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(EC Young Researcher Training Network ENIGMA)

An "*fast*" update about the XMM-Newton and coordinated MW campaign on OJ 287

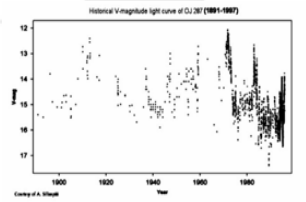
8th ENIGMA Meeting

Sept. 06-08, 2006 – Helsinki University of Technology and Metsähovi Radio Observatory, Otaniemi, Espoo, SUOMI-FINLAND

XMM-Newton observations and coordinated core MW campaign on OJ 287

Goals:

- ❑ Study the spectral-temporal behaviour of OJ 287 on both short and long time scales, and in different brightness states (before and during the possible cyclic outburst).
- ❑ X-ray data likely provide information on the high-energy (inverse Compton, IC) spectral component, while radio-to-optical observations map the behaviour of the synchrotron bump.
- ❑ Possibly to clarify underlying physics, and relevance of geometrical and energetic models.
- ❑ Search for multifrequency correlations.
- ❑ To challenge a satellite-triggered coordinated MW campaign on a well-know and peculiar blazar.



http://www.astro.utu.fi/OJ287MMVI/

* MMVI = 2006

OJ 287: XMM-Newton proposals

- ❑ 2 XMM-Newton observations (Cycle AO-4, PI: Stefano), and coordinated core WEBT campaign (CM: Stefano) performed in 2005. Satellite pointing dates: April 12, and Nov. 3-4, 2005. *Paper in preparation.*
- ❑ A 3rd XMM-Newton observation granted (Cycle AO-5, PI: Stefano) to be scheduled in a day between Nov.15-Nov.21, 2006 (43ksec). *MW core campaign announcement next week.*

Visibility of OJ 287 by XMM-Newton in 2005:

Source name	Other names	Redshift	EGRET detection	X-rays past observations	X-rays integral flux [erg cm^{-2} s^{-1}]	XMM AO-4 source visibility periods	Optical visibility window†
OJ 287	PKS 0851+202 PG 0851+202	$z = 0.306$	YES	Einstein,EXOSAT,ROSAT ASCA,*Beppo*SAX	1.35-5.0 $\times 10^{-12}$ (2-10 keV) (ASCA, SAX)	2005.Apr.12 - 2005.May.05 2005.Oct.16 - 2005.Nov.18	Oct-May

† Calculated for the mean latitude of the WEBT and ENIGMA collaboration telescopes.

The 2 XMM pointings performed in 2005:

April 12, 2005

Target_Name	RA	Dec	Position_Angle	
OJ 287	08:54:48.87	+20:06:30.6	285:05:17.8	
XMM Obs_Duration	XMM Obs: **Start Time**	XMM Obs: **End Time**	Satellite Revolution	IB
40000 sec	2005-04-12 at 12:55 UT	2005-04-13 at 00:03 UT	0978	E3

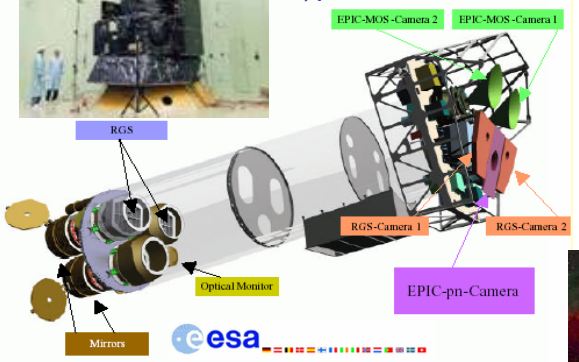
November 3-4, 2005

Target - PI	RA	Dec	Position_Angle	
OJ 287 - S. Ciprini	08:54:48.87	+20:06:30.6	104:13:22.6	
XMM Obs_Duration	XMM Obs: **Start Time**	XMM Obs: **End Time**	Satellite Revolution	IB
51000 sec	2005-11-03 at 20:59 UT	2005-11-04 at 11:09 UT	1081	E3

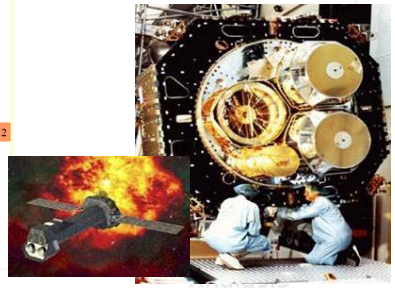
XMM-Newton Satellite

XMM-Newton has three mirror modules:

