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AW Cet, a RR Lyrae star with possible Blazhko effect

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Abstract: AW Cet has been observed during 23 nights. The GCVS does not list elements of this variable star and the ones in the AAVSO VSX database are based on the ASAS automatic survey. The present observing campaign was intended to verify the given elements and check the classification of this star as the available data prior to this study have been of low quality. A list of times of new maxima, the form of the light curve and results for a determination of period and epoch are given. In comparison to the dataset of ASAS and a single maximum of ROTSE we found improved elements. For AW Cet a period of P = 0.3376 ± 0.0010 [d] with the epoch E_0 = HJD 2455829.6963 ± 0.0056 and an amplitude of the light variation over a single period of Δm = 0.45 ± 0.05 mag has been found. The type of the star is RRc, but it also shows further variation of its maximum light as well as the time of maximum, which points to the possibility of a Blazhko effect. The database is still not dense enough to determine the Blazhko period which seems to be in the order of 20d. In the same field as AW Cet the star HMB22 = USNO-B1.0 0825-00672447 = VSX J025426.9-003400 has been found as a new variable star of type EA.

Introduction

AW Cet is a neglected RR Lyrae star which has been brought to our attention by G. Maintz (2011). The star does not have any elements in the GCVS. In the VSX database of the AAVSO elements based on the ASAS All Sky Survey are given. The position of AW Cet is at RA 02:54:03, Dekl. -00:25:12. Fig. 1 shows a finder chart with marks of both the comparison and check stars used in the data reduction.
According to VizierR of CDS, Strasbourg this star is listed in the GCVS (The GCVS Catalog (Vol. I-III), version 2011-May). The information is based on the work of J.S. Drilling (Drilling, 1973). As mentioned no period is given and as type only RR without specification of the subclass type ab, c or d.
As maximum brightness a value of 13.690 mag is given. In the GEOS RR Lyrae database (GEOS, 2008) only a single maximum at 2451398.082 is included for AW Cet based on data of ROTSE. The VSX database of the AAVSO lists a dataset (AAVSO, 2005) with an epoch E_0 = 2453670.379, a period P = 0.337362 and a type of RRc based on data from the All Sky Survey ASAS (ASAS, 2012).

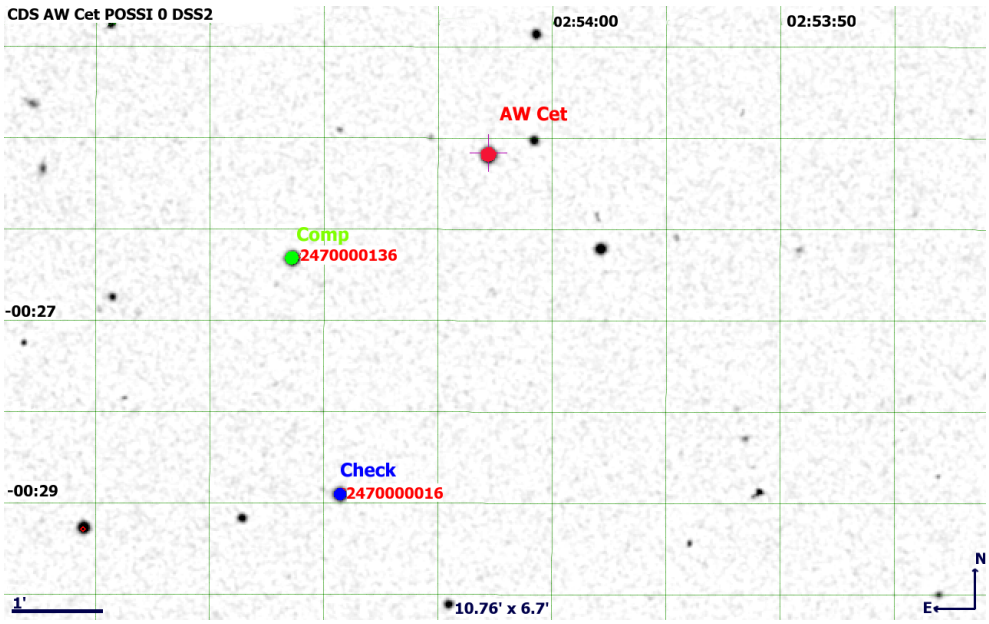

Fig. 1. Finder chart of AW Cet and identifications of comparison and check stars.

