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NEW STRÖMGREN PHOTOMETRY OF AI DRACONIS: NO PULSATIONS DETECTED

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Recently, Narusawa et al. (2002) reported on short period variability of the bright Algol-type eclipsing binary AI Draconis. These authors detected periodic oscillations with an amplitude of about 0.03 – 0.05 mag outside eclipses, which were interpreted as caused by the δ Scuti-type pulsations of the main component in the system. The confirmation of stellar pulsations in an eclipsing binary system is an important issue as such stars are attractive observing targets for asteroseismology (e.g. Mkrtichian et al. 2002, Kim et al. 2002). Independent determination of the physical parameters (mass, radius, temperature) gives strong constraints on the possible mode identification, thus allowing a firm asteroseismologic analysis. If confirmed, its eclipsing+pulsating nature would imply that AI Dra is one of the brightest (m_V =7.05 – 7.83 mag) among such stars with a relatively short-period ($P_{\rm orb} \approx 1.19$ days). That is why we made follow-up observations of the star in July, 2002. The main aim of this note is to present our results on the reported rapid variability.

The Strömgren *uvby* photometric observations were acquired on 8 nights in July, 2002 (all nights between July 19–27, except July 21). We used the 0.9-m telescope of the Sierra Nevada Observatory (Spain) equipped with a four-channel spectrograph photometer. For the differential photometry, we used HD 154199 ($V = 6.89$, $b - y = 0.044$, $m_1 = 0.169$, $c_1 = 0.978$ mag) and HD 154731 ($V = 8.21$, $b - y = 0.167$, $m_1 = 0.159$, $c_1 = 0.900$ mag) as a comparison and check stars, respectively (magnitudes are from SIMBAD database). The same stars were utilized by Narusawa et al. (2002) and other observers as well. The magnitude differences remained constant at a level of ±0.01 mag in *vby* and ±0.02 in *u* and the estimated photometric accuracy of the target data is ±0.006 mag in $b - y$, ±0.01 mag in V and m_1 and ±0.015 mag in c_1. We note that hints for variability of the check star at the millimag level were deduced (see later). The standardized dataset consists of 2634 individual points with a total coverage of 51 hours distributed almost equally in time and is available at the IBVS website as 5355-t2.txt

We could determine three new epochs of minimum, two corresponding to primary minima, one to a secondary minimum. We list them in Table 1. Data were phased with the ephemeris $HJD_{\rm min} = 2452480.5581 + 1.1988146E$, where the period was taken from the GCVS. The phased light and colour curves are presented in Fig. 1.

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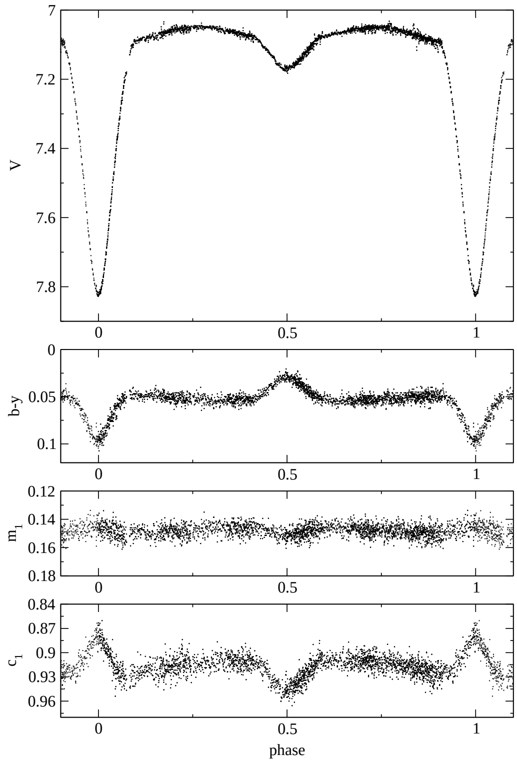

Figure 1. The light and colour curves of AI Dra.