- Instruments behind:
  1) RGS-1 and MOS-1
  2) RGS-2 and MOS-2
  3) pn

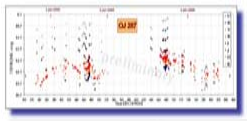


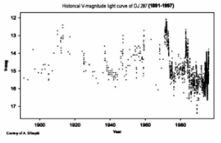
- EPIC: MOS1, MOS2 and pn
- RGS: RGS-1, RGS2
- OM: Optical Monitor

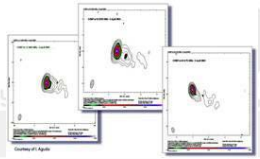


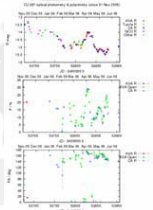
Other ongoing OJ 287 observations/campaigns

- Long term 2005-2008 monitoring project (ENIGMA Campaign) on OJ 287 (in the footsteps of the OJ-94 project, Aimo, Leo, Kari, Jochen, Stefano…).
- Optical photometry and polarimetry monitoring program on OJ 287 ongoing (Jochen, Kari).
- MAGIC ToO observations of OJ 287 performed in Nov. 2005 (Elina, no detection).
- Effelsberg radio IDV observations (4-days, Apr.12 and Nov. 8-9-10, 2005, Lars). *Paper in advanced stage.*
- VLBA and global 3mm-VLBI radio-structure/polarization observations performed (April 2005, Ivan). More VLBA & Global 3mm-VLBI observations ongoing (period 2005-2007, Tuomas).

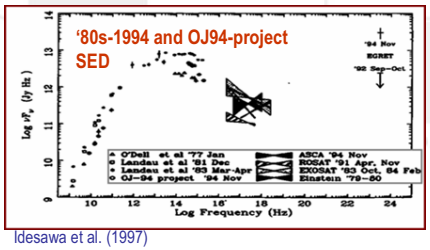




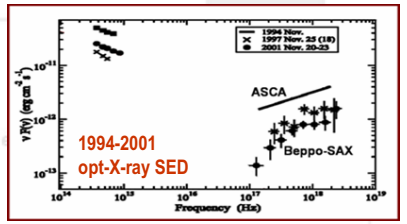




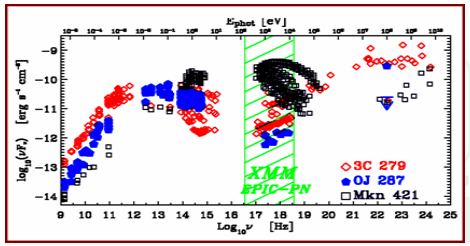
OJ 287: previous broadband SEDs



Idesawa et al. (1997)



Massaro et al. (2003)



Comparison among the SED of OJ 287 SED, with the SED of a HBL (TeV blazar) and a FSRQ prototype (Mkn 421 and 3C 279).

Source name	Other names	EGRET detection	X-rays past observations	X-rays integral flux [erg cm^{-2} s^{-1}]
OJ 287	PKS 0851+202	YES	Einstein,EXOSAT,ROSAT	$1.35\text{-}5.0 \times 10^{-12}$ (2-10 keV)
$z = 0.306$	PG 0851+202		ASCA,*BeppoSAX*	(ASCA, SAX)

XMM-Newton coordinated MW campaign participants 1

Institutes/Observatories participating in the MW coordinated campaign (XMM pointing-1/part-1 MW campaign list):

Optical Observatories:
- Osaka Kyoiku University Observatory - Kashiwara, Osaka, Japan (K. Sadakane)
- Lulin Observatory - Lulin, Taiwan (W. P. Chen)
- Xinglong Station of NAOC - Yanshan Mountains, China, (J.-H. Wu)
- ARIES Sampurnanand Telescope - Naini Tal, Uttaranchal, India (R. Sagar, G. Krishna)
- Abastumani Astrophysical Observatory - Mt. Kanobil, Georgia, (O. Kurtanidze)
- Crimean Astrophysical Observatory - Nauchny, Crimea, Ukraine (Y. Efimov, V. Larionov)
- Çanakkale Onsekiz Mart University Observatory - Çanakkale, Turkey (A. Erdem)
- Jakokoski Observatory - Jakokoski, Finland (P. Pääkkönen)
- Nyrölä Observatory - Nyrölä, Finland (A. Oksanen, K. Nilsson)
- Tuorla Observatory - Piikkio, Finland (L. Takalo, A. Sillanpää)
- Catania Observatory - Catania, Italy (A. Frasca)
- Campo Imperatore Observatory - L'Aquila, Italy (V. Larionov)
- Armenzano Observatory - Armenzano, Assisi, Italy (D. Carosati)
- Perugia Observatory - Perugia, Italy (G. Tosti, S. Ciprini)
- Torino Observatory - Torino, Italy (C. Raiteri, M. Villata)

