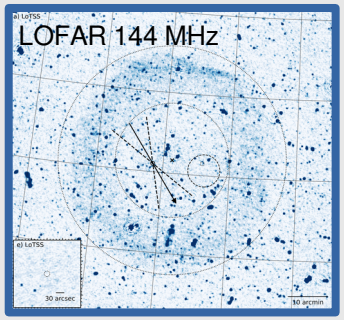




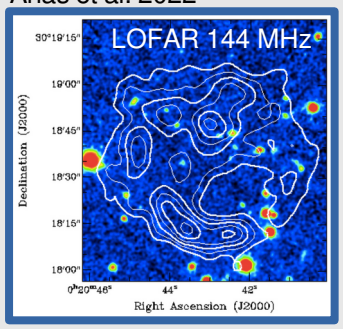
Gupta et al. 2022



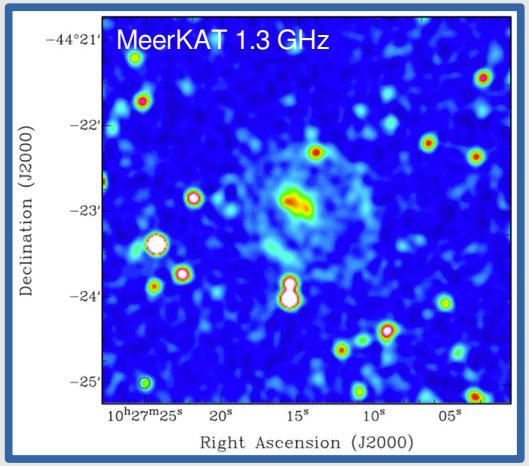
Norris et al. 2022



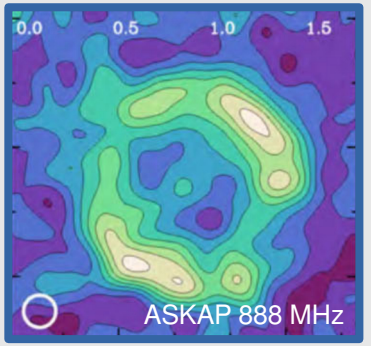
Arias et al. 2022



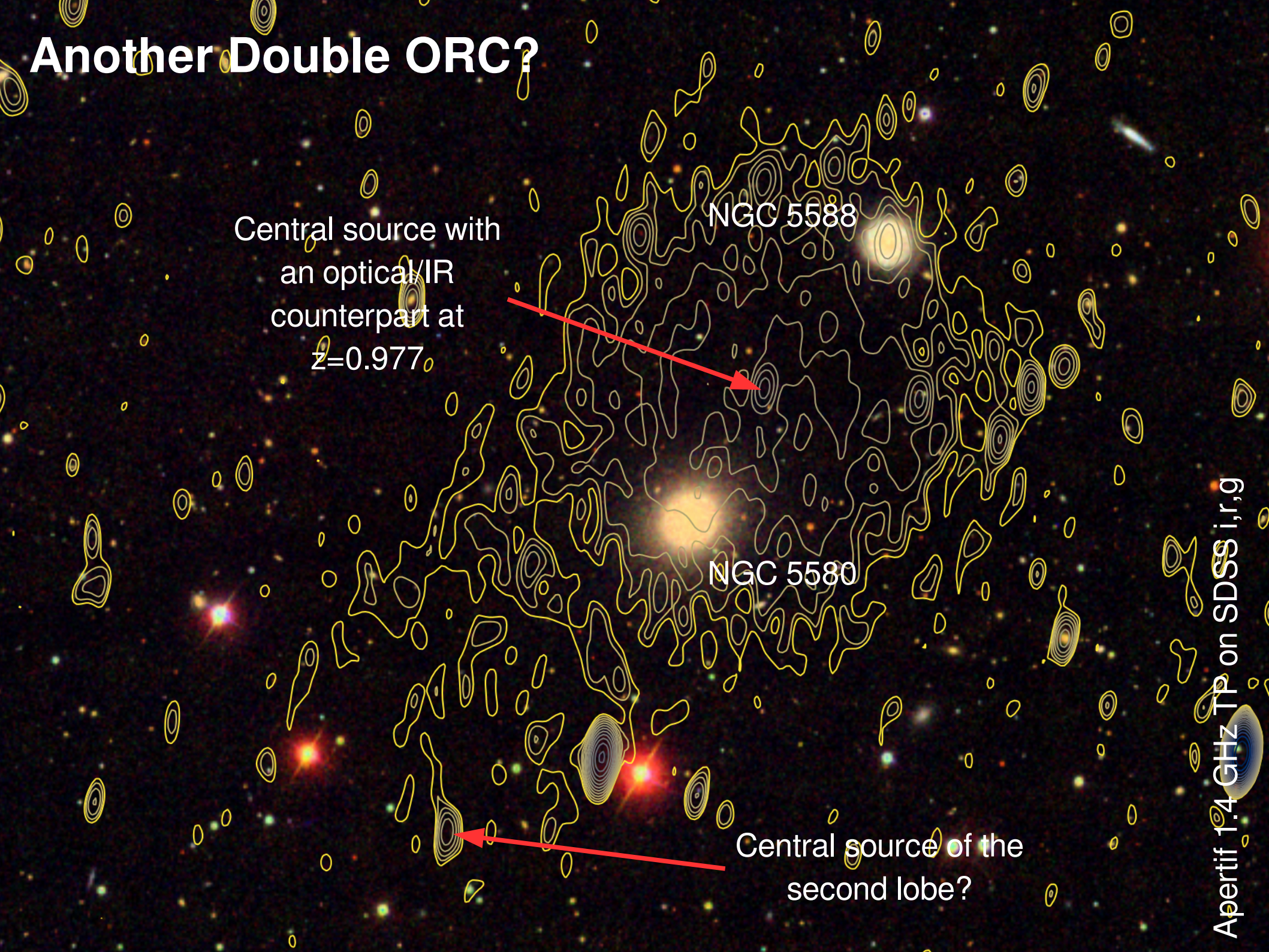