The full light curve does not show any extra scatter (larger than the one expected from the observational uncertainties) which might be associated with some additional short period variation. There are several overlapping parts of the phase diagram which were obtained on different nights. Their agreement also excludes night-to-night variations of the light curve shape larger than 0.015 mag, at least within the eight nights of our observations. Furthermore, the colour curves are consistent with a pure eclipsing light variation with two components of strongly different temperatures.

Besides the visual inspection of the light curves, we performed a frequency analysis of the individual *uvby* data. For this, we have subtracted the mean eclipsing light variation from the original observations. The residual data show the deviations from the mean. Any low-amplitude oscillation is expected to appear at certain but the same frequency in all bands with characteristic wavelength dependence of the amplitude.

For the analysis, we used `Period98` of Sperl (1998). Additionally, we have computed Fourier spectra for the comp *minus* check data to give further insights into the frequency content of our observations (see Fig. 2 for details). The results can be summarized as follows. We could not identify any high-frequency component in the residual light curves with an amplitude larger than 1 mmag. In the low-frequency range (i.e. $f < 10$ c/d) there is a peak exactly at 2 c/d and its alias peaks are also visible (see the window function in Fig. 2). We attribute this to an observational effect. On every night, the star was followed until its air mass not reached 2–2.3. That is why there is an increase in scatter (and consequently, slight shifts of the mean value) at the ends of the nightly subsets. Since none of the subsets is longer than half a day and they occur strictly repeatedly, the effect causes an apparent signal in the observations. And finally, contrary to our expectations, we did find a high-frequency component (at $f \approx 31.3$ c/d, or $P \approx 46$ min), but in

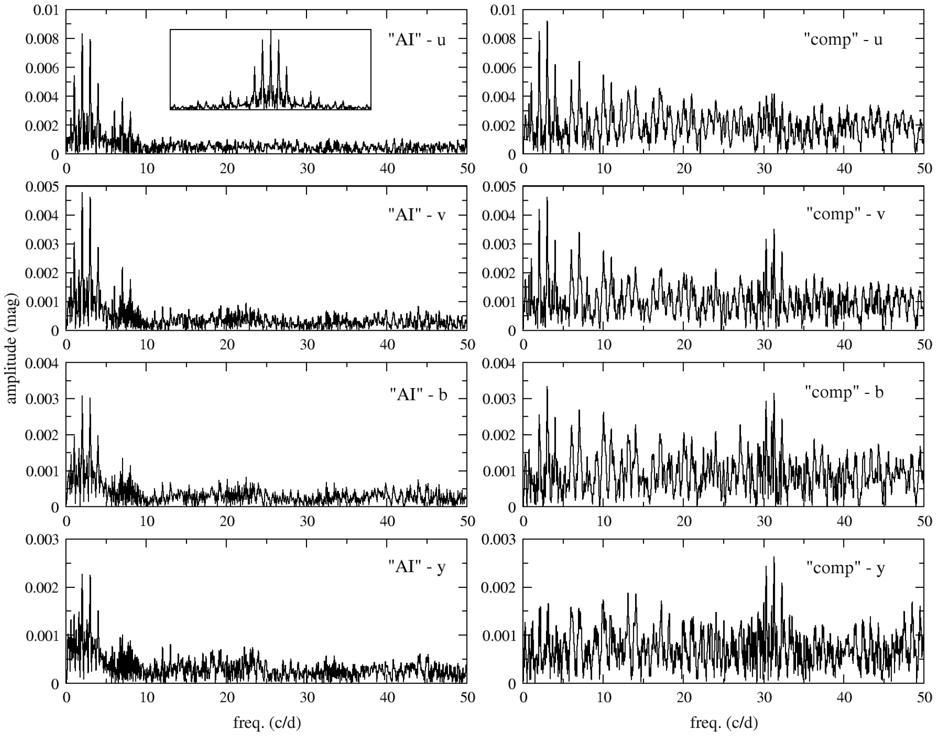

Figure 2. Frequency spectra of the residual and comp *minus* check data. The small insert shows the window function.

