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ON THE SUPERCYCLE OF TWO ECLIPSING SU UMa-TYPE DWARF NOVAE: V2051 Oph AND IY UMa

KATO, TAICHI[1]; STUBBINGS, ROD[2]; NELSON, PETER[3]; PEARCE, ANDREW[4]; GARRADD, GORDON[5]; KIYOTA, SEIICHIRO[6]

[1] Dept. of Astronomy, Kyoto University, Kyoto 606-8502, Japan, e-mail: tkato@kusastro.kyoto-u.ac.jp

[2] 19 Greenland Drive, Drouin 3818, Victoria, Australia, e-mail: stubbo@qedsystems.com.au

[3] RMB 2493, Ellinbank 3820, Australia, e-mail: pnelson@dcsi.net.au

[4] 32 Monash Ave, Nedlands, WA 6009, Australia, e-mail: Andrew.Pearce@worley.com.au

[5] PO Box 157, NSW 2340, Australia, e-mail: loomberah@ozemail.com.au

[6] Variable Star Observers League in Japan (VSOLJ), 1-401-810 Azuma, Tsukuba, 305-0031, Japan, e-mail: skiyota@nias.affrc.go.jp

V2051 Oph is a short-period eclipsing cataclysmic variable whose exact nature was a matter of controversy for a long time. Some authors suspected it to be a dwarf nova, while extensive studies by Warner and O'Donoghue (1987) proposed a low-field polar (synchronously rotating magnetic cataclysmic variable). It was only recently that regular detections of outbursts by amateur astronomers confirmed the dwarf nova nature, and finally Kiyota and Kato (1998) discovered superhumps, which led to a conclusion to the long-lasting controversy. The star is now recognized as a member of rare class of SU UMa-type dwarf novae, which show deep eclipses even during outbursts. Only a handful of such objects are known: Z Cha, OY Car, HT Cas, DV UMa and IY UMa, the last one of which will be discussed later in this paper. All of them have provided a wealth information about the structure of accretion disks.

Since past observation of V2051 Oph suggested relatively unusual spectroscopic and photometric features (Warner and O'Donoghue 1987), the next question is whether V2051 Oph shows typical outburst behavior as seen in other SU UMa-type dwarf novae. Thanks to the recent intensive visual monitoring, as a part of VSNET Collaboration (http://www.kusastro.kyoto-u.ac.jp/vsnet/), many outbursts have been detected. However, since V2051 Oph lies close to the ecliptic, some outbursts are inevitably missed because of solar conjunctions and the interference by the Moon. Table 1 lists the detected outbursts since 1997 August. V2051 Oph was sometimes more frequently detected around 14.5 mag, than in other observing seasons. It is not clear whether these detections were short normal outbursts, or enhanced activity in quiescence, as is sometimes observed in high-inclination systems (cf. Richter and Greiner (1995) for alternations between high/low states in a high-inclination dwarf nova, IR Com; see also http://www.kusastro.kyoto-u.ac.jp/vsnet/LClast/index/PEGIP.html for a recent example of IP Peg). Figure 1 shows the light curve drawn from these data. CCD observations (G.G. and S.K.) are also plotted. Large dispersions of magnitudes in most part reflect orbital variations caused by eclipses.

