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MAGIC discovery of the BL Lac 1ES 1727+502: multiwavelength observations, spectral behavior and variability

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Abstract. The MAGIC experiment is a system of two Imaging Atmospheric Cherenkov Telescopes located in the Canary Island of La Palma (Northern hemisphere). It has an energy threshold of 50 GeV, the lowest among the currently operating Cherenkov telescopes, which makes it particularly suitable for the observation of extragalactic sources at Very High Energies (VHE, E>100 GeV). MAGIC has detected numerous blazars, which are active galactic nuclei whose jet axis is pointed towards the observer.

Here we present one of our latest detections, the BL Lac 1ES 1727+502, located at redshift z=0.055. The source was a promising TeV candidate based on archival data and the observation that leads this detection was not triggered by any high state alert in other wavebands. We complemented our data with multiwavelength observations: optical data from the KVA telescope, UV, optical and X-ray data taken with the instruments on board the Swift satellite and High Energy (HE, 100;MeV< E < 100 ; GeV)data from the *Fermi*-LAT (Large Area Telescope). We studied the spectral energy distribution (SED) of 1ES 1727+502 and interpreted it with a one-zone synchrotron self-Compton model obtaining parameters typical for this class of sources.

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THE MAGIC TELESCOPES: OBSERVATIONS AND RESULTS

The MAGIC Telescopes, thanks to the combination of low energy threshold and sensitivity ($0.76 \pm 0.03\%$ of Crab Nebula flux in 50h of effective time above 290 GeV), are well suited instruments for observations of extragalactic sources [1]. Due to their limited field of view (3.5°) they observe pointings at selected sources and do not perform scans of the sky. A very successfull strategy is the selection of candidates from catalogs of lower energy bands. Indeed, the newly discovered 1ES 1727+502 was selected form [2], which provides a list of 33 promising TeV candidate BL Lac objects selected from a sample of 246 BL Lacs, as the brightest sources in radio versus X-ray flux plane and

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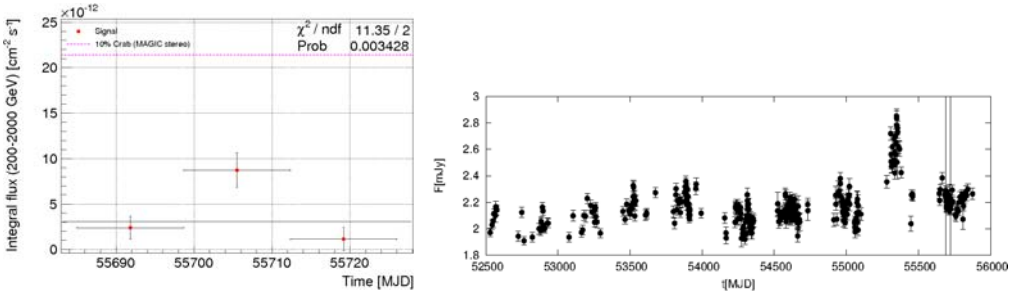

FIGURE 1. Light curves of 1ES 1727+502: (left panel) MAGIC observations in the energy range from 200 GeV to 2 TeV; (right panel) 10 years light curve of the optical R-band from the Tuorla blazar monitoring program. Vertical lines indicate the MAGIC observation window.

in the optical versus X-ray flux plane. In addition, several other BL Lacs (PG 1553+113, 1ES 1218+30.4, 1ES 1741+196, 1ES 0033+595) have been discovered in VHE γ-rays were selected from catalogs based on fluxes in lower energy ranges [2], [3].