Omar 2022



Koribalski et al. 2021

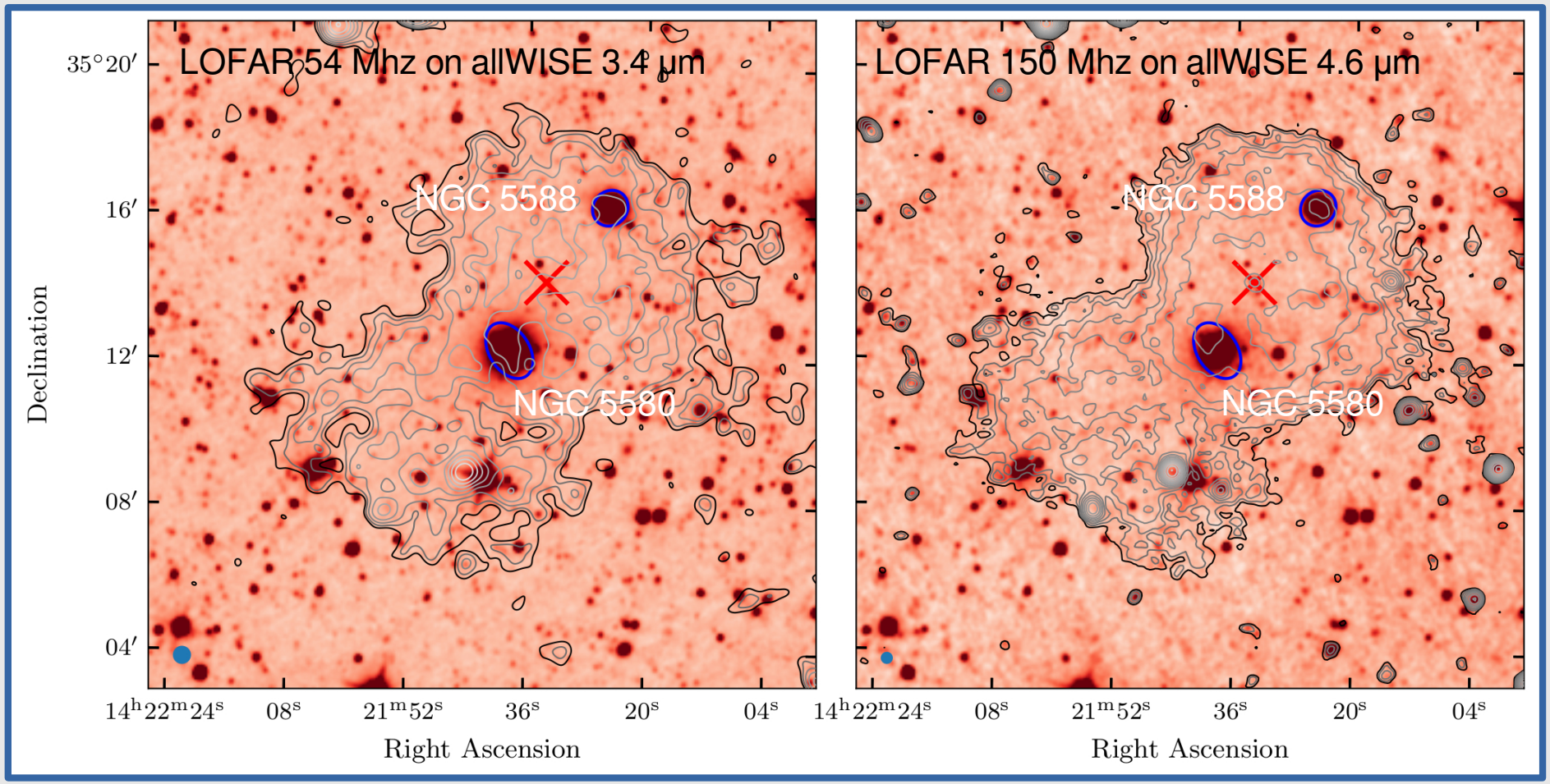


Filipović et al. 2022


Another Double ORC?
Central source with an optical/IR counterpart at z=0.977
NGC 5588
NGC 5580
Central source of the second lobe?
Apertif 1.4 GHz TP on SDSS i,r,g

