The GEOS RR Lyr survey: Analysis of light curve of the RR-Lyr star DY And

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Abstract

We analyse new observations of the under-studied RR-Lyr star DY And. These observations have been made between 2006 November 2 and 2008 November 28 with 20 to 30cm telescopes and CCD cameras. These observations allow to affine the period of the star and to set mean elements in agreement with former observations:

2454050.362 + 0.6030824 E

We show that a Blazhko effect exists with a period which remains to be determined but which might be of the order of 230 days. More observations are necessary.

1 Introduction

The variable star DY And is a RR-Lyr star of subtype RRab. GCVS (Kholopov et al., [1988]) in its 2008 web edition, gives the following data:
Coordinates: RA(2000.0)=23:58:42.16; DEC(2000.0)=+41:29:19.7.
Variation type RRab between 12.73 and 13.57 (V filter).
The GCVS elements are: 2450656.831 + 0.603087 E
The GCVS reference for these data is a "letter" from V.P. Tsesevich in 1958, which does allows to retrieve original publication. However, magnitude variations and elements have been improved between 2006 and 2008 GCVS editions. this improvements certainly do not correspond to Tsesevich's letter ! A reference to a finding chart is also given: Belyawsky ([1936]).

Recent designations of this star are GSC 03241-00213 and NSVS 3633664 (Wozniak et al., [2004]).

Very few references can be found in the litterature. DY And has been observed by Schmidt ([1991]) in the early 1990's. These observations are used again by Schmidt in two forthcoming papers (Schmidt, [1993] and Schmidt and Reiswig, [2002]). These are general purpose papers on variable stars in which a lightcurve with 16 observations may be found. Note that in his first paper Schmidt ([1991]) corrects the GCVS type RR to RRab and proposed a period of 0.6030 day instead of the old GCVS period of 0.604 day.

More recently, DY And has been observed by the Rotse-1 experiment the data of which are available on the NSVS web site (Wozniak et al., [2004]). Wils et al. ([2006]) analyse these data and propose the following elements: 2451521.65 + 0.60298 E

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Observer	instrument	Site
J.M. Llapasset	28cm Celestron 11, ST7XME SBIG CCD	Perpignan, France
J. Nicolas	28cm Celestron 11	Vallauris, France
P. de Ponthière	20cm LX200GPS Meade, ST-7XMEI SBIG CCD	Lesve, Belgium
M. Serrau	30cm	Rodez, France

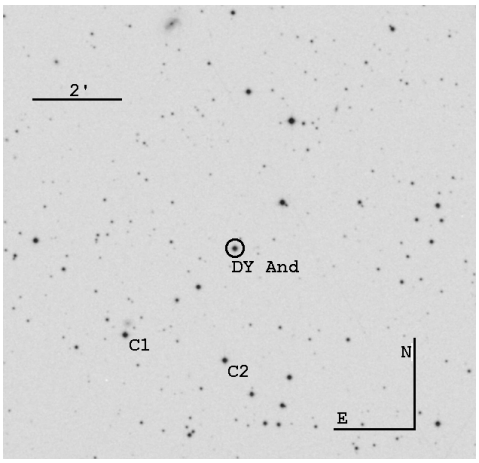

Table 1: Observers and instruments.

