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AD CMi

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The variability of AD CMi was discovered by Hoffmeister (1934). Abhyankar (1959) observed the star during five nights in 1959 and showed the star to be a short period pulsating variable with a period of 0.12297 day.

Since the correct identification of the type of variability of AD CMi a great number of photoelectric and CCD observations have been obtained by different observers and more than seventy times of maximum light are given in the literature (Abhyankar, 1959; Agerer & Hübscher, 1997, 1998, 2000, 2003; Agerer et al., 2001; Anderson & McNamara, 1960; Balona & Stobie, 1983; Breger, 1975; Burchi et al., 1993; Epstein & Epstein, 1973; Fu & Jiang, 1996; Hübscher, 2005; Hübscher et al., 1994; Jiang, 1987; Klingenberg et al., 2006; Langford, 1976; Rodríguez et al., 1988, 1990; Yang et al., 1992). The period change of AD CMi was studied by Jiang (1987), Rodríguez et al. (1988, 1990), Yang et al. (1992) and Fu & Jiang (1996). Fu & Jiang remarked that the groups of data points distributed above and below the parabolic fit curve which seemed to suggest a trigonometric function type period variation. They came to the conclusion that light time effect caused by orbital motion might explain the sine like variation and deduced a period of $P_B = 10965$ days ≈ 30 years and eccentricity $e = 0.59$ of the elliptical orbital motion and a rate of increase in the pulsation period $(1/P)(dP/dt) = 1.1 \times 10^{-8}$ yr^{-1}.

Radial velocity measurements could give further evidence for binary nature. Abhyankar (1959) and Balona & Stobie (1983) published radial velocity curves of AD CMi. Abhyankar (1959) gave mean radial velocity of the star as 34.5 km/s, while from the radial velocity data of Balona & Stobie (1983) obtained in 1977 and 1978 Rodríguez et al. (1988) deduced a mean value of 38.8 km/s. Recently, Derekas et al. (2006) reported new radial velocity measurements and deduced 35 km/s for the mean radial velocity of AD CMi.

During the past thirty-five years AD CMi was observed with the different instruments of the Konkoly Observatory on 11 nights. Different combination of the $UBVR_CI_C$ filters were used. Throughout the photoelectric observations the comparison star was GSC 00181-00490 (except for the nights 2453451 and 2453452 when GSC 00184-00604 was used) while for the CCD photometry the comparison star was GSC 00181-00708. All the photometric observations are given electronically through the IBVS website as files 5774-t3.txt, 5774-t4.txt, 5774-t5.txt, 5774-t6.txt and 5774-t7.txt.

On the whole 10 times of maximum light (Table 1) could be determined from our observations. Each light maximum was derived as an average over the B and V bands

Table 1. Observations at Konkoly Observatory

times of maximum HJD 2400000+	telescope	detector	observation duration
41681.5258	50-cm Cassegrain	pe	.4537 – .5860
41682.5090	50-cm Cassegrain	pe	.4589 – .5277
42461.4291	60-cm Newton	pe	.3485 – .4492
43572.3810	60-cm Newton	pe	.3480 – .3838
43936.2635	60-cm Newton	pe	.2658 – .3322
46775.6235	1-m RCC	pe	.5159 – .6498
48254.5171	1-m RCC	pe	.4410 – .6281
53452.2795	1-m RCC	pe	.2673 – .3880
54165.2862	60-cm Newton	CCD	.2343 – .4510
54172.2961	60-cm Newton	CCD	.2343 – .4186

since the times of maximum for these colour bands are not perceptibly shifted to each other. The typical error of maximum times derived from our observations is about 1 minute.

From the ASAS (Pojmanski, 2005) and NSVS (Woźniak et al., 2004) datasets normal maxima were derived through third order Fourier fits (The NSVS observations have been subject to heliocentric correction).

The Hipparcos database provides one useful time of maximum light. Since heliocentric corrections have not been applied to these data we determined a new epoch of maximum taking the heliocentric correction into account.

Kilambi & Rahman (1993) and Kim & Joner (1994) published photometry of AD CMi, which made the determination of ten further times of maximum light possible.

