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NEW V(RI)$_{\rm C}$ PHOTOMETRY OF SW LACERTAE AND AB ANDROMEDAE

DEREKAS, A.; KISS, L.L.; BEBESI, ZS.

Department of Experimental Physics and Astronomical Observatory, University of Szeged,
e-mail: l.kiss@physx.u-szeged.hu

In this note we present new CCD observations of two frequently observed close eclipsing binaries. The target stars, SW Lacertae (HD 216598, sp. type K0V, $V_{\rm max}$ ≈8.6 mag, P≈0.3207 d) and AB Andromedae (SAO 73069, sp. type G5V, $V_{\rm max}$ ≈9.6 mag, P≈0.3319 d), are known to exhibit strongly changing periods (SW Lac: Pribulla et al. 1999; AB And: Kalimeris et al. 1994). Furthermore, both stars show significant variations in the light curve shapes suggesting the presence of spots on the stellar surfaces (SW Lac: Pribulla et al. 1999; AB And: Djurašević et al. 2000). Therefore, continuous observations are needed to follow short- and long-term variations, either the period or the light curve shape is considered.

Our new data were acquired on seven nights in October, 2001, using the 0.4m Cassegrain-type telescope of Szeged Observatory. The detector was an SBIG ST–9 CCD (512×512 pixels) equipped with standard $V(RI)_{\rm C}$ filters. SW Lac was observed on four nights (Oct. 7, 12, 13 and 14), while AB And on three nights (Oct. 22, 23 and 27). As a result, full phase coverage was reached for both stars. The exposure time varied between 10 and 30 seconds, depending on the actual target brightness and weather conditions.

The data were reduced with standard tasks in IRAF[1]. We made aperture photometry with IRAF/DAOPHOT. The comparison and check stars were as follows: SW Lac – comp=GSC 3215-1586, check=GSC 3215-0906; AB And – comp=GSC 2763-0683, check=2763-0878. While the magnitude differences of the comparisons for AB And were constant within ±0.02 mag in all three bands, we found slightly changing data for the comparisons of SW Lac. Sample differential light curves obtained on Oct. 7, 2001 are shown in Fig. 1. The amplitude decrease with the increasing wavelength is characteristic for a pulsating variable. In order to determine which comparison is the variable one, we performed follow-up observations in V-band on December 8, 2001. The longer exposure times (50 to 90 seconds) allowed the use of many fainter field stars as additional comparisons. The measurements covering almost 6 hours revealed that the check star (GSC 3215-0906) changed its brightness on that night by about 0.05 mag. Thus, we conclude that it is a variable star and its use as comparison (or check star, as used by Borkovits & Bíró 1998 and Nelson 2000) for SW Lac should be avoided. Further observations are needed to clarify its real nature.

[1]IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

Table 1: New times of minimum for SW Lac and AB And

MJD_{min}	min	Filt.	MJD_{min}	min	Filt.
SW Lac			2452196.4256	I	V
2452190.3326	I	V	2452196.4266	I	R
2452190.3331	I	R	2452196.4255	I	I
2452190.3329	I	I	2452197.2274	II	V
2452190.4936	II	V	2452197.2279	II	R
2452190.4937	II	R	2452197.2280	II	I
2452190.4932	II	I	2452197.3869	I	V
2452195.3037	II	V	2452197.3880	I	R
2452195.3040	II	R	2452197.3885	I	I
2452195.3043	II	I	AB And		
2452195.4637	I	V	2452205.3345	I	V, R, I
2452195.4651	I	R	2452205.5026	II	V, R, I
2452195.4636	I	I	2452206.3326	I	V, R, I
2452196.2660	II	V	2452206.4982	II	V, R, I
2452196.2662	II	R	2452210.3151	I	V, R, I
2452196.2653	II	I	2452210.4806	II	V, R, I

The pure instrumental data were standardized in the usual way (e.g. Henden & Kaitchuk 1982) and the resulting differential photometry is available at the IBVS website (1498 and 692 individual points for SW Lac and AB And, respectively). The $(V - R_C)$ and $(V - I_C)$ colour indices were calculated for the epochs of V points by linear interpolation of the neighbouring R_C and I_C data. We show the obtained standardized light and colour curves in Fig. 2, where the data were phased using the updated periods taken from Pribulla et al. (2001).