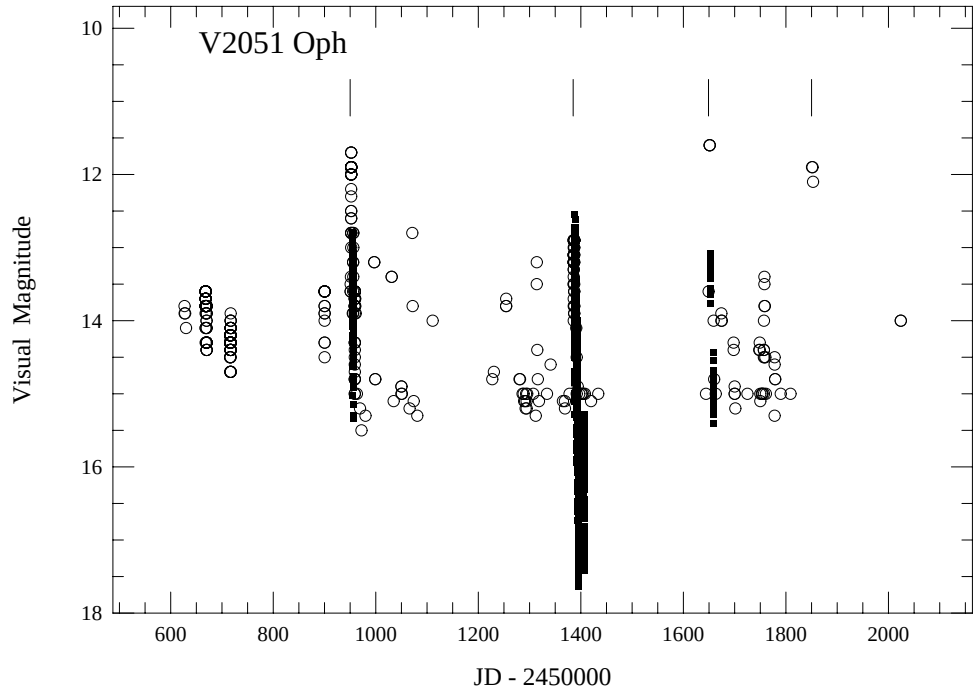

Figure 1. Overall light curve of V2051 Oph. Filled and open symbols represent CCD and visual observations, respectively. The superoutbursts are marked with ticks. Upper limit observations are not plotted for simplicity

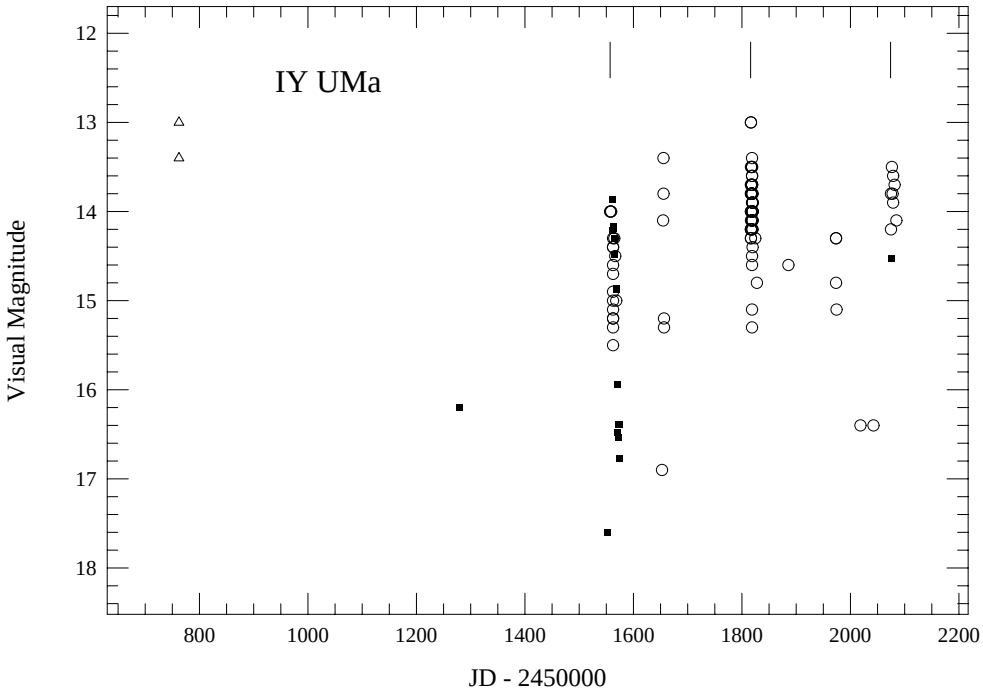

Figure 2. Overall light curve of IY UMa. Filled and open symbols represent CCD and visual observations, respectively. The first two open triangles are photographic discovery observations by Takamizawa. The superoutbursts are marked with ticks. Upper limit observations are not plotted for simplicity

