High Frequency Peakers

Young radio sources or flaring blazars?

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Outline

2. Young radio sources
   - From CSS to “extreme” GPS sources
   - A brief history

2. High frequency peakers: radio properties
   - Variability
   - Morphology
   - Polarization

3. High frequency peakers: the ambient medium
   - Neutral and Ionized gas
   - Ambient medium and the source evolution
1. Young Radio Sources

- $P_{1.4 \text{ GHz}} > 10^{25}$ W/Hz;
- Convex spectrum;
- Compact;
- Double/triple;
- Low polarization;
- Asymmetries.
1. Young radio sources

The youth scenario

Compact $\rightarrow$ Young

Kinematic ages
Spectral ages
\{ $10^3 - 10^4$ yr \}

Polatidis&Conway 03, Murgia+ 99, Murgia 03…

Compact $\rightarrow$ Frustrated

No evidence of particularly dense ISM

Fanti+ 00, Siemiginowska+ 05
The smallest sources have the highest turnover frequency (O’Dea 98)

HFPs are good candidates to be *newly born* radio sources (10^2 - 10^3 years).
1. Young radio sources

**Searching for HFP**

- Existence of “extreme” GPS objects peaking at very high frequency
  - Edge et al. (1996);
    RXJ1459+3337 as the prototype
- Multi-frequency observations of inverted-spectrum radio sources
  - Guerra+ 98; Partridge+ 03
    WMAP radio sources with rising spectrum from 1.4 up to 90 GHz
  - Dallacasa+ 00; Tinti+ 05; Orienti+ 07
    The “bright” HFP sample
  - Stanghellini+ (see poster session)
    The “faint” HFP sample
1. Young radio sources

**Rare gems**

Rapid evolution of radio emission:

- **peak moves to low frequency**
  - from 24 to 12 GHz in 7 yr

- **variability of the spectrum**
  - in the optically-thick part of the spectrum the flux density increases as the source expands

J1459+3337
The Bright HFP sample

Cross-correlation of the 87GB at 4.9 GHz and the NVSS at 1.4 GHz

- \( S_{4.9} > 300 \) mJy;
- \( \alpha < -0.5 \) (\( S \propto \nu^{-\alpha} \));

Simultaneous VLA observations from 1.4 GHz to 22.4 GHz to remove variable sources.

The final sample consists in 55 objects (Dallacasa et al. 2000):
- 11 galaxies;
- 36 quasars;
- 8 empty fields;
Contamination from BL Lac objects

Young radio sources

- No flux-density variability;
- “Double/Triple” structure;
- Unpolarized

Blazars

- Strong flux density variability;
- Core-Jet structure;
- Significantly polarized

Blazars may display the characteristics of young radio sources when their emission is dominated by a flare in the jet-base.
Multi-frequency VLA observations

4 epochs of high-sensitivity VLA observations at 9 different frequencies (1.4, 1.7, 4.5, 5.0, 8.1, 8.4, 15.3, 22.2 and 43.2 GHz) observed simultaneously have been carried out.

Multi-epoch variability index:

\[ V = \frac{1}{m} \sum_{i=1}^{m} \frac{(S_i - \bar{S}_i)^2}{\sigma_i^2} \]

\( V = 3 \) is the limit value of the variability (Orienti+ 07)
Variability

- All galaxies have \( V < 3 \);
- 21 sources (18 quasars and 3 BL Lacs) have \( V >> 3 \);
- 12 quasars no longer show a peaked spectrum;

Orienti+ 07, Tinti+ 05
Two-frequencies VLBA observations in the optically-thin part of the spectrum (Orienti+ 06).

- 6 sources (12%) “Core-Jet” morphology;
- 30 sources (61%) Unresolved
- 14 sources (27%) “Double/Triple” morphology;

Segregation between optical identification

- Galaxies have “Double/Triple” morphology (78%);
- Quasars/BL Lacs are either Core-Jet (16%) or Unresolved (71%)
2. HFP: radio properties

Morphology vs Variability

Double/Triple

Core-Jet

Unresolved

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4th CSS/GPS Workshop - Riccione (May 2008)
2. HFP: radio properties

**Morphology vs Variability**

- **Double/Triple**
  - J1511+0518
  - 15 GHz
  - Peak: 369.3, f.c.: 0.9 (mJy/beam)