Optical (cont.):
- Heidelberg Observatory - Heidelberg, Germany (J. Heidt)
- Michael Adrian Observatory- Trebur, Germany (J . Ohlert)
- Agrupacio Astronomica de Sabadell - Sabadell, Spain (J. A. Ros)
- KVA Telescope - La Palma, Canary Islands, Spain (L. Takalo, A. Sillanpää)
- Nordic Optical Telescope - La Palma, Canary Islands, Spain (T. Pursimo)
- Mt. Lemmon KASI Observatory - Mount Lemmon, Arizona, USA (L. Chung-Uk)
- Kitt Peak SARA Observatory - Kitt Peak, Arizona, USA (J. Webb)
- Tenagra Observatories - Sonoran desert, Arizona, USA (A. Sadun)
- Coyote Hill Observatory - Wilton, California, USA (C. Pullen)

Radio-mm:
- RATAN-600 (Special Astrophys. Obs.) (576 m) - Zelenchukskaya, Russia (Y. Kovalev)
- Metsähovi Radio Telescope (14 m) - Metsähovi, Finland (M. Tornikoski, A. Lahteenmaki)
- Noto Radio Observatory - Noto, Siracusa, Italy (C. Raiteri, P. Leto)
- Effelsberg Radio Telescope (100 m) - Effelsberg, Germany (T. Krichbaum, L. Fuhrmann)
- IRAM Millimeter Telescope (30 m) - Pico Veleta, Spain (T. Krichbaum, H. Ungerechts)
- Univ. of Michigan Radio Astron. Obs. (UMRAO) (26 m) - Dexter, Michigan, USA (M. Aller)

XMM-Newton coordinated MW campaign participants 2

Institutes/Observatories participating in the MW coordinated campaign (XMM pointing-2/part-2 MW campaign list):

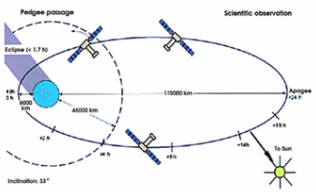
Optical/NIR Observatories:
- Osaka University - Osaka, Japan (K. Torii)
- Sobaeksan KASI Optic. Astr.Obs. - Sobaeksan, Korea (C.-U. Lee)
- Lulin Observatory - Lulin, Taiwan (W.-P. Chen)
- Tsinghua University - Beijing, China (J. Li)
- Xinglong Station of NAOC - Yanshan Mountains, China, (J.-H. Wu)
- ARIES Sampurnanand Tel. - Naini Tal, Uttaranchal, India (R. Sagar, G. Krishna)
- Mount Maidanak Observatory, Ulugh Beg Astronomical Institute - Mount Maidanak, Uzbekistan (M. A. Ibrahimov)
- Abastumani Astrophysical Observatory - Mt. Kanobil, Georgia, (O. Kurtanidze)
- Crimean Astrophysical Obs. - Nauchny, Crimea, Ukraine (Y. Efimov, V. Larionov)
- Çanakkale Onsekiz Mart University Obse. - Çanakkale, Turkey (A. Erdem)
- Saint Petersburg State Univ. Obs. - St. Petersburg, Russia (V. M. Larionov)
- Bulgaria National Astron. Obs. - Rozhen, Bulgaria (E. Ovcharov, A. Kostov)
- Jakokoski Observatory - Jakokoski, Finland (P. Pääkkönen)
- Tuorla Observatory - Piikkio, Finland (L. Takalo, A. Sillanpää)
- MonteBoo Obs., Masaryk University - Brno, Czech Republic (F. Hroch)
- Catania Observatory - Catania, Italy (A. Frasca)
- Campo Imperatore Obs. - Assergi, L'Aquila, Italy (A. Arkharov)
- Armenzano Observatory - Armenzano, Assisi, Italy (D. Carosati)
- Porziano Observatory - Porziano, Assisi, Italy (D. Capezzali)
- Perugia Observatory - Perugia, Italy (G. Tosti, S. Ciprini)

