Young radio sources: from newly born to short-lived objects

Monica Orienti
(INAF-IRA)

Co-I: D. Dallacasa, F. D’Ammando, G. Migliori
The life-cycle of the radio emission
Newly born radio sources

• Only a handful of objects with LS ~ a few pc is known. This number must increase for improving our knowledge of individual radio source evolution and its different paths.

• In newly born radio sources, changes in the radio spectrum produced by adiabatic expansion can be appreciable after a short time.

![Optically-thick](5 GHz)

![Optically-thin](22 GHz)

![Peak frequency](Frequency (GHz))
Searching for newly born radio sources

• Multi-epoch multifrequency observations to study the long-term light curve and spectral variability.

  3-5 epochs of VLA observations from 1 to ~30 GHz of 35 sources from the faint HFP samples.

• High frequency (> 5 GHz) pc-scale VLBI observations to determine the structure.

  VLBI observations from 8/15 to 15/22 GHz of 26 faint HFP sources.
JVLA and VLBA results

Different types of variability.

$\nu_p \sim 5$ GHz

$\nu_p \sim 6-5.5$ GHz

$\nu_p \sim 9-6.5$ GHz

$\nu_p \sim 4/8/3$ GHz

30% with double/triple structure, 30% resolved, 40% unresolved.
JVLA and VLBA results

Different types of variability.

30% with double/triple structure, 30% resolved, 40% unresolved.
Blazars or young objects?

\[ \nu_{p,1} = \nu_{p,0} \left( \frac{t_0}{t_0 + \Delta t} \right)^4 \]

\[ S_1 = S_0 \left( \frac{t_0 + \Delta t}{t_0} \right)^3 \]

\[ t_0 \sim 150^{+100}_{-50} \text{ yr} \]

\[ t_0 \sim 110^{+50}_{-30} \text{ yr} \]

\[ \nu_{\text{exp}} \sim 0.2^{+0.2}_{-0.05} c \]

Consistent with a young radio source in adiabatic expansion
Blazars or young objects?

Young sources in adiabatic expansion.

\( \nu_p \sim 5 \text{ GHz} \)
\( \nu_p \sim 6-5.5 \text{ GHz} \)
\( \nu_p \sim 9-6.5 \text{ GHz} \)
\( \nu_p \sim 4/8/3 \text{ GHz} \)

Orienti & Dallacasa 20
Blazars or young objects?

Contamination from blazars.

$\nu_p \sim 5 \text{ GHz}$

$\nu_p \sim 6-5.5 \text{ GHz}$

$\nu_p \sim 9-6.5 \text{ GHz}$

$\nu_p \sim 4/8/3 \text{ GHz}$

Orienti & Dallacasa 12

Orienti & Dallacasa 20

J1613+4223 U-band

J2000 Right Ascension

21 pc

J0754+3033 U-band

J2000 Right Ascension
97% show long-term variability;
51% show variability consistent with adiabatic expansion

$$v_{\text{exp}} \sim 0.1c - 0.7c$$

20% fast evolving sources with rapid flux density decrease in the optically-thin part of spectrum

Hardly progenitors of classical FRI/FRII sources

20% with steep ($\alpha > 1$) spectra
Count excess

Excess of young radio sources in flux-density limited catalogs cannot be explained with luminosity evolution.

The age distribution of a sub-samples of CSO peaks ~500 - 1100 yr.

(Gugliucci+05; An&Baan 12)
Searching for short-lived radio sources

**AIM:** constraining the incidence of fading objects at different evolutionary stages

**MODELS:**

1) intermittent radio emission lasts $10^{4-5}$ yr and recurs $10^{5-6}$ yr  
   (Reynolds&Begelman97)

2) intermittent radio emission lasts $<10^{3-4}$ yr and recurs $10^{4-5}$ yr  
   (Czerny+03)

**EXPECTATIONS:**

1) excess of MSO (LS > 1 kpc)

2) excess of CSO (LS < 1 kpc)
Searching for faders

B3-VLA CSS: 87/373 sources from B3-VLA with $S_{\,408} > 0.8$ Jy

Looking for candidate faders from the Fanti+01 B3-VLA CSS sample.

Selection criteria:

- Steep spectrum with $\alpha > 1.0$
- No evidence of active regions

18/87 CSS sources: 12/59 with LLS > 1 kpc, 6/28 with LLS < 1 kpc

VLA: 1 – 15 GHz

VLBA: 1.4 – 8.4 GHz
LS < 1 kpc: preliminary results

VLBA observations at 1.4, 5, 8.4 GHz

4/6 sources (~66%) with clear detection of the core

Orienti et al. in prep
LS < 1 kpc: preliminary results

VLBA observations at 1.4, 5, 8.4 GHz

2 out of 28 CSO sources (~7%) with LS < 1 kpc do not show active regions

Orienti et al. in prep
**LS > 1 kpc: preliminary results**

VLA observations from 1 to 14 GHz

Orienti et al. in prep

3 sources turned up to be LSO.

RM of the “CSS” component consistent with the Galactic value.

**Removed from the sample (now of 56 sources).**

RM ~ 3.5 rad/m²
LS > 1 kpc: preliminary results

3 MSO sources with active regions

\[ \alpha \sim 0.4 \pm 0.1 \]
**LS > 1 kpc: preliminary results**

6/56 (~10%) MSO sources with no obvious active regions (> 1.2).

\[ \alpha > 1.50 \pm 0.05 \]

\[ \alpha > 1.75 \pm 0.07 \]

\[ \alpha > 1.45 \pm 0.08 \]

Orienti et al, in prep
eMERLIN observations

- 2/6 with steep components
- 4/6 with core detection
- 2/56 (~3%) with no active regions
The life-cycle of the radio emission

~3% faders LS > 1 kpc

~7% faders LS < 1 kpc

~20% of HFP have fast evolution
Conclusions

- Young radio sources provide insight into the initial conditions of the evolution of the radio emission.

- The time scale of the radio emission is still far to be constrained.

- The high sensitivity and resolution of SKA, ngVLA and their precursors are crucial for our knowledge of the life cycle of the radio emission. They will play a pivotal role in finding relic and restarted sources, and will provide for the first time the possibility to investigate the **cosmological evolution** of young radio sources thanks to the study of the MHz-peaked spectrum population.
Thank you