Radio-loud AGN: is there a link between luminosity and cluster environment?

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Background

• The problem
  – AGN radio jets affect the galaxy cluster environment
  – AGN feeds on environment
  – What is the relationship between the radio properties and the environment?
Background

• Historical results
  – Comparing FRI and FRII RGs
  – Difference in environment at low redshift
    • Longair & Seldner (1979), Prestage & Peacock (1988)
  – Change of environment with redshift
    • Yee & Green (1987), Hill & Lilly (1991)

Hill and Lilly, 1991

\[ 0.34 < z < 0.7 \]
\[ z < 0.2 \]
Background

- Problems
  - Sample bias
  - Sub-sample selection
    - FRI/FRII vs HERGs/LERGs
  - Disentangling evolution

McLure et al, 2004
Background

- HERG/LERG results
- LERG luminosity correlates with environment richness
- HERG luminosity does not ...
- ... or maybe it does
- Possible evolution of HERG environment
  - Belsole et al
- ... Or not
  - Wold et al
Background

• Outstanding questions
  – Is radio luminosity related to environment richness?
  – Does the environment evolve?

• ERA programme
  – Examine radio luminosity vs environment at one redshift
  – Compare this with results across different redshifts
  – Use properties of intra-cluster medium as measure of environment richness
Samples

• Starting point
Samples

ERA sample

Comparison samples

z<0.03: Croston et al, 2008
0.1<z<0.5: Shelton et al (in preparation)
0.45<z<1.0: Belsole et al, 2007
ICM properties

- Temperature
  - $R_{500}$ radius
    (Arnaud et al, 2005)

- Luminosity
  - Surface brightness profiles
  - Beta model
Examples

**3C 427.1**
- FRII, classical double, LERG
- $L_{151} = 339 \times 10^{25}$ WHz$^{-1}$sr$^{-1}$
- Redshift = 0.572
- $R_{500} = 620$ kpc
- $L_x = 26.2 \times 10^{43}$ erg s$^{-1}$
- Temperature = 3.1 keV

**3C 330**
- FRII, classical double, HERG
- $L_{151} = 269 \times 10^{25}$ WHz$^{-1}$sr$^{-1}$
- Redshift = 0.549
- $R_{500} = 430$ kpc
- $L_x = 4.66 \times 10^{43}$ erg s$^{-1}$
- Temperature = 2.0 keV

**6C 0850**
- FRII, fat double, HERG
- $L_{151} = 14.1 \times 10^{25}$ WHz$^{-1}$sr$^{-1}$
- Redshift = 0.407
- $R_{500} = 648$ kpc
- $L_x = 4.85 \times 10^{43}$ erg s$^{-1}$
- Temperature = 2.9 keV

**TO 1307**
- FRI, jet, LERG
- $L_{151} = 2.00 \times 10^{25}$ WHz$^{-1}$sr$^{-1}$
- Redshift = 0.583
- $R_{500} = 347$ kpc
- $L_x = 0.97 \times 10^{43}$ erg s$^{-1}$
- Temperature = 2.0 keV
Results – ERA sample

Radio luminosity vs Environment richness

Weak correlation between radio luminosity and environment richness

<table>
<thead>
<tr>
<th>ERA sample</th>
<th>All data</th>
<th>p &lt; 0.05</th>
</tr>
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<tbody>
<tr>
<td>HERG</td>
<td>N/S</td>
<td></td>
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<tr>
<td>LERG</td>
<td>p &lt; 0.005</td>
<td></td>
</tr>
<tr>
<td>LERG, no 3C 295</td>
<td>p &lt; 0.02</td>
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Results – comparison samples

Radio luminosity vs Environment richness

<table>
<thead>
<tr>
<th></th>
<th>All samples</th>
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<tbody>
<tr>
<td>All data</td>
<td>( p &lt; 0.0001 )</td>
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<tr>
<td>HERG</td>
<td>( p &lt; 0.04 )</td>
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<tr>
<td>LERG</td>
<td>( p &lt; 0.0001 )</td>
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<table>
<thead>
<tr>
<th></th>
<th>Without Croston sample</th>
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<tbody>
<tr>
<td>All data</td>
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<tr>
<td>HERG</td>
<td>( p &lt; 0.04 )</td>
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<tr>
<td>LERG</td>
<td>( p &lt; 0.003 )</td>
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</tbody>
</table>

Supports result from ERA sample
Results – comparison samples

Redshift vs Environment richness

No evidence of environment evolution
Summary

• Indications of correlation between large-scale environment and radio luminosity
  – Potential scaling relation for AGN feedback models
• No evidence of environment evolution
  – But samples need improving
• Improve comparison data
  – Complete search of archives
  – Convert optical measures?
• Comparisons with host galaxy properties
  – Black hole mass (HST data and spectroscopy, McLure et al, 2004)
• Comparisons with optical environment measures
  – $B_{gg}$ (WHT wide-field imaging, Herbert, PhD thesis)