Table 1: Outbursts of V2051 Oph

JD start	peak mag	d[a] (d)	type	JD start	peak mag	d[a] (d)	type
2450626	13.8	3	normal	2451313	13.2	2	normal
2450668	13.6	3	normal	2451340	14.6	1	normal[c]
2450715	14.1	2	normal	2451385	12.9	8	super
2450900	13.6	1	normal	2451649	11.6	11	super
2450950	11.7	13	super	2451674	13.9	1	normal
2450996	13.2	3	normal	2451697	14.3	1	normal[c]
2451030	13.4	3	normal	2451747	14.3	2	normal
2451071	12.8	2	normal	2451756	13.8	3	normal
2451110	14.0	1[b]	normal	2451777	14.5	2	normal[c]
2451227	14.7	3	normal[c]	2451850	11.9	> 3	super
2451254	13.7	> 1	normal	2452024	14.0	1	normal
2451280	14.8	2	normal[c]				

[a] Duration of outburst (brighter than mag 15).

[b] Single estimate.

[c] Enhanced activity in quiescence?

As is evident from Table 1 and Figure 1, four definite superoutbursts were observed. The shortest interval between them was 201 d. The interval between the first and second being close to the double this period, there should have been a missed superoutburst during the conjunction period. The average supercycle, by assuming this presumably missed superoutburst, is 227 d. This is a quite typical supercycle for a relatively active SU UMa type dwarf nova (cf. Nogami et al. 1997). The cycle length of normal outbursts is more difficult to determine, but since the epochs of the first seven outbursts are well represented by a period of 45 d, this period may be a good candidate for the cycle length. However, if fainter brightenings to $\sim 14\overset{\mathrm{m}}{.}5$, observed between JD 2451110 and 2451777, are indeed normal outbursts, the cycle length of normal outbursts may need to be halved. In either cases, both the supercycle length and the cycle length of normal outbursts fall within a region occupied by usual SU UMa-type dwarf novae (cf. Nogami et al. 1997). This suggests that V2051 Oph is a fairly normal SU UMa-type dwarf nova, in terms of its outburst activity. This existence of a bright deeply eclipsing, fairly normal SU UMa-type dwarf nova would provide a promising tool for future detailed observations of accretion process in cataclysmic variables.

IY UMa (= TmzV85) was discovered by Takamizawa as a dwarf nova. Subsequent observations during the 2000 January outburst revealed that the object is a rare, deeply eclipsing SU UMa-type dwarf nova (Uemura et al. 2000a,b). Based on the observations of this superoutburst and other information, a number of authors suggested that IY UMa has a supercycle length comparable to southern eclipsing SU UMa-type dwarf novae (Uemura et al. 2000b; Patterson et al. 2000). However, the reliable determination of the supercycle length should require further detections of superoutbursts.

Based on the observations reported to the VSNET Collaboration, we have been able to identify seven outbursts (Table 2 and Figure 2), three of which (even disregarding the initial detection by Takamizawa) are superoutbursts. The last three superoutbursts occurred with a rigorous recurrent period of 285.5 d. Takamizawa's initial detection could be a superoutburst three cycles before the JD 2451557 outburst, but this is not conclusive because of a rather large $O - C$ of 61 d against the recent ephemeris. Whether this could

Table 2: Outbursts of IY UMa

JD start	peak mag	d[a] (d)	type	JD start	peak mag	d[a] (d)	type
2450762	13.0	-	super?	2451885	14.6[b]	-	normal
2451557	14.0	14	super	2451973	14.3	2	normal
2451654	13.4	3	normal	2452074	13.5	> 10	super
2451816	13.0	> 11	super				

[a] Duration of outburst.

[b] Single observation.

represent a change in the supercycle length needs to be tested by future observations.

The shortest interval between successive outbursts, including normal outbursts, was 69 d. This cycle length of normal outbursts is typical for an SU UMa-type dwarf nova with a supercycle length of 285.5 d.

In conclusion, IY UMa is confirmed to be the first, long-wanted, deeply eclipsing bright SU UMa-type dwarf nova in the northern hemisphere, which has typical outburst characteristics of a normal SU UMa-type dwarf nova.

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