Low frequency radio emission

LOFAR total intensity maps

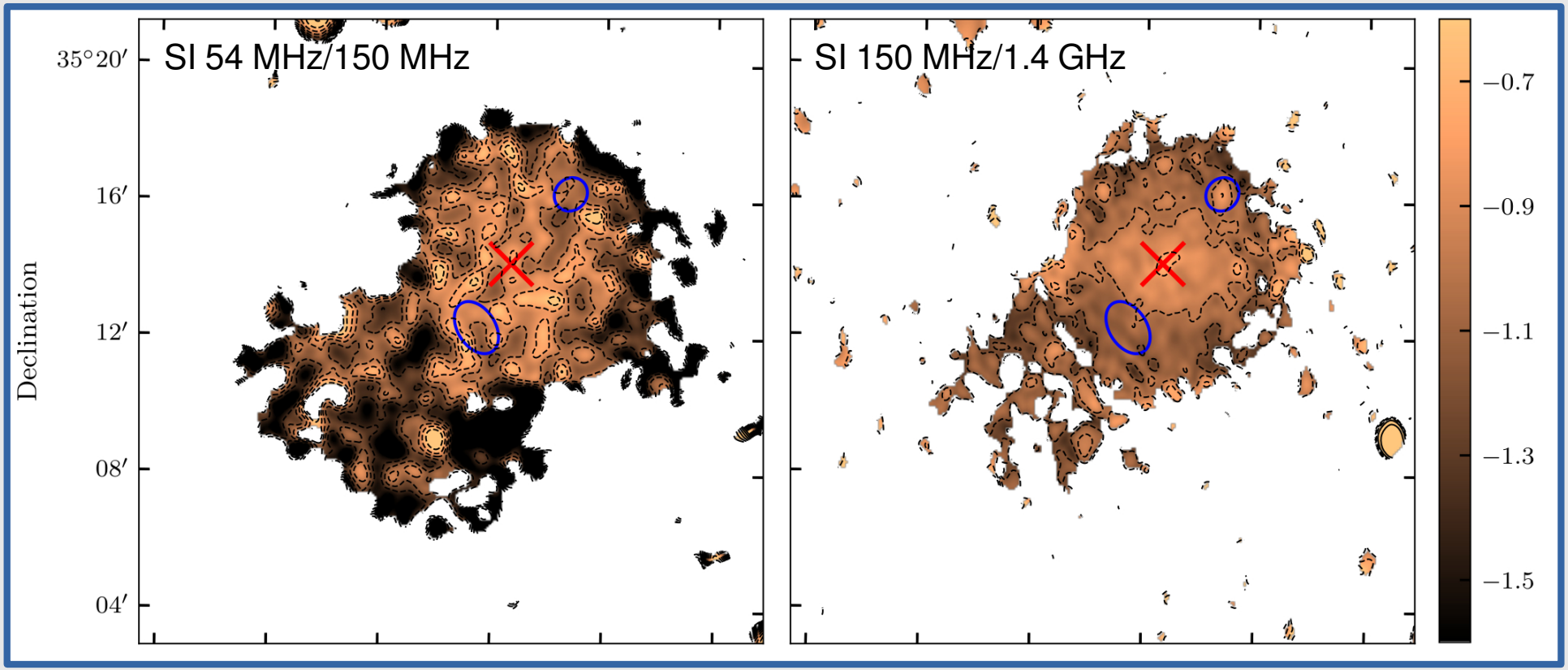


Adebahr et al. submitted

- Source is much more extended at LOFAR frequencies
- Dumbbell shape

Radio spectra

Spectral index



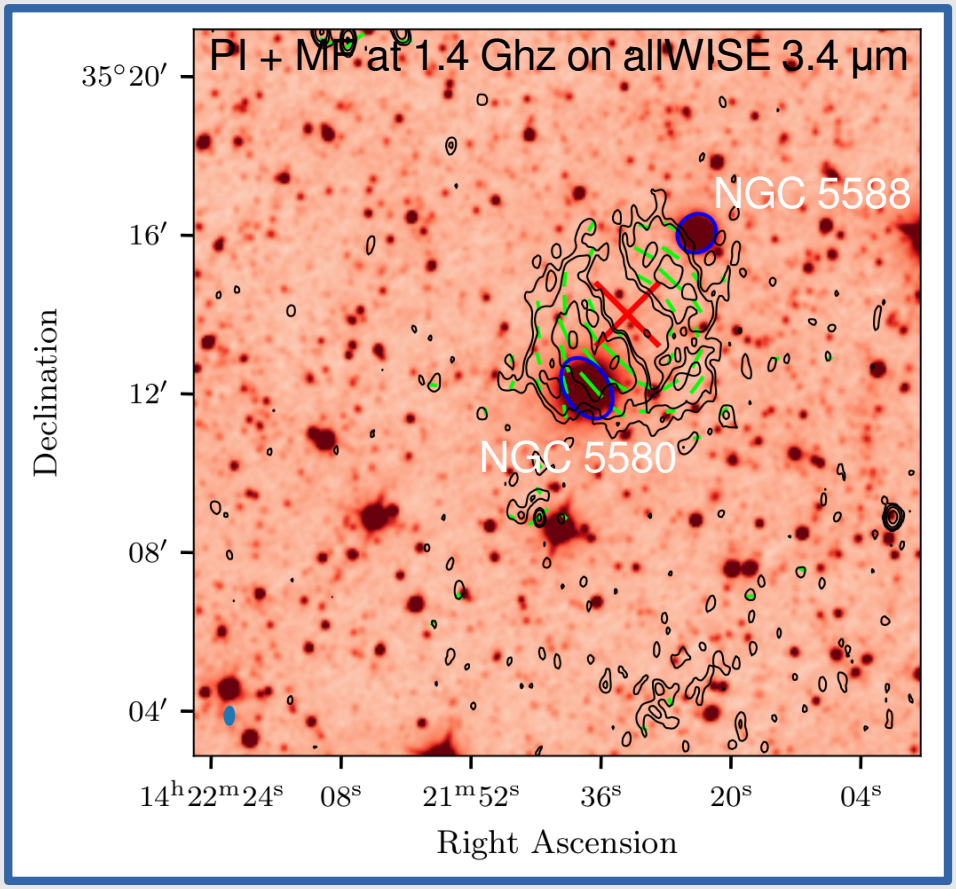
Adebahr et al. submitted

- Overall SI: -1.11±0.07, NW-circle: -1.04±0.05, SE-circle: -1.36±0.14
- Steepening towards the Southeast
- Between 150 MHz and 1.4 GHz steepening radially outwards from the central source of the northern circle

