COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5574

Konkoly Observatory
Budapest
12 November 2004

HU ISSN 0374 – 0676

DIFFERENTIAL PHOTOMETRY OF AW Vir IN APRIL 2004

ZBORIL, M.[1]; DJURAŠEVIĆ, G.[2]

[1] Astronomical Institute, Tatranská Lomnica, 059 60, Slovakia, e-mail: zboril@astro.sk

[2] Astronomical Observatory, Volgina 7, 11160, Belgrade, Yugoslavia and
Isaac Newton Institute of Chile, Yugoslav branch

The solar analogy of activity has been widely studied on a variety of active late-type stars. Here we present the study of activity centers (spots) on W-type overcontact binary AW Vir.

AW Vir (GSC 00303-00887,F8, m_V=11.0) is an eclipsing binary on which the photographic variability was reported in 1935 (Hoffmeister 1935). Since then, few both photoelectric and CCD observations have been made to obtain the minima times (2002 data, e.g. Agerer & Hubscher 2003). Detailed light curve analysis was made by Niarchos et al. (1997), who derived the mass ratio q, the masses and radii of components and found one cool spot on the primary (more massive and cooler) component (February 1982 dataset). Qian (2003) paid attention to the period changes of the system ($\sim 10^{-8}$ d.y^{-1}) and introduced a quadratic term in the minima ephemeris. He still found the $O-C$ diagram considerably scattered. We obtained new observations in April 2004 to fill in the gap in the observations and to continue tracing the activity signatures (spots) on this system. Such studies are important as the tidal effects on spots should be present on systems similar to AW Vir and, in addition, magnetic-induced activity cycles (magnetic flux tubes evolution) are of interest as well. The star was monitored during the spring season 2004 using the 0.6m telescope at Stará Lesná Observatory equipped with a single channel photometer.

Table 1: The log of observations.

Date	Filter	Obs.	S−CH
14.4.2004	BV	SL	0.02
15.4.2004	BV	SL	0.03
21.4.2004	BV	SL	0.03
22.4.2004	BV	SL	0.05

The standard differential BV photometry with the sequence . . . S – V – CH . . . was made as well as standard reduction process including the corrections for differential extinction. The check star (CH) was SAO 119 944 and the standard star (S) was SAO 119 935. The following linear ephemeris has been used

$$\mathrm{MinI} = \mathrm{HJD}\ 2\,445\,022.6528 + 0^{\mathrm{d}}.35399712\ \times E \qquad (1)$$

being very close to previous determinations.

The complete dataset is presented in Table 1 (raw data are available only electronically via IBVS web-page as files 5574-t4 – t10.txt). The final analysis was made using the code of Djuraševič, see Djuraševič et al. (2004) for the details.