Observer	Date (beginning of night)	Julian day	Number of meas. C	V	R
J.M. Llapasset	2006-11-02	2454042	88	87	88
J.M. Llapasset	2006-11-03	2454043	121	86	63
J.M. Llapasset	2006-11-07	2454047	87	71	67
J.M. Llapasset	2006-11-09	2454049	123	122	149
J.M. Llapasset	2006-11-10	2454050	92	83	29
J.M. Llapasset	2006-11-13	2454053	114	109	112
J.M. Llapasset	2006-12-01	2454071	64	57	59
J.M. Llapasset	2006-12-10	2454080	178	168	163
J.M. Llapasset	2007-09-08	2454352	161	72	72
J.M. Llapasset	2007-10-12	2454386	124		
J.M. Llapasset	2007-10-13	2454387	118		
J.M. Llapasset	2007-10-15	2454389	72		
J.M. Llapasset	2007-10-19	2454393	87		
J.M. Llapasset	2007-11-08	2454413	46		
J. Nicolas	2007-11-17	2454422	126		
J. Nicolas	2007-12-01	2454436	129		
J. Nicolas	2007-12-04	2454439	153		
J. Nicolas	2007-12-13	2454448	256		
P. de Ponthière	2008-10-09	2454749		114	
P. de Ponthière	2008-10-10	2454750		114	
M. Serrau	2008-10-18	2454758	69		
P. de Ponthière	2008-10-18	2454758		87	
J.M. Llapasset	2008-10-20	2454760	224		
J.M. Llapasset	2008-10-26	2454766	310		
J.M. Llapasset	2008-11-15	2454786	245		
J.M. Llapasset	2008-11-16	2454787	208		
J.M. Llapasset	2008-11-17	2454788	142		
J.M. Llapasset	2008-11-19	2454790	200		
J.M. Llapasset	2008-11-28	2454799	151		
	total		3688	1170	802

Table 2: Journal of observations (selected data with $\Delta m < 0.05 mag.$). The last 3 columns contain the number of observation made through V or R filters or without filter (C)

	identification	RA(2000)	DEC(2000)	B	V	R
C1	GSC 3241-0012	23h58m55.13s	+41°27'21.8"	13.96±0.35	13.26±0.40	12.87±0.36
C2	GSC 3241-0054	23h58m43.22s	+41°26'49.7"	14.69±0.35	13.75±0.40	13.13±0.36

Table 3: Comparison star used by J.M. Llapasset and J. Nicolas.

2 New Observations and data reduction

DY And has been observed during 3 seasons, 2006 to 2008. Table 1 lists the observers and their instruments and sites. Table 2 gives the journal of the observations.
During the first season, Jean Marie Llapasset observed DY And between 2006 November 2 (JD2454042) and 2006 December 10 (JD2454080) using a 28cm C11 telescope and a SBIG ST7XME CCD camera. The measurements were made unfiltered and through V and R filters. The exposure times were 30s for unfiltered measurements and 90s for V and R filters. He made again unfiltered measurements in 2007 between September 12 (JD 2454352) and November 8 (JD 2454413) and between October 20 and November 28 in 2008.
In 2007, Joël Nicolas observed DY And, also with a 28cm C11 telescope, between November 17 (JD 2454422) and December 13 (JD 2454448). Less observations have been collected in 2008. In addition to J.M. Llapasset's 7 nights, Pierre de Ponthière observed 3 nights and Marc Serrau 1 night in October.
The 4 observers collected 3688 unfiltered measurements, 1170 through V filter and 802 through R filter. Some measurements were affected by variable sky conditions. As a consequence in the following reductions, the measurements are rejected when internal error is greater than 0.05 magnitude. The number of measurements are listed in table 2. The aperture photometry performed by J.M. Llapasset and