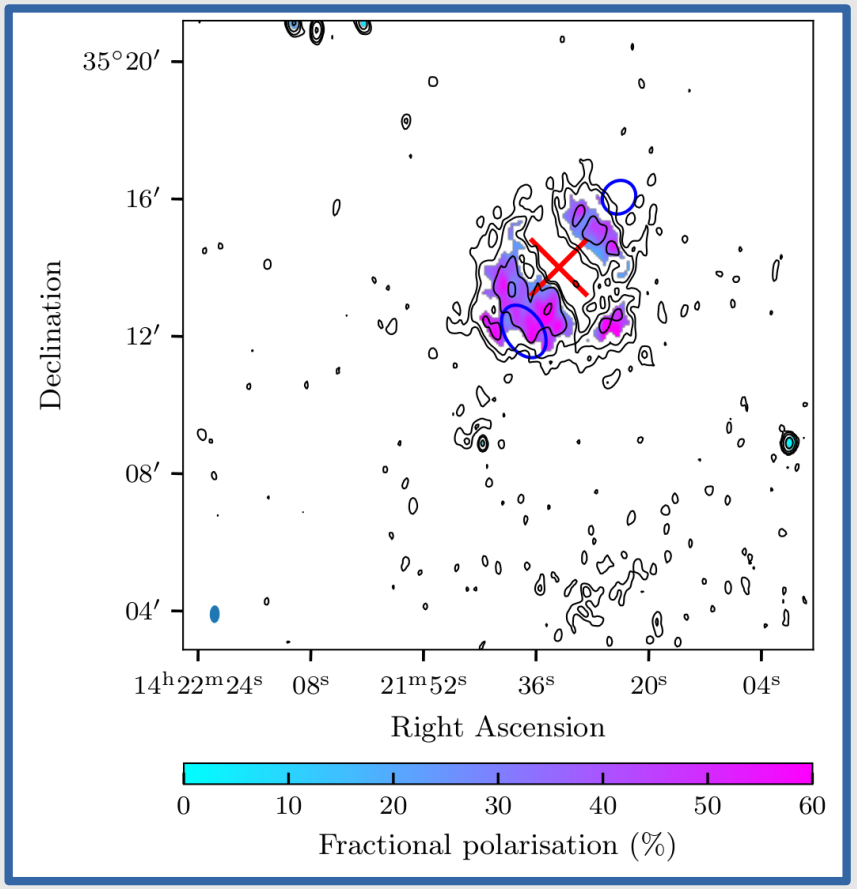
Magnetic fields

Polarised emission

- Only northern lobe shows polarisation at 1.4 GHz
- Magnetic field with a projected double arc morphology
- High fractional polarisation (up to 60%)



Adebahr et al. submitted



Adebahr et al. submitted

Scenario 1

Background galaxy cluster

Scenario 1:

