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Photometric observations of nine Algol systems

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1 Introduction

It is known that the light curves at the primary eclipse of many Algol-type binary systems are frequently disturbed. Olson (e.g., Olson 1982) called such phenomena “transient photometric disturbances” (TPDs, hereafter), and concluded that they occur due to the existence of circumstellar matter, hot/cool spot(s) and/or radius variations. In order to obtain more information about TPDs, we carried out photometric observations of several short period Algol binaries. Some comments on TPDs obtained by us are given.

2 Observations

We observed nine Algol systems (XZ And, R CMa, RZ Cas, TV Cas, AB Cas, U CrB, AI Dra, RW Mon and X Tri) with the 91-cm reflector equipped with the multi-channel polarimetric photometer (MCP) at the Dodaira Station of the National Astronomical Observatory of Japan [1] from November 1993 to April 1996. The MCP had eight channels (Kikuchi et al. 1979) with photomultipliers (EMI 9789QB, 6256B, 9658R) refrigerated with dry ice. The effective wavelengths of the MCP were 360 nm (ch.1), 420 nm (ch.2), 455 nm (ch.3), 530 nm (ch.4), 640 nm (ch.5), and 690 nm (ch.6), respectively (all of ch.7 and ch.8 and some of ch.1 were not used here due to large scattering in our observations). Further details of the MCP are described in Kikuchi (1988).

3 Results and Comments

A total of 20 primary eclipses were observed for above Algol systems and summarized in Table 1, together with the estimated heliocentric times of minima on ch.4. In the table, E indicates the number of orbits counted from the first eclipse observed for each system. We found TPDs in five systems, which are described in the followings.

3.1 RZ Cas

The primary minimum of RZ Cas is due to the partial eclipse, but it is known that the shape of light curve at the mid-eclipse has frequently changed (e.g., Narusawa et al. 1994). Ohshima et al. (1998, 2001) found the δ Sct type

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nonradial pulsation in the primary component (pulsational period is ca. 22 min). This has led us to understand that the change of shape is synthesized with the light variation of the partial eclipse and those of the oscillations. Ohshima et al. (2001) categorized the shapes into four types; the "F-type" with a flat bottom; the "V-type" with a V-shaped curve; and the "S-type" with a slant increasing or decreasing smoothly. Furthermore, the subtypes "Sa" and "Sb" were classified which indicate an ascending slant and a descending one respectively. According to the explanation by Ohshima et al. (2001), when the light maximum of the δ Sct pulsation coincides with the center of eclipse, the F-type is observed. When the light minimum of pulsation coincides with the mid-primary eclipse, the V-type light curve is observed. The intermediate case is the S-type (the light maximum of pulsation coincided with just before and just after the mid-eclipse yields the Sa- and Sb-type, respectively). We suppose that a partial-eclipsed curve, the "P-type" probably appears when the amplitude of pulsation is small.

Two of four primary eclipses obtained by us at the Dodaira Station are S-types. In the first night (1995 Nov. 2), the light curve seems to be Sa-type. Subsequently, the Sb-type was detected in the next night (1995 Nov. 3). Light curves of both nights were shown in Figure 1. These shapes indicate that the pulsational amplitude was not small at that time. On the other hand, two other light curves obtained in 1993/94 season seem to be undisturbed (i.e. P-types were observed).

3.2 AB Cas

We observed four primary eclipses of AB Cas during two seasons. The light curve on Jan. 25 in 1994 seems to be a flat type as shown in Figure 2. The duration of the flat bottom is about 18 min. Tempesti (1971) found that the primary component of AB Cas is a δ Sct-type star whose pulational period is 84 min, and Hong et al. (2017) revealed that its oscillation is due to the fundamental radial p-mode. Therefore, we suppose that the flat bottom occurred due to the same mechanism as RZ Cas (i.e. it is the F-type). Remaining light curves have no flat bottoms (they are P-types).

3.3 R CMa

We could observe one eclipse of R CMa, and the shape of light curve at the mid-eclipse was not so clear but seems to be flat (Figure 3). Mkrtichian & Gamarova (2000) found that the primary component of R CMa also shows the δ Sct type oscillation. Subsequently, Lehmann et al. (2018) found that its period is 1.12 hr. Thus, this portion is also probably F-type.

Moreover, the light curve has asymmetric shape (Figure 4) and the magnitude differences between descending and ascending branches are up to 0.10 mag. (ch.1 and 2), 0.08 mag. (ch.3), 0.07 mag. (ch.4) and 0.05 mag. (ch.5 and 6). The light curves on ch. 2 and ch. 4 were compared with B- and V-band of Koch (1960), respectively. From the result, we recognize that brightness of the descending branch is darker than that of the ascending one. Therefore, there is a possibility that the cool gas cloud which effectively absorb shorter wavelengths was seen at the before mid-primary phase.