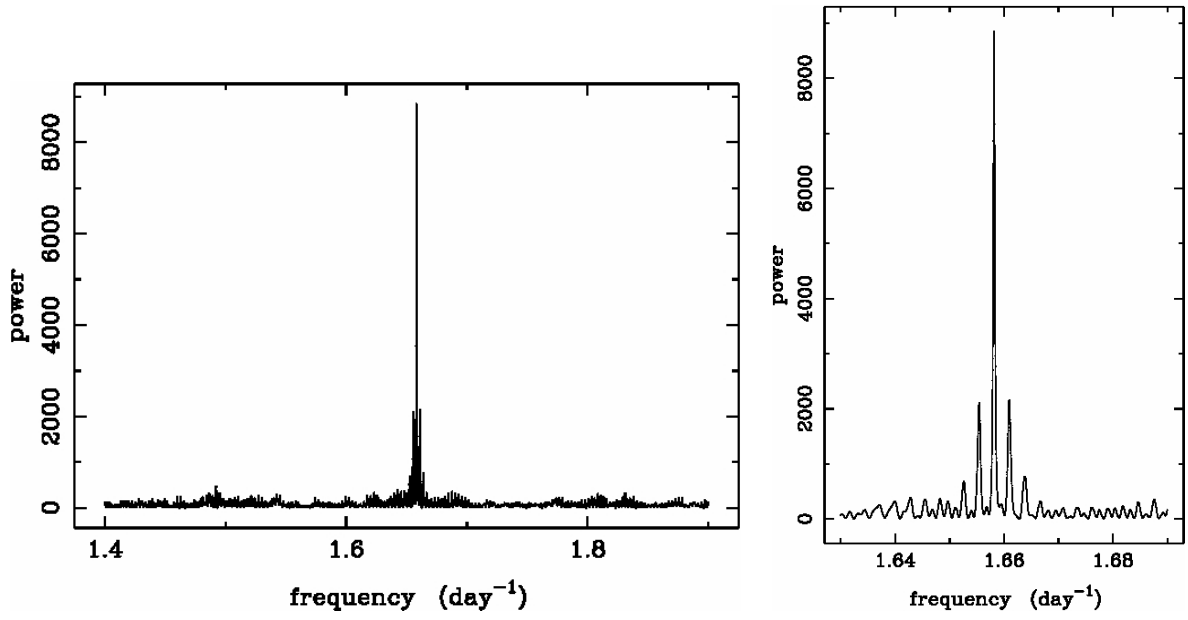

Figure 1: Periodograms.

J. Nicolas was performed on the variable star and on 2 comparison stars. The comparison stars, GSC 3241-0012 and GSC 3241-0054, are named here C1 and C2 respectiveley. Positions and photometric data from GSC catalog of the comparison stars are listed in table 3. The V magnitude is extracted from GSC

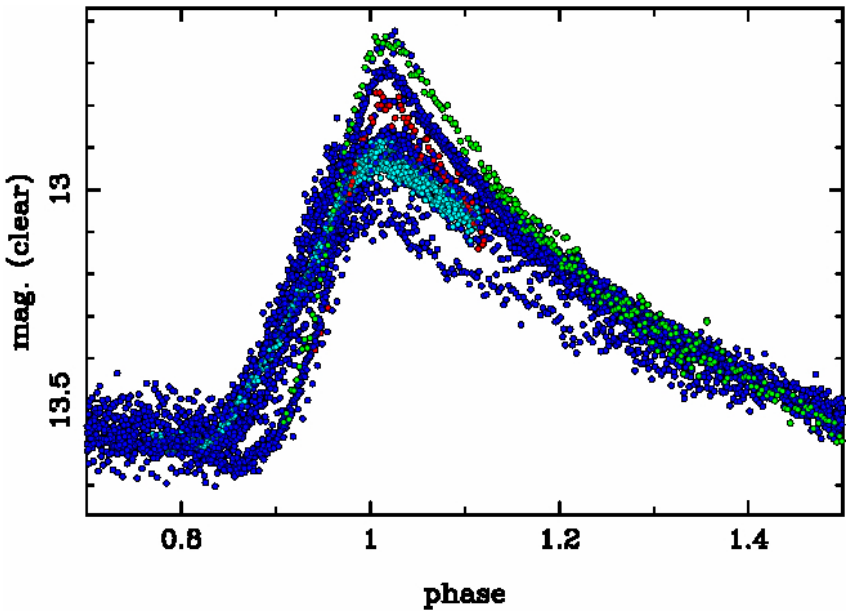

Figure 2: Folded light curve of "clear" data 2006-2008. Color coding: blue: J.M. Llapasset, turquoise: J. Nicolas. red: M. Serrau,