All the published and newly determined times of maximum light are given in Table 2 (available only in the electronic version on the IBVS website as 5774-t2.txt.) The $O-C$ values have been calculated by the formula:

$$C = \text{J.D. } 2436601.82736 + 0\overset{\text{d}}{.}12297451 \times E.$$

We attempted to fit the $O-C$ diagram by the sum of a quadratic and a trigonometric function, assuming that the $O-C$ diagram is a product of a slow linear period change and light time effect caused by binary motion:

$$O - C = a + bE + cE^2 + A\sin\varphi + B\cos\varphi.$$

φ is the solution of the Kepler equation:

$$\varphi - e\sin\varphi = 2\pi P_{\text{orb}}^{-1}(PE - T)$$

where e is the eccentricity, T the time of the periastron of the assumed elliptical orbit and P_{orb} is the orbiting period. The deduced parameters are:

$$a = -0.00002 \pm 0.00018, \qquad b = (-2.95 \pm 0.02) \times 10^{-7}, \qquad c = (1.93 \pm 0.03) \times 10^{-12},$$

$$A = -0.00440 \pm 0.00012, \qquad B = 0.00056 \pm 0.00042, \qquad e = 0.71 \pm 0.05,$$

$$P_{\text{orb}} = 15660 \pm 300, \qquad T = 13870 \pm 150.$$

Figure 1 shows the $O-C$ diagram fitted by the above formula.

After subtracting the quadratic function the $O-C$ residual is presented in Figure 2 fitted only with the trigonometric term. The satisfactory approximation indicates that the $O-C$ diagram of AD CMi can be interpreted by a slow increase in the pulsation

