CCD Photometry of a Newly Confirmed SU UMa-Type Dwarf Nova, NSV 4838

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Abstract

We present time-resolved CCD photometry of a dwarf nova, NSV 4838 (UMa 8, SDSS J102320.27+440509.8), during 2005 June and 2007 February outbursts. The two light curves showed superhumps with mean periods of 0.0699(1)d for the 2005 outburst and 0.069824(83)d for the 2007 outburst. Using its known orbital period of 0.0678d, we estimated the mass ratio of the system to be q = 0.13 based on an empirical relation. Although the majority of SU UMa-type dwarf novae having similar superhump periods show negative period derivatives, we found that the superhump period increased at \( \dot{P}/P_{\text{sh}} = +7(+3, -4) \times 10^{-5} \) during the 2007 superoutburst. We also investigated long-term light curves of NSV 4838, from which we derived 340d as a supercycle of this system.

Key words: accretion, accretion disks — stars: dwarf novae — stars: individual (NSV 4838) — stars: novae, cataclysmic variables

1. Introduction

Dwarf novae are a group of cataclysmic variable stars that consist of a white dwarf (primary) and a late-type star (secondary) (for a review, e.g., Warner 1995; Osaki 1996, 2005; Hellier 2001; Connon Smith 2007). The orbital periods of the majority of dwarf novae are below 9 hr (Gänssicke 2005). The secondary star fills its Roche lobe, transferring gas into the primary Roche lobe via the inner Lagrangian point (L1). This process results in the formation of an accretion disk around the primary. This accretion disk plays the main role in dwarf nova outbursts, which are driven by a thermal limit-cycle instability (Höfö 1979; Meinunger 1981; Cannizzo et al. 1988).

SU UMa-type dwarf novae form a subclass of dwarf novae, whose orbital periods are shorter than 2 hr, except for a few systems (e.g., Osaki 1989). These systems exhibit two types of outbursts. One is a normal outburst, whose duration is typically a few days. The other is a superoutburst, whose duration is longer than 10 d, and its maximum magnitude is brighter than that of a normal outburst by ~0.5 mag. During a superoutburst, the light curve shows tooth-like modulations, called a superhump with an amplitude of ~0.2 mag. The period of the superhump \( P_{\text{sh}} \) is a few percent longer than the orbital period \( P_{\text{orb}} \). This slightly longer periodicity and the modulation are attributed to a phase-dependent removal of angular momentum in a tidally deformed eccentric disk (Whitehurst 1988; Hirose & Osaki 1990; Murray 1998; Smith et al. 2007).

NSV 4838 [UMa 8 (Downes et al. 2001), SDSS J102320.27+440509.8 (Szkody et al. 2005)] was listed by Berger and Fringant (1977) as a class I (UV-richest) object. Downes et al. (1997) introduced this object as a candidate dwarf nova or a novalike star with its photographic magnitude ranging over 14.5p–16.5p. An optical spectrum was published by Szkody et al. (2005), in which Balmer emission lines were superimposed on a blue continuum. Szkody et al. (2005) also gave the SDSS quiescent magnitudes of the object as \( u' = 18.513 \), \( g' = 18.830 \), \( r' = 18.688 \), \( i' = 18.570 \), and \( z' = 18.514 \). Radial-velocity studies were implemented by Thorstensen et al. (unpublished), who determined \( P_{\text{orb}} = 0.0678 \) d (see also, Ritter & Kolb 2003). No 2MASS counterpart was detected, but the recent infrared photometry using the OAO/ISLE (a near-infrared imager and medium-resolution spectrograph for 188 cm telescope: Yanagisawa et al. 2006) yields \( H = 17.51(0.09) \) and \( K_s = 16.81(0.08) \). The SU UMa nature of the object was initially confirmed by T. Vanmunster by detecting superhumps during the 2005 June superoutburst. Here, we report on photometric studies of the 2005 June and 2007 February superoutbursts and of the long-term behavior of the object.
2. Observations

Time-resolved CCD photometry was performed from 2005 June 6 to June 14, and from 2007 February 7 to 28 at 5 sites. A log of observations is summarized in Table 1. Detailed information on sites is given in Table 2. The total number of frames amounted to 7428. The exposure time ranges from 30 s to 180 s without a filter. All CCD systems are close to the Kron-Cousins \(R\) band. After debiasing and flat-fielding, we performed aperture photometry using IRAF\(^1\) apphot for data of KU and Mhh, AIP4WIN (Berry & Burnell 2000) for data of JP, and FitsPhot 4.12 for data of Njh. The Kyoto team (Kyoto) used a Java-based point spread function (PSF) photometry package developed by one of the authors (TK). The differential magnitudes among individual sites were adjusted to that of the KU site, where we chose a comparison star, NOMAD 1340–0218270 (RA:10\(^h\)23\(^m\)33\(^s\)34, Dec:+44°03′26″0, \(V = 15.20, R = 15.16\)). The constancy of the star was checked by nearby stars in the same frame. A heliocentric correction was made for each data set before following analyses.

