ROXA: a new multi-frequency selected large sample of blazars with SDSS and 2dF optical spectroscopy

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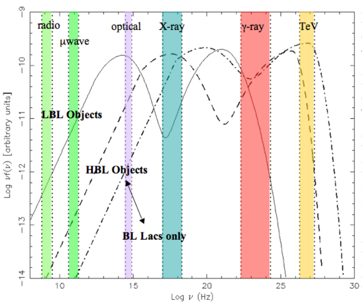
Although blazars are a small fraction of the overall AGN population they are expected to be the dominant population of extragalactic sources in the hard X-ray and gamma-ray bands and have been shown to be the largest contaminant of CMB fluctuation maps (Giommi et al. 2005). So far the number of known blazars is of the order of several hundreds, but the forthcoming AGILE, GLAST and Planck space observatories will detect several thousand of objects of this type.

We present the Radio - Optical - X-ray catalog built at ASDC (**ROXA**), a list of 816 objects among which 507 are confirmed blazars. Our catalog consists of 60% confirmed blazars (34% of which are new identifications). Only 19% of the candidates turned out to be certainly non-blazars demonstrating the high efficiency of our selection method. Our results are useful for the planning of future identification work of newly discovered sources with the SWIFT, AGILE, GLAST and Planck satellites.

The selection method:

- a multi-frequency selection technique based on a cross- correlation between radio and X-ray surveys: NVSS (Condon et al. 1998), ATCAPMN (ATCA catalogue of compact PMN sources in Tasker 2000), RASS (Voges et al. 1999; Voges et al. 2000) and GSC2 (Lasker 1995; McLean et al. 2000);
- for all radio/optical/X-ray matches we calculated the X-ray to optical (α_{xo}) and radio to optical (α_{ro}) spectral slopes and took only sources with α_{xo} and α_{ro} values within the blazar area (Perlman et al. 1998; Giommi et al. 1999; Landt et al. 2001; Padovani et al. 2006);
- we have assessed the quality of the sample using a subsample of 816 objects for which data from Sloan Digital Sky Survey - Data Release 4 (SDSS-DR4; Adelman_McCarthy et al. 2006), 2dF Galaxy Redshift Survey (2dFGRS; Colless et al. 2001) and 2dF QSO Survey (2dFQSO; Shanks et al. 2000) are available.



BL Lacs: non-thermal emission with no (or very weak) emission lines

FSRQs: non-thermal emission, with intense broad line emission

LBL & HBL:

LBL: - Synchrotron peak @ IR - Inverse Compton @ X-rays (mostly FSRQ, few BL Lacs)

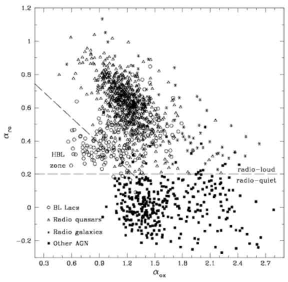
HBL: - Synchrotron peak @ UV/X-ray band (BL Lacs)

Source classification:

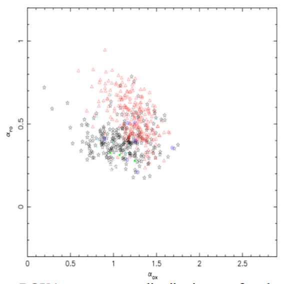
All candidates that had Multiple Optical Counterparts were associated to a single optical object through a visual inspection procedure using the NVSS, ESO and NED online services.

We defined a *transition class* for those objects that show properties in between two *standard* classifications.
Regarding Radio Galaxies and BL Lacs we defined sources to be :

- BL Lac if $L_x > 10^{44}$ erg/s or CaHK < 0.4 or both
- Radio Galaxy if CaHK >0.4 AND Lx < 5 10^{43} erg/s
- Radio Galaxy/BL Lac transition object if CaHK > 0.4 AND L_x between 5 10^{43} and 10^{44} erg/s



α_{ox}-α_{ro} distribution for a large sample of Active Galactic Nuclei. It is visible the radio loudness area, where place blazars and radio galaxies.



ROXA α_{ox}-α_{ro} distribution of the confirmed blazars. Symbols are as follows: ★ - BL Lac, ▲ - FSRQ, ● - HFSRQ, o - BL Lac/FSRQ, + - BL Lac candidate

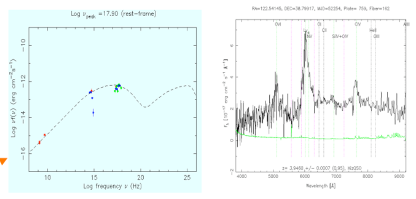
The Radio Optical X-ray ASDC (ROXA) blazar sample

Turriziani, Cavazzuti & Giommi, 2007 (A&A)

Available parameters: Name, Ra, Dec, Z, Rmag, Bjmag, Vmag, Gmag, 20cm Radio flux, X-ray flux, Class, aox, aro, arx, lx, Lradio, Alpha_r

