

## BVRI OBSERVATIONS OF AH Her IN OUTBURST

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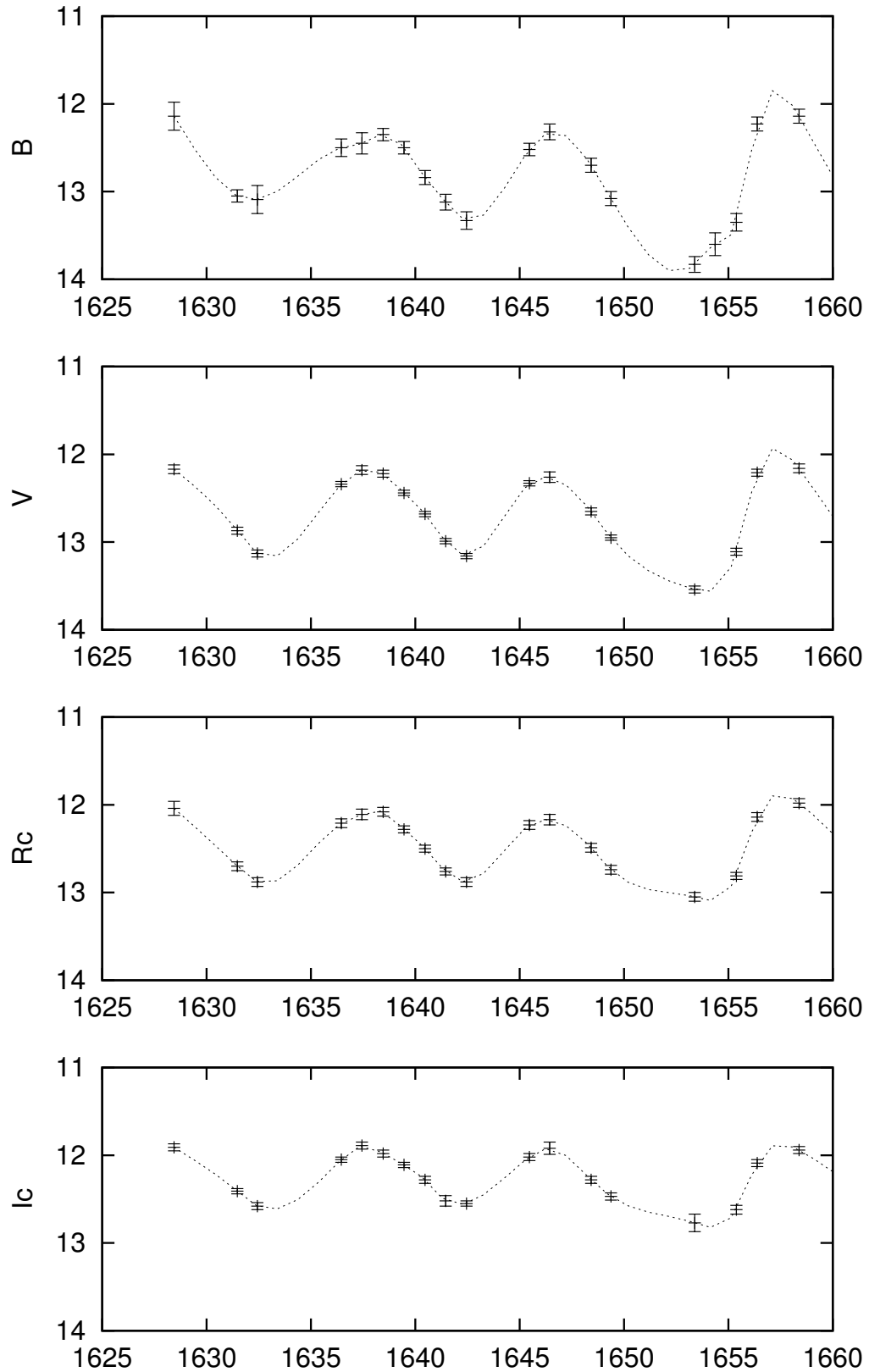
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Dwarf Novae (DNe) are close binaries with mass transfer from a late-type main-sequence or slightly evolved secondary, to a white dwarf primary. Mass is transferred from the late-type star, through the inner Lagrangian point towards the white dwarf primary. This material forms an accretion disk around the primary. The main features of DNe are recurrent outbursts: unpredictable rises of luminosity, about 2–6 mag, with a recurrence time-scale from tens to hundreds of days and with duration of about a week. The dwarf novae may be subdivided into U Gem stars (normal light curves), SU UMa stars (presence of superhumps and superoutbursts) and Z Cam stars (presence of standstills in the light curve). AH Her is a DN of Z Cam subtype: during the decline, after the maximum, it shows occasionally periods of standstill during which the brightness is approximately constant. AH Her varies in magnitude from  $V = 14.3$  in quiescence to  $V = 11.3$  during outbursts, that last 4–18 days and recur at intervals of 7–27 days (Ritter & Kolb 1998). The colour index  $B - V$  varies from 0.04 to 0.13 in the maximum of an outburst, while in the minimum  $B - V$  varies from 0.24 to 0.55 (Bruch 1984). Williams (1983) reported a spectroscopic study of the star: he published a spectrum of the variable at minimum and he gave the equivalent width of some lines of the Balmer series. Moffat & Shara (1984) determined from photometric observations an orbital period of 0<sup>d</sup>.247. Previously Wargau et al. (1983) have suggested that AH Her has an orbital period of  $5.9 \pm 0.5$  hours, based on the rate of decline after outbursts. Horne et al. (1986) made spectroscopic observations and determined an orbital period of 0<sup>d</sup>.258116. They found a mass ratio  $M_2/M_1 = 0.80$  with  $M_1 = 0.95M_\odot$  and  $M_2 = 0.76M_\odot$ ; the calculated inclination of the orbital plane is  $i = 46^\circ$ , with a secondary of the K spectral type.

