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

Number 5304

Konkoly Observatory
Budapest
6 August 2002

HU ISSN 0374 – 0676

INFRARED LIGHT CURVES OF THE ALGOL BINARY AI Dra

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AI Dra (SAO 30164, HD 153345) was reported as a variable star by Schilt & Hill (1938) and as an eclipsing binary by Reim & Geyer (1955). Complete photoelectric light curves were observed by Cester (1960), Mauder (1962), Winiarski (1971) and more recently by Degirmenci et al. (2000) and Jassur, Kaledian & Kermani (2001). From the results of the published light curve analysis, carried out by different authors with differents analysis codes, the nature, transit or occultation, of the primary eclipse seems unclear (see Degirmenci et al., 2000 for references). Degirmenci et al. (2000) suggested that the system has a third component, with an orbital period of about 23 yr, but the L_3 contribution in the analysis of the B and V light curves that they recorded with the Wilson-Devinney (1971) code does not modify the parameters obtained. The spectroscopic observations (see Khalesseh, 1999 for references) suggest that the spectral types of AI Dra's components are A0 V and a late F or early G V–IV. The last radial velocity curves published by Khalesseh (1999) indicate a mass ratio q=m_1/m_2=2.33.

We observed AI Dra in the infrared J, H and K bands on different nights during 1996 and 1997 (see Table 1). The observations were carried out with the 1.5 m TCS telescope at the Observatorio del Teide (Tenerife, Canary Islands). A photometer with a focal plane chopper, and an InSb detector cooled with liquid nitrogen was used. Both the chopping amplitude and the aperture were set to 15″. AI Dra is a relatively bright system, providing a signal to noise ratio greater than 500 in each individual measurement. BD+52°2018, with a spectral type (A0) and magnitude very similar to that of AI Dra, was the main comparison star and showed no variability during the observation runs. The differential magnitudes of AI Dra (star–comparison) were arranged in heliocentric orbital phases according to the ephemeris of Kholopov (1985), namely,

$$\mathrm{MinI} = 2443291.627 + 1\overset{\mathrm{d}}{.}1988146\ \mathrm{E} \quad .$$

In order to determine new geometrical elements from our first IR light curves of AI Dra, we used the code developed by Budding & Zeilik (1987). This program, based on the Information Limit Optimization Technique (ILOT), takes into account the ellipticity, gravity darkening and reflection effects. As output, it gives equivalent spherical radii to describe the sizes of the distorted stellar components, and their partial light contribution in the analysed light curve. It has been shown that this code produces geometrical parameters in good agreement with those derived using other existing light-curve fitting codes, even for contact binaries (see Banks 1993 and references therein). A circular orbit was assumed, as emerged from the duration and orbital phases of both eclipses. The limb darkening coefficients were interpolated from the values given by Claret, Díaz–Cordovés & Giménez (1995). The adopted temperatures, T_1= 9600 K and T_2= 6000 K, corresponding to A0V + F8–G0V–IV, (Straizys & Kuriliene 1981), were always fixed parameters. With the aim of having homogeneous photometric elements, we have also re-analysed the B and V light curves of Degirmenci et al. (2000). Different fits were performed, taken as initial values those obtained by differents authors. A third light was also considered, but the solutions pointed out a negligible L_3 contribution. The results of our best fits are given in Table 2, and the B, V, J, H and K models together with the observations are plotted in Figure 1. The obtained values are in good agreement with Jassur, Kaledian & Kermani (2001) and with some fits proposed by Mezzetti et al. (1980). However the B and V solutions given by Degirmenci et al. (2000) depart slightly from our solutions, with a smaller relative radii for the primary star, $r_1 \simeq 0.29$, and $k = \frac{r_2}{r_1}$=1.03. We have performed alternative B,V,J,H and K light curves fits with k=1.03 as fixed parameter, being also possible to attain an acceptable set of solutions with relative radii similar to Degirmenci et al. (2000) values, but the solutions given in Table 2 are slightly better. Fits were also carried out keeping the Khalesseh (1999) determination, namely k=0.78, as fixed parameter. Again we obtain a set of acceptable solutions, with a larger relative radius for the primary ($r_1 \approx$ 0.34), although the fits show larger errors.

From our analysis, we can conclude that AI Dra is an eclipsing binary with partial eclipses, discarding the previously suggested occultation solution.