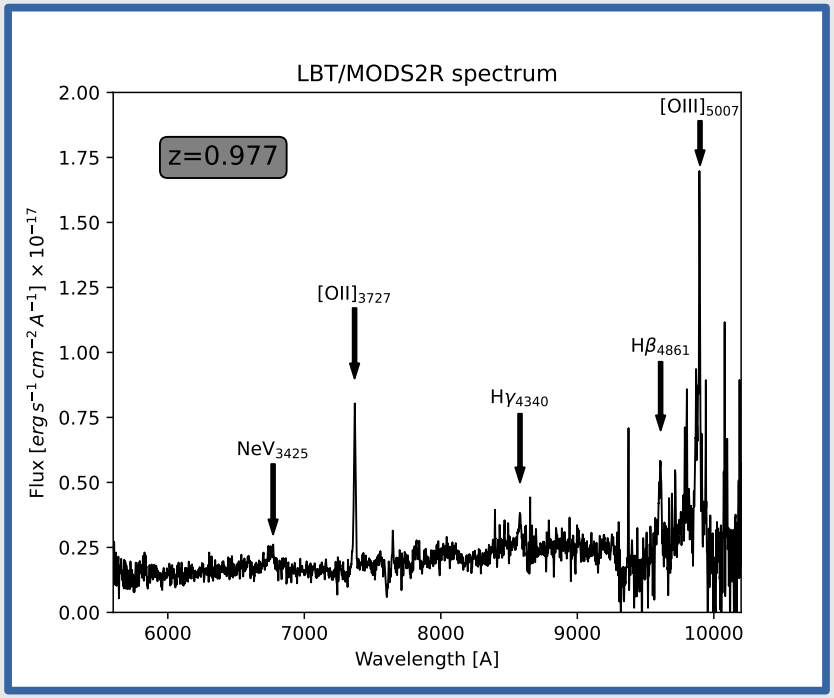
- The ORC is located at z=0.977 and was generated by the central source(s)

  → Diameter of the ORC: 6 Mpc! (PI: 2.4 Mpc)

  → Could only be located in a massive cluster, but we do not see any X-ray emission

- The central host galaxy is a normal AGN as confirmed by optical spectra taken by the Large Binocular Telescope
- Such a massive cluster even at this redshift would show a SZ-signature

Background cluster scenario unlikely!



