High redshift blazars:

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What is a blazar?

A jetted AGN, whose jet is relativistic ($\Gamma \sim 10$) and is “pointing at us”.
To be more quantitative:

$$\Theta_{\text{view}} < 1/\Gamma$$

→ For each blazar, $2\Gamma^2$ radio-loud AGN pointing elsewhere: FR I and FRII radio-galaxies
Goals

- Relativistic jets as the most efficient engines
- Black holes in radio loud sources are big
- Blazars can be seen at high redshifts
- Especially in hard X-rays
- Search of heavy black holes in the young Universe
The “blazar sequence”

Log $\nu L_\nu$ [erg s$^{-1}$]

Log $\nu$ [Hz]

FSRQs

BL Lacs

BAT

Integral

Fossati et al. 1998; Donato et al. 2001
2 years – 4σ  Ackermann+ 2011

175 BL Lacs
310 FSRQ
with z

Energy index $\alpha_\gamma$

$L_\gamma$ [erg s$^{-1}$]
2 years – $4\sigma$  Ackermann+ 2011

Energy index $\alpha_\gamma$

$L_\gamma$ [erg s$^{-1}$]
SDSS+1LAC

Do we really need to divide blazars?

Sbarrato+ 2011
Fermi big blazars: powerful, with emission lines
Low energy synchro peak: leave the disk naked!
Torus with WISE:

Calderone+ 2012

300 K  1500 K

Low energy synchro peak: leave the disk naked!
$M=2 \times 10^9$

Low energy synchro peak: leave the disk naked!
torus
disk
X-ray corona

synchro
Small B

0227-369
$z = 2.115$

EC

$\log \nu F_\nu$ [erg cm$^{-2}$s$^{-1}$]

$\log \nu L_\nu$ [erg s$^{-1}$]
The most luminous blazars

BAT and INTEGRAL even bigger blazars: $z$ up to $\sim 4$
(compare with Fermi: $z < 3$)
jet power and accretion luminosity

\[ P_r = \text{radiation} \sim \frac{L_{\text{obs}}}{\Gamma^2} \]

\[ P_e = \text{relat. electrons} \]

\[ P_p = \text{protons} \]

\[ P_B = \text{B-field} \]

\[ P_{\text{jet}} = P_e + P_p + P_B \]

Shakura-Sunyaev disk: \( L_d \)

\(~10^{17}\text{ cm}\)
$P_{\text{min}} = 2P_r \sim 2L_{\text{obs}} / \Gamma^2$ "model independent"

$P_{\text{jet, min}} = L_d$

All sources with emission lines

$2P_r$ is the minimum $P_{\text{jet}}$
If one proton per emitting electron

$P_j \sim M c^2 > L_d \rightarrow \text{next talk!}$
Pause

1. \( P_{\text{jet}} \sim M c^2 \), even larger than \( L_d \)
2. For all \( M/\dot{M}_{\text{Edd}} \)
3. BL Lacs → ADAF  FSRQs → SS
4. \( L_{\text{BLR}}/L_{\text{Edd}} \) divides BL Lacs from FSRQs
5. Matter, not magnetic, dominated
The second most distant blazar: $z=5.3$
B2 1023+01 = SDSS J1026+254

One of the 31 AGNs with radio-loudness $R>100$
and $z>4$ in the SDSS (DR7)

Strong radio ($\sim$200 mJy @ 1.4 GHz)

Large radio-loudness ($R\sim5000$)

GROND (simult. photometry in 7 opt-IR filters)
$1026+25 \ z=5.3$

$\Gamma=14$

$\Theta_v=3^\circ$

Sbarrato+ 2012
$1 = 2\Gamma^2 \sim 200 - 500$
# radio-loud = 450 # blazars...

\[ \log \Phi(M > 10^9 M_\odot) \text{ [Gpc}^{-3}\text{]} \]

Radio-quiet

Radio-loud

\[ \log L_{\text{opt}} > 47 \text{ Hopkins 07} \]

\[ \log L_x > 47.2 \]

B2 1023

4 blazars

0906

Ajello+ 2009; Volonteri+ 2011...
4 blazars
Conclusions

- BL Lac - FSRQ divide at $L_{\text{disc}}/L_{\text{Edd}} \sim 10^{-2}$
- Jets are powerful, matter dominated
- Search for early and heavy black holes $\rightarrow$ blazars
- One means $\sim 400$
- X-rays better than $\gamma$-rays