PROCEEDINGS OF SCIENCE

X-ray spectral variability of TeV Blazars

The case of the newly discovered TeV Blazar RGB J0152+017

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VHE γ-ray emission was discovered from the high-frequency-peaked BL Lac object RGB J0152+017 in Nov. 2007. Observations with the X-ray satellite Swift (XRT, UVOT) and the optical telescope ATOM from Nov. 2007 to Jan. 2008 show flux variations on time scales of ~ 10 days but with different variability patterns. This implies that at least 30% of the host-galaxy subtracted optical and UV flux is due to synchrotron emission from a compact component. Simultaneous observations of RGB J0152+017 by Swift/XRT and RXTE/PCA reveal that the spectra obtained from the non-imaging RXTE/PCA detector with its large field of view are contaminated by nearby bright X-ray sources.

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1. Introduction

RGB J0152+017 is a newly discovered TeV BL Lac object [1] at $\alpha_{J2000} = 1^h52^m39.8^s$, $\delta_{J2000} = 1^\circ 47' 18.7''$ with a redshift of $z = 0.08$. The detection of VHE γ-rays took place in November 2007 by the H.E.S.S. experiment with a signal of 6.6σ (standard deviation) within 14.7 hours [7]. The directly triggered simultaneous, multiwavelength observations from radio to X-rays allowed to derive the spectral energy distribution (SED) and to clearly define RGB J0152+017 as a high-frequency-peaked BL Lac (HBL). The details are presented by J.P. Lenain in these proceedings [6]. During the period covered in the detection paper, no variation in flux was detected in any waveband.

Follow-up observations with the X-ray satellites Swift (XRT, UVOT) and RXTE (PCA) and the optical telescope ATOM were taken in Dec 2007 / Jan 2008. This provide the opportunity for a multiwavelength temporal study on a longer time frame, which is presented here.

The simultaneous observation by Swift/XRT and RXTE/PCA reveal that the spectra from the non-imaging PCA detector are contaminated by nearby sources with bright X-ray emission. We discuss this problem here in detail for RGB J0152+017.

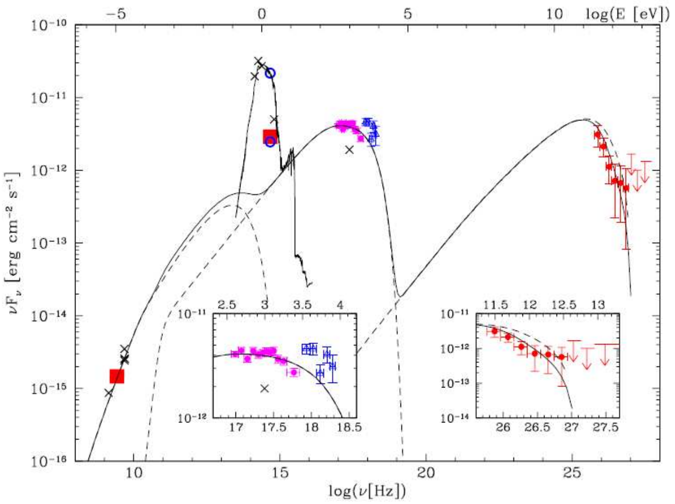

Figure 1: The spectral energy distribution of RGB J0152+017 [1]. The simultaneously observed multifrequency data are plotted in color (optical flux is host-galaxy corrected), while historical data are in black.

2. X-ray flux variation

The observations with the Swift satellite were performed from 13. November 2007 to 13. January 2008. The spectra obtained by the X-ray telescope (XRT [2]) onboard Swift can be described by a power-law taking into account a fixed component for the galactic absorption ($N_H = 2.72 \times 10^{20}$ cm^{-2}, LAB Survey, [5]). Interestingly, the X-ray flux in the energy range $2 - 10$ keV varies non-monotonically on time scale of ~ 10 days while the spectral shape stays similar (see Fig. 2). The significant variation in the X-ray flux is a confirmation of the assumption that the peak in the SED in the X-ray domain results from synchrotron emission as concluded in [1].