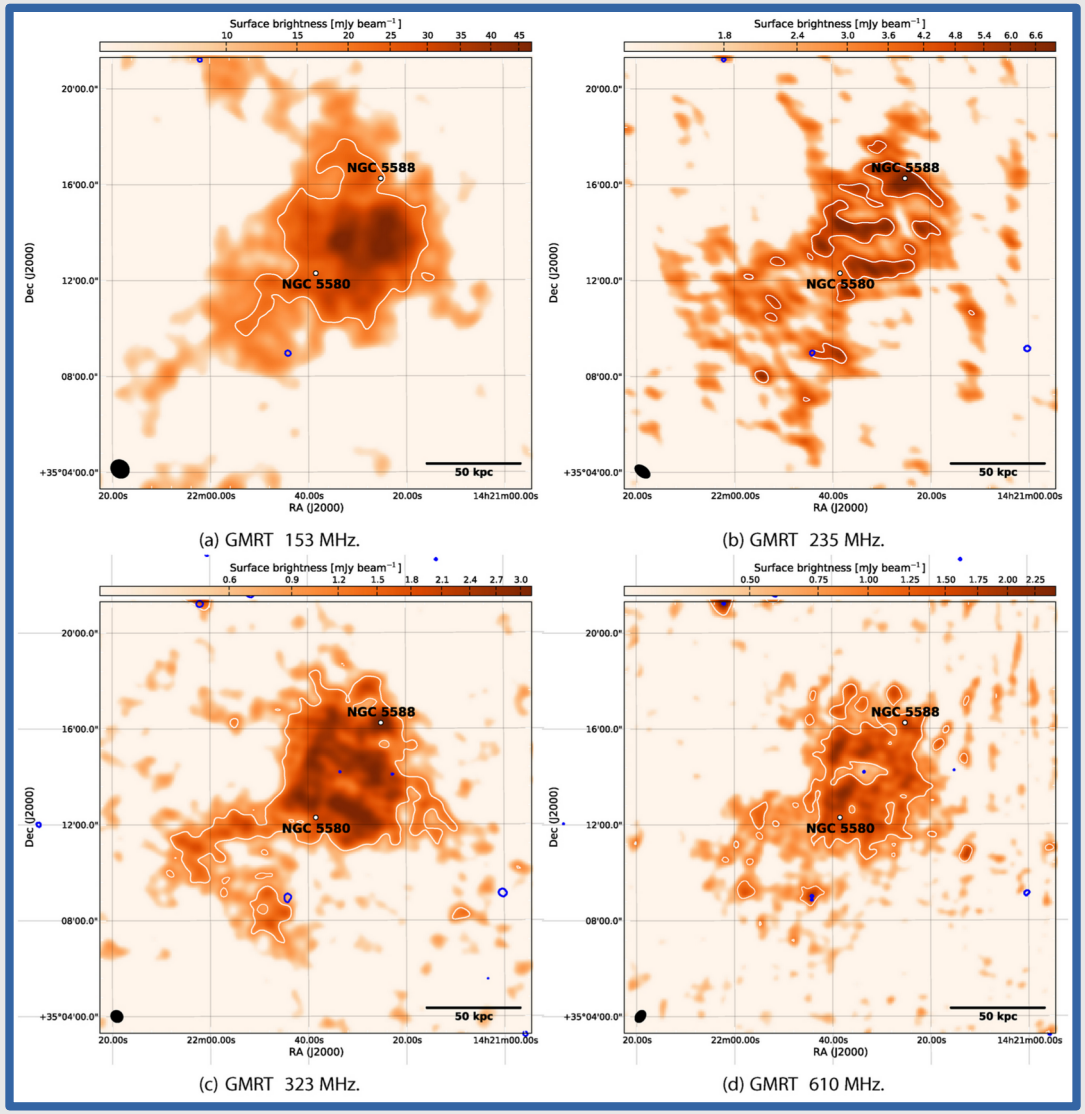
Adebahr et al. submitted

Scneario 2

Lobes of a dying AGN in NGC5580?

- Source was known since 2014 and detected at four different radio frequencies
