Discovery and Multi-wavelength Study of a BL Lac RGB J0152+017

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Abstract

RGB J0152+017 was discovered in TeV γ-rays by the HESS array of Cherenkov telescopes in October 2007. The discovery triggered a broad multi-wavelength observation campaign ranging from radio (Nancay telescope) and optical band (ATOM telescope) over X-rays (RXTE and Swift satellites) to the TeV observations with the HESS experiment. Simultaneous spectral and temporal variability measurements were obtained, which are used to study the acceleration mechanisms in the jet of the BL Lac object. The broadband spectral energy distribution (SED) is derived for the first time, and is well described by a synchrotron self-Compton emission model, with parameters commonly found in TeV blazars. RGB J0152+017 is found to be a high-frequency peaked BL Lac from the SED.

RGB J0152+017

RGB J0152+017 is an example of a BL Lac object, located at z=0.080. It has a high radio and X-ray flux, which make it a viable candidate for γ-ray emission in TeV energy range.

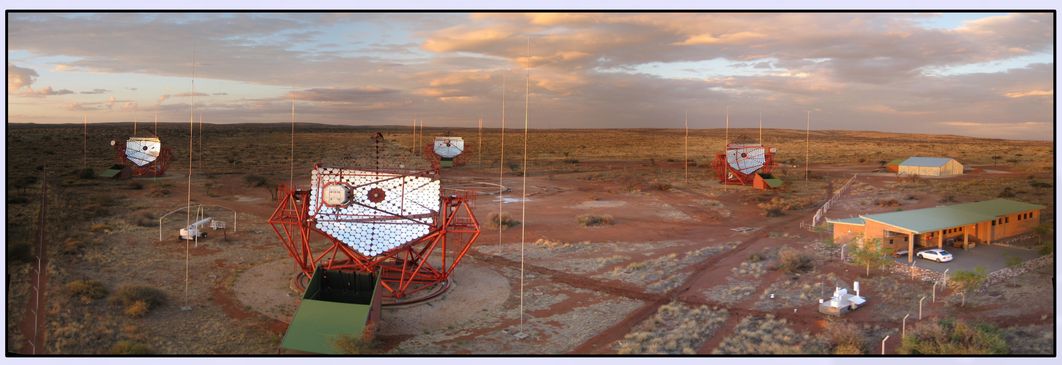

Figure 1: *The array of four H.E.S.S. IACT telescopes in Namibia*

H.E.S.S. Telescopes

The H.E.S.S. Collaboration operates an array of four imaging atmospheric-Cherenkov telescopes (IACTs), located in Namibia. Each telescope has 107 m^2 mirror area and a camera consisting of 960 pixels providing a wide field of view of 5^o. Images of γ-ray showers are analysed in order to reconstruct the direction and energy of the primary γ photon. Background suppression is based on a system of cuts on the image parameters (e.g. width). For further details see *Aharonian et al. (2006)*.

VHE observations and results

RGB J0152+017 was observed in October and November 2007 by the full array of four H.E.S.S. IACT telescopes. The total live-time used for analysis amounts to 14.7 h.

A signal of 173 γ-ray events is found from the direction of RGB J0152+017. The statistical significance of the detection is 6.6 σ. The detection was reported by Nedbal et al. (2007) and Aharonian et al. (2008).

Figure 2 shows the differential spectrum of RGB J0152+017. Between the energy threshold of 240 GeV and 3.8 TeV it is well described by a power law $dN/dE = \Phi_0(E/TeV)^{-\Gamma}$ with a photon index $\Gamma = 2.95 \pm 0.36_{stat} \pm 0.20_{syst}$ and normalization at 1 TeV of $\Phi_0 = (5.7 \pm 1.6_{stat} \pm 1.1_{syst}) \times 10^{-13}$ cm^{-2} s^{-1} TeV^{-1}.

