Review of canonical scenarios of γ-ray jet emission from recent HE-VHE observations of 3C 279 with MAGIC

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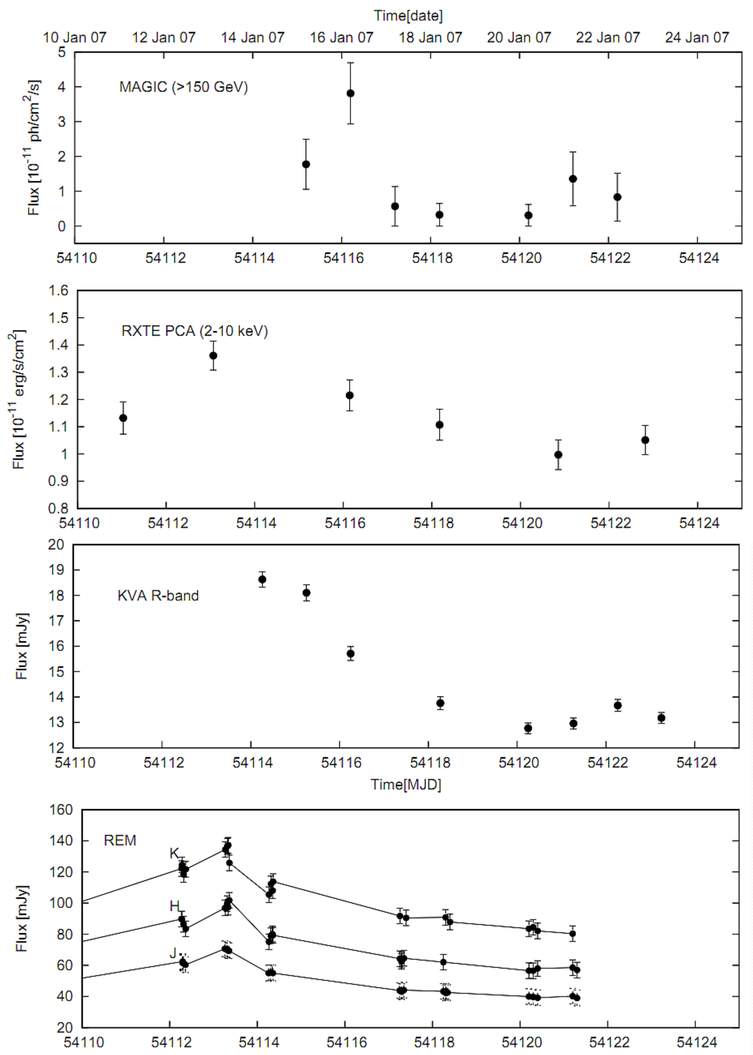
Description:

- MAGIC is a system of two 17 m diameter imaging air Cherenkov telescopes, situated on the canary island La Palma. It is sensitive to very high energy (VHE) γ-rays between 50 GeV and several tens of TeV.
- The single MAGIC-I telescope discovered VHE γ-ray emission from the flat spectrum radio quasar 3C 279 in 2006 [1].
- Additional observations in January 2007 (triggered by exceptionally bright optical emission) and December 2008 - April 2009 (bright GeV γ-ray flare, triggered by FERMI).
- A short VHE γ-ray flare (one day) was detected on January 16th 2007 at 5.4 σ post-trial.
- Quasi-simultaneous data was collected at optical, IR and X-ray frequencies and for 2009 also γ-ray data from FERMI to determine spectral energy distributions (SED) and light curves.
- The VHE γ-ray flare occurred when the activity decreased in other wavebands, possibly due to separate emission regions (see figure on the right, [2]).
- No VHE γ-ray detection during the 2009 observations (not simultaneous to the GeV γ-ray flare).
- The fit parameters of the purely leptonic model fits can be found in the table below as well as the SEDs of all the model fits to the 2006, 2007 and 2009 data.



Model	γ_{min}	γ_b [10^3]	γ_{max} [10^5]	n_1	n_2	B [G]	K [10^4 cm^{-3}]	R [10^{16}cm]	δ	θ [deg]	τ_{BLR}	R_{BLR} [10^{17}cm]	R_{IR} [10^{18}cm]
2006 One-zone BLR	1	2.5	3.5	2	3.7	0.15	2	5	20	2.9	0.015	4	–
2006 One-zone IR	1	2	2	2	4	0.19	1	4.5	27	2	–	–	4
2007 Two-zone: Opt-X-ray zone	1	0.5	0.03	2	4.3	2.2	5.5	5	18	3.1	0.05	6	–
2007 Two-zone: VHE zone	45	20	5	2	4.3	0.1	0.01	10	18	3.1	–	–	2.5
2009 One-zone BLR	1	0.33	0.2	2	3.5	0.8	23	3	20	2.1	0.1	6	–

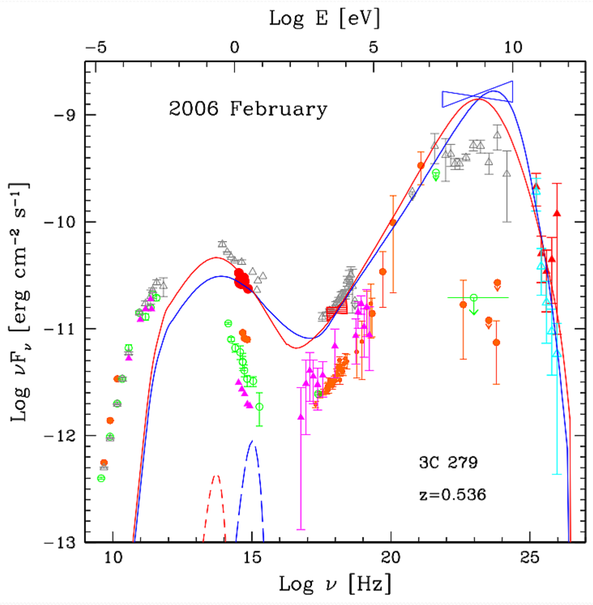


Fig. 2: 2006 February SED of 3C 279. The lines assumes EC emission inside (blue) and outside (red) the BLR (from a single region). Dashed lines correspond to blackbody radiation from the IR torus (red) and BLR (blue).