- Extended radio emission is the remnant of a past activity cycle of the AGN in NGC5580

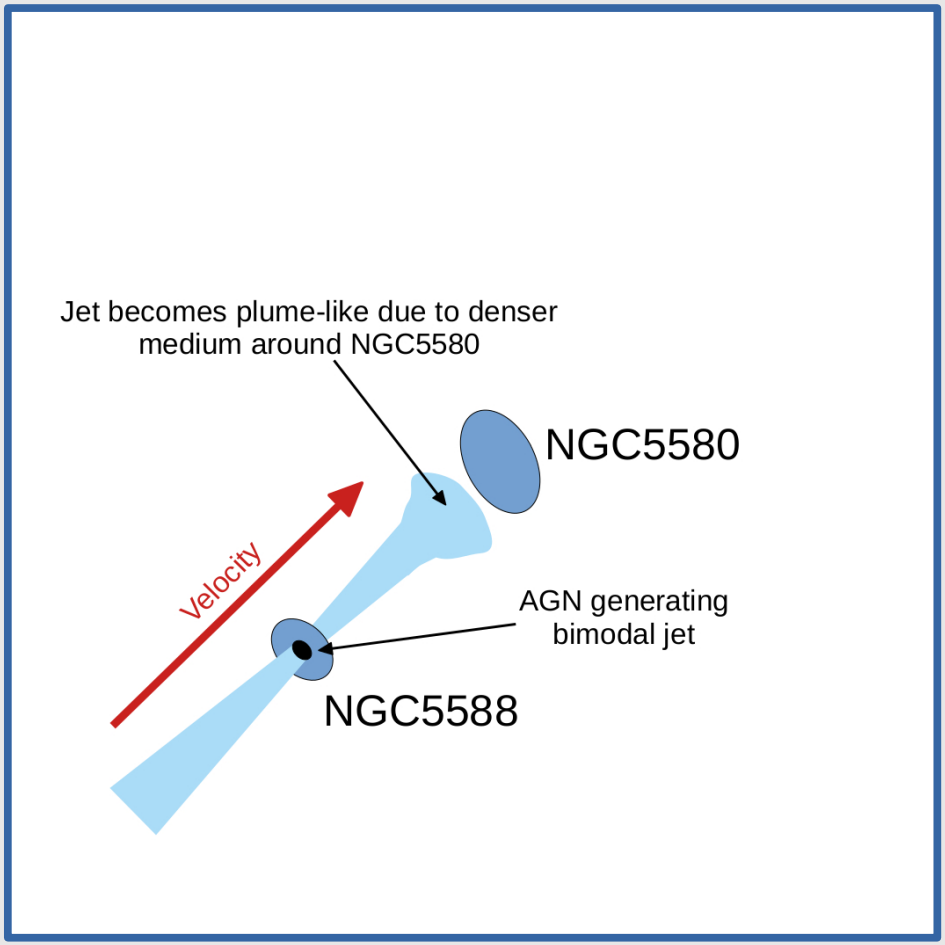
Example of a dying radio galaxy outside of dense environtments?

