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Blazars – INTEGRAL and Supermassive Black Hole Binaries

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Abstract. We refer on analysis of the ESA INTEGRAL satellite data for blazars, promising sources to be observed during their active states. We further refer on searches for and analysis of supermassive binary black holes requiring very long time intervals (50 years and more) provided by digitised astronomical plates.

Keywords. Active Galactic Nuclei, Blazars, INTEGRAL.

1. Introduction

Blazars represent the most extreme class of active galaxies. They are observed in all wavelength bands – from radio through VHE gamma frequencies, with maximum spectral output and largest variability often at gamma ray energies. It is obvious that blazars represent suitable targets for INTEGRAL satellite (Winkler *et al.*, 2003) especially during active states (flares).

2. INTEGRAL observations

The INTEGRAL observations are divided into the following categories: (i) AO-1,2,3 Program (allocated pointed observations), (ii) Core Program CP (Galactic Plane Scans, Galactic Center Deep Exposure,...), and (iii) Objects inside FOV of AO-1,2,3 observations. Blazars in the INTEGRAL Galactic Plane Scans (GPS) represent a promising group of objects for the study within the INTEGRAL CP. The GPS zone is usually neglected by extragalactic astronomers due to heavy obscuration: in optical, ∼20% of the sky is obscured by our Galaxy, while the gamma–ray telescopes on board INTEGRAL allow detectability of up to few mCrabs in the most exposed GPS regions. Seven optically bright (with V$\leqslant$17 mag, to be detected by the INTEGRAL OMC camera) blazars were identified within galactic scans of INTEGRAL, namely: 1ES 0647+250, PKS 0823-223 (no gamma from EGRET, grav. lensing candidate), 1ES 2344+514 (TeV gamma ray source, very close), 8C 0149+710 (BL Lac candidate?), 4C 47.08, 87GB 02109+5130 (poorly understood blazar, TeV candidate), and BL Lac (the prototype). While the prototype object BL Lac is well studied, most of the INTEGRAL GPS blazars are poorly investigated and poorly understood so far. The study with Sonneberg Observatory Archival Plates reveals that most of these objects are optically variable, hence a gamma ray variability can be expected. Below the detection limit of the INTEGRAL OMC on board camera is blazar NRAO530 (1730-130), which is an example of blazar with violent optical activity (4 mag within 1 month). In flare, the object is expected to be much brighter also in gamma. This strengthens the role of optical monitoring and ToO program – the

flare can be recognized by optical monitoring with small (D ∼50 cm) telescopes. All the above mentioned blazars in INTEGRAL GPS have been investigated with INTEGRAL CP data (IBIS and JEM-X telescopes). We have no positive detection by high energy instruments on board INTEGRAL yet (except marginal detection of 1ES 0647+250). The targets' quiet level is still below the sensitivity threshold of the instruments. However, the positive detection may be possible in the future as (i) there will be more cumulative time available and (ii) the probability to see a blazar during a flare (and hence much brighter) will also increase with time. Additional blazars have been identified in the fields represented by the AO-1 and AO-2 observations of other scheduled targets, covered by up to 400 ksec cumulative exposure time. The analysis of these objects is in progress.

Regarding the pointed observations of blazars by INTEGRAL, the AO-2 ToO blazar observation No. 220049 by Pian *et al.* (2005) has provided promising results. This collaborative proposal was based on extended optical and/or X-ray monitoring (RXTE ASM and others) of flaring activity of a large list of blazars and, alternatively, on soft gamma-ray monitoring by INTEGRAL itself (serendipitous detection of a flaring blazar in the IBIS FOV). Then ToO INTEGRAL observation was activated meeting the trigger criteria (major flaring event). Blazar S5 0716+714 was the target of this ToO observation. This is a BL Lac object, intensively monitored at radio and optical wavelengths. The ToO was triggered by optical activity – 2 outbursts up to the extreme level of R = 12.1 mag (historical maximum, light increase by 1 mag in 2 weeks and 2 magnitudes in 4 months) and, consequently, the INTEGRAL ToO observation was performed in the time interval 2004 April 2–7 (Pian *et al.*, 2005). Very recently, an INTEGRAL AO-3 ToO observation of 3C454.3 (z=0.859) was performed, with preliminary results given by L. Foschini *et al.* (2005, PI E. Pian with a large collaboration). This ToO was triggered by high optical (T. Balonek, VSNET alert) and X-ray (BAT Swift) activity of the source. The INTEGRAL observation started 2005 May 15, at 18:40 UT, with exposure of 200 ksec. The source was clearly detected by IBIS/ISGRI in the 20–40 and 40–100 keV energy bands, with a significance of 20 and 15 sigma.

In the second project, we have gathered data from the literature and observational campaigns in order to establish long-term optical light curves of the selected blazar binary black hole candidates – to study periodic behavior in their light curves and other interesting features (intense outbursts, flares, quiescent level behavior). However, there are several crucial data gaps that disable to confirm periodicity or a BBH model (that has already been built up for several of these blazars). Therefore we intend to go to databases of astronomical plates (e.g. Sonneberg Observatory, Germany (about 280,000 plates), Harvard College Observatory, USA (about 500,000 plates), UKSTU plate collection ROE Edinburgh, UK (18,000 very deep plates), and Leiden Observatory, NL (40,000 plates)) to fill in these gaps. Within this project, we intend to reach the following results: (i) improve historical light curves of candidates, (ii) periodicity and light curve analysis, (iii) confront the new light curve of the selected blazars with the corresponding theories, (iv) establish a detailed model at least of one of the candidates, (v) draw statistical conclusions, (vi) provide the data to wide scientific community.

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References

Foschini, L. *et al.*, 2005, ATEL 497
Pian, E. *et al.*, 2005, A&A 429, 427
Winkler, C. *et al.*, 2003, A&A, 411, 7