1.2 (Morrison et al., [2001]) and B and R from GSC-II. The finding chart in figure of table 2 shows the position of the variable star and comparison stars on an image from Digital Sky Survey. In the following, the magnitudes of DY And are computed from the difference of instrumental magnitudes relative to C1. The GSC-II R magnitude of C1 is added to DY And R measurements and the GSC 1.2 V magnitude to DY And V measurements, though the GSC magnitudes are given with a large photometric uncertainty.
P. de Ponthière used GSC 3241-486 as comparison star and GSC 3241-174 as check star. Each data point correspond to the stacking of 4 images, resulting an exposure time of 120s. The aperture photometry is done in a circle of a diameter of 5 pixels (7.04 arcsec).
M. Serrau calculated the variable magnitude by doing a linear regression on the magnitude of the stars GSC 2789.1773, GSC 3241.54, GSC 3241.486, GSC 3241.252 and GSC 3241.620. He used GSC 3241.22 as a check star.

3 Period analysis

In order to determine the present pulsation period, we performed a period analysis on the unfiltered data from 2006 to 2008. For this purpose, we computed periodograms by fitting multiharmonic Fourier series (Schwarzenberg-Czerny, [1996]) The result gives a frequency 1.65816 ± 1.710^{-4} c/d corresponding to a period of 0.60308 ± 610^{-5} day which is in very good aggreement with the period of the GCVS. The periodogram is diplayed in figure 1. The right panel is a zoom of left panel around the main frequency. The side peaks correspond to pullution of the main signal by the one year observation window and its harmonics. These peaks hide the possible Blazhko side peaks if the Blazhko period is greater than ∼100 days.
However, the folded light curve obtained with observations made with "clear" filter (figure **??**: elements 2454050.362 + 0.60308 E) show unambiguously a modulation of amplitude. We then tried to find the Blazhko period on the variation of magnitudes at maximum and O-Cs. Using O-Cs to find Blazhko period is not straight forward, since O-C also depend on the pulsation period we use. On

maximum HJD	mag. at maximum	O-C (day)	E	Observer
2454047.3420±0.0040	-0.3000	-0.0094	-567	J.M.Llapasset
2454050.3660±0.0050	-0.3320	-0.0008	-562	J.M.Llapasset
2454053.3750±0.0050	-0.3390	-0.0072	-557	J.M.Llapasset
2454352.5161±0.0019	-0.4900	0.0060	-61	J.M.Llapasset
2454386.2896±0.0026	-0.3910	0.0070	-5	J.M.Llapasset
2454387.4948±0.0022	-0.4220	0.0060	-3	J.M.Llapasset
2454389.3018±0.0017	-0.4110	0.0038	0	J.M.Llapasset
2454393.5257±0.0028	-0.4080	0.0061	7	J.M.Llapasset
2454413.4287±0.0028	-0.3910	0.0075	40	J.M.Llapasset
2454422.4693±0.0023	-0.3820	0.0019	55	J.Nicolas
2454448.3995±0.0020	-0.3300	-0.0004	98	J.Nicolas
2454750.5460±0.0030		0.0028	599	P. de Ponthière
2454758.3870±0.0040		0.0037	612	M. Serrau
2454787.3361±0.0018	-0.5580	0.0050	660	J.M.Llapasset

Table 4: Lists the observed maxima.

the contrary, the variation of amplitude and magnitude at maximum depends only on the modulation due to Blazhko effect. The disavatage is however that it depends on the phorometric precision and the analysis have to be done only with homogeneous photometric systems. We then plotted the magnitudes at maximum of the maxima observed by J.M. Llapasset and N. Nicolas because they both use similar devices and made the photomoetry in comparison with the same star.The values are listed in table 4 and plotted on the left panel of figure 3. According to the 2007 observations it seems that the period is greater than 100 days. Next, in order to make use of the maxima of 2006 and 2008

