Abell 399-401 radio bridge study
Using wide-field facet calibration

Jurjen de Jong

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SPARCS 2022
Galaxy cluster merger
Galaxy cluster merger

Copyright: Abell 1758: ESA/XMM-Newton (X-rays); GMRT/TGSS (radio); 1E2215: NASA/Chandra (X-rays), GMRT (radio); CIZA J2242: ESA/XMM-Newton (X-rays); ASTRON/WSRT (radio)
Radio bridge: Abell 399-401

- Filament between pre-merging clusters
- Magnetic fields and cosmic rays
- Diffuse synchrotron emission
- Abell 399-401: ~3 Mpc at z=0.072

Govoni et al. 2019
Radio bridge origin

- Lifetime electrons vs. bridge size → sub-Mpc vs. ~Mpc scale
- In-situ re-acceleration of fossil electrons
- Particle injection by shocks, AGN, Galactic winds, ...
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<thead>
<tr>
<th></th>
<th>Fermi-I (weak shocks)</th>
<th>Fermi-II (turbulence)</th>
</tr>
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<tbody>
<tr>
<td><strong>Radio distribution</strong></td>
<td>Substructure</td>
<td>Smooth/volume-filling</td>
</tr>
<tr>
<td><strong>Radio/X-ray correlation</strong></td>
<td>Weak</td>
<td>Strong</td>
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(Govoni et al. 2019) (Brunetti et al. 2020)
Open questions

1) Origin of cosmic rays in the radio bridge?

2) What is the main (re-)acceleration mechanism in the radio bridge?
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1) Origin of cosmic rays in the radio bridge?

2) What is the main (re-)acceleration mechanism in the radio bridge?

**Problem:** Radio bridges are diffuse
LOFAR Data

- Abell 399-401
- 6x8-hour LOFAR observations
- HBA [120-168 MHz]
- Dutch stations
Calibration

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## Calibration

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<td>Large object</td>
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Results

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Recalibration vs. Standard (DDF)

😊 Similar sensitivity
Recalibration vs. Standard (DDF)

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😁 Dynamic range improvement factor ~1.6
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😕  Recalibration costs 16500 extra CPU core hours (expensive!)
Recalibration vs. Standard (DDF)

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😔 Recalibration costs 16500 extra CPU core hours (expensive!)
Radio/X-ray trend

A399
A401

LOFAR

XMM-Newton

$log(I_R) = a \log(I_X) + b$

Best fit
2σ
Correlation

$log(I_R)$ (Jy/arcsec²)
$log(I_X)$ (counts/s/arcsec²)
Results

1) Fossil plasma
Results

1) Fossil plasma

2) Trend between radio and X-ray
Results

1) Fossil plasma

2) Trend between radio and X-ray

3) Steep spectral index $\rightarrow \alpha > 1.5$

(Nunhoeke et al. 2021)
Results

1) Fossil plasma

2) Trend between radio and X-ray

3) Steep spectral index $\rightarrow \alpha > 1.5$

(Prepared by Brunetti et al. 2020)
Summary

Calibration:
1. Recalibration strategy improves calibration of diffuse structures.
2. Computationally expensive.

Science:
3. Radio bridge emission likely generated by Fermi-II re-acceleration of fossil plasma.
4. Fossil plasma might originate from past AGN activity.

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