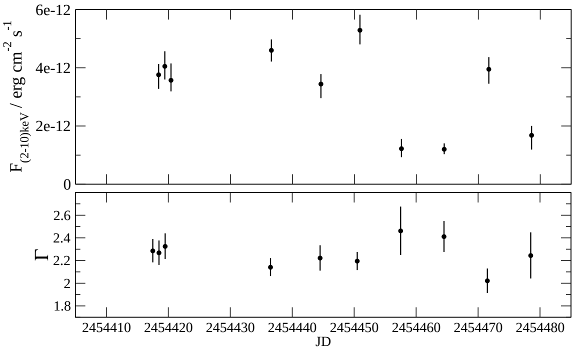

Figure 2: X-ray flux in energy range 2 - 10 keV and photon index Γ of a single power-law fit versus time

During the period 2454418 - 2454451 JD, where the X-ray emission of RGB J0152+017 is at a nearly constant flux level, the shape of the summed spectra can be very well described ($\chi^2/dof = 117.9/118$) by two power-laws with photon indices of $\Gamma_1 = 2.02 \pm 0.05$, $\Gamma_2 = 2.77 \pm 0.11$ and a break energy of $E_{\text{break}} = (1.66 \pm 0.12)$ keV. The resulting unabsorbed flux is $F_{0.5-2\,\text{keV}} \sim 5.3 \times 10^{-12}$ erg cm^{-2} s^{-1} and $F_{2-10\,\text{keV}} \sim 3.1 \times 10^{-12}$ erg cm^{-2} s^{-1}. Due to the low photon statistics for the low state, we unfortunately cannot confirm whether these spectral properties changes.

3. Temporal analysis

The Swift satellite contains also the instrument UVOT [8], which measures the UV and optical emission in the bands (central wavelengths): uvw2 (188 nm), uvm2 (217 nm), uvw1 (251 nm), u (345 nm), b (439 nm) and v (544 nm). This observations were taken contemporary to the Swift/XRT measurements. Also the ATOM telescope [3], which is an optical telescope located at the H.E.S.S. site, observed RGB J0152+017 at the same time in the R-band (640 nm). The resulting lightcurves are shown in Fig. 3.

The displayed absolute magnitudes of the R-band measurements by the ATOM telescope (provided by M. Hauser and J. Herzog) contain a systematic error of ~ 0.07 mag, because the reference star could not yet be precisely calibrated due to non photometric weather. The relative magnitudes are less uncertain by a factor of ~ 5 and exhibit a significant increase in flux.

An increase is also determined in the uvw1 and u-band over the whole observing time while the measured magnitudes in the uvm2 band show similar variability pattern as detected in the X-ray regime.

The poor sampling at other wavebands prohibits varibility studies in those bands. Nevertheless the variability observed in the U and R bands on time scales < 10 days indicates that the emission region must be compact. Therefore at least 30% of the optical flux in the SED (see Fig. 1) can be explained by synchrotron emission.

The different trends over the whole time frame in the X-ray and optical bands lead to the conclusion that the maximum frequency of the synchrotron emission in the X-ray domain shift to slightly lower energies during the two month of simultaneously multiwavelength observations.