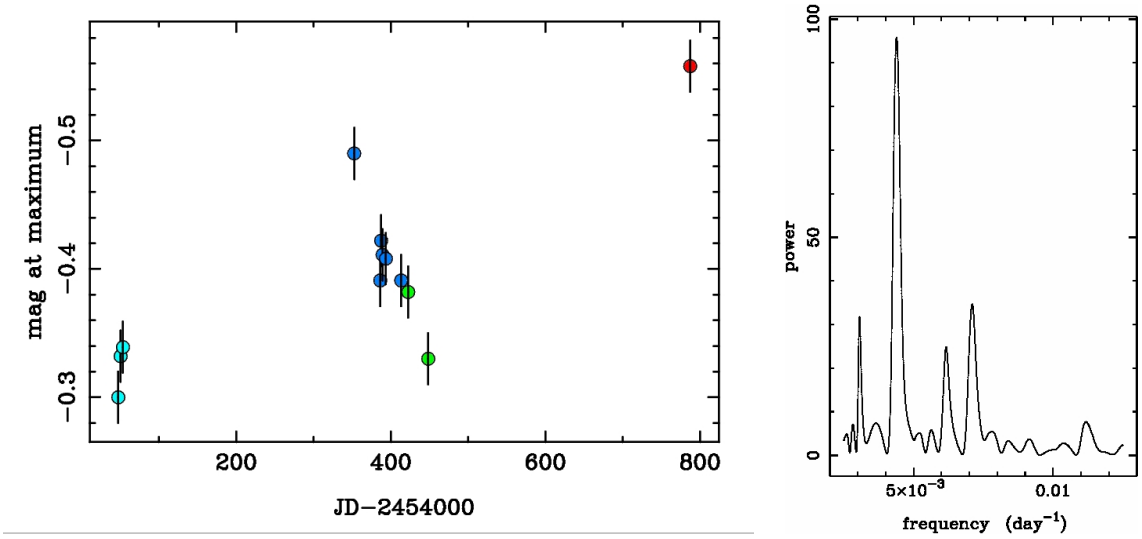

Figure 3: Amplitude modulation: variation of magnitude at maximum and corresponding periodogram.

seasons, we tentatively performed a periodogram analysis of these 12 maxima. The result is shown in the right panel of figure 3. A peak appears at the frequency 0.00439 day^{-1} which correpond to a pe-

riod of 228+-15 days (the uncertainty of the period is determined from the width of the peak on the periodogram). In Order to improve the pulsation period we plotted the O-C diagram (figure 4) includ-

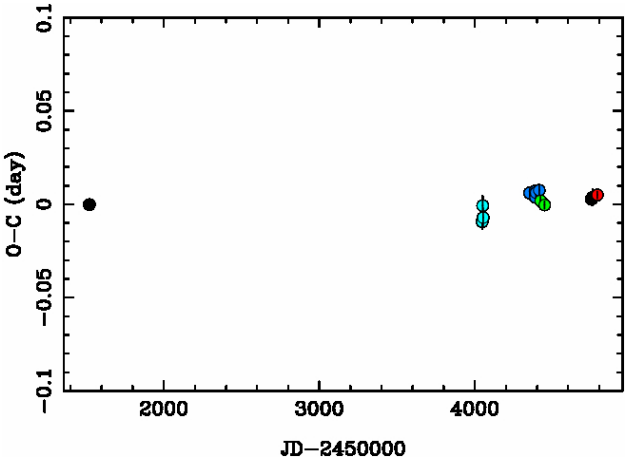

Figure 4: O-C versus time.

ing the mean maximum observed by Rotse and published by Wils et al. ([2006]) at HJD 2451521.650. this allows to refine the period to 0.6030805 and we eventually use the elements (see O-Cs in table 4):

HJD 2454389.298 + 0.6030805 E

The folded curves of O-C and magnitude at maximum with Blazhko period are shown in figure 5. Both O-C and magnitude at maximum seem to be compatible with a Blazhko period of 228 days. We note that the variation of O-C is quite small, while the modulation of amplitude is big. We also notice that the variation of O-C is not classical but its behaviour is not quite similar, however, to what de Ponthière et al (2009) found for CX Lyr.