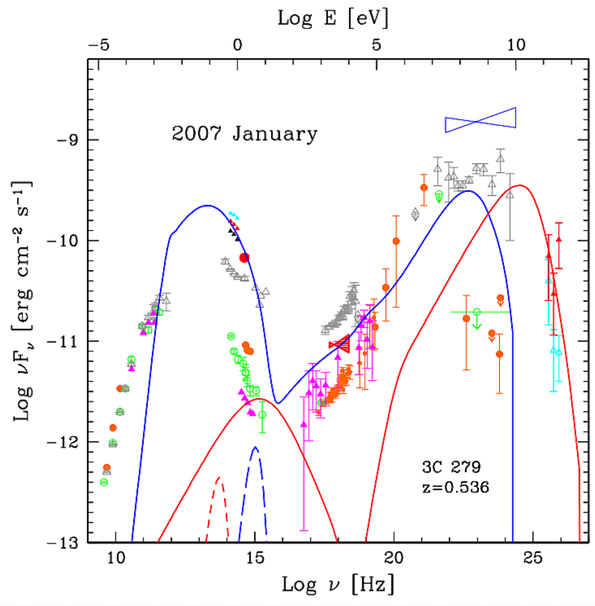


Fig. 3: SED of 3C 279 on January 2007 16th. The two lines show the emission from inside (blue) and outside (red) the broad line region. Dashed lines as in Fig. 2.

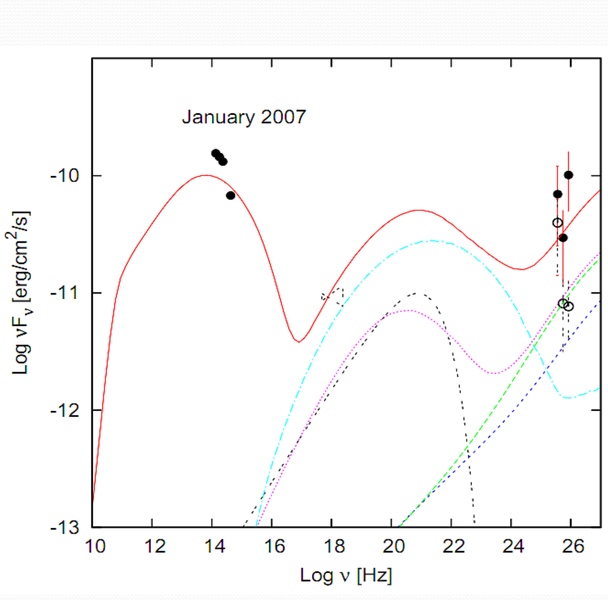


Fig. 4: Lepto-hadronic model of the January 2007 SED. For a detailed list of all the components see [3]. The total fit shown as red line.

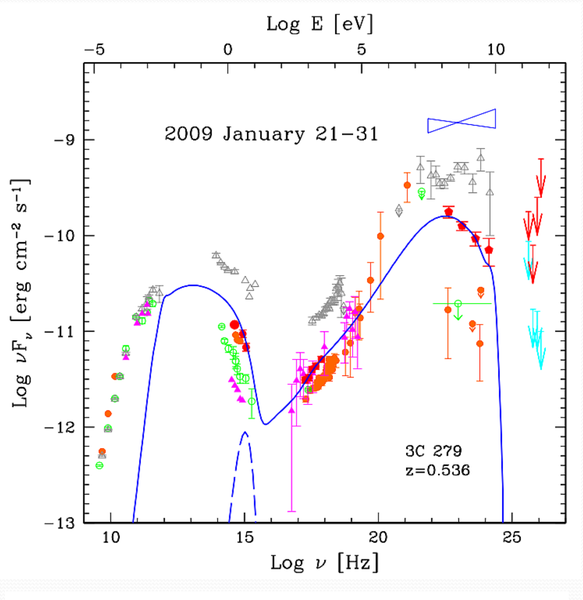


Fig. 5: January 2009 SED: Emission region assumed to be inside the BLR. Blue dashed line: blackbody radiation from the IR torus.

Conclusions:

- An extensive study of the SED and light curves of 3C 279 has been performed.
- The SED of 2007 January disfavors standard one-zone SSC+EC models (emission region inside as well as outside the BLR).
- A Two-zone model (VHE γ-rays produced outside the BLR) and a lepto-hadronic model satisfactorily describe our data.
- Only two more flat spectrum radio quasars have been detected in VHE γ-rays: PKS 1510-089 [4] and PKS 1222+21 [5]. In both cases the VHE γ-ray emission cannot be explained by the canonical emission scenario, as discussed in [3] and [5].
- One of the possible solutions is the assumption that the VHE γ-ray emission comes from a small blob inside the jet [6].
- The non-detection at VHE γ-rays during the 2009 observation period is consistent with a low optical to X-ray and Fermi γ-ray emission.
- The MAGIC detection in January 2007 took place at the beginning of the rotation of the optical polarization angle, thus confirming that such events are recurrently accompanied with γ-ray flares in 3C 279 (see [3] for details).
- A simultaneous detection of a γ-ray flare by MAGIC together with the FERMI/LAT is necessary to test (and distinguish between) the two zone and lepto-hadronic models with better accuracy.

References

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