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Long-term multi-wavelength variability and correlation study of Markarian 421 from 2007 to 2009.

Ahnen M.L., Ansoldi S., Antonelli L.A., Antoranz P., Babic A., Banerjee B., Bangale P., Barres de Almeida U., Barrio J.A., Becerra Gonzalez J., Bednarek W., Bernardini E., Biasuzzi B., Biland A., Blanch O., Bonnefoy S., Bonnoli G., Borracci F., Bretz T., Buson S., Carosi A., Chatterjee A., Clavero R., Colin P., Colombo E., Contreras J.L., Cortina J., Covino S., Da Vela P., Dazzi F., De Angelis A., De Lotto B., de Ona Wilhelmi E., Di Pierro F., Dominguez A., Dominis Prester D., Dorner D., Doro M., Einecke S., Eisenacher Glawion D., Elsaesser D., Fernandez-Barral A., Fidalgo D., Fonseca M.V., Font L., Frantzen K., Fruck C., Galindo D., Garcia Lopez R.J., Garczarczyk M., Garrido Terrats D., Gaug M., Giammaria P., Godinovic N., Gonzalez Munoz A., Gora D., Guberman D., Hadasch D., Hahn A., Hanabata Y., Hayashida M., Herrera J., Hose J., Hrupec D., Hughes G., Idec W., Kodani K., Konno Y., Kubo H., Kushida J., La Barbera A., Lelas D., Lindfors E., Lombardi S., Longo F., Lopez M., Lopez-Coto R., Majumdar P., Makariev M., Mallot K., Maneva G., Manganaro M., Mannheim K., Maraschi L., Marcote B., Mariotti M., Martinez M., Mazin D., Menzel U., Miranda J.M., Mirzoyan R., Moralejo A., Moretti E., Nakajima D., Neustroev V., Niedzwiecki A., Nievas Rosillo M., Nilsson K., Nishijima K., Noda K., Nogues L., Orito R., Overkemping A., Paiano S., Palacio J., Palatiello M., Paneque D., Paoletti R., Paredes J.M., Paredes-Fortuny X., Pedalletti G., Perri L., Persic M., Poutanen J., Prada Moroni P.G., Prandini E., Puljak I., Rhode W., Ribo M., Rico J., Rodriguez Garcia J., Saito T., Satalecka K., Schultz C., Schweizer T., Shore S.N., Sillanpaa A., Sitarek J., Snidaric I., Sobczynska D., Stamerra A., Steinbring T., Strzys M., Takalo L., Takami H., Tavecchio F., Temnikov P., Terzic T., Tescaro D., Teshima M., Thaele J., Torres D.F., Toyama T., Treves A., Verguillo V., Vovk I., Ward J.E., Will M., Wu M.H., Zanin R. (The MAGIC Collaboration), Blinov D.A., Chen W.P., Efimova N.V., Forne E., Grishina T.S., Hovatta T., Jordan B., Kimeridze G.N., Kopatskaya E.N., Koptelova E., Kurtanidze O.M., Kurtanidze S.O., Lahteenmaki A., Larionov V.M., Larionova E.G., Larionova L.V., Ligustri R., Lin H.C. McBreen B., Morozova D.A., Nikolashvili M.G., Raiteri C.M., Ros J.A., Sadun A.C., Sigua L.A., Tornikoski M., Troitsky I.S., Villata M.
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ADC_Keywords: BL Lac objects ; Galaxies, Markarian ; Gamma rays ; Radio sources

Keywords: astroparticle physics -
 BL Lacertae objects: individual: Markarian 421 -
 radiation mechanisms: non-thermal

Abstract:
 We perform an extensive multi-band variability and correlation study of the TeV blazar Mrk 421 on year time scales, which can bring additional insight on the processes responsible for its broadband emission. We observed Mrk 421 in the very high energy gamma-ray range with the Cherenkov telescope MAGIC-I from March 2007 to June 2009. The 2.3-year long MAGIC light curve is complemented with data from the Swift/BAT and RXTE/ASM satellites and the KVA, GASP-WEBT, OVRO, and Metsahovi telescopes from February 2007 to July 2009, allowing for an excellent characterisation of the multi-band variability and correlations over year time scales.

