PROCEEDINGS OF SCIENCE

Roma-BZCat: a multifrequency Blazar catalogue

Enrico Massaro[a], Paolo Giommi[b], Cristina Leto[b], Paolo Marchegiani[a], Alessandro Maselli*[a], Matteo Perri[b], Silvia Piranomonte[c] and Silvia Sclavi[d]

[a] *Dipartimento di Fisica, Sapienza - Università di Roma*
Piazzale A. Moro 2, I-00185, Roma, Italy
[b] *ASI Science Data Center (ASDC)*
c/o ESRIN, via G.Galilei, I-00040, Frascati, Italy
[c] *INAF-Osservatorio Astronomico di Roma*
via di Frascati 33, I-00040, Monte Porzio Catone, Italy
[d] *Stazione Astronomica di Vallinfreda*
Via del Tramonto, I-00020, Vallinfreda (RM), Italy

E-mail: enrico.massaro@uniroma1.it

We present a new catalog of blazars based on multi-frequency surveys and on an extensive review of the literature data. Blazars are classified as BL Lacertae objects, as Flat spectrum radio Quasars or as Blazars of uncertain/transitional type. Each object is identified by a root name, coded as BZB, BZQ and BZU for these three subclasses respectively, and by its coordinates. This catalogue is being built as a tool useful for the identification of the extragalactic sources that will be detected by present and future experiments for X and gamma-ray astronomy, like *Swift*, AGILE, GLAST and SIMBOL-X. An electronic version is available from the ASI Science Data Center web site at **http://www.asdc.asi.it/bzcat**. The on-line list includes more than 2500 objects and is continuously updated.

Workshop on Blazar Variability across the Electromagnetic Spectrum
April 22-25 2008
Palaiseau, France

*Speaker.

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1. Introduction

From a general viewpoint a Blazar can be defined as an *Active Galactic Nucleus whose emission is dominated by non-thermal radiation, amplified by relativistic effects*. Many surveys have been carried out to identify new Blazars and their number is continuously increasing. Nevertheless, only a relative small number of Blazars have been studied intensively. There are still many unsolved problems about the origin of the Blazar phenomenon, the physical processes occurring in the nuclear region, and about the cosmological evolution of these sources. Furthermore, because of their very broad spectral emission, Blazars are expected to play an important role in the generation of the extragalactic background and of its fluctuations in several energy bands.

Blazars constitute the most numerous class of extragalactic γ-ray sources. The knowledge of the Blazar population is, therefore, very relevant in high energy astrophysics. For this reason a complete list of Blazars, based on an accurate examination of literature data, can be very useful for carrying out some of the scientific goals of space observatories like *Swift*, AGILE, GLAST, PLANCK and SIMBOL-X.

In this contribution we describe the present status of the "Multifrequency Blazar Catalogue", also named *ROMA-BZCat*, that is available on-line at the ASDC web site and that is continuously updated and extended. This catalogue can also be used as a basic list of sources useful for the selection of samples for statistical studies of Blazar properties and evolution.

2. The *Roma – BZCat*

The *Roma – BZCat* is structured into two parts. Part 1, at present the only one available on-line, contains the lists of Blazars, which are classified in three main groups, according to their spectral properties. Each Blazar is identified by a three-letter code, where the first two are **BZ** for Blazar and the third one specifies the type, followed by the truncated equatorial coordinates (J2000).

The codes are:

- **BZB**: BL Lac objects, used for AGNs with a featureless optical spectrum, or having only absorption lines of galaxian origin and weak and narrow emission lines;
- **BZQ**: Flat Spectrum Radio Quasars, with an optical spectrum showing broad emission lines and dominant Blazar characteristics;
- **BZU**: Blazars of Uncertain type, for sources having peculiar characteristics but showing Blazar activity: for instance, occasional presence/absence of broad spectral lines or features, transition objects between a radio galaxy and a BL Lac, galaxies hosting a possible low luminosity Blazar Nucleus, etc ...;

BZB objects are listed in the first two Tables of the catalog (but they are not distinguished in the on-line version): Table I contains all firmly identified BL Lacs, whereas Table II includes sources considered *candidate BL Lac objects*, in particular those for which we could not find either in literature or on the web, an optical spectrum or a good description of it. BZQ sources listed in Table III are FSRQs and other quasars showing evident Blazar characteristics like a large and fast

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optical variability (OVV sources) and a high linear polarisation (HPQ sources). Finally, we listed in Table IV BZU sources with a short note to explain the reason of this classification.

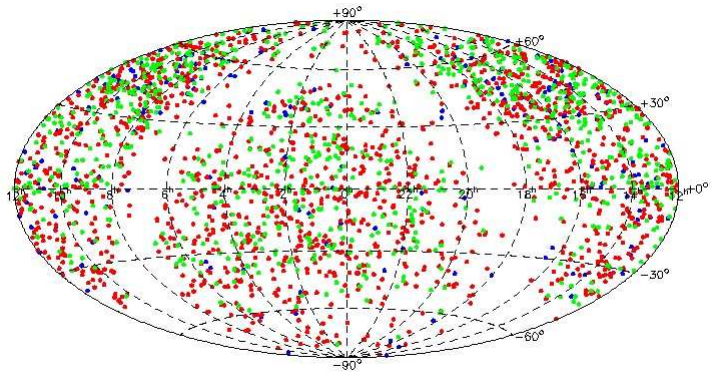

Figure 1: Aitoff projection in equatorial coordinates showing the distibution of Blazars in the first two volumes of *Roma – BZCat*. Red points indicate BZB sources and green points BZQ objects; the empty belt corresponds to the Milky Way, the most crowded region corresponds to the SDSS field.