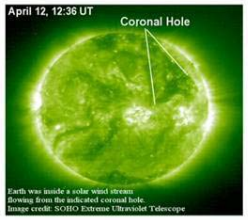
Optical (cont.):
- Torino Observatory - Torino, Italy (C. Raiteri, M. Villata)
- Heidelberg Lander. - Heidelberg, Germany (L. Ostorero, D. Emmanoulopoulos)
- Michael Adrian Observatory- Trebur, Germany (J . Ohlert)
- KVA Telescope - La Palma, Canary Islands, Spain (L. Takalo, A. Sillanpää)
- Nordic Optical Telescope - La Palma, Canary Islands, Spain (T. Pursimo)
- INAOE Tonantzintla Obs. - Tonantzintla, Puebla, Mexico (O. Lopez-Cruz)
- Mt. Lemmon KASI Obs. - Mount Lemmon, Arizona, USA (C.-U. Lee)
- Ohio University MDM Obs. - Kitt Peak , Arizona, USA (M. Boettcher)
- Kitt Peak SARA Obs. - Kitt Peak, Arizona, USA (J. Webb)
- Tenagra Observatories - Sonoran desert, Arizona, USA (A. Sadun)
- National Astr. Obs. of San Pedro Mártir - Baja California Peninsula, Mexico (E. Benitez, D. Dultzin-Hacyan.)
- Coyote Hill Observatory - Wilton, Sacramento, California, USA (C. Pullen)

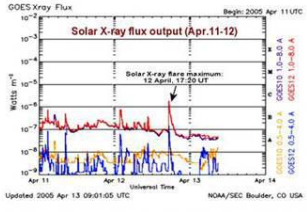
Radio-mm:
- RATAN-600 (Special Astr. Obs.) (576 m) Zelenchukskaya, Russia (Y. Kovalev)
- RT-22 Crimean Astr.l Obs. (22m) - Simeiz, Crimea, Ukraine (A. Volvach)
- Metsähovi Radio Tel. (14 m) - Metsähovi, Finland (M. Tornikoski, A. Lahteenmaki)
- Noto Radio Obs. (32m) - Noto, Siracusa, Italy (P. Leto, C. Raiteri)
- Effelsberg Radio Tel. (100 m) - Effelsberg, Germany (T. Krichbaum, L. Fuhrmann)
- IRAM Millimeter Tel. (30 m) - Pico Veleta, Spain (T. Krichbaum, H. Ungerechts)
- Univ. of Michigan Radio Astr. Obs. (UMRAO) (26 m) - Dexter, Michigan, USA (M. Aller)

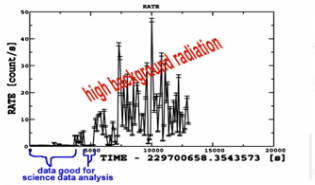
Beware of the weather conspiracy 1

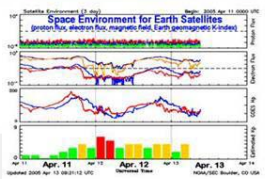
Bad space weather: 1st XMM obs. (April 12, 2005) affected by high background radiation and stopped. *EPIC pn*: the excellent camera collected enough photons to construct a spectra. *RGS*: no detection. *OM*: UV-opt. observations performed. Time lost added to the 2nd pointing.





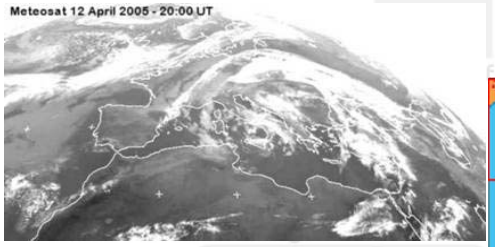






Beware of the weather conspiracy 2

Bad atmospheric weather: Optical ground-based observations obstructed by bad weather in Europe during the 1st (April 12, 2005) XMM-Newton pointing.

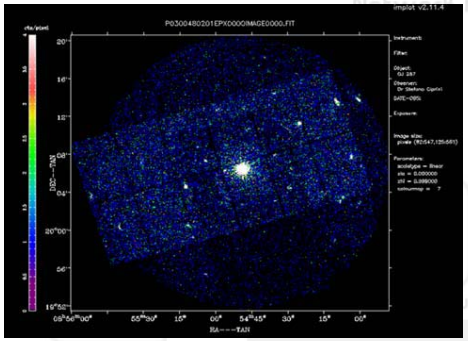


5 Optical observatories in center Italy (2 amateur, 3 professional) alerted/involved personally for April 12... but bad luck with weather!