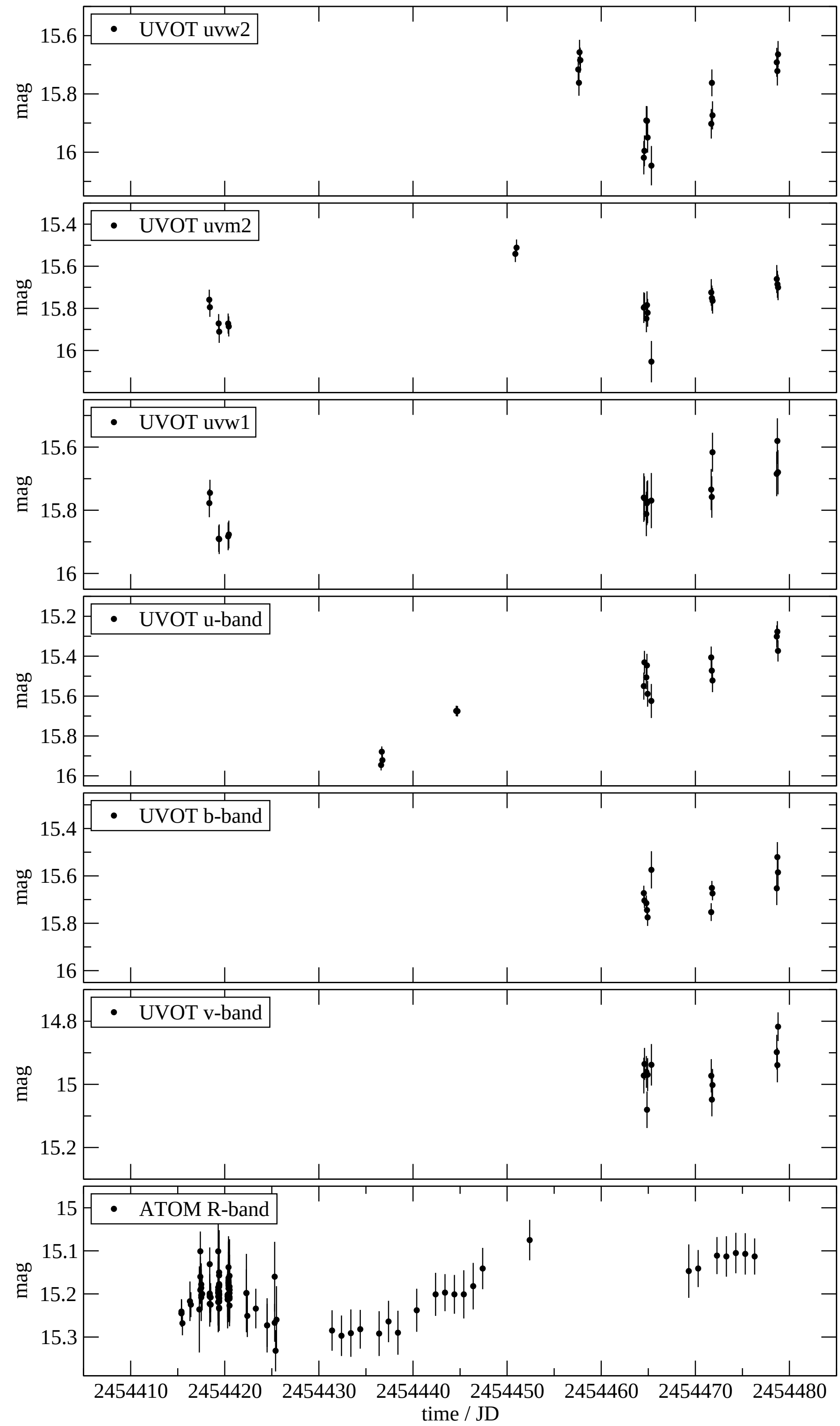

Figure 3: UV and optical measurements by Swift/UVOT and ATOM of RGB J0152+017

4. Contamination of RXTE spectra

The simultaneous observations from 13. Nov to 16. Dec 2007 with the X-ray satellites Swift and RXTE highlight that the RXTE flux level in the overlapping energy range is higher by a factor of 2 than the flux measured by Swift simultaneously (see Fig. 4). The used RXTE/PCA detector [4] is a non-imaging detector with a large field of view of 1°. It is therefore necessary to investigate the probability that the RXTE spectra are contaminated by nearby bright X-ray sources.

The ROSAT/PSPC All Sky Survey at the region compatible with the FoV of the RXTE/PCA detector in Figure 5 illustrates that several bright X-ray sources are included in the field of view of the non-imaging PCA detector. The X-ray fluxes measured by ROSAT in the energy range 0.1 – 2.4 keV of these sources are comparable to each other. For RGB J0152+017 and the galaxy cluster Abell 267 at the edge of the field of view of RXTE/PCA, we obtained additional information by the Swift and XMM-Newton observations respectively.