We observed this Dwarf Nova intermittently at the Astronomical Observatory of the Perugia University from 28/06/1997 to 04/10/1997, for a total of 31 observational nights. The instruments used and the photometric techniques have been already described in Spogli et al. (1998). We used the calibration stars reported in Misselt (1996) with the numbers 1, 2, 3. Moreover we calibrated these comparison stars with the  $I_c$  filter by observing, on photometric nights, several standard stars (Landolt 1992) having  $B - V$  from  $-0.2$  to  $1.4$ , over a wide range of airmass. The weighted means of the values obtained are:  $I_c(1) = 12.07 \pm 0.03$ ,  $I_c(2) = 14.22 \pm 0.05$ ,  $I_c(3) = 13.40 \pm 0.04$ .

The results presented here are part of a project devoted to gain multi-band light curves of a sample of DNe, with the goal of increasing the historical database and information on this class of variable sources which can help to constrain theoretical models. Table 1 shows



**Figure 1.**  $BVR_cI_c$  light curves of AH Her from 28/06/1997 to 26/07/1997. The numbers reported in the abscissa are the Julian Days starting from 2449000. The dotted lines connect consecutive points by natural cubic splines after rendering the data monotonic

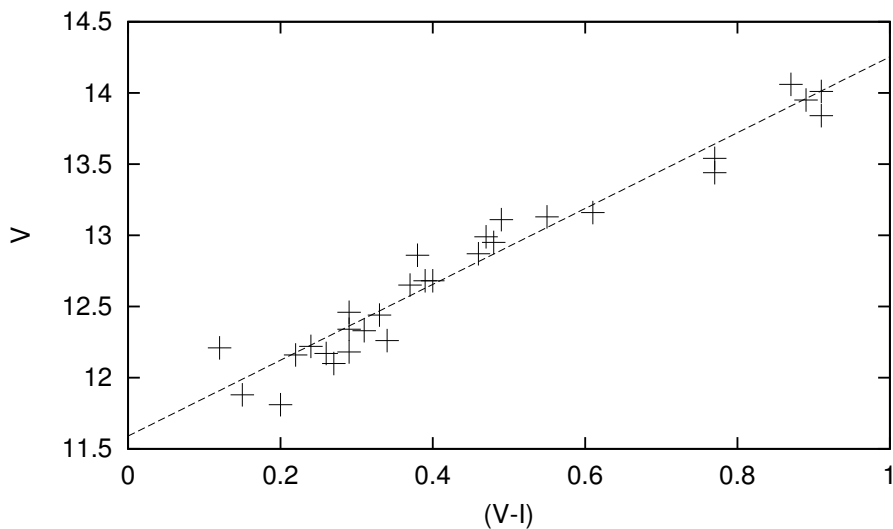
the main characteristics of the light curves, while all the photometric data are reported in Table 2. In the first part of the light curve we can see quite symmetric low-amplitude oscillations (see Fig. 1), followed by more pronounced outbursts in the final part of our observations, after JD 2450658 (see Table 2).

Table 1

	$B$	$V$	$R_c$	$I_c$
Maximum Outburst	$11.78 \pm 0.07$	$11.81 \pm 0.03$	$11.72 \pm 0.03$	$11.61 \pm 0.02$
Minimum of Light	$14.60 \pm 0.10$	$14.06 \pm 0.04$	$13.72 \pm 0.04$	$13.19 \pm 0.04$
Mean Values at Minimum	$14.1 \pm 0.3$	$13.8 \pm 0.3$	$13.4 \pm 0.2$	$13.0 \pm 0.2$
Outburst Amplitude	2.8	2.1	2.0	1.6
	$B - V$	$V - R_c$	$V - I_c$	
Mean values at Maximum	0.06	0.12	0.25	
Mean Values at Minimum	0.33	0.42	0.85	

Figure 2 shows the colour–magnitude diagram for AH Her: obviously it is bluer during the outburst and redder in quiescence, but it is worth to note that the data seem to be well represented by a linear regression, and there is not a loop typical of other DNe (see, for example, Spogli et al. 2000a,b). This evidence, together with the symmetric light curve with comparable rise and decline times, may be in agreement with the inside-out model of the outburst described by Cannizzo & Kenyon (1987). However, for a conclusive sentence more precise observations are required, especially in the  $B$  band where the contamination of the secondary star is less important.

To study the behaviour of the optical continuum of the DN during the various outbursts, we converted the  $BVR_cI_c$  magnitudes in fluxes using the same procedure described in Spogli et al. (1998). We corrected the interstellar reddening adopting  $A_V = 3.1$  and  $E_{B-V} = 0.03$  (Bruch 1984). The spectral flux distribution of AH Her, during the several outbursts, is well described by a power law ( $F(\nu) \propto \nu^\alpha$ ) with the slope  $\alpha$  that varies from  $\alpha = 0.3$  to  $\alpha = 0.7$ , while during quiescence the emission is dominated by the secondary star.