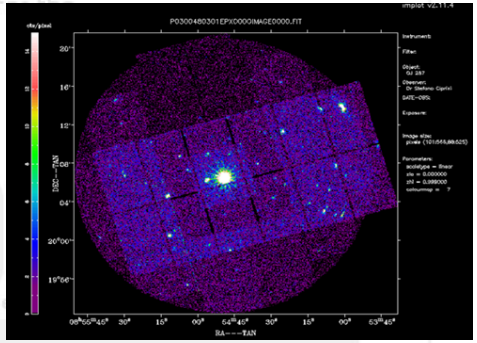
OJ 287 XMM-Newton: X-ray EPIC images

EPIC: large frame + medium filter used. Data processed with XMM-SAS v. 6.5.
Intervals of high background filtered. Spectral analysis of PN + MOS1+MOS2 data with XSPEC.

April 12, 2005

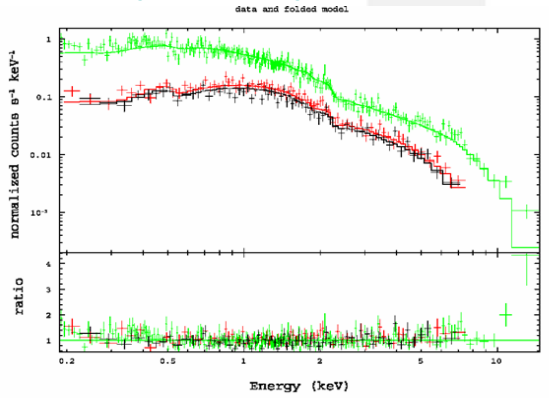


Nov. 3-4, 2005



OJ 287 XMM-Newton: X-ray EPIC spectrum Apr. 12, 2005

Date: April 12, 2005 - OJ 287, z=0.306.
XMM-Newton *EPIC: PN* + *MOS1* + *MOS2* spectra
Model: single power law + galactic absorption in the 0.2-10 KeV range



H column density:
$N_H = 3.09 \times 10^{20}$ cm^{-2}

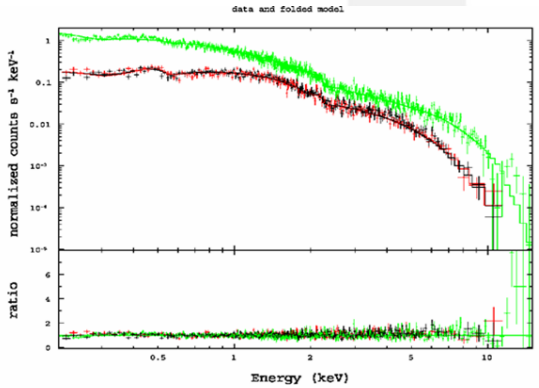
Power-law photon index:
$\Gamma = 1.628 \pm 0.023$

Reduced chi-squared:
$\chi_r^2 = 1.035$, d.o.f.=367

Flux density (2-10 KeV):
$F_{2-10keV} = (2.47 \pm 0.8) \times 10^{-12}$ erg s^{-1} cm^{-2}

OJ 287 XMM-Newton: X-ray EPIC spectrum Nov. 3-4, 2005

Date: November 3-4, 2005 - OJ 287, z=0.306.
XMM-Newton *EPIC: PN* + *MOS1* + *MOS2* spectra
Model: broken power law + galactic absorption in the 0.2-10 KeV range



H column density:
$N_H = 3.09 \times 10^{20}$ cm^{-2}

Broken power-law photon indexes:
$\Gamma_1 = 2.65\,(-0.07/+0.12)$
$\Gamma_2 = 1.79 \pm 0.02$
break energy: 0.69 KeV

Reduced chi-squared:
$\chi_r^2 = 1.030$, d.o.f.=927

Flux density (2-10 KeV):
$F_{2-10keV} = (1.82 \pm 0.07) \times 10^{-12}$ erg s^{-1} cm^{-2}

Preliminary summary on the X-ray observations

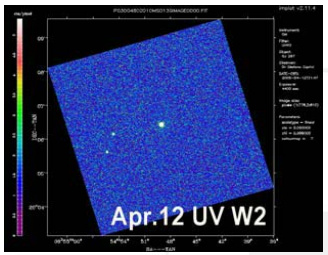
- Apr.12 (XMM 1st obs.): Best fit: simple single power law component (IC?).
- Nov.3-4 (XMM 2nd obs.): Best fit: broken power law component (break ~0.7 keV), (Synch.tail+IC ? Break signature between the synchrotron and IC components ?)
- X-ray observations provided information on the high-energy (IC) spectral component.
- Different brightness states, flux variations: $F_{2-10keV} = 2.47 \times 10^{-12}$(1st), and $F_{2-10keV} = 1.82 \times 10^{-12}$(2nd), erg s^{-1} cm^{-2} (previous obs.: fluxes in the range $1.35-5.0 \times 10^{-12}$ erg s^{-1} cm^{-2}).
- Spectral variability: single/broken power law, slope variation.

