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THE PHOTOMETRIC PERIOD OF THE OLD NOVA V368 AQUILAE[1]

The fast ($t_3 = 45^d$) classical nova V368 Aql erupted in 1936 and was discovered by Tamm (1936). A minimum spectrum taken by Lynds is described by Warner (1976) to contain broad and moderately strong H and He II emission lines. This agrees with the description by Duerbeck and Seitter (1987). The spectrum published by Williams (1983) is featureless. No further observations of V368 Aql in quiescence are published. The time-resolved photometric observations of this faint ($V \approx 17\overset{m}{.}2$) star presented in this Bulletin were obtained as part of a project aimed at the detection of orbital modulations in quiescent novae. The data were taken at the 0.6m–telescopes of the Laboratorio Nacional de Astrofísica (LNA), Brasopolis, Brazil. A blue-coated GEC CCD with 384×576 22μ pixels was used at a scale of $0\overset{''}{.}58$/pix. The seeing during the observations ranged typically from $1\overset{''}{.}3$ to $2\overset{''}{.}0$. An R filter (Kron-Cousins) was used to optimize photon counting statistics. Dome white spot and twilight sky flat fields as well as bias frames were taken and averaged for each run. The dark count correction was found to be negligible. A journal of observations is given in Table 1.

Table 1: Journal of observations

Date	Start (MHJD)*	Duration (hours)	Number of points	Epoch (MHJD)*
1990, May 25	48037.314	1.1	11	
1990, May 26	48038.215	3.4	30	
1990, May 27	48039.227	1.7	13	
1993, Jul 15	49183.954	5.9	49	
1993, Jul 16	49185.133	1.6	18	
1993, Jul 17	49186.109	3.5	21	
1993, Jul 18	49186.971	7.3	67	
1993, Jul 19	49188.048	5.4	53	
1993, Jul 20	49188.969	6.9	54	49189.022
1993, Aug 13	49212.960	4.3	16	
1993, Aug 26	49226.937	5.5	58	49227.002

*MHJD ≡ HJD − 2400000.5

The raw data were reduced using standard procedures. The instrumental magnitudes of the variable and three nearby comparison stars were derived by the PSF fitting algorithm of DAOPHOT (Stetson 1987). The presence of irregular short–term variations due to flickering confirms the identification of Duerbeck (1987). The right ascension and declination offsets in arcseconds to the comparison stars C1, C2 and C3 are (−10,−57), (−2,41) and (−6,22), respectively. Our comparison C3 corresponds to star #3 in Klemola's (1968) finding chart.

[1]Based on observations made at the Laboratório Nacional de Astrofísica/CNPq, Brasil

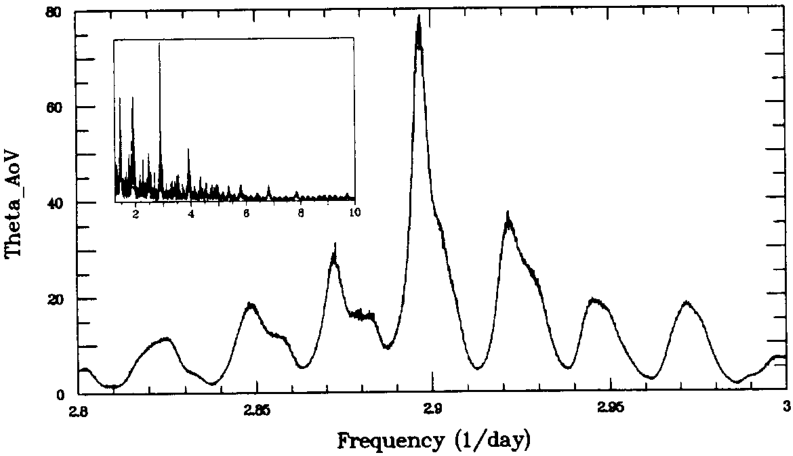

Fig. 1: AoV periodogram of the 1993 data. The peak close to 2.9 day^{-1} corresponds to the binary period. The inset shows the periodogram over a wider range in frequencies.

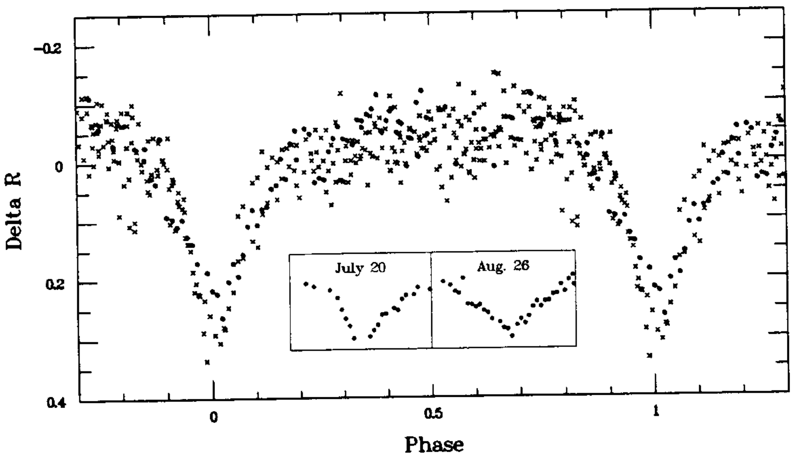

Fig. 2: Phase-folded differential light curve of V368 Aql for P = 0.34521 days. Crosses and dots refer to 1993, July and Aug., respectively. The insets show the two fully observed eclipses on the same scale.