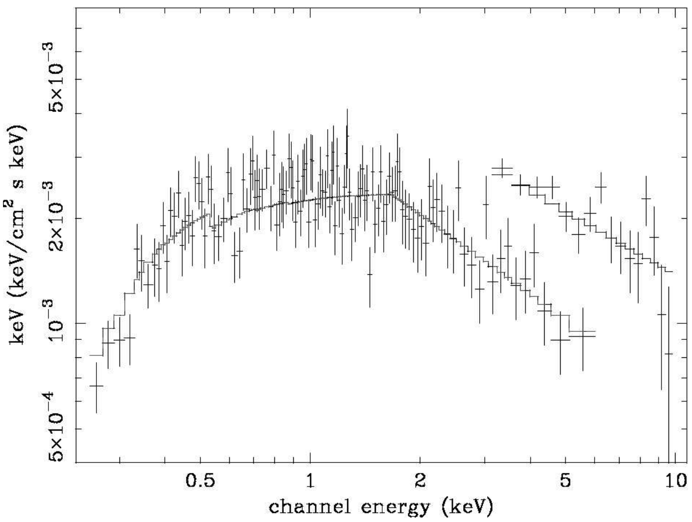

Figure 4: Simultaneously measured Swift/XRT and RXTE/PCA spectra (sum of Nov/Dec 2007 spectra) of RGB J0152+017. The line correspond to a two power-law model considering the galactic absorption.

The other X-ray bright sources are identified as a quasar and an active galaxy in the Veron-Cetty & Veron 2001 catalogue [9]. A lack of subsequent X-ray observations for these two sources makes it impossible to reconstruct the RXTE/PCA spectra of RGB J0152+017 due to their potential variability. Also the interpolation of the flux obtained in the ROSAT energy band to higher energies introduces uncertainties due to lack of information about their spectral shape. Therefore the RXTE/PCA spectra can only be taken as an upper limit in the energy range 2 – 10 keV for SED modelling.

The contamination of RXTE/PCA spectra by nearby X-ray bright sources is a potential problem for all RXTE/PCA observations of AGN with faint X-ray emission.

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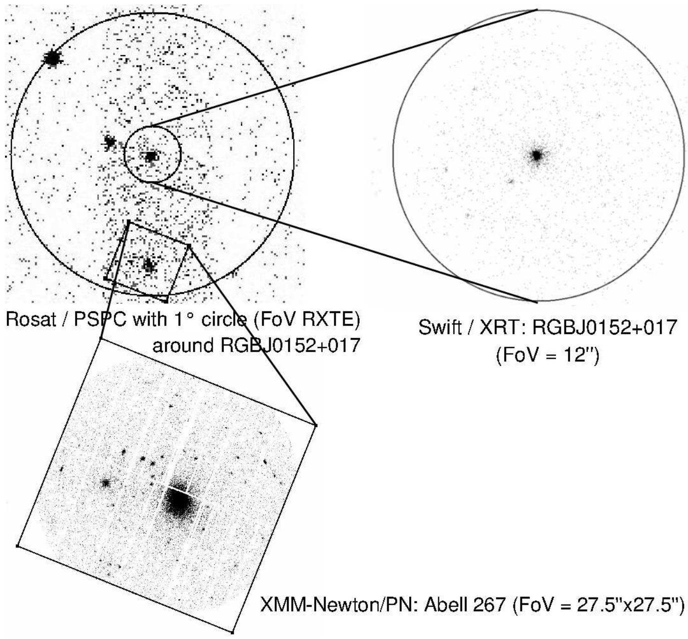

Figure 5: Rosat/PSPC, XMM-Newton and Swift/XRT observations of RGB J0152+017 and the nearby bright sources in the field of view of the non-imaging PCA detector of RXTE.

References

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