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

Number 5735

Konkoly Observatory
Budapest
22 November 2006

HU ISSN 0374 – 0676

IV CASSIOPEIAE: A PROBABLE PHOTOMETRIC TRIPLE STAR

WOLF, M.[1]; ZEJDA, M.[2]; KIYOTA, S.[3]; MAEHARA, H.[4]; NAGAI, K,[5]; NAKAJIMA, K.[6]

[1] Astronomical Institute, Charles University Prague, V Holešovičkách 2, CZ-180 00 Praha 8, Czech Republic, e-mail: wolf@cesnet.cz

[2] Institute of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic

[3] VSOLJ, 4-405-1003 Matsushiro, Tsukuba 305-0035, Japan

[4] VSOLJ, 1-13-4 Namiki, Kawaguchi, Saitama 332-0034, Japan

[5] VSOLJ, 5-9-3 B-305 Honson, Chigasaki, Kanagawa 253-0042, Japan

[6] VSOLJ, 124 Teratani, Isato, Kumano, Mie 519-4673, Japan

The semi-detached eclipsing binary IV Cassiopeiae (GSC 4001.1104, SVS 948, FL 3529; $\alpha_{2000} = 23^{\rm h}49^{\rm m}31\overset{\rm s}{.}5$, $\delta_{2000} = +53^\circ08'05''$, Sp. A4, $V_{\rm max} = 11.0$ mag) is a relatively frequently observed binary with an orbital period almost exactly one day. This system was selected as a possible candidate for the study of the pulsating component and thus it was also included to our new observational project. IV Cas was discovered to be a variable star on Moscow plates by Faddeejeva in 1940 (Meshkova, 1940). Later Florja (1946) derived the first light elements

$$\text{Pri. Min.} = \text{HJD}2428991.302 + 0\overset{\rm d}{.}9985232 \times E$$

and confirmed the eclipsing character of light changes. Due to the relatively short orbital period and rapid magnitude changes this variable was often observed visually. Recently, Kim et al. (2005) in their photometric study discovered a short-periodic pulsating component with a frequency of 37.672 cycles per day (period about 38 min). The current linear light elements are also given in the database of Kreiner (2004)†:

$$\text{Pri. Min.} = \text{HJD}2452500.3506 + 0\overset{\rm d}{.}9985120 \times E.$$

This variable is also included in the latest catalogue of close binaries with δ Scuti component (Soydugan et al., 2006).

Our new CCD photometry of IV Cas was carried out during several nights in October 2005 and November 2006 at the Brno observatory, Czech Republic, and three private observatories in Japan. Different telescopes, CCD cameras, filters and exposure times were used (see Table 1). The nearby stars GSC 4001.0776 ($V = 12.05$ mag) on the same frame as IV Cas served as a primary comparison star during observations in Brno. See also http://nyx.asu.cas.cz/~lenka/dbvar/ for more information about these observations. The new times of primary minimum and their errors were determined using the least squares fit of the data, by the bisecting chord method or by the Kwee–van Woerden

†http://www.as.ap.krakow.pl/ephem/

Table 1: New times of primary minimum of IV Cas

JD Hel. – 24 00000	Epoch	Error (days)	N	Telescope, camera, filter
52464.4044	11627.0	0.0007	26	40-cm, ST-7, clear
53671.6040	12836.0	0.0001	180	20-cm, ST-7, R
54045.0455	13210.0	0.002	201	20-cm SC, ST-9XE, V
54045.0464	13210.0	0.001	455	20-cm, ST-7E, V
54047.0437	13212.0	0.002	205	20-cm SC, ST-9XE, I_c
54047.0440	13212.0	0.0005	279	25-cm SC, CV-04, B

algorithm. These times of minimum are presented in Table 1. In this table, N stands for the number of observations used in the calculation of the minimum time. The epochs were calculated according to the light elements given in the GCVS catalogue. Figure 1 shows the differential B magnitudes during the primary minimum observed at JD 24 54047.

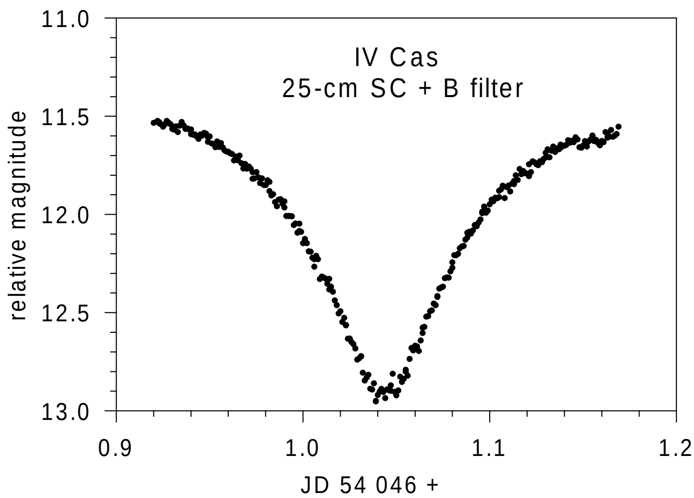

Figure 1. A plot of differential B magnitudes obtained during the primary eclipse of IV Cas on November 7, 2006 by K. Nakajima

The change of period and possible light-time effect of IV Cas were studied by means of an $O-C$ diagram analysis. We took in consideration all older visual and photographic times of minima found in special databases of AAVSO and BRNO[†] observers as well as new photoelectric times given in Diethelm (2003), Demircan et al. (2003), Dworak (2004), Cook et al. (2005) and our own results. The sinusoidal deviations of the $O-C$ values are well remarkable and could be caused by a light-time effect. For its solution we used all these times with different weights. A preliminary analysis of the third body gives the following parameters:

[†]http://www.aavso.org/observing/programs/eclipser/ebtom.shtml, http://var.astro.cz/ocgate

P (period)	$= 21800 \pm 500$ days
	$= 59.7 \pm 1.4$ years
T (time of periastron)	= J.D. 24 43455 ± 50
A (semi-amplitude)	$= 0.0336 \pm 0.0008$ day
ω (length of periastron)	$= 341.1 \pm 2.5$ degrees
e (eccentricity)	$= 0.09 \pm 0.03$

These values were obtained by the least squares method together with the mean light elements

$$\text{Pri. Min.} = \text{HJD}2440854.6280(5) + 0\overset{\text{d}}{.}99851658(12) \times E.$$

The $O-C$ diagram is plotted in Fig. 2.