Table 1: Observing runs

Observation Date	Observed Filters
29–30 April 1996	H, K
5–6 May 1996	J, H, K
6–7 May 1996	J, H, K
4–5 June 1996	J, H, K
2–3 July 1996	J, H, K
26–27 August 1996	J, H, K
27–28 August 1996	J, H, K
16–17 June 1997	J, H, K
17–18 June 1997	J, H, K

Table 2: *ILOT* light curves solutions

	B filter	V filter	J filter	H filter	K filter
L_1	0.952 ± 0.002	0.911 ± 0.002	0.729 ± 0.002	0.665 ± 0.002	0.643 ± 0.002
L_2	0.058 ± 0.002	0.089 ± 0.002	0.271 ± 0.002	0.335 ± 0.002	0.357 ± 0.002
r_1	0.309 ± 0.001	0.311 ± 0.001	0.319 ± 0.001	0.311 ± 0.001	0.316 ± 0.001
r_2	0.285 ± 0.001	0.288 ± 0.001	0.296 ± 0.001	0.289 ± 0.001	0.294 ± 0.001
$k = \frac{r_2}{r_1}$	0.926	0.929	0.934	0.930	0.933
i	$77\overset{\circ}{.}9 \pm 0\overset{\circ}{.}1$	$78\overset{\circ}{.}0 \pm 0\overset{\circ}{.}1$	$77\overset{\circ}{.}3 \pm 0\overset{\circ}{.}1$	$77\overset{\circ}{.}6 \pm 0\overset{\circ}{.}1$	$77\overset{\circ}{.}5 \pm 0\overset{\circ}{.}1$
${\chi_r}^2$	55	43	452	376	439
ϵ	0.008	0.007	0.01	0.01	0.01
N of points	111	111	302	332	334

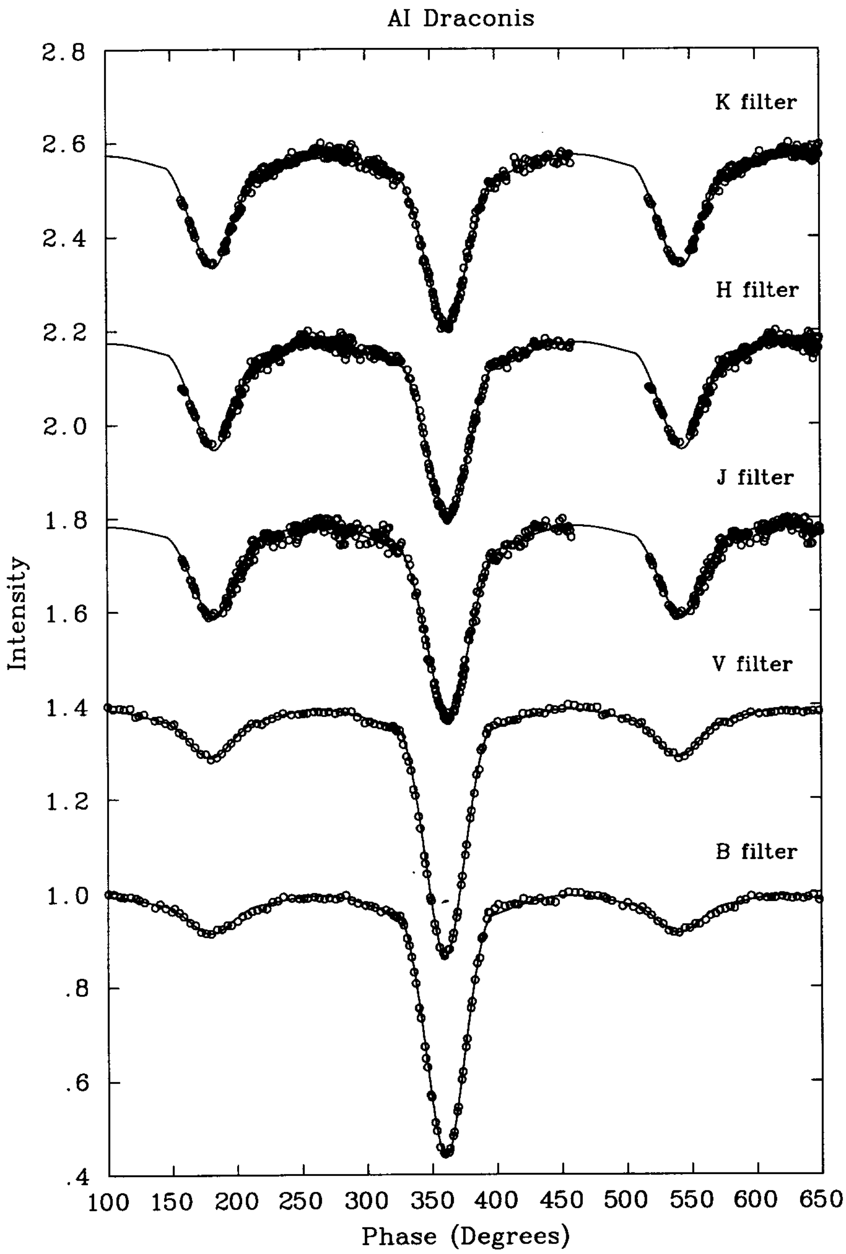

Figure 1. Observed light curves and the fits obtained with *ILOT*. For clarity, the V, J, H and K curves have been shifted by $0\overset{m}{.}4$, $0\overset{m}{.}8$, $1\overset{m}{.}2$ and $1\overset{m}{.}6$ respectively.

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