In the ASAS All Sky Survey database, three sets of data can be found. Figure 2 gives a distribution in time of those data, which show the very sparse coverage of AW Cet by ASAS. A calculation of the period with these data gives the following result:

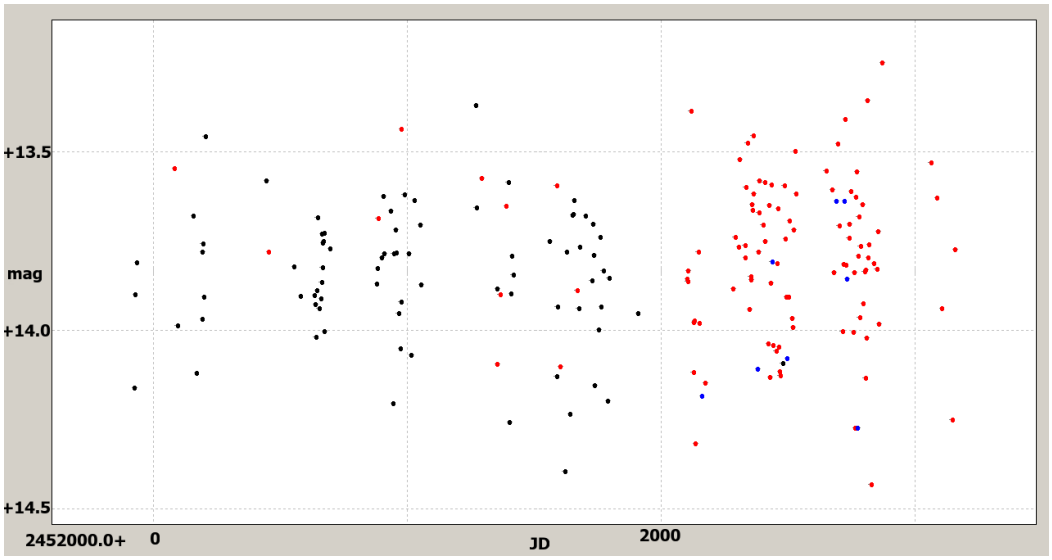

Fig. 2. ASAS datasets in PERANSO (Vanmunster, 2011) between JD 2452000 and 2455000

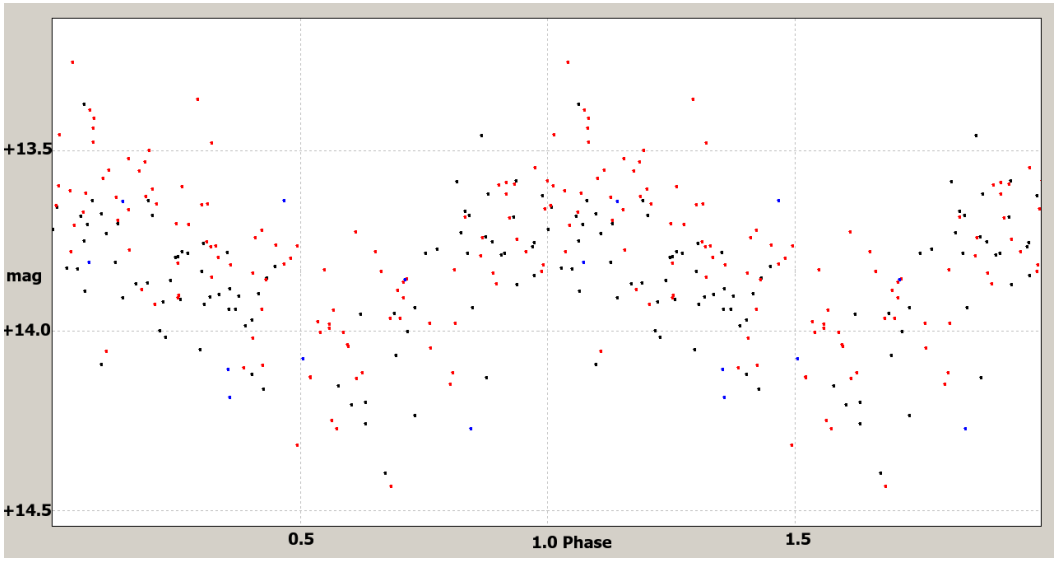

Fig. 3. Light curve of AW Cet resulting of the available ASAS data.