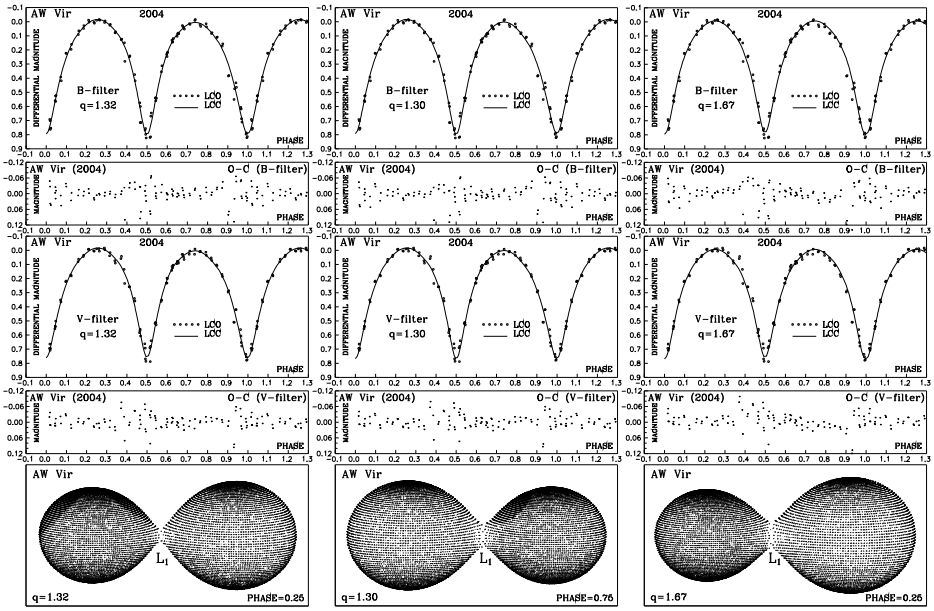

Figure 1. Observed (LCO) and final synthetic (LCC) light curves of AW Vir with final $O-C$ residuals obtained by analysing B and V observations **(left - two spots hypothesis ; middle - one spot hypothesis; right - without spots)** and the corresponding view of the system obtained with the resulting parameters.

Table 2: Times of minima.

Date	Filter	Min.	Min. type	$O-C$	$(O-C)$
14.4.2004	B	53110.4280	I	0.26	0.25
14.4.2004	V	53110.4278	I	0.25	0.25
15.4.2004	B	53111.4894	I	0.26	0.25
15.4.2004	V	53111.4897	I	0.26	0.25
21.4.2004	B	53117.3291	II	0.08	0.07
21.4.2004	V	53117.3308	II	0.08	0.07
22.4.2004	B	53118.3935	II	0.08	0.07
22.4.2004	V	53118.3961	II	0.09	0.08

Note: $(O-C)$ by Qian (2003).

The results are presented in Table 3. The shape of the light curve changed since the previous study (Niarchos et al. 1997) and we found the activity centers on the less-massive and hotter component. Though we could not decide between single and/or two-spot models, the spots cooler than the surrounding photosphere at intermediate latitudes confirm the tidal effect just with their locations. The system without spots gives the worst fit to the light curves. In addition, the mass ratio of the components had to be changed. The spots on the more-massive components are unrealistic as well, what is demonstrated with the convergence properties of the modelling. The times of minima do not fit well the quadratic ephemeris of Qian (2003) and at least suggest the importance of spots in the system. The overcontact factor for the binary is up to 10%. The times of minima derived by us are presented in Table 2.

Acknowledgements: The referee is cordially thanked for valuable comments.

Table 3: Results of the simultaneous analysis of the AW Vir B,V light curves obtained by solving the inverse problem for the Roche model with and without spots on the less-massive (hotter) component.