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### Table 1. Log of observation.

| Date (UTC) | HJD−240000 | Number of frames | Exposure time (s) | ID of the observers* |
|------------|------------|------------------|-------------------|----------------------|
| 2005 Jun  6| 53528.3834 | 46               | 45–60             | JP                   |
| 2005 Jun  7| 53529.3923 | 96               | 45–60             | JP                   |
| 2005 Jun  8| 53530.3811 | 107              | 45–60             | JP                   |
| 2005 Jun  9| 53531.3804 | 111              | 45–60             | JP                   |
| 2005 Jun 13| 53535.3978 | 6                | 60                | JP                   |
| 2005 Jun 14| 53536.4019 | —                | 1                 | JP                   |
| 2007 Feb  7| 54139.2154 | 70               | 180               | KU                   |
| 2007 Feb  9| 54141.2600 | 19               | 30                | Njh                  |
| 2007 Feb 10| 54142.2642 | 35               | 180               | KU                   |
| 2007 Feb 11| 54143.9669 | 912              | 30                | Mhh                  |
| 2007 Feb 12| 54143.9454 | 189              | 180               | KU                   |
| 2007 Feb 14| 54146.1660 | 139              | 30                | Njh                  |
| 2007 Feb 15| 54147.1399 | 850              | 30                | Mhh                  |
| 2007 Feb 16| 54148.0700 | 445              | 30                | Kyoto                |
| 2007 Feb 18| 54150.0437 | 1028             | 30                | Mhh                  |
| 2007 Feb 19| 54150.9889 | 457              | 30                | Kyoto                |
| 2007 Feb 20| 54151.2283 | 74               | 180               | KU                   |
| 2007 Feb 21| 54152.1114 | 100              | 180               | KU                   |
| 2007 Feb 23| 54155.0150 | 80               | 180               | KU                   |
| 2007 Feb 25| 54157.3127 | 33               | 180               | KU                   |
| 2007 Feb 26| 54158.2717 | 28               | 180               | KU                   |
| 2007 Feb 28| 54160.1487 | 30               | 180               | KU                   |

*See table 2.

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### Table 2. List of observers.

| ID | Observer | Site | Telescope |
|----|----------|------|-----------|
| JP | J. Pietz | Erftstadt, Germany | 20 cm |
| KU | T. Yasuda+* | Kagoshima, Japan | 100 cm |
| Kyoto | A. Imada+† | Kyoto, Japan | 40 cm |
| Mhh | H. Maehara | Saitama, Japan | 25 cm |
| Njh | K. Nakajima | Mie, Japan | 25 cm |

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\(^1\) IRAF (Image Reduction and Analysis Facility) is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with National Science Foundation.

\(^2\) http://www.geocities.jp/nagai_kazuoi/dload-1.html.
3. Results

3.1. 2007 February Superoutburst

3.1.1. Light curve

The light curve obtained during the 2007 February superoutburst is shown in figure 1. The plateau phase lasted for at least 12 d, and the variable almost linearly faded at a rate of 0.10(1) mag d\(^{-1}\). After the plateau stage, NSV 4838 entered the rapid decline phase at a rate of 0.86(1) mag d\(^{-1}\). These values were typical for the superoutburst of SU UMa-type dwarf novae. Although the data were noisy during the post outburst stage, a hint of rebrightening was seen on HJD 2454157.

3.1.2. Superhump

In order to estimate the mean superhump period during the plateau stage, we performed the phase dispersion minimization method (PDM, Stellingwerf 1978) using 6750 points between 2007 February 7 and 19. Figure 2 shows the resultant theta diagram, indicating that the best-estimated period is 0.069824(83) d. The error of the period was estimated by using the Lafler-Kinman class of methods (Fernie 1989). Daily averaged light curves folded by this period are displayed in figure 3. Also shown is a representative light curve on 2007 February 12 (HJD 2454143.9454–2454144.3882) obtained by KU (figure 4). The absence of eclipses indicates a low-to-mid inclination of NSV 4838.

3.1.3. Superhump period change

We measured the maximum timings of superhumps, which are summarized in table 3. A linear regression yielded the following equation on the superhump maximum timings:

\[
\text{HJD}(\text{max}) = 2454139.2590(24) + 0.069802(21) \times E.
\]

Using this equation and table 3, we obtained the \(O-C\) diagram displayed in figure 5. The solid curve in this figure indicates the best-fitting quadratic equation between \(E = 0\) and 101, which is given by

\[
O - C = -3.75(1.11) \times 10^{-3} - 1.62(0.41) \times 10^{-4} E
+ 3.09(0.40) \times 10^{-6} E^2.
\]
Fig. 4. Enlarged light curve obtained by KU on 2007 February 12. A characteristic feature of superhumps is visible. The absence of eclipses means a low-to-mid inclination of NSV 4838.

