X-ray-Radio Study of a Sample of 3CRR Sources

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Aim of this work

To study the physical/geometrical differences of radio sources belonging to the same sample, but characterized by different radio and optical classification.

To identify the jet and disk relative X-ray contribution to the spectrum of radio sources

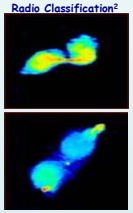
The Studied X-ray sample

93 objects of the *3CRR* sample[1]

($F_{178MHZ} \geq 10$Jy, $\delta \geq 10^o$, $|b| \geq 10^o$)

with 5 GHz core flux known and one X-ray observation available from literature or from Chandra and XMM-Newton archives.

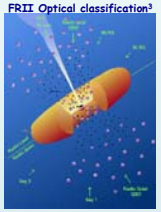
Radio Classification[2]



18 FRIs

75 FRIIs

FRII Optical classification[3]



34 Quasars

8 Weak Quasars (BLRGs)

33 NLRGs : 26 HEGs, 7 LEGs

LEG : $EW_{[OIII]} < 10$ Å and/or [OII] / [OIII] > 1

[1] Laing, Riley, Longair 1983, MNRAS, 204,151;
[2] Fanaroff & Riley, 1974, MNRAS 167, 31;
[3] Jackson & Rawlings 1997, MNRAS 286,241

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Comparison betweeen FRI and FRII sources

- FRIs are less luminous than FRIIs in the X-ray band (Fig. 1)
- FRIs are less efficient in converting gravitational energy into radiation (Fig.2), confirming the weaker emission line L [OIII] luminosity (Fig.3) (L[OIII] is thought to trace accretion luminosity).

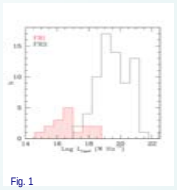

Fig. 1

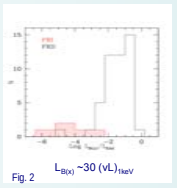

Fig. 2 $L_{B(x)} \sim 30\ (vL)_{1keV}$

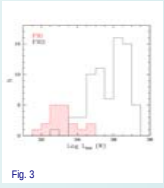

Fig. 3

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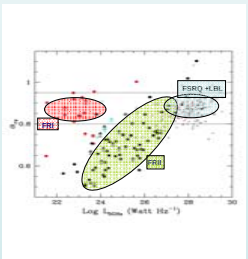
α_{rx} traces the relative jet/disk contribution to the total spectrum.



This appears evident if FR sources are compared to Blazars, i.e. Flat Spectrum Radio Quasar (FSRQ) and low-frequency-peaked BL Lac objects (LBL) .

Blazars, FRI and FRII occupy different regions of the α_{rx}- L_{5GHz} plane

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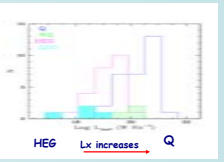
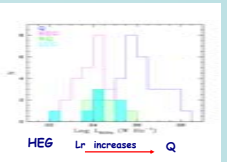
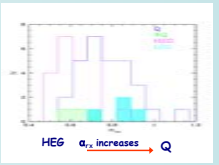
Comparison among different FRII optical classes

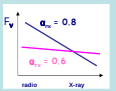






$$\alpha_{rx} = \frac{\text{Log}\,(L_{1keV} / L_{5GHz})}{\text{Log}\,(\nu_{5GHz} / \nu_{1keV})}$$

Broad radio-x-ray spectral index α_{rx} is flatter when the nuclear luminosity is weaker



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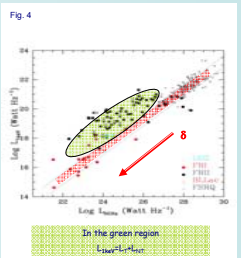
The dotted lines define a red area in which FSRQ and BLLac are expected to slide when the angle of sight increases , i.e. when the Doppler factor $\delta = [\gamma(1 - \beta\cos\theta)]^{-1}$ decreases.

Fig. 4



FRIs are mostly within the dotted lines (red region). They are Jet (Non-Thermal radiation) dominated $L_{1kev} \sim L_{NT}$.

Almost all FRII sources (green region) are outside the "deboosting" area .The 1 keV X-ray excess is due to the presence of an accretion flow (thermal emission L_T).

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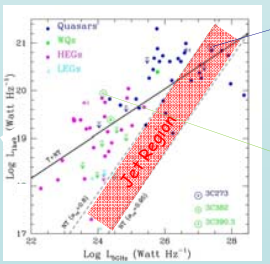
The above argument is supported by the sources (3C 273, 3C 382, 3C 390.3), for which was possible to quantify the relative jet (NT)- accretion (T) contribution. In fact they are in the right position on the L_{1kev}- L_{5GHz} plane



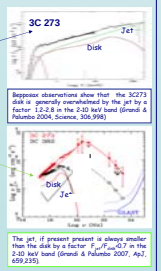


Fig.4 zoomed

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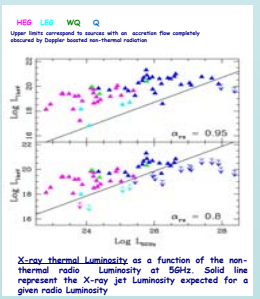
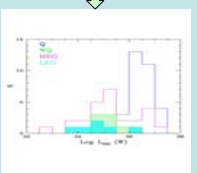
It is possible to disentangle accretion flow (T) and jet (NT) at 1 keV.

(L_{5Ghz}, α_{rx}) ⟹ L_{1keV} (NT) ⟹ L_{1keV} (T)



X-ray thermal Luminosity as a function of the non-thermal radio Luminosity at 5GHz. Solid line represent the X-ray jet Luminosity expected for a given radio Luminosity

The thermal emission increases from HEGs to Quasars. Quasars are the most powerful sources of thermal photons, as also attested by the emission line L[OIII] luminosity.



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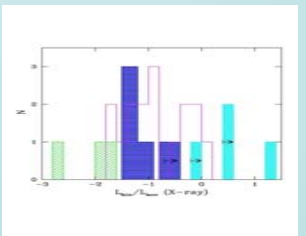
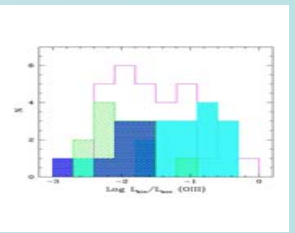
Relative Kinetic (L_{kin}) to radiative power (L_{acc}) in FRII sources

$L_{acc} \propto (uLT)_{1keV}$ or alternatively to $L\alpha$ L[OIII] (Heckamn et al. 2004 ApJ 613,109)

$L_{kin} \propto (L_{151MHz})^{6/7}$ (Willott et al. 1999, MNRAS, 309, 1017)





WQs and Qs prefer to dissipate gravitational power by radiation. LEGs prefer to transfer power to jets.

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Conclusions

- FRIs are less efficient than FRIIs in converting gravitational energy into radiation.
- The accretion flow is an important X-ray component in all the FRIIs but LEGs.
- LEGs could be objects in which the cold gas component is exhausted.
- α_{rx} traces the relative jet/disk contribution to the total spectrum and can be used to estimate the accretion flow X-ray Luminosity.
- When $\alpha_{rx} \sim 0.8$, the jet becomes dominant because of the beaming effect amplification . The non-thermal radiation gains an advantage over the thermal one, although the disk is still very powerful (see the 3C 273 case).