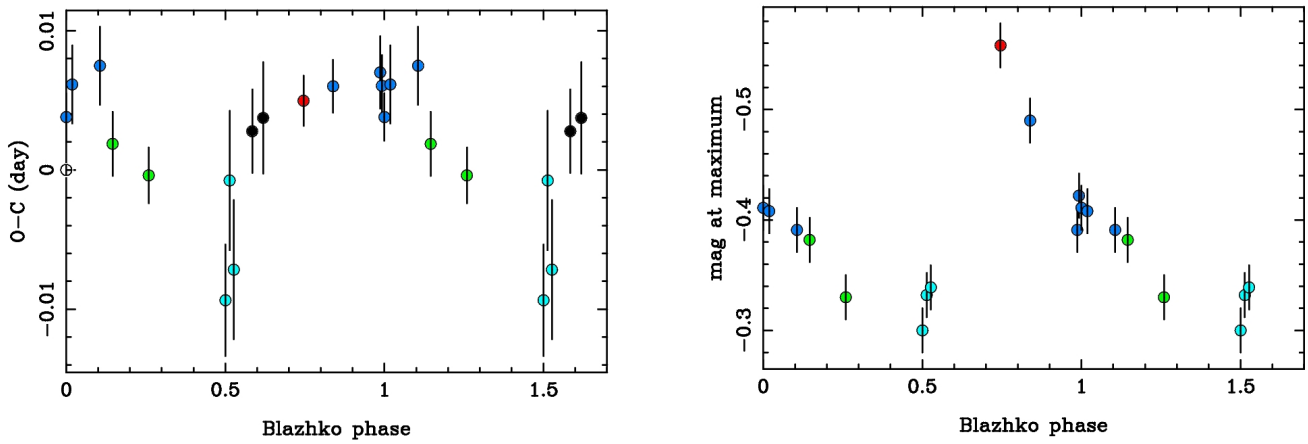

Figure 5: Blazhko effect: folded curves of O-C and magnitude at maximum with Blazhko period.

4 Filtered data

Finally we folded the filtered measurements done in 2006 by J.M. Llapasset (figure 6). "clear" data for the same period are also plotted. The V-R plot is the plot of the difference of magnitude measured