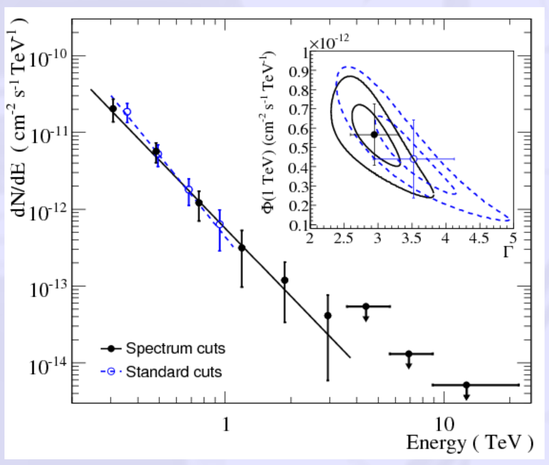

Figure 2: *Differential spectrum obtained during observations in October and November 2007. The black (blue) points show a spectrum obtained using spectrum (standard) cuts. The inset depicts the 1 and 2 σ significance contours of the power-law fit.*

Search for variability

Figure 3 Shows nightly evolution of flux above 300 GeV from RGB J0152+017. There is no significant variability observed. The lightcurve is well fit by a constant with χ^2/DOF = 17.2/12. The overall integral flux above 300 GeV is $I = (2.70 \pm 0.51_{stat} \pm 0.54_{syst}) \times 10^{-12}$cm^{-2} s^{-1}.

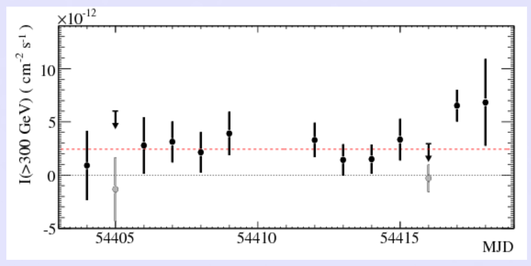

Figure 3: *Mean nightly VHE flux above 300 GeV during observations in October and November 2007.*

Multiwavelength observations

Radio observations by *Nancay* telescope

RGB J0152+017 was observed by the Nancay Radio Telescope (Theureau et al. 2007) in 22 60-second runs on November 12 and 14. A flux density of 56 ± 6mJy is determined at 2685MHz for RGB J0152+017. No significant variability is found in the data.

Optical observations by *ATOM*

The target was observed by ATOM nightly between November 10 and 20. No significant variability is found on a nightly timescale. The host galaxy is subtracted using parameters from Nilsson et al. (2003). The core flux in the R-band (640 nm) is found to be 0.62 ± 0.08mJy

X-ray observations by *Swift* and *RXTE*

RGB J0152+017 was observed by the *Swift/XRT* (Burrows et al. 2005) for 5.44 ks on November 13-15 2007 as a target of opporunity (ToO). No significant variability is found. The spectrum can be derived by a broken powerlaw (Γ_1 = 1.93 ± 0.20, Γ_2 =2.82 ± 0.13, E_{break} = 1.29 ± 0.12 keV) with a Galactic absorption of 2.72×10^{20} cm^{-2}. The unabsorbed flux is determined to be $F_{0.5-2\ keV} \sim 5.1 \times 10^{-12}$ erg cm^{-2} s^{-1} and $F_{2-10\ keV} \sim 2.7 \times 10^{-12}$ erg cm^{-2} s^{-1}.

Using *RXTE/PCA* (Jahoda et al. 1996), 3.2 ks exposure of simultaneous data on November 13-15 2007 were obtained. The resulting flux F_{2-10} keV $\sim 6.8 \times 10^{-12}$ erg cm^{-2} s^{-1} is in disagreement with the one obtained by *Swift*, which is attributed to a contamination by a nearby galaxy cluster Abell 267.

Spectral energy distribution (SED)

Simultaneous observations in radio, optical, X-ray and TeV energy range allowed first determination of the SED of RGB J0152+017 (see Fig. 4).
The SED can be well described by a model containing:

- Non-thermal leptonic Synchrotron Self-Compton (SSC) model describing well the *Swift* X-ray and H.E.S.S. VHE data.
- Optical emission from the dominating host galaxy, modelled by the PEGASE code (Fioc & Rocca-Volmerange 1997).
- The radio data are well described by a separate synchrotron model for an extended jet (Katarzynski et al. 2001)

The model parameters of the emitting region are: Doppler factor δ=25, radius of the emitting region $R = 1.5 \times 10^{15}$ cm and magnetic field B=0.10 G.

Furthermore, the shape and flux of the synchrotron part of the spectrum lead us to identify the AGN as a high frequency BL Lac (HBL).