3.4 U CrB

The depth of the primary eclipse of U CrB on ch.1 on April 5 in 1996 was shallower than that of April 12 in 1995 as shown in Figure 5. The difference of 0.03 mag. is larger than the margin of error (differences of other channels were almost the same as errors). we regard this depth-change as an effect of circumstellar matter or the pulsation (Narusawa 2021 suggests the primary component of this star is a MAIA-type variable).

3.5 XZ And

The shape of one (1995 Feb. 22) of three light curves of XZ And was not clear but looked like the F-type that lasted ca. 17 min as shown in Figure 6 (other two had no clear flat bottoms). Moreover, Blitzstein (1954) wrote that the primary minimum of this system was the total eclipse and its duration was 0.0076 day (11 min). According to the Yang's solution (2013), the primary minimum is partial of the 'grazing' eclipse. Hence, these bottoms were not F-types but the pseud-totality caused by the grazing eclipse. Similar phenomenon appears in another Algol-type system S Equ (Narusawa 2021).

4 Summary

We carried out photometric observations of nine short period Algol-type binaries, and obtained a total of 20 primary eclipses. We found TPDs in five systems; RZ Cas, R CMa, AB Cas, U CrB and XZ And. We conclude that more than half of all TPDs occurred due to the influence of the pulsation. Although, Olson (1982) studied about TPDs without any consideration on the pulsation, we strongly feel that future work will surely need it. Other details of this study will be published elsewhere.

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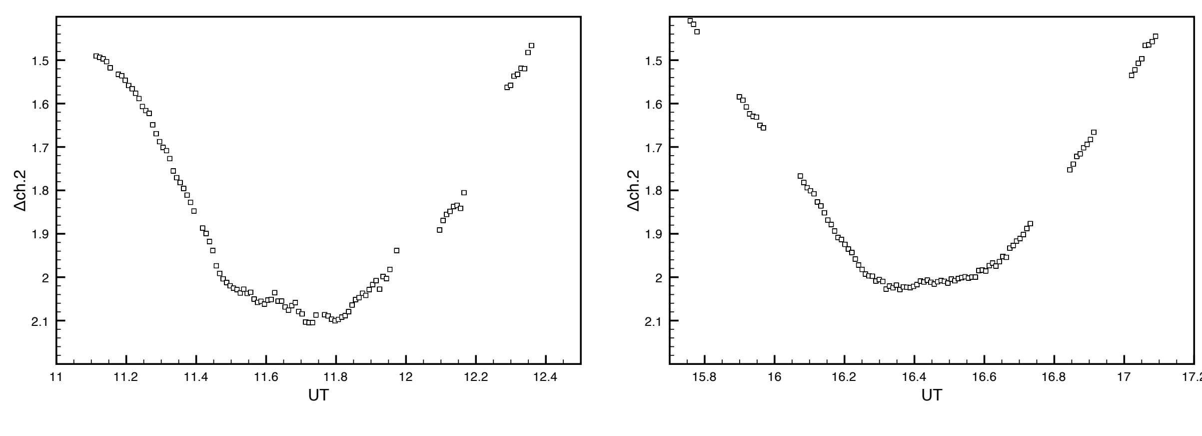

Figure 1: Differential light curves of the primary minimum of RZ Cas on ch. 2. (Left panel: Nov. 2 1995. Right panel: Nov. 3 1995.) The abscissa is the Universal Time.

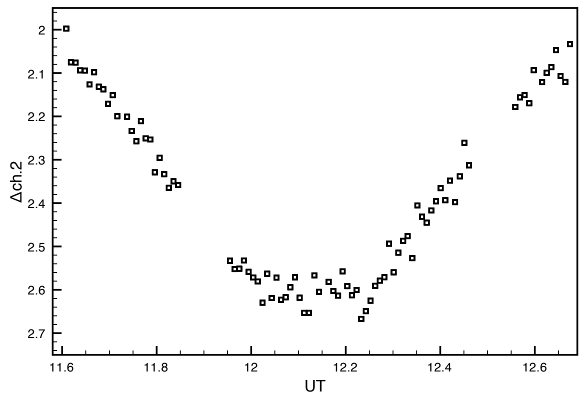

Figure 2: Same as in Figuer 1, but for the enlarged portion near the bottom of AB Cas on ch.2 on Jan. 25 1994.