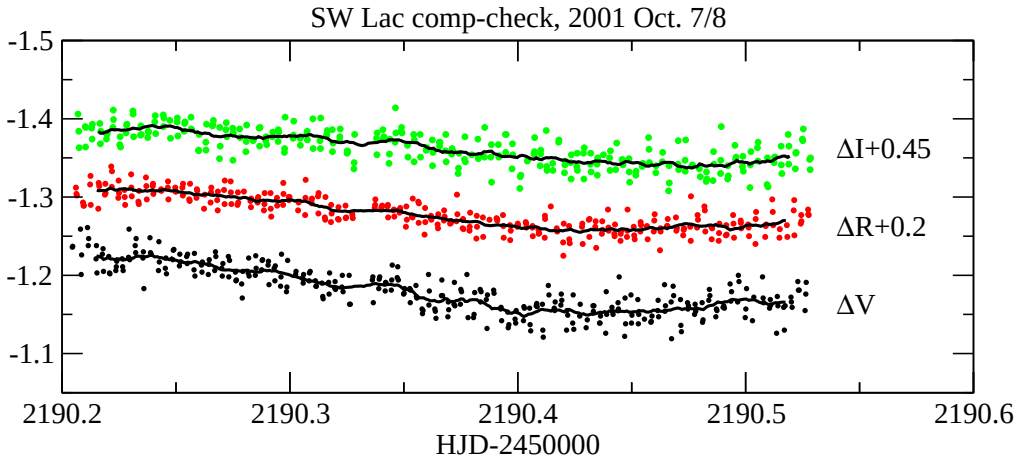

Figure 1. Differential light curves of the comparison stars of SW Lac. The solid lines denote running averages (binning length: 20 points).

In order to check the present status of the period change for SW Lac and AB And, we have updated their $O - C$ diagrams. For this purpose, 42 new times of minimum were determined from the original instrumental differential $V(RI)_C$ data by fitting low-order (4−5) polynomials to the lowest parts of the light curves. In order to check the

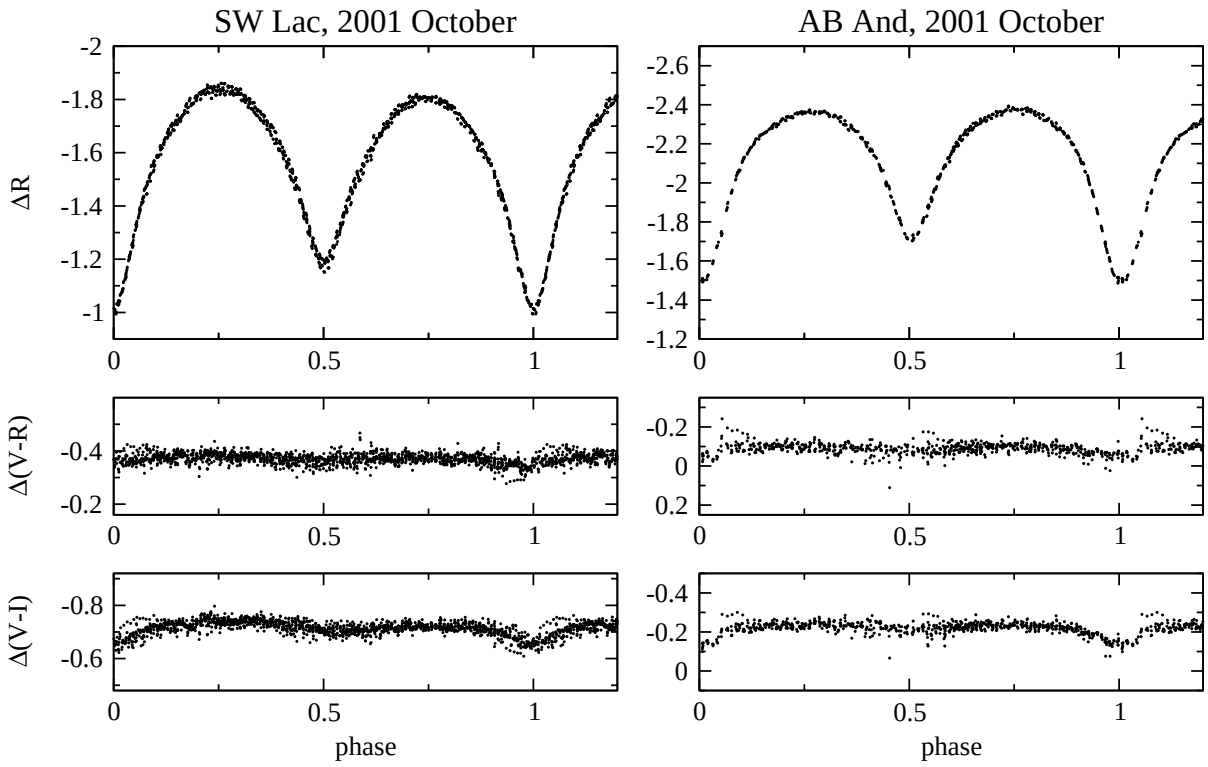

Figure 2. Standardized light and colour curves of SW Lac (HJD_0=2452190.3326) and AB And (HJD_0=2452205.3350).