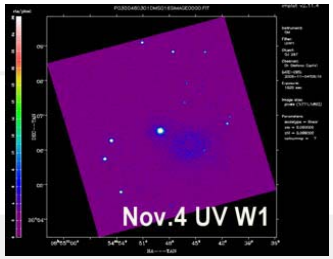
OJ 287 XMM-Newton: OM opt-UV observations

- Optical Monitoring instrument (OM). Summary of the observations obtained:

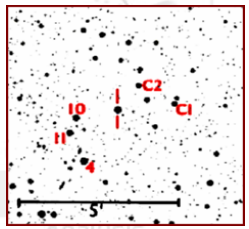
	UVW2	UVM2	UVW1	U	B	V
lambda (A)	2120	2310	2910	3440	4500	5430
Num. of images (Apr.12):	1	2	2	1	1	1
Num. of images (Nov.3-4):	0	0	8	1	1	1

Example of 2 ultraviolet (UV) images





The "usual" optical finding chart



OJ 287 XMM-Newton: OM opt-UV observations

Preliminary results:

	UVW2	UVM2	UVW1	U	B	V
lambda (A)	2120	2310	2910	3440	4500	5430

- Agreement of the U,B,V calibrated OM mags with the reported comparison stars values. (XMM-OM "space"-mags are suitable to make a nice comp. stars calibration sequence for the OJ 287 field in opt. UBV filters).
- High brightness of OJ 287 in UV bands during both the pointings (synch. peak in UV, or UV therm. bump, or...?).

Apr.12, 2005: OJ 287 magnitudes

OM-band	MAG	ERR
V		0.01
B		0.01
U		0.01
UV-W1		0.01
UV-W1		0.01
UV-M2		0.01
UV-M2		0.01
UV-W2		0.01

Preliminary values

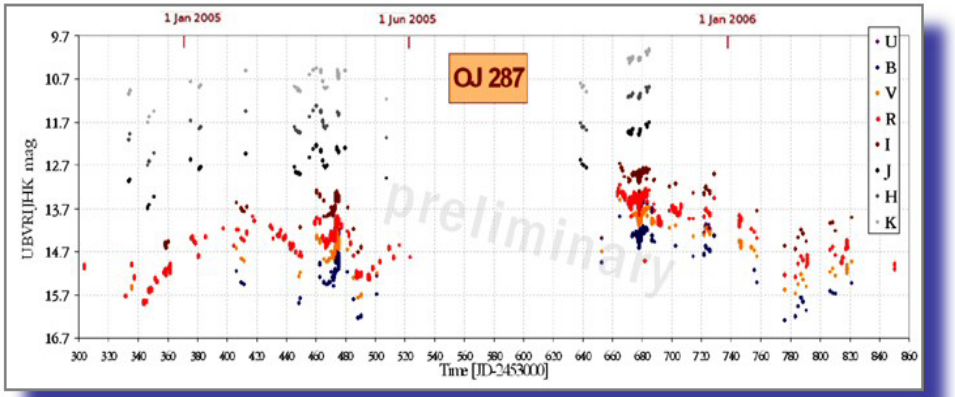
Nov.3-4, 2005: OJ 287 magnitudes

OM-band	MAG	ERR
V		0.01
B		0.01
U		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01
UV-W1		0.01

Preliminary values

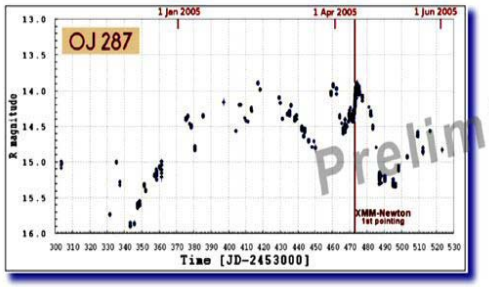
OJ 287: optical/NIR coordinated extended campaing: data galore!

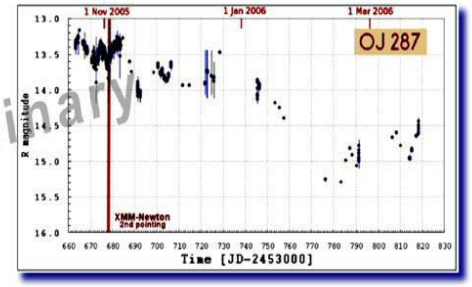
Extended-campaign/monitoring: some month around the 2 XMM pointing dates. 2 observing (night-time visibility) seasons. Part1 + part2, total period: Oct. 2004 – April 2006.