Table 1: Times of minimum and Nightfall light curve solution

HJD_{min}	2452479.3600 (I)	2452480.5581 (I)	2452483.5539 (II)
	primary	secondary	
temperature	9800 K (fixed)	5680±50 K	
mean radius	0.287±0.015	0.296±0.015	
fill factor	0.67±0.03	1.00±0.03	
inclination	$77\overset{\circ}{.}4\pm0\overset{\circ}{.}5$		

the comparison star data. The amplitude shows the expected wavelength dependence for stellar pulsation (the bluer the band the higher the amplitude is). The lack of this frequency in the residual data suggests that the check star is the variable one, not the comparison. Therefore, we conclude that the secondary comparison HD 154731 is a low-amplitude δ Scuti star, which is in accordance with its spectral type (A2). On the other hand, we can safely exclude δ Scuti-type oscillations of AI Dra above the millimag level. The 0.03 – 0.05 mag oscillations reported by Narusawa et al. (2002) are not confirmed.

Finally, we have fitted the mean *uvby* light curves of AI Dra to derive physical parameters of the components from Strömgren photometry for the first time. For this, we have used the Nightfall software of Wichmann (1998). We have adopted the spectroscopic mass-ratio of $q = 0.43$ by Khalesseh (1999), while the primary's temperature was fixed at 9800 K (Değirmenci et al. 2000). The best Nightfall solution was found when included detailed reflection calculations (3 iterations), square-root terms in the limb-darkening law and fractional visibility. All four bands were used to reach the optimal fit (Fig. 3). Here the mean residuals range from -0.0105 mag (in u) to -0.0006 mag (in y). The parameters

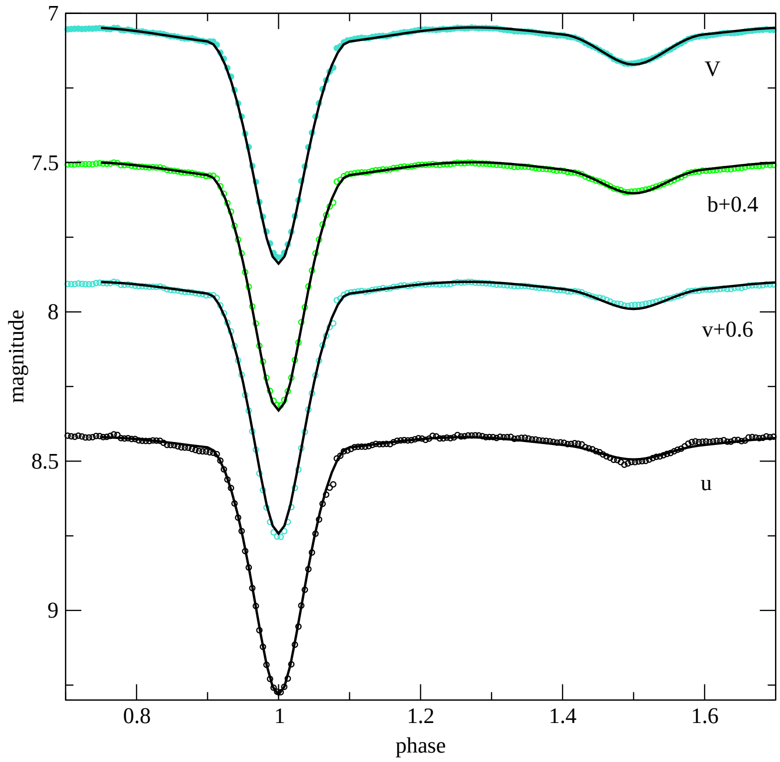

Figure 3. Light curve fits (solid lines) of the mean data (dots) for AI Dra.

of the system, including the three new epochs of minimum are summarized in Table 1.

Generally, our results are consistent with the previous parameter determinations. The secondary is likely to fill its Roche-lobe, thus the system is in semi-detached configuration. This is exactly the same conclusion as found by, e.g. Değirmenci et al. (2000). The infrared light curve solution of Arévalo & Lázaro (2002) is also in good agreement with ours. Therefore, our Strömgren photometry gave supporting evidence for the overall picture of the system outlined by earlier studies. Further accurate photometric observations are expected to yield more information on the presence or absence of short period variability on a much longer time base.

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