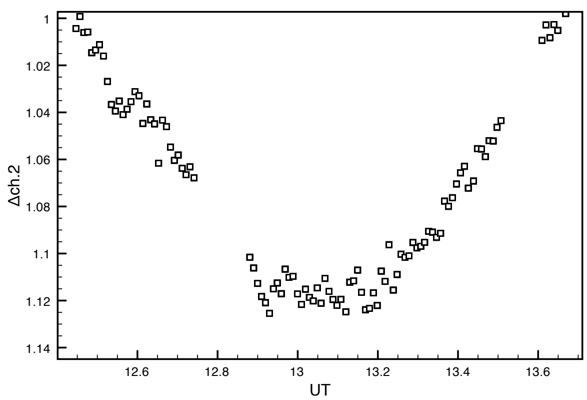

Figure 3: Same as in Figure 2, but for R CMa on ch.2 on Feb. 19 1995.

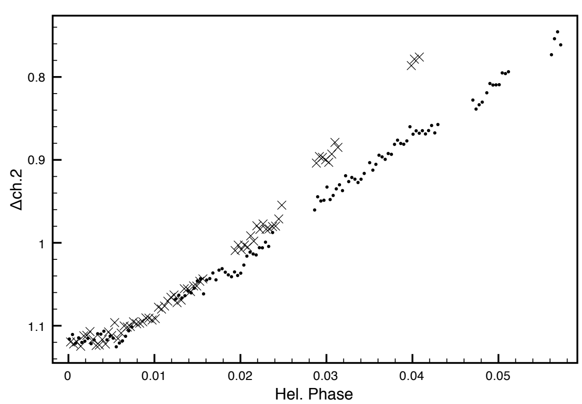

Figure 4: Light changes of the primary minimum of R CMa on ch.2 on Feb. 19 1995. Crosses and dots sings represent ascending and descending branches, respectively.

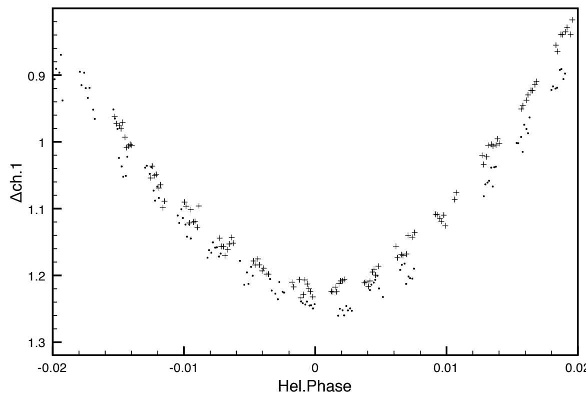

Figure 5: Same in Figure 2, but for U CrB on ch.1. Dots and pulses sings represent on Apr. 12 1995 and Apr. 5 1996, respectively.

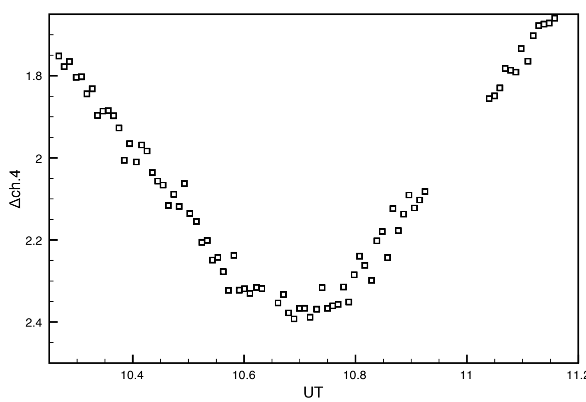

Figure 6: Same as in Figure 2, but for XZ And on ch.4 on Feb. 22 1995.

Table 1: Table 1. Estimated times of the observed primary minima

Star	Date	E	Min I (HJD) (+2400000)	Comparison star BD
XZ And	1994 Jan. 23	0	49375.96682(5)	+40°0405
	1995 Feb. 22	291	49770.94366(2)	
	1995 Nov. 4	479	50026.11828(8)	
R CMa	1995 Feb. 19	-	49768.04875(8)	-15°1734
RZ Cas	1993 Nov. 4	0	49296.07973(5)	+67°0224
	1994 Jan. 22	66	49374.96772(5)	
	1995 Nov. 2	609	50023.99283(5)	
	1995 Nov. 3	610	50025.18902(5)	
TV Cas	1993 Nov. 5	-	49297.07269(6)	+58°24
AB Cas	1993 Nov. 4	0	49295.99337(4)	+70°187
	1994 Jan. 25	60	49378.00750(4)	
	1995 Dec. 1	554	50053.25266(2)	
	1995 Dec. 4	556	50055.98632(3)	
U CrB	1995 Apr. 12	0	49820.13455(6)	+ 31°2724
	1996 Apr. 5	104	50179.17139(7)	
AI Dra	1994 Oct. 23	0	49648.95076(6)	+52°2018
	1995 Feb. 22	102	49771.22864(5)	
RW Mon	1994 Jan. 24	0	49377.11713(8)	+08°1400
	1994 Jan. 26	1	49379.02288(8)	
X Tri	1995 Nov. 6	-	50028.20450(4)	+27°0317

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