Recurrent Radio Activity in Active Galactic Nuclei

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Tidal Disruption Events and AGN Outbursts
25-27 June 2012
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Cygnus A

hot spot
lobe
jets
core

$z=0.0561$
size
$2^\prime$
$100 \text{ kpc}$
Time evolution

- AGN
- JET
- external medium (IGM)
- bow shock
- jet shock
- COCOON
- shocked jet material
- shocked IGM
- observable radio lobe
- observable region
- shock wave
- jet flow
The largest radio galaxies

Late type galaxy AGN hosts have weak radio emission and small-scale jets.

Early type galaxy AGN hosts have strong radio emission and large-scale jets.
.... there are few exceptions
Discovery of an exotic galaxy, Speca

$z = 0.137$, spiral-host triple-double radio galaxy

Double-Double Radio Galaxies

**DDRG** – two unequal sized, two sided, double lobed, edge-brightened (FRII) radio sources from two different cycles of activity (Schoenmakers, 2000, MNRAS, 315, 371)

**interruptions related to:**
- refueling of the central engine
- instabilities in the accretion disk
- jet production mechanism

~20 objects known (Saikia, & Jamrozy 2009)

Age determination

5 arcminutes

older?

younger?
Synchrotron Radiation

Synchrotron emission results from relativistic electrons spiraling in weak magnetic fields

Energy distribution \( N(E) \sim E^p \)
Spectrum shape \( S_\nu \sim \nu^{-\alpha} \) (for radio galaxies \( p=-2.5, \alpha=0.75 \))

Evolution of radio spectrum with time:
steepening of the spectrum at high frequencies results from
the radiative losses of electrons with the highest energy

Spectral model parameters:
• \( \alpha_{\text{inj}} \): power law index at frequencies lower than the break frequency
• \( \nu_{\text{br}} \): break frequency after which the spectrum steepens
• behavior of the spectrum after the break frequency
Spectral models

**Theoretical Synchrotron Aging Spectra**

\[ \log \text{[Flux Density]} \]

\[ \log [\text{Frequency}] \]

\[ t_{\text{syn}} \propto \frac{B^{1/2}}{(B^2 + B_{iC}^2)[\nu_{br}(1 + z)]^{-1/2}} \]

\[ B_{iC} = 0.32(1 + z)^2 \text{ [nT]} \]

\[ B \sim B_{\text{eqw}} \propto \frac{1 + \kappa}{\eta} \left( \frac{L}{V} \right)^{2/7} \]
J1548-3216 multifrequency radio maps: GMRT, VLA
Spectral age 75 Myr
Spectral age 9 Myr
J1835+6204
\begin{itemize}
  \item \textbf{synch. age [Myr]} \hspace{2cm} 22
  \item \textbf{quiescent phase [%]} \hspace{2cm} <5
\end{itemize}

J0041+3224
\begin{itemize}
  \item \textbf{synch. age [Myr]} \hspace{2cm} 26
  \item \textbf{quiescent phase [%]} \hspace{2cm} 4-28
\end{itemize}

<table>
<thead>
<tr>
<th>Source</th>
<th>Alt. name</th>
<th>Opt. Id.</th>
<th>Redshift</th>
<th>$l_{in}$ kpc</th>
<th>$l_o$ kpc</th>
<th>Notes</th>
<th>References</th>
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<td>J0041+3224</td>
<td>B2 0039+32</td>
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</table>

Saikia & Jamrozy, 2009, BASI, 37, 63
4C02.27 DDRQ

Saikia & Jamrozy, 2009
X-shaped sources

two low-surface-brightness lobes oriented at an angle to the high-surface-brightness radio lobes, giving the total source an 'X' shape.

the two pairs of lobes pass symmetrically through the location of the host galaxy.

- backflow (Leahy and Williams 1984),
- buoyancy (Worrall, et al. 1995),
- conical precession (Parma, et al.1985),
- reorientation of the jet axis (e.g. Dennett-Thorpe et al. 2002),
- existence of an unresolved binary AGN system with two pairs of jets (Lal, Rao 2007).
NGC 1128
separation 8 kpc

PKS 2149-158

separation 13.5” = 15.8kpc

All in one

- FRII/FRI
- DDRG
- X-shape
- Recent merger
u 16.85

early type gal. $< 2.83$ late type gal.

concentration index 2.814

2m Faulkes Telescope Nort, Hawaii
$z = 0.053716$

AGN of LINER type

$\log(\text{BH mass}/M_\odot) = 8.47 +/- 0.32$
The goal of our study is to understand the relationship between the central AGN and the environment of the galaxy.

CGCG292-057 provides a unique opportunity to measure both the age of the radio source and the star formation history of the galaxy, both of which are connected to the merger history of the galaxy.
size = 266 kpc

arm-length ratio = 1.17

$\log P_{1.4 \text{GHz}} = 24.33 \text{ W/Hz}$

(below the FRI/FRII luminosity break)
size 23.1 kpc
arm-length ratio 1.54
peak-flux ratio 1.50
inclination angle $\sim$ 79 degr
The aim of our work in the radio domain is to obtain physical parameters of the outer and the inner lobes of CGCG292-057 on the basis of a wide range multifrequency radio observations (GMRT and VLA)

- spectra of the outer and inner lobes
- spectral and dynamical age
- injection spectra of each cycle of activity
- time scales of activity and relation to the host galaxy
- interaction of the inner lobes with the ISM
Dying Cygnus A
Reincarnated Cygnus A

Need the proper tools: LOFAR, SKA ...
Thank you