Epoch E_0 = 2451925.735 and period P = 0.3374 ±0.0001[d]. As shown in Fig. 3 the variation of the data is about ± 0.25 mag.

Observations

All data of AW Cet result from observations taken remotely at the Remote Observatory Atacama Desert (ROAD) in Chile and a shared AAVSOnet Observatory in Cloudcroft, New Mexico.

In total 23 times series were acquired between 24.09. and 20.10.2011.
A 40 cm f/6.8 Optimized Dall Kirkham (ODK) telescope equipped with a FLI 16803 CCD and a 30 cm Schmidt Cassegrain telescope with a ST9XME CCD camera, both with ASTRODON V photometric filters have been used.
The image exposure was 60 sec with the FLI16803 CCD camera and 120 sec with the ST9XME.
GSC 4700-0136 (V mag 13.53) was used as comparison star and as check star GSC 4700-0016 (V mag 13.9).
The magnitudes of the comparison stars are based on the NOMAD (2005) catalog accessed via VIZIER. Fig. 1 shows a finder chart for AW Cet including comp and check stars.
All images were V-filtered CCD images. The images were dark subtracted and flat fielded. The analysis in terms of absolute magnitudes was done using software developed by P. de Ponthierre (2010).

Maxima

From the observations these maxima times have been calculated and used:

HJD	variation	Max	±
T Observed	±	brightness	in mag
2455829.6963	0.005630	13.491	0.014
2455831.723252	0.00564	13.461	0.014
2455832.745393	0.0097	13.474	0.013
2455833.765743	0.00714	13.478	0.012
2455837.792799	0.0098	13.512	0.013
2455839.814079	0.00685	13.470	0.011
2455841.850527	0.00346	13.444	0.011
2455848.932432	0.00721	13.502	0.028
2455849.960123	0.00875	13.513	0.043
2455850.984602	0.00688	13.519	0.037
2455851.977520	0.00496	13.524	0.017

Tab. 1. Times of maxima given in HJD. The used method to determine the maximum time has been a polynomial fit of 5^{th} degree to the data using PERANSO.

The software PERANSO was used to analyze all light curves. For the period determination the Lomb-Scargle method in PERANSO was used. The maximum timings have been determined using a polynomial function. Fig. 4 shows the respective phase-diagram.