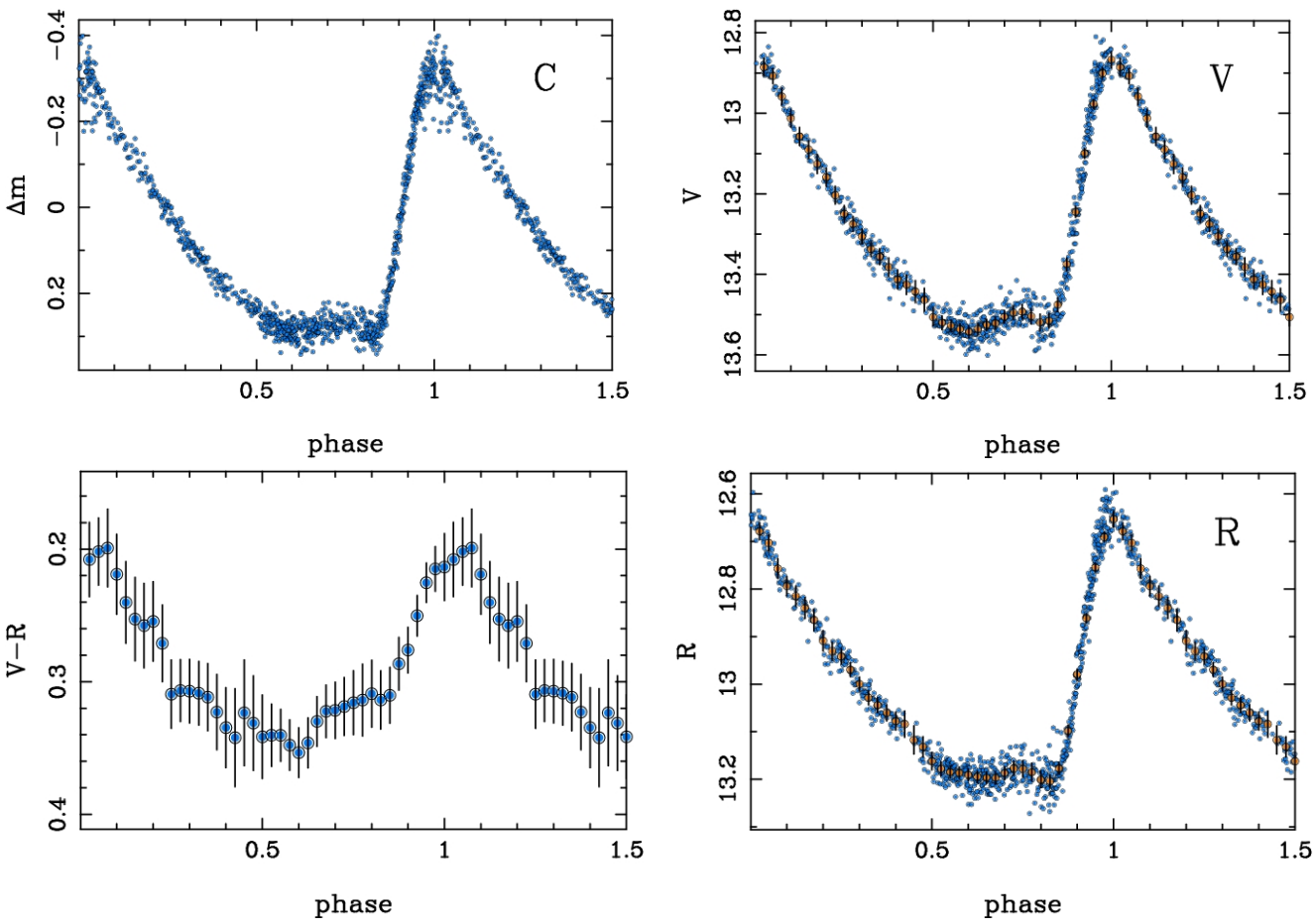

Figure 6: Folded lightcurves of filtered measurements done in 2006 by J.M. Llapasset. "clear" data for the same period are also plotted. The V-R plot is the plot of the difference of magnitude measured through V and R filters.

through V and R filters. To obtain the V-R folded light curve, we first computed the average of the V and R magnitude in intervals of 0.025 period and then made the difference of both. One note that these filtered data were obtained on during about one month and that no Blazhko effet was noticable. Accoding to figure 5 these observations were obtained during Blazhko minimum. The amplitude was 0.70 in V and 0.55 in R. We cannot determine the amplitude of the maximum observed in V by P. de Ponthière at JD 2454750 because the observations did not include the minimum, but we can say it was largely greater than 0.9 mag.

5 NSVS data

The NSVS (Northern Sky Variability Survey) server (http://skydot.lanl.gov/nsvs/nsvs.php) contains 248 mesurements of DY And from ROTSE-1 (http://www.rotse.net/). These mesurements were used by Wils et al. ([2006]) to compute the normal maximum 2451521.650 and to find a period of 0.60298 . Figure 8, left panel, shows the folded light curve obtained with Wils et al.'s elements. The right panel shows the Rotse data folded with the mean elements determined in the present paper.

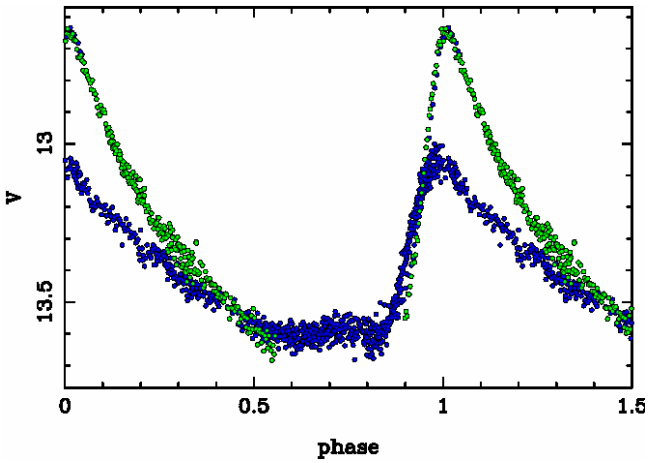

Figure 7: Folded light curve of V measurements by J.M. Llapasset in 1006 and P. de Ponthière in 2008. P. de Ponthière's points are in green.