OJ 287: XMM pontings and part1+part2 optical light curves

During both the 2 GO XMM-Newton observations performed, OJ 287 was flaring in the optical bands. …*The source was not shy when observed by XMM!*



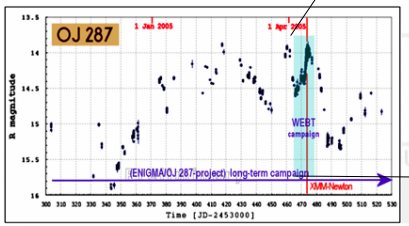


- Part 1 period data: Oct. 2004 - May 2005. Part 2 period data: Oct. 2005 – April 2006. Monitoring observations + intensive WEBT campaign around the 2 XMM-pointing date.
- Optical outburst and high brightness during the 2nd XMM pointing (Oct.-Nov. 2005).

OJ 287 part-1 MW campaign: optical light-curve

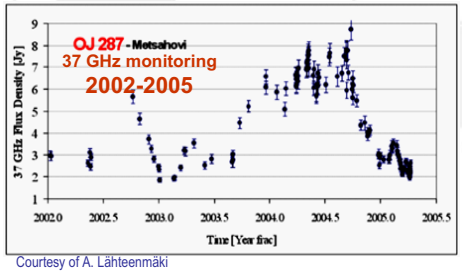
Oct. 2004 - May 2005. Monitoring observations + intensive WEBT core campaign (5 days, Apr. 10-14, 2005) around the 1st XMM-pointing date (April 12, 2005):

- Intermediate/high brightness level. Brightness increased of 2 mag in about 2.5 months.
- Optical flare during the pointing: increase of ~ 0.8 mag in 8 days, large drop of ~ 1.4 mag in 13 days.
- Apr.12: almost 0.3 mag brightness increase in less than 9 hours!

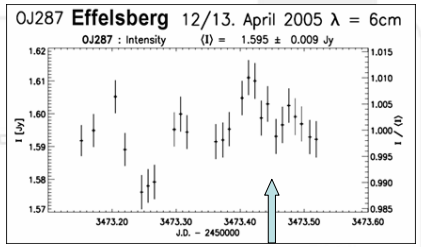


OJ 287 part-1 campaign: some radio observations

OJ 287: April 2005, radio flux and structure:

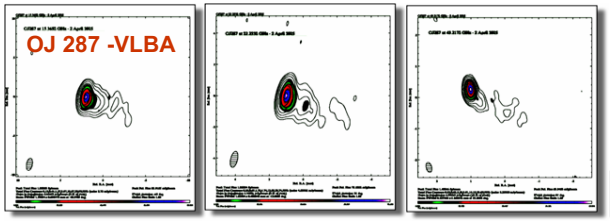


Courtesy of A. Lähteenmäki



Courtesy of L. Fuhrmann

IDV ~ 3%



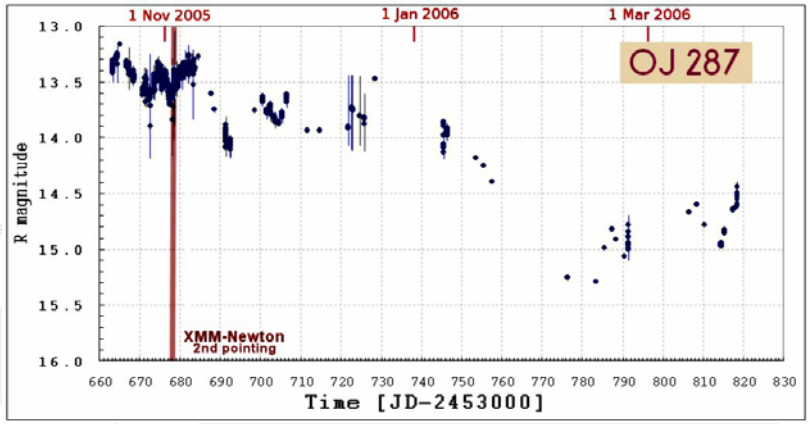
VLBA radio structure/polarization observations in 3 bands (April 2, 2005).