- **Core-Jet**
  - J0329+3510
  - 15.3 GHz
  - Peak: 354.69, f.c.: 5.68 (mJy/beam)

- **Unresolved**
  - J1412+1334
  - 15.3 GHz
  - Peak: 102.2, f.c.: 4.41 (mJy/beam)

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Simultaneous VLA observations at 4.5, 8.4, 15 and 22 GHz + information from the NVSS at 1.4 GHz show that:

- 26 (58%) have fractional polarization >1%;
- 17 (38%) are completely unpolarized;
- All the galaxies are unpolarized;
- 17 (66%) of quasars are highly-polarized;
- Sources with V<3 are unpolarized.
2. HFP: radio properties

2. Summary

From the information derived by flux density variability, morphology and polarization we find that:

The majority of quasars are:
- Variable;
- “Core-Jet” or Unresolved morphology;
- Polarized emission (>1%).

The majority of galaxies are:
- No Variability
- “Double-Triple” morphology
- Unpolarized or slightly (<1%) polarized
The characteristics shown by HFP with different optical identification are consistent with the idea that the HFP spectrum in galaxies and quasars originates in different regions:

- Mini-lobes in galaxies.
- Compact regions related to the core in quasars.

Only 25 (45%) of the 55 sources of the sample can still be considered *genuine young radio source* candidates.
3. **HFPs: the ambient medium**

- Investigate the physical conditions of the ISM:
  1) settled medium (circumnuclear torus);
  2) unsettled, clumpy medium;

- Investigate different phenomena:
  a) Jet-ISM interaction;
  b) outflows;
The HI and young radio sources

Larger incidence of HI absorption in young radio sources than in “normal” radio galaxies (Morganti et al. 2001);

- Anti-correlation LS – $N_{HI}$
  (Pihlström+ 03; Vermeulen+ 03 Gupta+ 06);
- Gas distribution:
  - Spherical, radially declining density;
  - Circumnuclear disk/tours (Mundell+ 03).
The HFP sources do not seem to follow the extrapolation to smaller LLS of the correlation found by Pihlström et al. (2003).

The absence of high HI column density can be explained in a torus/disk scenario, by geometrical and orientation effects.
Extended emission in HFPs

• On kpc-scales:
  - J0111+3906 (Baum+ 90); J0428+3259 (Tinti+ 05)

• On pc-scales:
  - OQ 208 (Luo+ 07); J1511+0518
3. HFPs: the ambient medium,

**HI Absorption**

**J0111+3906**

\[ \Delta v \sim 100 \text{ km/s} \]
\[ \tau \sim 0.44 \]
Circumnuclear structure

**OQ 208**

\[ \Delta v \sim 2000 \text{ km/s} \]
\[ \tau \sim 0.005 \]
Outflows

Carilli+ 98; Morganti+ 05; Orienti+ 07
3. HFPs: the ambient medium

**Ionized medium**

### J0111+3906

\[ \alpha = 3.2 \pm 0.5 \]

Circumnuclear disk

Marr+ 01; Kameno+ 00; Luo+ 07

### OQ 208

\[ \alpha = 4.1 \pm 0.3 \]

Inhomogeneous medium

Marr+ 01; Kameno+ 00; Luo+ 07
3. HFPs: the ambient medium

**Ambient medium**

HFPs entirely reside within the innermost region of the host galaxy with rich and dense ISM.

Higher incidence of free-free absorption (Dallacasa’s talk)

Conway 96; Peck+ 99; Kameno+ 00; Orienti+ 07
The ISM and the source growth

Strong flux-density and arm-length asymmetries in compact (< 15 kpc) radio sources

Jet-cloud interactions?
(Jeyakumar’s talk)
3. HFPs: ambient medium

3. Summary

- Lower incidence of HI absorption w.r.t. CSS/GPS sources
- Line profiles with different characteristics
- High detection rate of free-free absorption
  - Circumnuclear disk/torus
  - Inhomogeneous ambient medium

- The presence of a dense and dishomogeneous ambient medium may influence the source growth by
  - Flux-density asymmetries
  - Arm-length asymmetries

A better knowledge of the ambient medium will enable us to draw a more reliable picture on the fate of the source evolution
**Extended emission in HFPs**

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