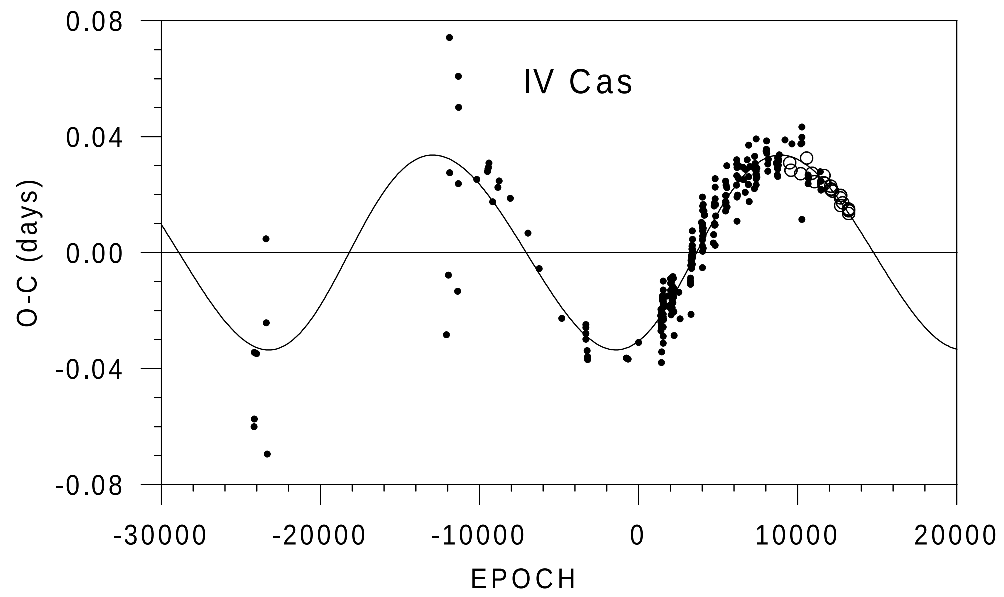

Figure 2. $O-C$ diagram for IV Cas. The numerous visual and photographic times are denoted by dots, the photoelectric and CCD times by circles. The sinusoidal curve corresponds to the third body orbit with a period of about 60 years and a semi-amplitude about 48 minutes

Assuming a coplanar orbit ($i_3 = 90°$) and adopting a total mass of the eclipsing pair with A4 primary to be $M_1 + M_2 \simeq 3.0\ M_{\odot}$, we can obtain a lower limit for the mass of the third component $M_{3,\min}$. The mass function has a value $f(M) = 0.056\ M_{\odot}$, from which the minimum mass of the third body follows as 0.96 $M_{\odot}$. A possible third component of spectral type about G9 with the bolometric magnitude of $m_3 \simeq 5.0$ mag (Harmanec, 1988) produces a detectable third light of $L_3 \simeq 4.5$ % of total light.

Our result indicates, that IV Cas is probably next member of a small group of triple systems with pulsating primary component deserving a regular monitoring (Y Cam – Broglia & Marin, 1974; DG Leo – Lampens et al., 2005; HD 207651 – Henry et al., 2004). Only a relatively small part of the third body orbit is well-covered by the precise photoelectric observations. Therefore, new high-accuracy timings of this eclipsing system are necessary in order to confirm the light-time effect and to improve its parameters given above.

Acknowledgements. This investigation was supported by the Grant Agency of the Czech Republic, grants No. 205/04/2063 and No. 205/06/0217. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, and of NASA's Astrophysics Data System.

References:

Broglia, P., Marin, F., 1974, *A&A*, **34**, 89
Cook, J.M., Divoky, M., Hofstrand, A., Lamb, J., Quarderer, N., 2005, *IBVS*, No. 5636
Demircan, O., Erdem, A., Ozdemir, S., Cicek, C., et al., 2003, *IBVS*, No. 5364
Diethelm, R., 2003, *IBVS*, No. 5438
Dworak, S.W., 2004, *IBVS*, No. 5502
Florja, N.F., 1946, *Variable Stars*, **6**, 4
Harmanec, P., 1988, *Bull. Astr. Inst. Czech.*, **39**, 329
Henry, G.W., Fekel, F.C., Henry, S.M., 2004, *AJ*, **127**, 1720
Kim, S.-L., Lee, C.-U., Koo, J.-R., et al., 2005, *IBVS*, No. 5669
Kreiner, J.M., 2004, *Acta Astronomica*, **54**, 207
Lampens, P., Frèmat, Y., Garrido, R., Peña, J.H., et al., 2005, *A&A*, **438**, 201
Meshkova, T.S., 1940, *Variable Stars*, **5**, 304
Soydugan, E., Soydugan, F., Demircan, O., Ibanoglu, C., 2006, *MNRAS*, **370**, 2013