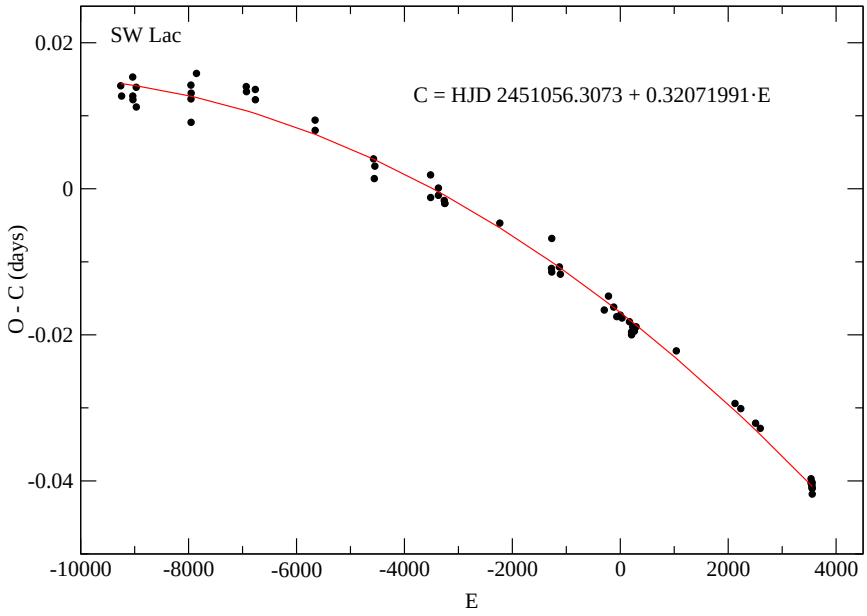

Figure 3. The $O-C$ diagram of SW Lac between 1990 and 2001. The ephemeris was taken from Pribulla et al. (1999), while the individual epochs of this diagram are available electronically at the IBVS website.

presence of some systematic differences between the epochs in different photometric bands, we have calculated the mean differences for both stars. The results for SW Lac are $\langle \mathrm{min_V} - \mathrm{min_R} \rangle = -55 \pm 38$ s and $\langle \mathrm{min_R} - \mathrm{min_I} \rangle = +35 \pm 57$ s, indicating that there is a tendency for earlier minima in V than in R, and I minima are simultaneous with R within the uncertainty limit. No significant differences which exceed the observational errors was found in the case of AB And. Table 1 lists the mean of the minima times of the $V(RI)_c$ observations for AB And, and the $V(RI)_c$ minima times separately for SW Lac.

Since the most recent period update was published by Pribulla et al. (2001), we compared our epochs to predictions based on their elements (numbers in parentheses). The mean $O-C$ values are the following: SW Lac (P=0.32071510 d, $\mathrm{MJD_0}$=51056.2896) $\langle O-C \rangle = -0.0062$ d (≈ -9 min); AB And (P=0.33189106, $\mathrm{MJD_0}$=51534.2504) $\langle O-C \rangle = +0.0020$ d ($\approx +3$ min). Longer $O-C$ diagrams covering the last 10 years revealed that the period of SW Lac has been continuously decreasing (well-defined downward parabola, as shown in Fig. 3). Contrary to SW Lac, AB And had constant period in the last decade (see Pribulla et al. 1999 and Borkovits & Hegedüs 1996 for discussions of the long-term behaviour). We conclude that the latest ephemeris given by Pribulla et al. (2001) for AB And is still applicable, while for SW Lac one should include the long-term behaviour of the period change into the predictions with the following quadratic elements:

$$HJD_{\mathrm{min}} = 2451056.2903 + 0.32071414(65) \cdot E - 2.57(30) \cdot 10^{-10} \cdot E^2$$

The light curve of SW Lac clearly shows the magnitude difference between the maxima (δV=0.05 mag, δR_{C}=0.04 mag, δI_{C}=0.03 mag), which is usually attributed to stellar spots on the components. A spot-fitting analysis is beyond the scope of the present paper, here we only note that BV photometry obtained in 1997 (Kiss et al. 1999) yielded such light curves, which showed larger asymmetries (δV=0.10 mag). For AB And, δV=0.02 mag, δR_{C}=0.02 mag, δI_{C}=0.01 mag and significant asymmetries of the minima were found, suggesting similar spot activity in 2001 as found by Djurašević et al. (2000) for 1990 (see their Fig. 1). A detailed analysis will address the long-term evolution of spot activity for both stars, for which follow-up observations are planned in the next few years.

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