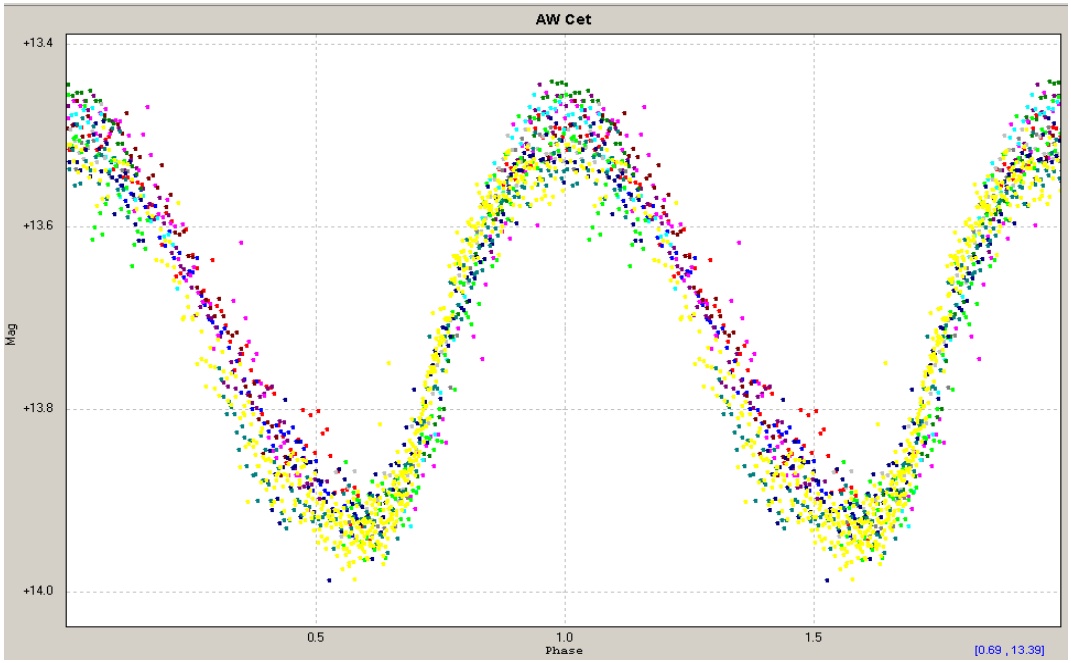

Fig. 4, Phase diagram (light curve) for AW Cet, each colour represents another observation set.

The deduced parameters for epoch and period are given as heliocentric elements:

Epoch: E_0 = 2455829.6963 ± 0.0056 HJD
Period: P = 0.3376 ± 0.0010 [d]
Amplitude of light variation: of Δm = 0.45 ± 0.05 mag
Maximum magnitude: M_{max} = 13.491 ± 0.025 mag

In total 1512 observations were used, that span about 29 days.

If we use the Epoch from the VSX given in the introduction, then the maximum of the phase diagram lies at about 0.94 for our data.

Based on the phase diagram it is obvious and supports the information given in the VSX database of the AAVSO, that AW Cet is a RRc type RR Lyr star.

Comparisons and O-C discussion

Source	HJD				O-C	Unc.
	T Observed	Unc . ±	T Calculated		O-C	in minutes	± in minutes
E_0	2455829.696300	0.005630	2455829.696300		0.000	0.000	8.1‘
VSX	2453670.379000		2453670.406700		-0.028	-39.888	
ASAS	2451925.735000	0.001	2451925.689900		0.045	64.944	1.4‘
ROTSE	2451398.082000		2451398.021100		0.061	87.696	

Tab. 2. Calculated times of maxima with E_0 = 2455829.6963 and P = 0.3376.

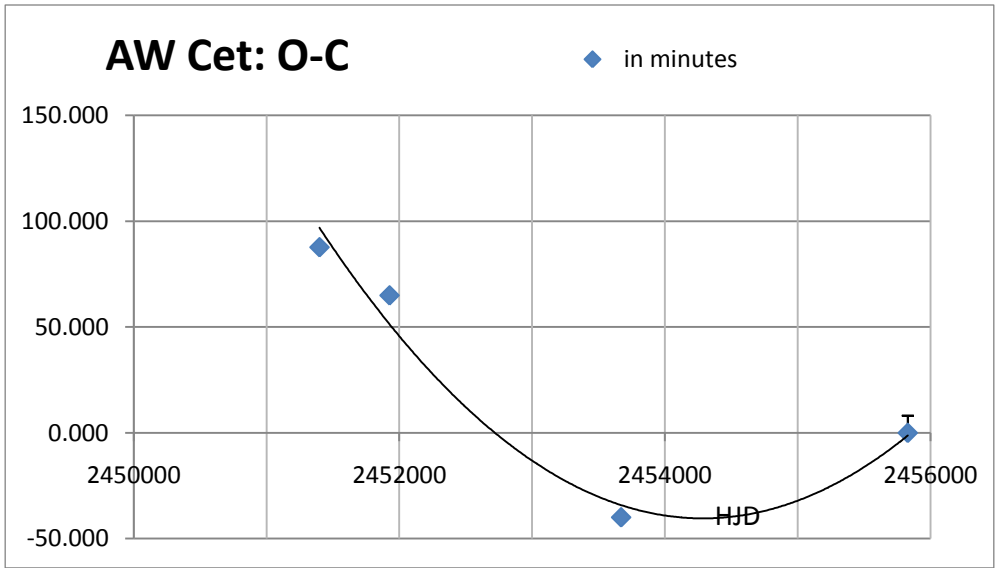

Fig. 5. Calculated (O-C) values in minutes based on elements listed in Tab. 2.