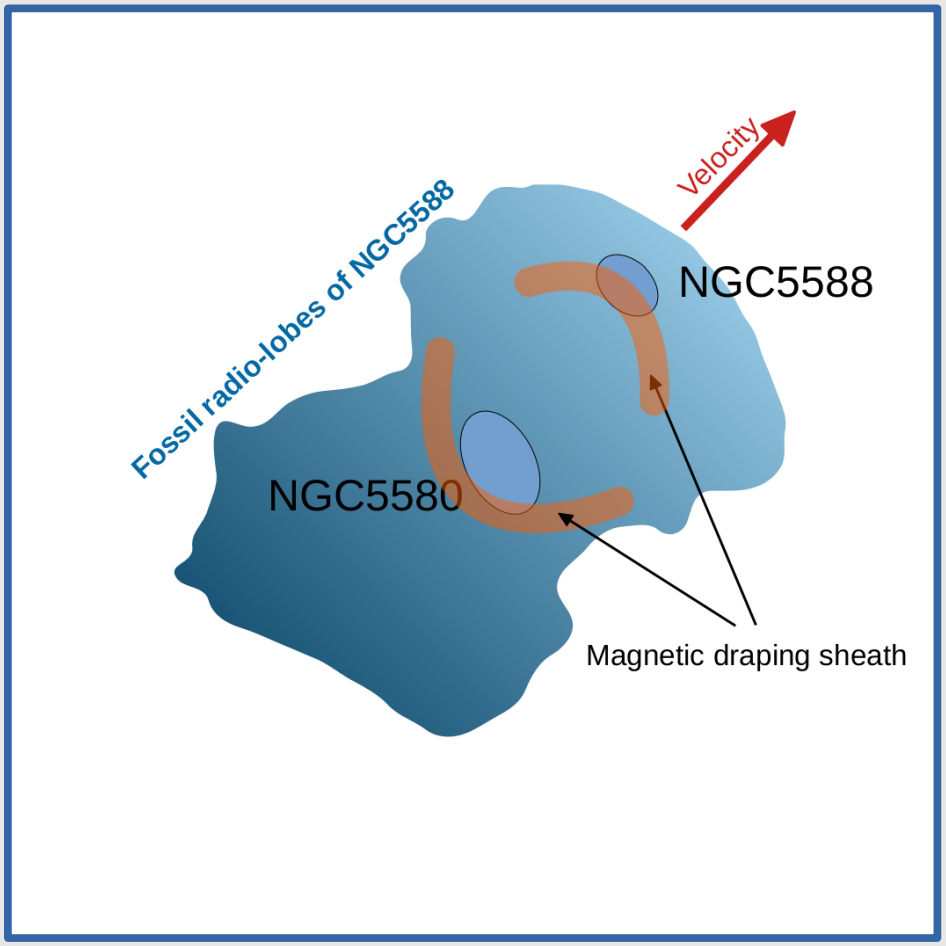


De Gasparin et al. 2014

Scenario 2

Magnetic draping of fossil radio emission





Magnetic field in fossil radio emission generated by NGC5588 in the past gets draped around the galaxies

Summary

- Second double ORC detected
  - Nearby object generated by galaxy interaction
  - Magnetic draping can explain the polarised emission
  - Central source just a by-chance coincidence (does not show unusual features confirmed by optical spectrum)

ORCs are not a homogeneous class of objects, but rather different types with a manifold of possible origins

(AGN activity, Starbursts, Supernovae, Galaxy interactions, TDEs)

Do we see only the brightest objects of a faint population of ORCs?

or

Are ORCs very rare objects and can only be generated under very specific certain prerequisites?