The BL Lac object 1ES 1727+502 was first observed with MAGIC-I between May 2006 and May 2007 for a total of 6 hours. These observations did not lead to a significant detection and the data were merged in a staked analysis of 20 BL Lacs [4]. It was observed with the stereo system during June 2010, after an alert of high activity state in the optical band but the data were rejected by quality selection due to the presence of Calima (strong dust wind origination from Sahara desert). The observations that led to the detection of VHE γ-rays were performed, with the stereoscopic system, between May 6th and June 10th 2011 for a total of $\sim$12.6 h of medium-high zenith angle (22°-50°), in false-source tracking mode (wobble [5]) observations. The analysis was done with the standard MAGIC analysis framework "MARS" [6]. An excess of 73 ± 15 γ-like events above 150 GeV, corresponding to a statistical significance of 5.5σ (calculated with equation 17 of [7]), from a point like source at a position consistent with the one reported in the catalog was found. The integral flux above 150 GeV is estimated to be $(2.12 \pm 0.43)\%$ of the Crab Nebula flux and the differential flux can be described by a simple power law function $dF/dE = f_0(\mathrm{E}/300\,\mathrm{GeV})^{\alpha}$, where $f_0 = (8.0 \pm 3.1) \cdot 10^{-12}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}\,\mathrm{TeV}^{-1}$ and $\alpha = (-3.2 \pm 0.4)$. The obtained flux was unfolded to take into account the effects of finite energy resolution and subsequently corrected for the absorption due to the Extragalactic Background Light (EBL) pair-production using the model described in [8]. The VHE γ-ray light curve between 200 GeV and 2 TeV (Fig. 1, left panel: in order to have a unifrom distribution of nights with observations, a 14 day binning from May 4th 2011 is applied, resulting in three time bins with 4 or 5 observing nights each) shows that the emission is compatible with a constant flux of $(3.1 \pm 0.8) \cdot 10^{-12}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. While the relatively low probability of a constant flux (0.3%) might indicate variability, the sparse binning and additional systematic errors due to moon light and larger zenith angles can well explain this effect.

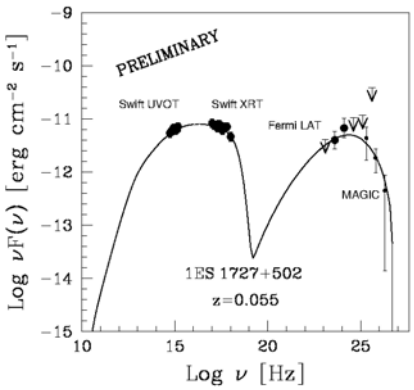

FIGURE 2. Multiwavelegth SED fitted with a one zone synchrotron Self Compton model [9] using a χ^2 minimization technique [10].

SPECTRAL PROPERTIES

1ES 1727+502 has been part of the Tuorla blazar monitoring program[1] for more than 10 years, starting from 2002. It was observed with the 1m Tuorla telescope and the 35 cm KVA telescope, both located in La Palma. The optical lightcurve (Fig. 1, right panel), shows that the source was mostly quiescent, except for an enhancement in the flux during Spring 2010. This flux increase triggered MAGIC follow up observation but the data have been rejected by quality selection.

Unfortunately, since there are no simultaneous observation of BL Lac 1ES 1727+502 in the X-ray band, we have used archival data from the XRT and UVOT instruments on board of the *Swift* satellite from April and May 2010. These data are from the same period of the increase of the optical R-band flux, but we can include them in the compilation of the multiwavelength spectral energy distribution (SED) because they were taken when the optical flux was not in a high state yet and the R-band SED point obtained from the KVA telescope fits the UVOT SED points.

The BL Lac 1ES 1727+502, was observed also in HE γ-rays by the *Fermi*-LAT. The data sample selected for this analysis (P7SOURCE_V6), covers observations from August 4th, 2008 to July 20th, 2011. The emission, over this period, is consistent with a constant flux. For the compilation of the SED, three months of data were used, centered on the MAGIC observation period.

All the multiwavelength data described above were used for the compilation of the SED (Fig. 2). It was fitted with a one zone synchrotron self Compton model [9] using a χ^2 minimization technique [10], with parameters typical for this kind of sources. For the population of electrons: Lorentz factors $\gamma_{min} = 10^3$, $\gamma_{break} = 1.4 \cdot 10^4$ and $\gamma_{max} = 6.2 \cdot 10^5$, spectral indeces $n_1 = 1.8$ and $n_2 = 3.2$ and normalization factor $1.6 \cdot 10^3$ cm^{-3} and for the astrophysical environment: magnetic field 0.1 G, radius of emitting region $1.6 \cdot 10^{16}$ cm and Doppler factor 9.8.

[1] http://users.utu.fi/kani

CONCLUSIONS

The newly discovered 1ES 1727+502 shows little variability in the optical R-band, is bright in X-rays, has a hard spectrum in the *Fermi*-LAT band and is bright in the VHE γ-ray range. It is interesting to compare this results with the ones presented in the stacked AGN sample observed with MAGIC-I: the spectral index of 1ES 1727+502 in the MAGIC energy range is compatible with the average spectral index of the stacked AGN sample: 3.2 ± 0.4 compared to 3.1 ± 0.51. Moreover, it confirms the predictions made by [2] proving that the selection of sources from X-ray catalogs is a successful approach for the discovery of new VHE blazars.

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