Fig. 5 shows the four values given in Tab. 2 versus the calculated O-C values based on the determined period and Epoch. The points are connected with a parabolic function as it seems that the period might have been changed during the about 7 years of coverage. However, this could also be due to the rather scattered data as one can see e.g. from the ASAS survey as given in Figs. 2, 3. Nevertheless a parabolic curve gives a better representation of the data.

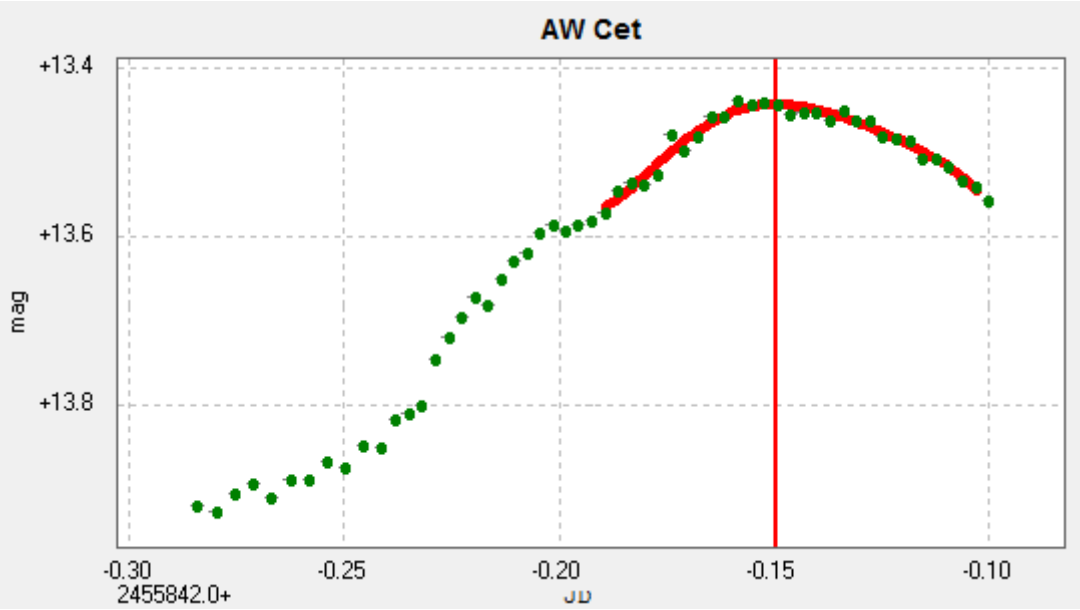

Fig. 6. A typical night's observation of AW Cet with the fit (red line) to determine the time of maximum. Also a shoulder is visible in the rising part of the light curve.