Quantity	Hip. I. – two spots	Hip. II. – one spot	Hip. III. – without spots
n	202	202	202
$\Sigma(\mathrm{O}-\mathrm{C})^2$	0.1924	0.1954	0.2453
σ	0.0309	0.0312	0.0349
$f_{\mathrm{h,c}}$	1.0	1.0	1.0
$\mathrm{A_{h,c}}$	0.5	0.5	0.5
$\beta_{\mathrm{h,c}}$	0.08	0.08	0.08
$\mathrm{T_h}$	6200	6200	6200
$\mathrm{A_{s1}}=\mathrm{T_{s1}}/\mathrm{T_h}$	0.65 ± 0.08	0.66 ± 0.12	
θ_{s1}	33.8 ± 1.8	25.2 ± 1.8	
λ_{s1}	351.2 ± 2.2	344.1 ± 4.1	
φ_{s1}	45.2 ± 4.7	39.5 ± 5.5	
$\mathrm{A_{s2}}=\mathrm{T_{s2}}/\mathrm{T_h}$	0.93 ± 0.01		
θ_{s2}	40.4 ± 2.2		
λ_{s2}	183.4 ± 4.9		
φ_{s2}	40.9 ± 4.1		
$\mathrm{T_c}$	6078 ± 23	6189 ± 23	6100 ± 26
$\mathrm{F_h}$	1.006 ± 0.002	1.020 ± 0.002	1.029 ± 0.003
i [°]	82.1 ± 0.4	83.3 ± 0.4	83.8 ± 0.4
$q=m_{\mathrm{c}}/m_{\mathrm{h}}$	1.32 ± 0.04	1.30 ± 0.05	1.67 ± 0.06
$a_1^{\mathrm{h,c}}$[B]	$+0.3369,+0.3645$	$+0.3369,+0.3395$	$+0.3369,+0.3594$
$a_2^{\mathrm{h,c}}$[B]	$+0.5521,+0.3976$	$+0.5521,+0.5378$	$+0.5521,+0.4262$
$a_3^{\mathrm{h,c}}$[B]	$+0.0590,+0.2836$	$+0.0590,+0.0798$	$+0.0590,+0.2419$
$a_4^{\mathrm{h,c}}$[B]	$-0.1039,-0.1940$	$-0.1039,-0.1123$	$-0.1039,-0.1773$
$a_1^{\mathrm{h,c}}$[V]	$+0.4165,+0.4408$	$+0.4165,+0.4187$	$+0.4165,+0.4363$
$a_2^{\mathrm{h,c}}$[V]	$+0.5507,+0.4218$	$+0.5507,+0.5387$	$+0.5507,+0.4457$
$a_3^{\mathrm{h,c}}$[V]	$-0.1962,+0.0071$	$-0.1962,-0.1774$	$-0.1962,-0.0306$
$a_4^{\mathrm{h,c}}$[V]	$-0.0039,-0.0937$	$-0.0039,-0.0122$	$-0.0039,-0.0771$
$\Omega_{\mathrm{h,c}}$	4.2273	4.1612	4.6842
Ω_{in}	4.2471	4.2233	4.7788
Ω_{out}	3.6798	3.6571	4.1935
f_{over}[%]	3.48	10.98	16.16
$\mathrm{R_{h,c}}[\mathrm{D}=1]$	0.336, 0.381	0.341, 0.385	0.323, 0.408
$\mathrm{L_h}/(\mathrm{L_h}+\mathrm{L_c})(\mathrm{B;V})$	0.433; 0.432	0.433; 0.433	0.410; 0.409

Note: n - total number of the B and V observations, $\Sigma(\mathrm{O}-\mathrm{C})^2$ - final sum of squares of residuals between observed (LCO) and synthetic (LCC) light curves, σ - standard deviation of the observations, $q=m_{\mathrm{c}}/m_{\mathrm{h}}$ - mass ratio of the components, $f_{\mathrm{h,c}}$, $\beta_{\mathrm{h,c}}$, $\mathrm{A_{h,c}}$ - nonsynchronous rotation coefficients, gravity-darkening exponents and albedo of the components, $T_{h,c}$ - temperature of the hotter primary and cooler secondary, $\mathrm{A_{S1,2}}$, $\theta_{\mathrm{S1,2}}$, $\lambda_{\mathrm{S1,2}}$ and $\varphi_{\mathrm{S1,2}}$ - spots temperature coefficients, angular dimensions, longitudes and latitudes (in arc degrees), $\mathrm{F_{h,c}}$ - filling factors for the critical Roche lobe of the hotter (less-massive) star, i [°] - orbit inclination (in arc degrees), $a_1^{\mathrm{h,c}}$, $a_2^{\mathrm{h,c}}$, $a_3^{\mathrm{h,c}}$, $a_4^{\mathrm{h,c}}$ - nonlinear B and V limb-darkening coefficients of the components (Claret's formula), $\Omega_{h,c}$, Ω_{in}, Ω_{out} - dimensionless surface potentials of the components and of the inner and outer contact surfaces respectively, f_{over}[%] - degree of overcontact, $R_{h,c}$ - polar radii of the components in units of the distance between the component centre and $\mathrm{L_h}/(\mathrm{L_h}+\mathrm{L_c})$ - (B;V) luminosity of the hotter star (including spots).

References:

Agerer, F. and Hubscher, J. 2003, *IBVS*, No.5484

Djurašević, G., Albayrak, B., Selam, S. O., Erkapic, S., Senavci, H. V. 2004, *NewA*, **9**, 425

Hoffmeister, C. 1935, *Astr. Nachr.*, **255**, 401

Niarchos, P. G., Hoffmann, M., Durbeck, H. W. 1997, *A&AS*, **124**, 291

Qian, S. 2003, *MNRAS*, **342**, 1260