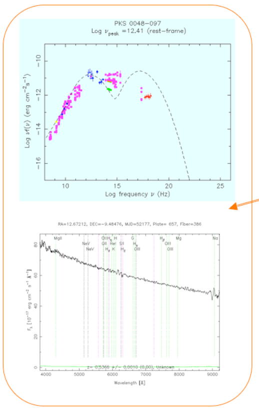
GO | BL Lacs | Radio Galaxies | FSRQs | SSRQs | QSORadioLoud | Reset | Latex | txt | SDSS DR4

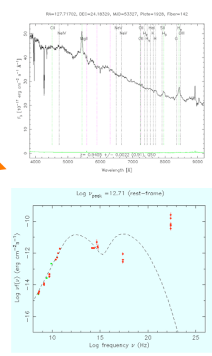
Entry number		Source name (ROXA name)	RA (J2000.0) hh mm ss.d	Dec (J2000.0) dd mm ss.d	Redshift Z	Bjmag	Gmag	Radio flux 1.4GHz(mJy)	X-ray flux microJy	Source classification
Subset selection mode: inclusive					Stat	Stat	Stat	Stat	Stat	
1 Select	Entry details	ROXA J000345.1-110818.4	00 03 45.1	-11 08 18.4	1.57	0	20	354.1	0.044	QSO RLoud steep radio sp.
2 Select	Entry details	ROXA J000416.6-290235.0	00 04 16.6	-29 02 35.0	0.55	18.2	0	16.1	0.144	QSO RLoud
3 Select	Entry details	ROXA J000559.2+160948.9	00 05 59.2	+16 09 48.9	0.45	0	15.4	805.3	1.049	QSO RLoud steep radio sp.
4 Select	Entry details	ROXA J000558.4-275858.1	00 05 58.4	-27 58 58.1	0.62	18	0	309.1	0.12	QSO RLoud flat radio sp.
5 Select	Entry details	ROXA J000622.6-000424.3	00 06 22.6	-00 04 24.3	1.04	0	20	3898.2	0.074	QSO RLoud steep radio sp.
6 Select	Entry details	ROXA J001130.4+005751.8	00 11 30.4	+00 57 51.8	1.49	0	20.4	167.3	0.065	QSO RLoud flat radio sp.
7 Select	Entry details	ROXA J001339.1-322443.8	00 13 39.1	-32 24 43.8	0.26	18.5	0	155.7	0.056	Radio Galaxy /BLtransition obj.
8 Select	Entry details	ROXA J002300.6+144656.6	00 23 00.6	+14 46 56.6	0.39	0	20.5	7.5	0.1	BL Lac

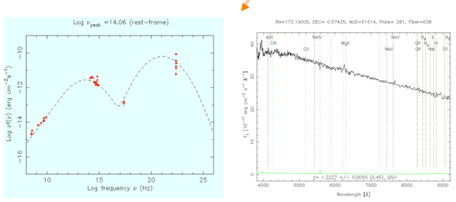


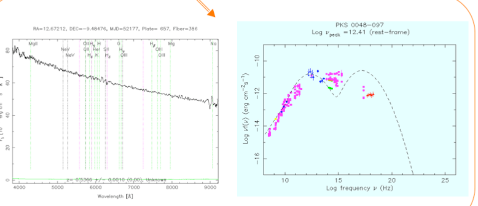
Source identification statistics in the ROXA catalog

Classification	Previously known objects	New objects	Total	Sample %
BL Lac	180	60	240	29.4
FSRQ	146	99	245	30
BL Lac/FSRQ Transition Obj.	1	7	8	1.0
BL Lac candidate	7	7	14	1.7
Confirmed blazars	**334**	**173**	**507**	**62.1**
R.G./BL Lac transition obj.	0	25	25	3.1
R.G./FSRQ transition obj.	0	2	2	0.2
Radio Galaxies	24	8	32	3.9
SSRQ	59	43	102	12.5
QSO Radio Loud	60	50	110	13.5
Galaxies NELG	12	2	14	1.7
BLRG	3	0	3	0.4
Others	19	2	21	2.6
Total	511	305	816	100









We have built *ROXA* as a complement to the work of Soward-Emmerd et al. (2003, 2004, 2005), as we share their goal of significantly enlarging the existing blazar catalogs in order to understand blazars statistical properties and to select interesting objects for upcoming high energy astronomy missions like AGILE, and GLAST. Soward-Emmerd et al. 2005, with a single-band approach, selected flat-spectrum radio sources and then used optical telescopes for spectroscopic follow-up observations, whereas in this work we use a multi-frequency approach that requires no additional telescope time. Moreover, the selection of radio sources results mostly in the discovery of LBL sources whereas our flux limits, which are mostly driven by the relatively shallow X-ray sensitivity of the RASS survey, favor objects such as HBL since they emit the maximum of their synchrotron emission near or within the X-ray band.
This bias towards HBL sources is strengthened by the Ultra-Violet excess requirement in the SDSS spectroscopical target selection (Richards et al. 2002). The presence of HBLs allows *ROXA* to contribute with new targets for GeV/TeV observations.