

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

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Abstract. Blazars are a small fraction of the overall AGN population but contribute in a fundamental way to the extragalactic cosmic backgrounds in the hard X-ray and γ -ray bands and are the largest contaminant of CMB fluctuation maps. 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 a very large number of new objects of this type. We present the Radio - Optical - X-ray catalog (ROXA), a list of 816 objects among which are 510 confirmed blazars. This is useful for the planning of future identification work using SWIFT, AGILE, GLAST and Planck data.

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INTRODUCTION

Blazars are the rarest ($\sim 5\%$) and most extreme type of Active Galactic Nuclei (AGN) known. All sources of this type can be seen as part of a general paradigm in which AGN are divided into Thermal Emission Dominated (TED) AGN, where the emitted radiation is mostly generated through the accretion process onto a super-massive black hole, and Non-Thermal Emission Dominated (NTED) AGN, where the observed emission is mostly non-thermal and is generated in a jet of material moving away from the nucleus at relativistic speeds [e.g. [1]]. Within this framework blazars are the small subset of NTED AGN in which the jet is closely aligned to the line of sight causing their emission to be strongly amplified by relativistic effects [as originally proposed by [2]]. We recognize a source as a blazar if it shows the properties usually associated to aligned beamed emission such as strong and rapidly variable emission in all energy bands, from radio to GeV, sometimes TeV energies, core dominated radio emission with flat radio spectral index, superluminal motion of radio compact regions, the presence of one sided jets (a jet on the other side is thought to exist, but with emission that is heavily dumped by relativistic effects) and high brightness temperatures ($T_b \sim 10^{11} - 10^{18} K$), close to or above the Compton limit ($T_b \approx 10^{12}$).

THE CATALOG

We present the ROXA catalog built at ASDC [3], a list of 816 objects among which 510 are confirmed blazars. Of the remaining sources 110 are confirmed QSOs (by the SDSS or 2dF optical spectra) but their radio spectral slope is currently not available and therefore they remain blazar candidates. 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. Our catalog includes 173 new blazar identifications, or about 10% of all presently known blazars. The relatively high flux threshold in the X-ray energy band (given by the RASS survey) preferentially selects objects with high f_x/f_r ratio leading to the discovery of new High Energy Peaked BL Lac (HBLs) that have the synchrotron peak in the UV - X-ray band and the inverse Compton peak in the GeV region. Our catalog therefore includes many new potential targets for GeV-TeV observations.

TABLE 1. ROXA Catalog Statistic

Class	Known objects	new objects	Total	Sample %
BL LAC	182	60	242	29.7%
FSRQ	147	99	246	30.1%
BL Lac/FSRQ transition obj.	1	7	8	1.0%
BL LAC candidate	7	7	14	1.7%
confirmed blazars	337	173	510	62.5%
R.G./BL Lac transition obj.	0	24	24	3.0%
R.G./FSRQ transition obj.	0	2	2	0.2%
Radio Galaxies	24	8	32	3.9%
SSRQ	59	43	102	12.5%
QSO RL	60	50	110	13.5%
Galaxies NELG	12	2	14	1.7%
BLRG	2	0	2	0.2%
others	18	2	20	2.5%
Total	512	304	816	100%

The selection method

For the definition of our sample we relied on the availability of large catalogs of astronomical objects combined with on-line services offering simple access to finding charts and magnitude estimates. The method is similar to that used for the DXRBS [4, 5] and the Sedentary Survey [6, 7] and consists in three steps: 1) a first cross-correlation between radio and X-ray surveys: the NRAO VLA Sky Survey (NVSS, [8]), ATCAPMN (ATCA catalogue of compact PMN sources), ROSAT All Sky Survey and Guide Star Catalog (GSC2); 2) for all radio/optical/X-ray matches we calculated the X-ray to optical (α_{ox}) and radio to optical (α_{ro}) spectral slopes and took only sources with α_{ox} and α_{ro} values within the blazar area [9, 6, 4, 5]; 3) 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, 2dF Galaxy Redshift Survey and 2dF QSO Survey are available.

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 also defined a *transition class* for those objects that show properties in between the two *standard* classifications of Radio Galaxies and BL Lacs:

- BL Lac if $L_x > 10^{44}$ erg s⁻¹ or CaH&K < 0.4 or both
- Radio Galaxy if CaH&K > 0.4 AND $L_x < 5 \times 10^{43}$ erg s⁻¹
- Radio Galaxy/BL Lac transition object if CaH&K > 0.4 AND L_x between 5×10^{43} and 10^{44} erg s⁻¹

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