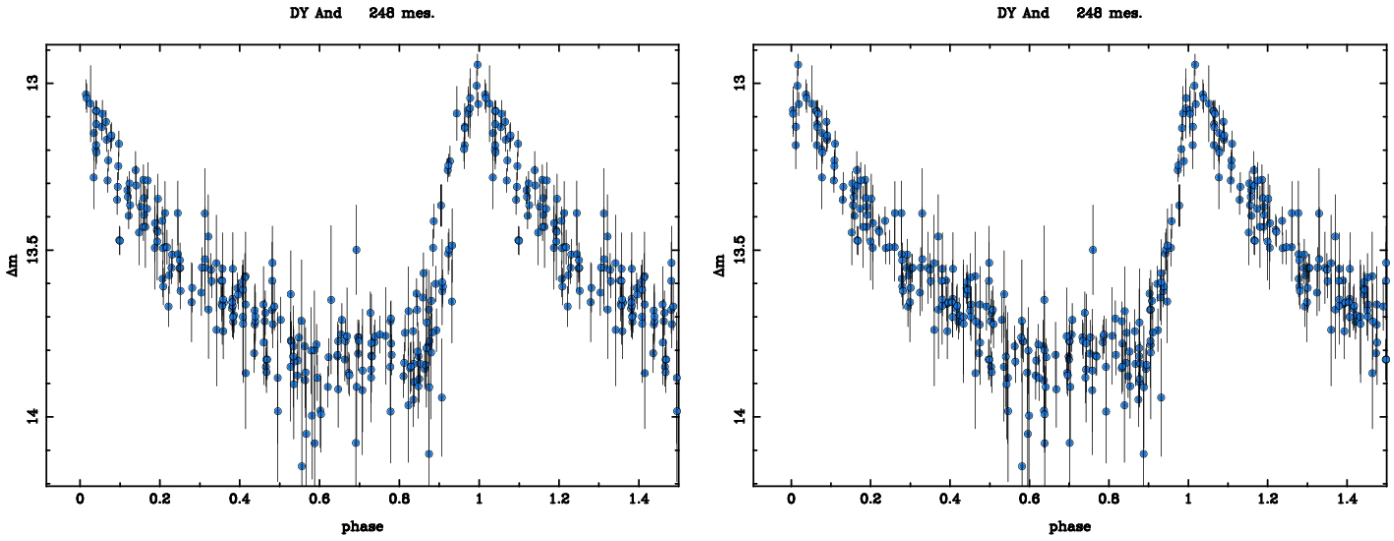

Figure 8: folded lightcurves of NSVS data

6 Acknowledgments

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References

[1936] Belyawsky S., 1936, VS 5, 36.

[1988] Kholopov, P. N., et al. 1988, General Catalogue of Variable Stars, Moscow: Nauka Publishing House, 1988, 4th ed., edited by Khopolov, P.N.,

[2001] Morrison J.E., Roeser S., McLean B., Bucciarelli B., Lasker B., 2001, A.J. 121, 1752

[1991] Schmidt E. G., 1991, AJ 102, 1766.

[2002] Schmidt E. G., 2002, AJ 123 965-982.

[1993] Schmidt E. G., Reiswig D. E., 1993, AJ vol. 106 2429.

[1996] Schwarzenberg-Czerny, A., 1996, ApJ 460, L107.

[2006] Wils P., Lloyd C., Bernhard K., 2006, MNRAS 368, 1757.

[2004] Wozniak P.R., Vestrand W.T., Akerlof C.W., Balsano R., Bloch J., Casperson D., Fletcher S., Gisler G., Kehoe R., Kinemuchi K., Lee B.C., Marshall S., McGowan K.E., McKay T.A., Rykoff E.S., Smith D.A., Szymanski J., Wren J., 2004, AJ, 127, 2436