

A Catalogue of X-ray Spectral Properties of BLLacs



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ABSTRACT An XMM-Newton catalogue of BL Lac X-ray properties is presented based on a search of X-ray counterparts for the 1122 BL Lac objects listed in the 12th edition of the Véron-Cetty and Véron (2006) Catalogue. X-ray counterparts were searched for in the more than 5000 fields of XMM-Newton pointed observations that were public before August 2006. The cross-correlation yielded a total of 205 XMM-Newton observations which, after the list was filtered, corresponds to 50 different sources. X-ray data from the three EPIC cameras were extracted form the XMM-Newton Archive (XSA) and homogeneously analyzed using the latest SAS software version and updated calibration files. Event files, camera images, light curves and spectra have been extracted from each one of the sources in our sample. The results of the analysis will be presented in terms of the spectral properties of the sample in the 0.2 – 10 keV energy band.

Data Sample

Introduction

According to the unified scheme of active galactic nuclei (AGNs), blazars are radio-load AGN that display highly variable, beamed, non-thermal emission, covering a broad range from radio to gamma-ray energies (Urry, 1995). The blazar class encompasses BL Lacertae (BL Lac) and flat spectrum radio quasars (FSRQ) objects, which main difference lies in their emission lines and their spectral energy distribution (SED) properties. Observationally, the SED of blazars, in a vF_v representation, shows two broad distinctive peaks (e.g. Fossati (1998)). Low luminosity BL Lac present the first peak of their SED at UV/X-ray energies (referred to as High-energy peaked BL Lacs, HBLs) while their higher luminosity counterparts present the first peak of the SED around IR/Optical energies (Low energy peaked BL Lacs, LBLs) (Padovani (1995)), where it is considered that both are the two extremes of a continuous distribution. For the higher luminosity sources, FSRQs, their first SED peak lies in the IR energy band and a new population of FSRQs with HBL-like SEDs (HFSRQ) suggests that they follow a similar sequence, in terms of their SED, than BL Lac objects (see Perlmann (1998) and Padovani (2004)). The validity of the blazar sequence has recently been put into question by Padovani (2006), hence, the search for objects outside the sequence will be of importance to settle this matter.

The properties of the blazar non-thermal emission point to a relativistic origin in a jet oriented at a small angle to our line of sight. The interpretation of the first spectral component of the SED is widely adopted to be due to synchrotron radiation of relativistic electrons moving along the jet. Different models differ as to the origin of the second spectral component, leptonic (e.g. Ghisellini 1999, Sikora 2001) or hadronic (e.g. Mucke 2003). BL Lacs are rare objects, and very few of them have been observed with a sensitivity like the one provided by XMM-Newton to be able to disentangle these different models, their spectra show power law shapes with a wide range of spectral indices. Perlman et al (2006) analysed a uniform sample of 13 BL Lacs observed with XMM-Newton finding that their spectra can be best fit by curved spectra which grow steeper approx. logarithmically across the band. The theoretical explanation for such a spectrum would be related to episodic particle acceleration in these highly variable sources.

The purpose of the present investigation is to contribute to the study of BL Lac characteristics by extracting the available information on the X-ray properties of all BL Lacs observed by XMM-Newton, being targets or serendipitous sources in the fields of other targets.

Data Extraction and Analysis

A catalogue of X-ray properties of BL Lacs has been produced based on public XMM-Newton data, extracted from the XMM-Newton Science Archive (XSA). Only data from the EPIC-pn and EPIC-MOS cameras on-board XMM-Newton are considered here. The EPIC cameras have a ~30 arcmin field of view (FOV) with ~6 arcsec (PSF FWHM) spatial resolution and 70-80 eV energy resolution in the energy band 0.2-10 keV. The observations analysed here were taken in imaging mode with a combination of different window modes (Small Window, Large Window and Full Frame), with different filters (Thick, Medium and Thin).

The steps performed were:

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· Identification of the XMM-Newton fields where BL Lacs from the VC&V06 catalogue are present.

· Extraction of the EPIC data of these fields from the XSA archive. • Data reduction with the latest Science Analysis System (SAS) software (v7.0.0) and calibration files as to September 2006. · Source detection in all the selected fields and cross correlation of the detected sources with the BL Lacs from the VC&V06 catalogue. · If positively identified, light curves, fluxes and spectral information are produced.

A series of perl scripts have been created to perform all these steps in a systematic way, using a GRID application that makes the processing faster and more efficient (Ibarra and de la Calle, 2006).

References

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1122 BL Lac Sample from

Véron-Cetty and Véron (2006)

Galactic Coordinates

keV

0.2-2

2. - 10. keV

Val.

The sample presented here is the result of the crosscorrelation of the BL Lac sub-sample given in the 12th version of the Véron-Cetty and Véron (2006) (VC&V06) catalogue with all public observations available in the XMM-Newton archive up to August 2006. The BL Lac sub-sample of the VC&V06 catalogue consists of 1122 confirmed, probable or possible BL Lac objects. The cross-correlation yielded a total of 205 XMM-Newton observations (OBSIDs) corresponding to 59 different sources, which after the list was filtered, 105 OBSIDs remained corresponding to 50 different sources. The side figures show the sky distribution of the sources from the VC&V06 catalogue and from our sample. The sources in our sample are a combination of XMM-Newton 33 target and 17 serendipitous objects where no selection constrains have been applied to the selection process other than detectability. Only 41 sources in our sample have a measured redshift, and includes objects with redshift up to 0.615 (one with redshift 1.89) with 2.4% of them having redshifts below 0.1 and 93% below 0.5. At least 18 objects are known HBLs and 3 known LBLs.



50 XMM-Newton BL Lac

Catalogue Information



as an example the light curve for 1ES0033+595.

 $(E_{\rm Reak})$ with photon indices $\gamma_{\rm I}$ and $\gamma_{\rm r}$ below and above $E_{\rm Reak}$ and with fix and free column density $N_{\rm IR}$. The right figures and the table show an example of the information derived for 1ES0033+595 from the EPIC-pn data.



Summary and Future Work

Summar

An XMM-Newton catalogue of BL Lacs X-ray properties has been produced by searching the XSA archive for X-ray counterparts of the 1122 BL Lac objects listed in the 12th edition of the VCK VIG catalogue. X-ray counterparts were searched for in more than 5000 XMM-Newton fields resulting in the positive identification of 50 sources. This lead to a significant increment of the number of BL Lacs detected in X-rays. • The catalogue contains source images, light curves and X-ray spectral information. This information allows to classify the BL Lacs according to their X-ray properties and simultaneously helps in defining the properties of the different classes of objects.

· Variability timescales and dependence of this variability with flux, energy or other properties could allow to disentangle the possible physical mechanisms behind.

Future Work

 The information in the sample, together with information at other wavelengths, will allow us to identify candidates for TeV emission. More data on
TeV blazars is needed to understand whether the physical properties observed in the known objects are general to this class of blazar or are particular cases of a much broader scenario

The best candidates in our sample will be studied more in depth and further observations will be requested for XMM-Newton and SUZAKU.





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