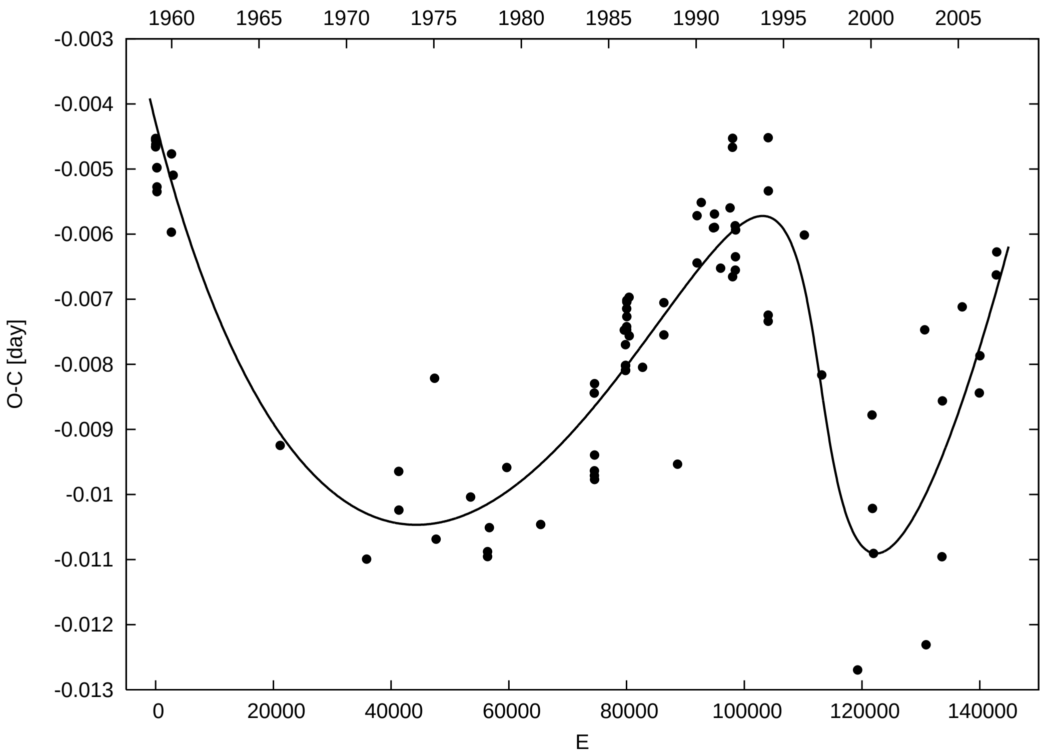

Figure 1. $O - C$ diagram of AD CMi

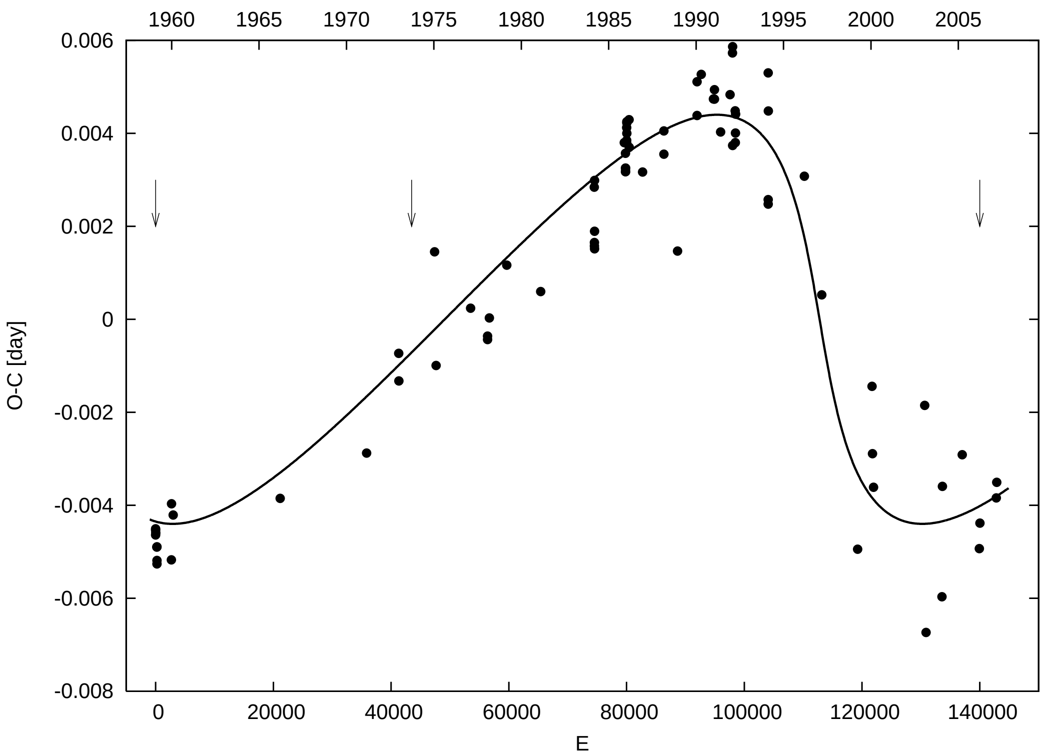

Figure 2. $O - C$ diagram of AD CMi after the subtraction of the quadratic function. The arrows indicate when radial velocity data were obtained

period with a rate of $(1/P)(dP/dt) = (9.32 \pm 0.11) \times 10^{-8}$ yr^{-1} and by the light time effect caused by binary motion on an elliptical orbit with orbiting period $P_{\rm orb} = 42.88 \pm 0.83$ yr, eccentricity $e = 0.71 \pm 0.05$, projected semi major axis $a \sin i = 1.092 \pm 0.080$ AU and the longitude of the periastron passage $\omega = 175° \pm 4°$.

The slow increase in the pulsation period is in accord with evolutionary theories (Breger & Pamyatnykh, 1998).

The spectroscopic observations did not show any sign of a companion, therefore on the one hand an upper limit can be given for the mass of the companion, on the other hand the mass function provides a lower limit. The mass function is $f(M) \approx 7.2 \times 10^{-4}\ M_\odot$. If we assume that the mass of AD CMi is around 2 $M_\odot$, the mass of the companion should be between 0.15 and 1 $M_\odot$. For the radial velocity (semi) amplitude $K \approx 1.1$ km/s can be deduced. This value is not in conflict with the radial velocity data.

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