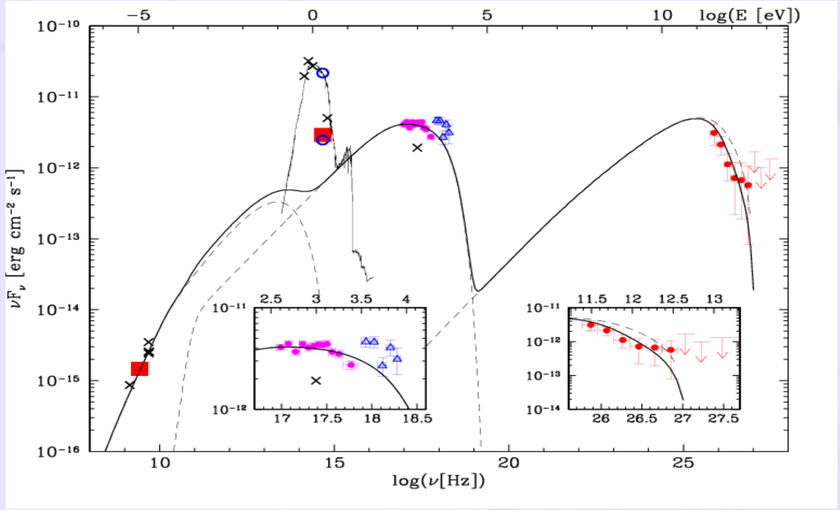

Figure 4: *The spectral energy distribution of RGB J0152+017. Shown are the H.E.S.S. spectrum (red filled circles and upper limits), and contemporaneous RXTE (blue open triangles), Swift/XRT (corrected for Galactic absorption, magenta filled circles), optical host galaxy-subtracted (ATOM) and radio (Nancay) observations (large red filled squares).*

Acknowledgements

The support of the Namibian authorities and of the University of Namibia in facilitating the construction and operation of H.E.S.S. is gratefully acknowledged, as is the support by the German Ministry for Education and Research (BMBF), the Max Planck Society, the French Ministry for Research, the CNRS-IN2P3 and the Astroparticle Interdisciplinary Programme of the CNRS, the U.K. Science and Technology Facilities Council (STFC), the IPNP of the Charles University, the Polish Ministry of Science and Higher Education, the South African Department of Science and Technology and National Research Foundation, and by the University of Namibia.We appreciate the excellent work of the technical support staff in Berlin, Durham, Hamburg, Heidelberg, Palaiseau, Paris, Saclay, and in Namibia in the construction and operation of the equipment.
This research has made use of the NASA/IPAC Extragalactic Database (NED). The authors thank the RXTE team for their prompt response to our ToO request and the professional interactions that followed. The authors acknowledge the use of the Swift publicly available data as well as the public HEASARC software packages. This work uses data obtained at the Nancay Radio Telescope. The authors also thank Dr. Mira Veron-Cetty for fruitful discussions.

References

Aharonian, F. et al. (H.E.S.S.Collaboration) 2006, A&A, 457, 899,
Aharonian, F. et al. (H.E.S.S.Collaboration) 2008, A&A, 477, 481
Burrows, D. N., Hill, J. E., Nousek, J. A., et al. 2005, Space Science Reviews,120, 165
Fioc, M. & Rocca-Volmerange, B. 1997, A&A, 326, 950
Jahoda, K., Swank, J. H., Giles, A. B., Stark, M. J., Strohmayer, T., Zhang, W.,& Morgan, E. H. 1996, Proc. SPIE, 2808, 59
Katarzynski, K., Sol, H., & Kus, A. 2001, A&A, 367, 809
Katarzynski, K., Sol, H., & Kus, A. 2003, ASPC, 290, 339
Nedbal, D., Benbow, W., Costamante, L., et al. 2007, The Astronomer's Telegram, 1295, 1
Nilsson, K., Pursimo, T., Heidt, J., et al. 2003, A&A, 400, 95
Theureau, G., Hanski, M. O., Coudreau, N., Hallet, N., & Martin, J.-M. 2007,A&A, 465, 71

37th COSPAR Scientific Assembly
Montreal, Canada, 13 - 20 July 2008