For each source the following data are reported: J2000 coordinates, *R* magnitude (mainly from USNO-B1), radio flux density at 1.4 GHz (from NVSS or other catalogs, if not known the flux at another frequency is given), the observed X-ray flux in the 0.1–2.4 keV energy interval, mostly from ROSAT archive, and the redshift. Some synthetic useful notes are also given for a limited number of Blazars: (e.g. member of a galaxy cluster, detection of emission lines, etc...).

The total number of Blazars listed at the date of this workshop in the *Roma – BZCat* is 2513 and their distribution in the sky is shown in Fig. 1.

3. New Blazar surveys

In the recent years new surveys have become available and the number of Blazar candidates has grown rapidly. An important multifrequency sample is the Radio-Optical-X-ray built at ASDC (*ROXA*, Turriziani et al. 2007), that was obtained by means of a cross-correlation between large radio (*NVSS*, *ATCAPMN*) and X-ray surveys (*RASS*) together with the *SDSS-DR4* and *2dF* data to spectroscopically identify the candidates. The *ROXA* sample consists of 816 objects and includes 173 newly discovered Blazars. Note that the relatively high threshold of the X-ray flux of the RASS survey preferentially selects objects with high F_X/F_{radio} ratio, hence HBL objects.

Another sample of BL Lac candidates, including 386 sources, was obtained by Collinge et al. (2005) using the *SDSS* spectroscopic database in a field of 2860 deg^2. These sources were divided into the two groups of 240 “probable" and 146 “possible" BL Lac candidates, the former selected by colors unlike those of DC white dwarf stars and some evidence of extragalactic nature, such as a redshift estimate and/or a radio/X-ray counterpart. In this sample there are several sources without a radio counterpart, and this possibility raises the problem of the existence of radio-quiet (or optically selected) BL Lacs. A sample of “optically selected" BL Lac candidates was already studied by Londish et al. (2002), as a by product of the much wider *2QZ* sample of QSOs (Croom

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et al. 2001). However, in a more recent paper, Londish et al. (2007) reported a further analysis of an expanded and revised sample of potential optically identified BL Lacs and concluded that there can be no significant population of radio-quiet BL Lac objects. Although in principle we cannot exclude the existence of high-z HBL objects with a sub-mJy flux density in the GHz band, we preferred to maintain our criterion to include in the *Roma-BZCAT* only sources with a confirmed or high confidence radio counterpart.

A new very important survey aimed to Blazar identification is the Candidate Gamma Ray Blazar Survey (*CGRaBS*) (Healey et al. 2008) selected to identify sources having the greatest similarity to the EGRET Blazars, and for the majority of them an optical follow-up provided the counterpart identification and spectroscopy. For the sake of completeness, we decided to add to the *Roma-BZCAT* all *CGRaBS* sources classified as FSRQs, although their spectra are not available in literature and/or on-line. These sources are denoted by the note CG, but sources of unknown type and without redshift were not included.

4. Spectral Energy Distributions

The second Section of the *Roma – BZCat* is devoted to the presentation of detailed data for a selection of interesting Blazars. In particular, for each object we build the Spectral Energy Distribution (SED) using a large collection of non-simultaneous multi-frequency data. Although SEDs of extragalactic sources are indeed given in the NED database, these are mainly based on fluxes derived from catalogs (particularly in the radio band), rather than on individual papers. We included, when possible, many other data from papers and on-line databases; in the case of monitoring campaigns the lowest and highest flux levels were considered. Sources have been selected to represent the various Blazar types, with a special attention to those detected in the γ- and hard X-ray ranges.

5. Conclusion

The main scientific goals that led us to the compilation of the *Roma – BZCat* were:
i) to have the most complete list of published Blazar, useful for the identification of the counterparts of high energy sources;
ii) to have a list of extragalactic objects useful to compare the properties of the population of non-thermal extragalactic sources with other types of AGNs;
iii) to have a population from which it will be possible to extract samples satisfying statistical criteria to investigate Blazar properties and evolution;
iv) to have a large database of SEDs for different types of Blazars to study radiation mechanisms and relativistic beaming effects.

An open problem is that of the completeness of the catalog: there is, in fact, a deficiency of Blazars in the southern sky because of the smaller number of surveys in comparison to the North emisphere. Many new discovered Blazars and candidates, for instance, have been identified using spectroscopic observations available in the SDSS.

The catalog will be published in a series of four volumes, each one containing Blazars in a six hour wide Right Ascension interval. The first volume (Massaro et al. 2005) was printed in 2005 and the second one (Massaro et al. 2008) has been printed in April 2008. We plan to complete the

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entire sky and the publication of the two other volumes before the end of 2008. The on-line version of the catalog **http://www.asdc.asi.it/bzcat** gives the general Tables and, for each source, offers the additional possibility to use the ASDC "Data Explorer" tool, to help search for more information from several on-line databases.

6. Acknowledgements

This work has made extensive use of the following on-line facilities: the National Extragalactic Database (NED), The Astrophysics Data System (ADS), SIMBAD, etc. We acknowledge funding from ASI grant I/010/06/0. We thank Roberto Primavera for his help in the preparation of the on-line version of the catalog.

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