Description:
 Data of Mrk 421 are presented for the following instruments and bands from radio to very high energy gamma-rays: Metsahovi (37GHz), OVRO (15GHz), GASP (R band), RXTE/ASM (2–10keV), Swift/BAT(15–50keV), MAGIC (>400 GeV). The observation period is from 10th February 2007 (MJD 54141) to 23rd July 2009 (MJD 55035). Figure 2 includes the light curves of the above mentioned instruments. Figure 3 and 4 show the fractional variability F_{var} for these light curves of the above mentioned light curves for the whole time span (Fig. 3) and for the separate time spans P1, P2, P3 (Fig. 4).

Objects:

RA	(2000)	DE	Designation(s)
11 04 27.31	+38 12 31.8		Mrk 421 = QSO B1101+384

File Summary:

FileName	Lrecl	Records	Explanations
ReadMe	80	.	This file
tabfig2.dat	112	1750	Light curves of Mrk 421 from radio to VHE from MJD 54141 to MJD 55035
tabfig3.dat	77	10	Fractional variabilities of Mrk 421 from radio to VHE from MJD 54141 to MJD 55035
tabfig4.dat	69	12	Fractional variabilities of Mrk 421 from radio

See also:

- [J/A+A/545/A117](#) : Monitoring of Mrk 421 at 15 and 24 GHz (Lico+, 2012)
[J/A+A/559/A75](#) : 43GHz observation of the blazar Mrk 421 (Blasi+, 2013)
[J/A+A/576/A126](#) : The 2009 multiwavelength campaign on Mrk 421 (Aleksic+, 2015)
[J/A+A/578/A22](#) : Mrk 421 in March 2010 (Aleksic+, 2015)
[J/ApJS/222/6](#) : 4.5yr obs. of Mrk 421 with ARGO-YBJ + Fermi (Bartoli+, 2016)

Byte-by-byte Description of file: [tabfig2.dat](#)

Bytes	Format	Units	Label	Explanations
1- 15	A15	---	Inst	Instrument
17- 25	A9	---	Band	Band/energy range
27- 38	E12.6	Hz	bFreq	band frequency, lower boundary
40- 51	E12.6	Hz	BFreq	band frequency, upper boundary
53- 64	F12.6	d	MJDSt	Modified Julian Date, observation (time bin) start
66- 77	F12.6	d	MJDEnd	Modified Julian Date, observation (time bin) end
79- 86	A8	---	x_Flux	Flux unit
88- 99	E12.6	---	Flux	Flux
101-112	E12.6	---	e_Flux	Flux error

Byte-by-byte Description of file: [tabfig3.dat](#)

Bytes	Format	Units	Label	Explanations
1- 15	A15	---	Inst	Instrument
17- 25	A9	---	Band	Band/energy range
27- 40	A14	---	Selec	Date selection, all data or simultaneous (1)
42- 50	F9.6	[Hz]	logFreq	Frequency
52- 59	F8.6	[Hz]	e_logFreq	Frequency error
61- 68	F8.6	---	Fvar	Fractional variability (2)
70- 77	F8.6	---	e_Fvar	Fractional variability error

Note (1): Date selection defines for the calculation of Fvar if all data from the light curves from X-ray to radio is used (as shown in Figure 2) or if only simultaneous data to the MAGIC light curve is selected. Of the MAGIC light curve all data is selected.

Note (2): If the fractional variability is 0 or negative, the resulting value is not given in the table. Then either no variability is given or the instrument is not sensitive enough to detect it.

Byte-by-byte Description of file: [tabfig4.dat](#)

Bytes	Format	Units	Label	Explanations
1- 15	A15	---	Inst	Instrument
17- 25	A9	---	Band	Band/energy range
27- 38	F12.6	d	MJDSt	Modified Julian Date, observation (time bin) start (1)
40- 51	F12.6	d	MJDEnd	Modified Julian Date, observation (time bin) end (1)
53- 60	F8.6	---	Fvar	Fractional variability (2)
62- 69	F8.6	---	e_Fvar	Fractional variability error

Note (1): Time range of light curve for calculation of Fvar.

Note (2): If the fractional variability is 0 or negative, the resulting value is not given in the table. Then either no variability is given or the instrument is not sensitive enough to detect it.

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