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## THE 1997 SUPEROUTBURST OF THE SU UMa-TYPE DWARF NOVA V2176 CYGNI

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This object was discovered as a new cataclysmic variable star (CV) by Hu et al. (1997) at  $m_R = 13.3$  and 13.5 on 1997 August 28 and 31, respectively, during the BAO supernova survey, and identified with USNO A1.0 1425.09823278 ( $\alpha = 18^{h}27^{m}11^{s}63$ ,  $\delta = +54^{\circ}17'51''.5$  (J2000.0),  $m_r = 19.9$ ,  $m_b = 20.3$ ). The spectrum they obtained on Aug. 31 showed Balmer absorption lines and weak HeI lines, typical features of CVs in outburst.



Figure 1. Overall light curve of V2176 Cygni during the 1997 superoutburst, derived from observations at N. Copernicus Observatory, CBA Belgium, CBA Denmark and combined with visual VSNET data

$JD_{start}$ 2450(	$JD_{end}$	Count	Filter	Station	$JD_{start}$ 2450	$JD_{end}$	Count	$\operatorname{Filter}$	Station
607 409 607 6F4		109	0	Dalaium	706 204	500	1	0	Danmanla
097.408	097.034	192	U	Беідіцш	100.294	_	1	U	Denmark
698.315	698.482	121	$\mathbf{C}$	$\operatorname{Belgium}$	706.348	706.677	299	$\mathbf{C}$	$\operatorname{Belgium}$
698.331	698.355	16	$\mathbf{C}$	$\operatorname{Denmark}$	707.269	707.439	117	R	$\operatorname{Brno}$
699.311	-	1	$\mathbf{C}$	Denmark	709.282	709.424	97	R	$\operatorname{Brno}$
699.320	699.425	31	R	$\operatorname{Brno}$	709.282	709.439	124	$\mathbf{C}$	Denmark
700.297	700.502	36	R	$\operatorname{Brno}$	709.396	709.526	96	$\mathbf{C}$	$\operatorname{Belgium}$
702.051	702.164	70	V	Ouda	712.258	712.474	139	R	$\operatorname{Brno}$
702.324	702.338	3	$\mathbf{C}$	$\operatorname{Denmark}$	710.280	710.450	100	$\mathbf{C}$	Denmark
702.336	702.661	262	$\mathbf{C}$	$\operatorname{Belgium}$	710.905	710.999	110	V	Ouda
703.109	703.157	29	V	Ouda	711.000	711.136	82	V	Ouda
703.415	703.579	112	R	$\operatorname{Brno}$	711.298	711.438	84	$\mathbf{C}$	Denmark
704.263	704.572	257	R	$\operatorname{Brno}$	711.405	711.671	196	$\mathbf{C}$	$\operatorname{Belgium}$
705.288	705.367	49	$\mathbf{C}$	Denmark	714.283	_	1	$\mathbf{C}$	Denmark
705.300	705.664	322	$\mathbf{C}$	$\operatorname{Belgium}$					

Table 1: Overview of the data. C means unfiltered CCD

The discovery of the variable was relayed to the VSNET mailing list by Kato (1997), which allowed several CCD observers around the world to immediately start monitoring of this newly discovered object. Figure 1 shows the overall light curve obtained from data sets of N. Copernicus Observatory, CBA Belgium and CBA Denmark. Since dwarf novae change their colors during an outburst only a little, we could quite easily calibrate the different observation systems used in the aforementioned observatories, after which the global light curve of Figure 1 was constructed. This curve is in good agreement with the data set presented by visual observers (included in a plot) on VSNET (Kato 1997).

The Brno data were obtained with a 0.40-m Newtonian reflector and an SBIG ST-7 CCD camera with Kron–Cousins R-band filter. Images were dark-corrected and flat-fielded, prior to starting differential aperture photometry, using the package Munidos, which itself is based on Daophot II (http://munipack.astronomy.cz). No filter was applied on final data and only some images were omitted because of bad weather conditions.

The Ouda data were obtained with the 0.60-m reflector and a Thomson TH7882 CCD camera through a Johnson V filter. We reduced the Ouda frames using an aperture photometry package developed by T. Kato, after the standard corrections of debiasing and flat-fielding.

Time-resolved and differential (variable – comparison) CCD photometry of V2176 Cyg was done at CBA Belgium using a 0.35-m f/6.3 Schmidt–Cassegrain telescope, mounted on an AstroTechniek FM-98 German equatorial mount, and equipped with a SBIG ST-7 CCD camera (Kodak KAF-0400 CCD for imaging and Texas Instruments TC211 CCD for guiding). For a complete description of the CBA Belgium Observatory equipment and software, see (Vanmunster et al. 2000).

An important feature in the overall light curve of the 1997 superoutburst of V2176 Cygni is the dip, which is followed by a rebrightening. A very similar behavior was also observed in AL Com (Nogami et al. 1997). The light curve of the 1996 outburst of AL Com was interrupted by a dip, showing a rate of decline of about 1 mag d<sup>-1</sup> (from visual observations). In the case of V2176 Cygni, the rate of decline is about 0.8 mag d<sup>-1</sup> (from the overall light curve presented in Figure 1). AL Com also showed a small dip just after the first one. This feature was not clear in our overall data (due to bad weather conditions). The run at JD 2450702 shows a rapid fading of the system (see Figure 2) which was followed by rebrightening, observed on the next night (Figure 3). Of course we do not now if this was a real dip, because important data during that phase are missing, but we can suspect a similarity in the case of V 2176 Cyg too.



Figure 2. Rapid decline after first dip as observed at CBA Belgium



Figure 3. Rising from probable second dip mentioned in the text as observed at CBA Belgium



Figure 4. Light curve with superhumps from Brno observatory

During the V2176 Cyg outburst, superhumps were detected, allowing the classification of this system as an SU UMa-type dwarf nova. Using the PDM (Stellingwerf, 1978) technique, we derived a superhump period value  $P = 0.056 \pm 0.003$  d using data presented at Figure 4. Founded period was in very good agreement with the one reported by Vanmunster (Vanmunster, 1997) as  $P = 0.0561 \pm 0.0004$  d. Unfortunately, the data obtained at all stations were too noisy to detect possible variations in the superhump period value, over the course of the outburst. Evidently, this should be the subject of further observations during future outbursts.

Between 1997 and the beginning of 2001, no further optical activity of V2176 Cygni has been reported, despite intensive monitoring by various groups of observers around the world. We therefore suspect that the system has a very long baseline for superoutbursts. This is a typical footprint of WZ Sge type variables. Given the large outburst amplitude (about 7 magnitudes) and the long recurrence time, combined with the observed light curve modulations and the dip, V2176 Cygni seems to be a very likely WZ Sge type candidate. Needless to say that this object is a very interesting target for further systematic study.

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