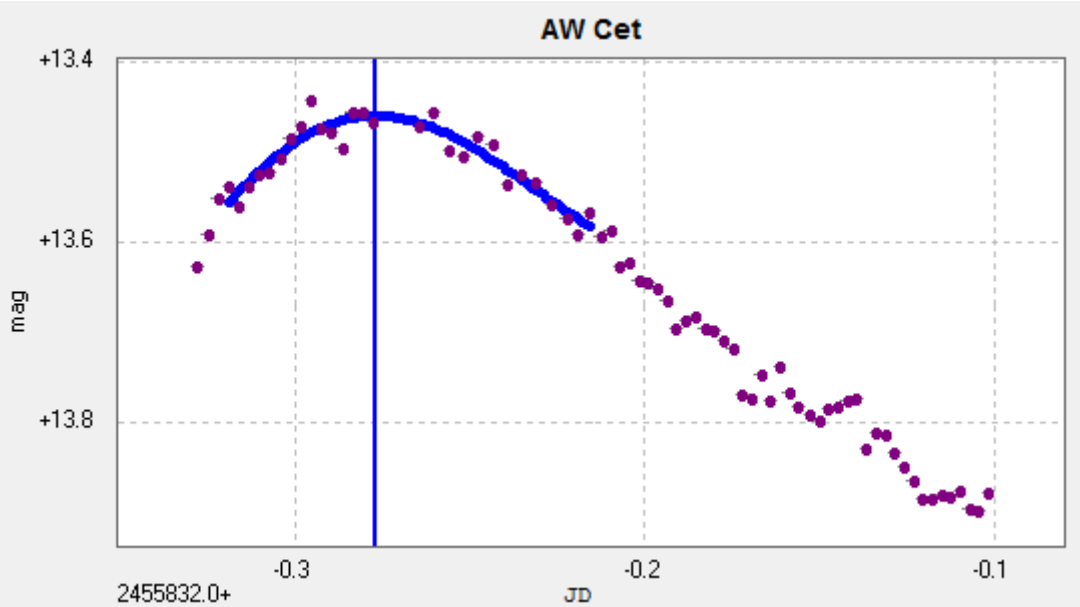

Fig. 7. Another typical night's observation of AW Cet with the fit (blue line) to determine the time of maximum.

Fig. 6 and 7 show typical nights observations and the quality of the data. Hence, the visible scatter in Fig. 4 is not due to a scatter in the data for individual nights, but has another reason.

BLAZHKO Effect

The phase diagram in Fig. 4 shows that the maximum magnitudes are scattering over a range of 0.1 magnitudes. Also the times of maxima vary slightly as can be seen from Tab. 3 and the respective O-C diagram given in Fig. 8.

HJD					O-C	
T Observed	±	T Calculated		O-C	in minutes	± in '
2455829.695618	0.00563	2455829.696300		-0.000682	-1.0	8.1
2455831.723252	0.00564	2455831.721900		0.001352	1.9	8.1
2455832.745393	0.00970	2455832.734700		0.010693	15.4	14.0
2455833.765743	0.00714	2455833.747500		0.018243	26.3	10.3
2455837.792799	0.00980	2455837.798700		-0.005901	-8.5	14.1
2455839.814079	0.00685	2455839.824300		-0.010221	-14.7	9.9
2455841.850527	0.00346	2455841.849900		0.000627	0.9	5.0
2455848.932432	0.00721	2455848.939500		-0.007068	-10.2	10.4
2455849.960123	0.00875	2455849.952300		0.007823	11.3	12.6
2455850.984602	0.00688	2455850.965100		0.019502	28.1	9.9
2455851.977520	0.00496	2455851.977900		-0.000380	-0.5	7.1

Tab. 3. Observed versus calculated maxima times with E_0 = 2455829.6963 and P = 0.3376.