**Figure 2.** Colour index variation in the light curve. The dashed line shows the linear fitting

Table 2

JD (2449000+)	$B$	$V$	$R_c$	$I_c$
1628.4448	$12.20 \pm 0.10$	$12.17 \pm 0.05$	$12.04 \pm 0.08$	$11.91 \pm 0.04$
1631.4781	$13.05 \pm 0.07$	$12.87 \pm 0.04$	$12.70 \pm 0.05$	$12.41 \pm 0.03$
1632.4342	$13.09 \pm 0.16$	$13.13 \pm 0.04$	$12.88 \pm 0.05$	$12.58 \pm 0.04$
1636.4552	$12.50 \pm 0.10$	$12.34 \pm 0.03$	$12.21 \pm 0.05$	$12.05 \pm 0.03$
1637.4438	$12.45 \pm 0.10$	$12.18 \pm 0.05$	$12.11 \pm 0.06$	$11.89 \pm 0.04$
1638.4592	$12.35 \pm 0.07$	$12.22 \pm 0.04$	$12.08 \pm 0.05$	$11.98 \pm 0.04$
1639.4631	$12.50 \pm 0.07$	$12.44 \pm 0.03$	$12.28 \pm 0.04$	$12.11 \pm 0.03$
1640.4631	$12.84 \pm 0.08$	$12.68 \pm 0.03$	$12.50 \pm 0.04$	$12.28 \pm 0.04$
1641.4557	$13.12 \pm 0.09$	$12.99 \pm 0.03$	$12.76 \pm 0.04$	$12.52 \pm 0.06$
1642.4545	$13.33 \pm 0.10$	$13.16 \pm 0.03$	$12.88 \pm 0.05$	$12.55 \pm 0.03$
1645.4701	$12.50 \pm 0.07$	$12.33 \pm 0.03$	$12.23 \pm 0.05$	$12.02 \pm 0.04$
1646.4325	$12.32 \pm 0.09$	$12.26 \pm 0.06$	$12.17 \pm 0.06$	$11.96 \pm 0.06$
1648.4199	$12.70 \pm 0.08$	$12.65 \pm 0.04$	$12.49 \pm 0.05$	$12.28 \pm 0.04$
1649.3727	$13.08 \pm 0.08$	$12.95 \pm 0.03$	$12.74 \pm 0.05$	$12.47 \pm 0.04$
1653.3877	$13.83 \pm 0.09$	$13.54 \pm 0.04$	$13.05 \pm 0.05$	$12.77 \pm 0.07$
1654.3621	$13.60 \pm 0.13$			
1655.3806	$13.35 \pm 0.10$	$13.11 \pm 0.04$	$12.81 \pm 0.04$	$12.62 \pm 0.05$
1656.3796	$12.23 \pm 0.08$	$12.21 \pm 0.04$	$12.14 \pm 0.05$	$12.09 \pm 0.04$
1658.3826	$12.14 \pm 0.08$	$12.16 \pm 0.05$	$11.98 \pm 0.05$	$11.94 \pm 0.04$
1668.3495	$14.13 \pm 0.14$	$13.84 \pm 0.04$	$13.38 \pm 0.04$	$12.93 \pm 0.04$
1673.3448	$12.52 \pm 0.07$	$12.46 \pm 0.03$	$12.30 \pm 0.05$	$12.17 \pm 0.04$
1675.3425	$12.99 \pm 0.07$	$12.86 \pm 0.03$	$12.67 \pm 0.04$	$12.48 \pm 0.03$
1681.3215	$14.60 \pm 0.10$	$14.06 \pm 0.04$	$13.72 \pm 0.04$	$13.19 \pm 0.04$
1683.3186	$14.31 \pm 0.10$	$13.95 \pm 0.04$	$13.54 \pm 0.04$	$13.06 \pm 0.04$
1686.4093	$11.81 \pm 0.14$	$11.88 \pm 0.04$	$11.72 \pm 0.05$	$11.73 \pm 0.06$
1690.3251	$11.78 \pm 0.07$	$11.81 \pm 0.03$	$11.77 \pm 0.04$	$11.61 \pm 0.02$
1709.3043	$13.66 \pm 0.09$	$13.44 \pm 0.04$	$13.08 \pm 0.04$	$12.67 \pm 0.03$
1710.3026	$14.27 \pm 0.11$	$14.01 \pm 0.04$	$13.53 \pm 0.04$	$13.10 \pm 0.03$
1714.2986		$13.71 \pm 0.04$	$13.33 \pm 0.05$	
1716.2952	$12.03 \pm 0.07$	$12.10 \pm 0.03$	$11.95 \pm 0.04$	$11.83 \pm 0.03$
1726.2805	$12.87 \pm 0.08$	$12.68 \pm 0.03$	$12.52 \pm 0.04$	$12.29 \pm 0.03$

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