The light curves of 1993, July 20 and Aug. 26 show minima with a depth of $\approx 0^{\rm m}\!.25$. Their epochs were measured by fitting a polynomial to the minima and are quoted in Table 1. During other nights, ingresses or egresses of such minima were observed. We subjected the 1993 data to a periodogram analysis using the AoV algorithm of Schwarzenberg-Czerny (1989). The resulting periodogram (Fig. 1) shows a strong maximum close to the frequency of 2.9 days^{-1} along with some alias peaks. The inset in Fig. 1 shows a larger part of the periodogram on a compressed scale. A fit of a high order polynomial to the principal periodogram peak yields a period of

$$P = 0.34521 \pm 0.00015\,\text{days} = 8^{\rm h}17^{\rm m}6^{\rm s} \pm 13^{\rm s}$$

The data, folded on this period, are shown in Fig. 2. Long–term variations have been subtracted before folding. Crosses and dots correspond to the observations of 1993, July and Aug., respectively. The minimum epoch of July 20 was chosen as zeropoint of phase. The scatter in the data is largely due to real variations; the RMS residuals obtained from comparison stars with similar brightness is $0^{\rm m}\!.03$. The period error is a conservative estimate. It yields a phase shift of 0.05 between the well covered minima of July 20 and Aug. 26 which would easily be detected in the folded light curve. The measured minima epochs yield the same period as the periodogram analysis within the errors if 110 cycles are assumed to have elapsed between the July and August minima. The alias periods can be rejected because the light curves folded on them are unacceptable. The observing runs of 1990, May 25 were all rather short and do not contain eclipses. Since the period is not known with enough precision to calculate phases for these data they are not shown in Fig. 2. The insets in Fig. 2 show the individual eclipses of 1993, July 20 and Aug. 26 on the same scale. The total phase range is $-0.2 \ldots 0.2$. It is seen that the shape of the minima can vary considerably.

We interpret the light curve minima as eclipses of the primary component of V368 Aql by the secondary. The period is then the orbital period which is quite large for a cataclysmic variable (CV). According to the canonical model the secondary should then contribute an appreciable fraction to the total light. This is compatible with the spectrum shown by Williams (1983) which is flat or even slightly inclined to the red. The phase folded light curve shows no evidence of an orbital hump before the eclipse while the eclipse itself appears to be slightly asymmetric.

The ingress and egress phases of the eclipses not being well defined, their total width cannot be easily measured. It is of the order of 0.2 in phase which appears to be rather large for a CV. However, such a width is not impossible. Assuming the secondary to be on the main sequence (although at such a long period this assumption may be violated to a certain degree), the period – secondary mass relation for CVs predicts $\mathcal{M}_{\rm sec} \approx 1\ \mathcal{M}_{\odot}$. Assuming further a large mass ratio of $\mathcal{M}_{\rm sec}/\mathcal{M}_{\rm prim} \approx 1$ (but not larger in order to permit stable mass transfer), the accretion disk to reach out to 70% of the mean Roche lobe radius of the primary, and the orbital inclination to be close to 90°, the phase difference between first and last contact of the disk eclipse is ≈ 0.18, compatible with the observations. Totality would last only 0.035 in phase which (in view of the scatter of the data) is also not in contradiction with the observations. The small depth of the eclipses of only $\approx 0^{\rm m}\!.25$ appears to be a problem if a total eclipse is required to explain their width. But this is not necessarily the case. Assuming the disks in quiescent novae to be similar to those of dwarf novae in outburst, the M_V –

P relation of Warner (1987) predicts $M_V = 3\overset{m}{.}50$ for a mean orbital inclination. Let the secondary have the absolute magnitude and colours of the sun, we find from Allen (1973) that $M_{R,\mathrm{sec}} = 4\overset{m}{.}31$. The primary is assumed to have $V - R \approx 0$ (Leibowitz et al. 1994). The depth then yields $M_{R,\mathrm{prim}} = 5\overset{m}{.}8$ if the eclipses are total. Using the correction formula for orbital inclinations of Paczyński and Schwarzenberg-Czerny (1980), the above numbers are compatible if $i \approx 84°$. Thus, the large eclipse width and its low depth can be explained within the canonical model of CVs. A high quality spectrum of V368 Aql which should be dominated by a roughly solar type component would show whether this scenario is viable or not.

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