Courtesy of I. Agudo

OJ 287 part-2 MW campaign: optical light-curve

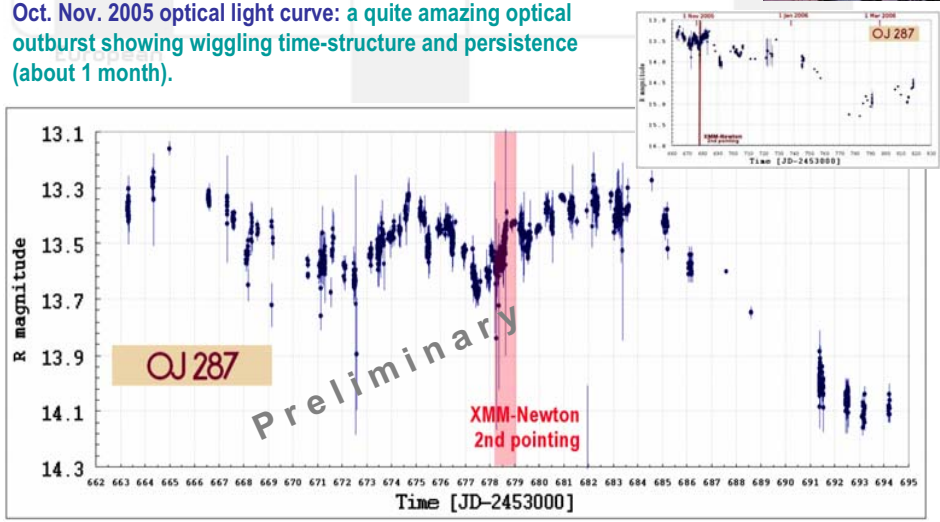
Oct. 2005 – Apr. 2006. Monitoring observations + intensive WEBT core campaign (about 20 days) around the 2nd XMM-pointing date (Nov.3-4, 2005):

- OJ 287 showed a persisting outburst (about 1 month, R-band peaks around mag=13.2/13.3) .



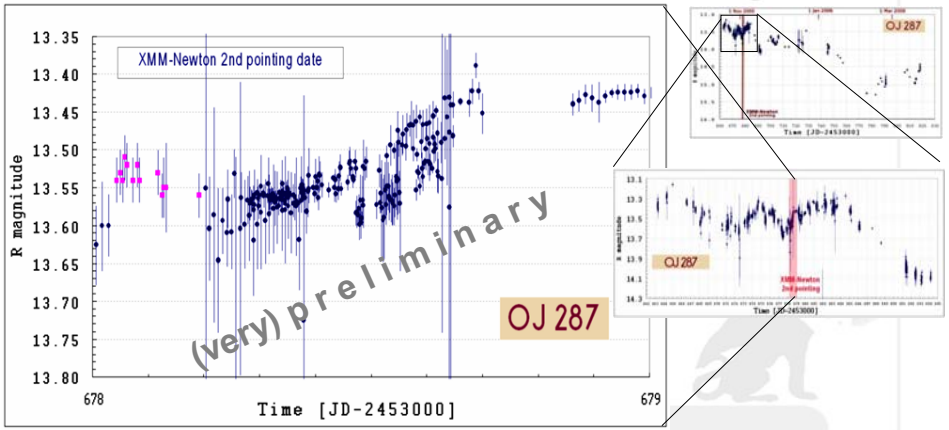
OJ 287 part 2 MW campaign: Oct.-Nov. 2005 optical surprise

Oct. Nov. 2005 optical light curve: a quite amazing optical outburst showing wiggling time-structure and persistence (about 1 month).



OJ 287 part 2 MW campaign: Oct.-Nov. 2005 optical surprise

Oct. Nov. 2005 optical light curve: optical brightness increasing during this 2nd XMM ppinting date too.



OJ 287 XMM-Newton MW-campaign: few comments

- The OJ 287 MW campaign was a challenge. It was the first time too. Much work needed: the XMM GO proposal (2 stages for each of the 2 proposals accepted); MW observations requests and tuning; information support-interaction with the ground based obs. (e.g. about 300 email received); reduction of satellite and optical data (about 3700 data points only in the R-band); data assembling; data analysis; results publication...
- MW campaigns are beautiful but do not forget: - time needed; - manpower; - possible and useful funding (data analysis and campaign management help).
- Reduced final radio data are easier to handle with respect to heterogeneous optical data coming usually from very different (professional and amateur) observatories.
- Optical data can better provide temporal variability information (light curves) because of the narrow spectral extension and long-term databases (3-4 time decades can be investigated).
- The long-term monitoring at radio/optical bands is important to characterize blazars variability on different timescales. Models profit of temporal variability information on several time decades, and of SEDs containing simultaneous radio-optical spectra.
- Satellite triggered campaigns are very appealing for ground-based observers (amateur or not).

Farewell

8th ENIGMA Meeting

Sept. 06-08, 2006 – Otaniemi, FINLAND