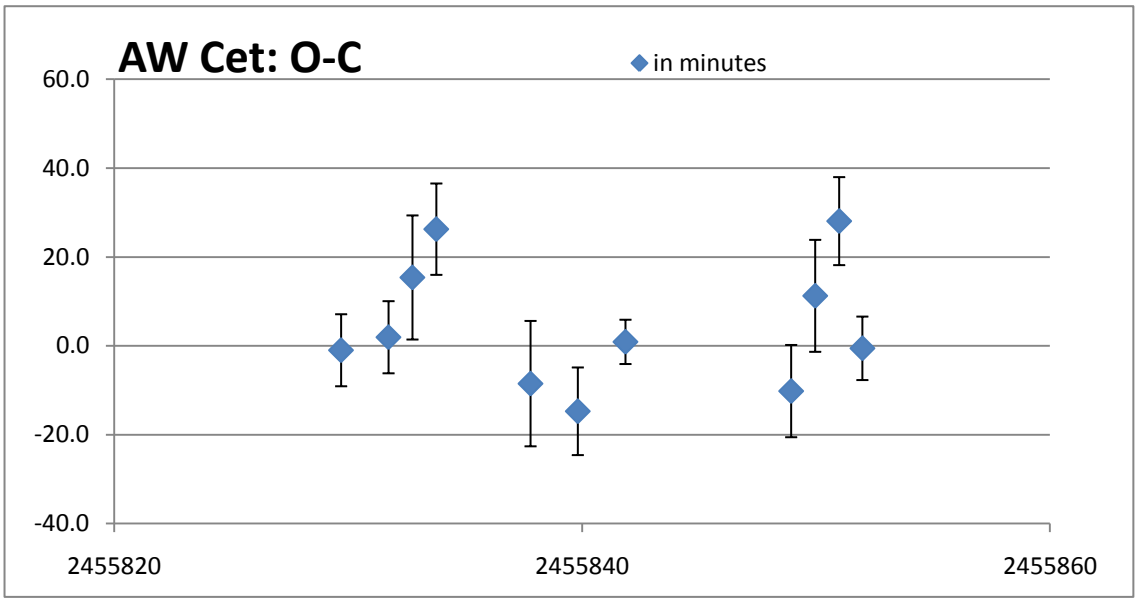

Fig. 8. Calculated (O-C) values in minutes with our new elements.

The O-C values have a range of ± 20 min. This cannot be explained with a scatter in the data of individual nights as can be seen in Fig. 6, 7. A possible explanation could be the so-called Blazhko effect quite commonly observed for RRab type RR Lyrae stars. This effect modulates both the time of maximum and magnitude at maximum in a periodic way. The Blazhko effect for RRc stars is rather rare and a final conclusion can only be drawn if more observations are available. Based on the distribution of the O-C data from Fig. 8 one could deduce a possible Blazhko period around 20 d, but further observations are needed.

Possible new variable star in this field

The star HMB22 = USNO-B1.0 0825-00672447 = VSX J025426.9-003400 (= GSC2 S00200032697) at RA: 02 54 26.94 and DEC: -00 34 00.9 has also been identified to be variable. This star has been found by MUNIWIN's (Motl, 2006) all-star variation detection. The photometric analysis has been more difficult than for the main target, because the exposure time has been rather short as this star is much fainter.

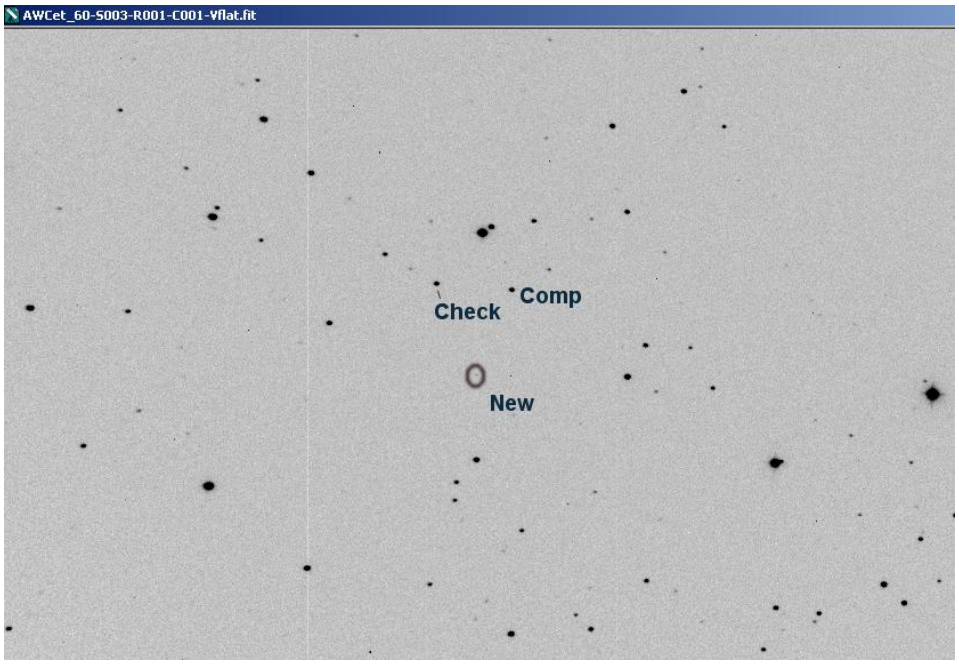

Fig. 8. Finder chart for HMB22 = USNO-B1.0 0825-00672447 = VSX J025426.9-003400.

For differential photometry the star HMB22 = USNO-B1.0 0825-00672447 = VSX J025426.9-003400 was identified with an astrometric plate solution by THELI (Schirmer, 2012), and reading the USNO online catalogue with Skycat (ESO, 2012). As comparison star GSC 4700-0453 (V band 14.06 mag) has been used and as check star GSC 4700-0555 (V band 13.95 mag). Magnitudes are again based on the NOMAD catalog. For identification in the GSC2 the new variable star is listed as S00200032697 (16.34 mag), the comparison stars are listed in the GSC catalogue.

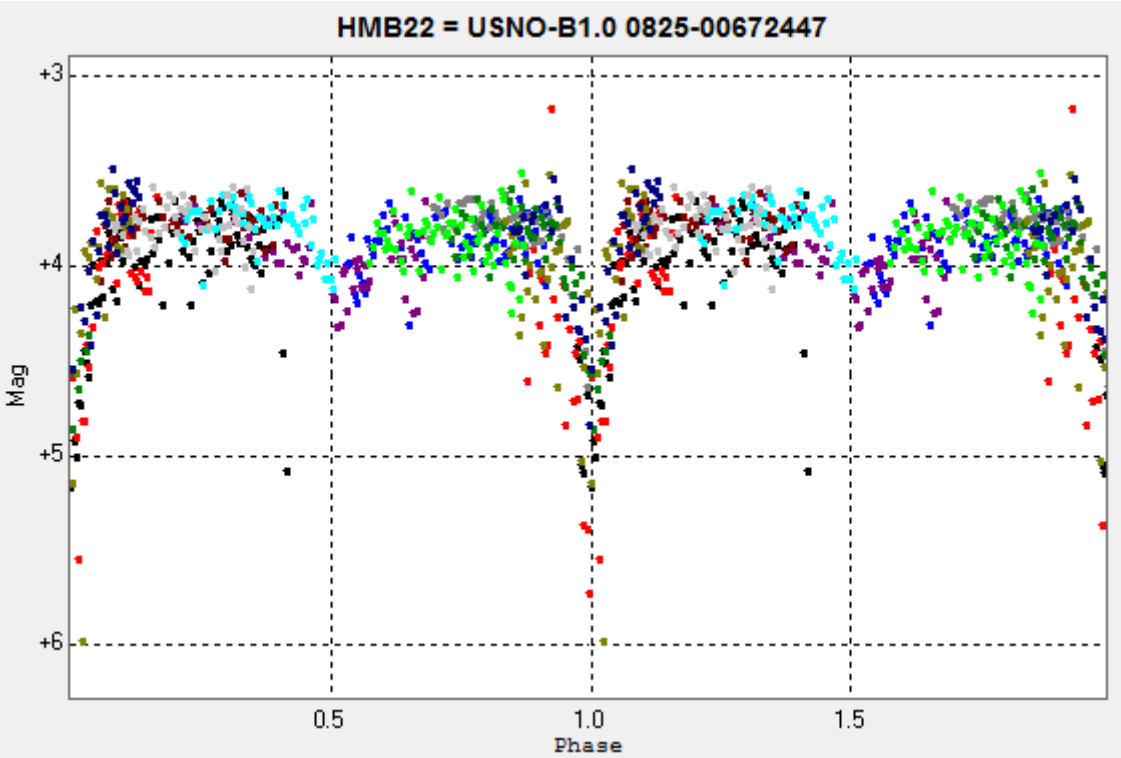

Fig. 9. Phase diagram (light curve) for HMB22 = USNO-B1.0 0825-00672447 = VSX J025426.9-003400, each colour represents another observation set. The brightness is not absolute.

The deduced parameters for epoch and period are given as heliocentric elements:

Epoch: E_0 = 2455829.6700 ± 0.00465
Period: P = 0.56786 ± 0.0067 [d]
Amplitude of light variation: of Δm = 1.0 ± 0.3 mag
Minimum magnitude: M_{min} = 17.3 ± 0.3 mag

In total 651 observations were used, that span about 26 days. Based on the phase diagram (Fig. 9) of the new variable it is evident that it is an eclipsing binary of EA type. We lately got to know, that this new variable star might be covered by SDSS and it would be helpful to compare it to those magnitudes.

Acknowledgements:
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