Table 3. Timings of the superhump maxima.

| $E$ (Cycle count) | HJD−2450000 |
|-------------------|-------------|
| 0                 | 4139.2549   |
| 1                 | 4139.3247   |
| 44                | 4142.3284   |
| 54                | 4143.0243   |
| 55                | 4143.0943   |
| 56                | 4143.1634   |
| 57                | 4143.2360   |
| 68                | 4144.0064   |
| 69                | 4144.0733   |
| 70                | 4144.1444   |
| 71                | 4144.2129   |
| 72                | 4144.2850   |
| 73                | 4144.3563   |
| 100               | 4146.2519   |
| 101               | 4146.3194   |
| 113               | 4147.1551   |
| 114               | 4147.2272   |
| 115               | 4147.2954   |
| 127               | 4148.1296   |
| 128               | 4148.1980   |
| 129               | 4148.2658   |
| 155               | 4150.0748   |
| 156               | 4150.1461   |
| 157               | 4150.2157   |
| 158               | 4150.2872   |
| 159               | 4150.3544   |
| 169               | 4151.0520   |
| 170               | 4151.1188   |
| 172               | 4151.2564   |
| 173               | 4151.3283   |

Also shown in this figure is the dashed curve by fitting a quadratic equation between $E=0$ and 73. This is given by

$$ O - C = -3.97(1.05) \times 10^{-3} - 8.57(6.66) \times 10^{-4} E + 1.95(0.90) \times 10^{-6} E^2. \quad (3) $$

From these quadratic equations, we obtained $P_\dot{\text{dot}} = \dot{P}/P = 8.9(1.1) \times 10^{-5}$ from the former equation and $P/\dot{P} = 5.6(2.6) \times 10^{-5}$ from the latter. These results imply that the superhump period increased at $\dot{P}/P = 7(+3,-4) \times 10^{-5}$ in the middle of the plateau phase.

After $E=100$, the data points could be fitted by a linear equation. This indicates that the superhump period remains almost constant during this phase. A linear regression to the observed maximum timings between $E=100$ and 174 yields

$$ \text{HJD}(\text{max}) = 2454139.2969(20) + 0.06954(1) \times E. \quad (4) $$

Using the above equations in conjunction with the $O - C$ diagram, we found that a sudden period decrease occurred between $E=80$ and $E=100$.

3.2. 2005 June Superoutburst

The light curves during the 2005 June outburst are shown in figure 6. From HJD 2453528 to HJD 2453532, the magnitude declined at the rate of 0.06(1) mag d$^{-1}$. Although this value is smaller compared to the average decline rate of the plateau stage (0.10 mag d$^{-1}$: Warner 1995), such a slow decline
Variable Star Observers (AA VSO) light curve generator, we and other information, such as the American Association of. This value is in accordance with that obtained during the declining trends, we also performed PDM for the data over the first 4 nights, and found a weak signal at 0.0699 (1) d. This value is in accordance with that obtained during the 2007 February superoutburst. Judging from the above results and other information, such as the American Association of Variable Star Observers (AAVSO) light curve generator, we conclude that we observed NSV 4838 from the late stage of the superoutburst.

3.3. Mass Ratio

It is well known that the mass ratio of the system is related with the fractional superhump excess (Patterson 1998; Patterson et al. 2005; Knigge 2006). Here, we use an empirical relation derived by Patterson (1998),

$$
\epsilon = \frac{0.23 \Delta}{1 + 0.27 \Delta},
$$

where $\epsilon$ is the fractional period excess and $\Delta$ the mass ratio of the system. Using $P_{sh} = 0.0698$ d and $P_{orb} = 0.0678$ d (Thorstensen, unpublished, see also Ritter & Kolb 2003), we can estimate the mass ratio of NSV 4838 to be 0.13. This result is in accordance with that using other relations, such as equation (8) of Patterson et al. (2005) and equation (7) of Knigge (2006).

4. Discussion

4.1. Long-Term Behavior of NSV 4838

The present photometric studies have shown the basic properties of NSV 4838. The mean superhump period, the fractional superhump excess, and the duration of the plateau stage are quite typical of the “textbook” SU UMa-type dwarf novae (Warner 1995). We also investigated the long-term behavior of NSV 4838 largely based on the AAVSO light curve generator after the 2005 June superoutburst. The data include 229 negative observations (in which an upper limit of the magnitude is given) and 104 positive observations (in which the magnitude is given) from 2005 June to 2008 April. Although the short baseline of the archival data and its faintness even at the maximum brightness cannot give profitable results as to whether some outbursts were missed, we detected six outbursts in total. Figure 8 shows long-term light curves of NSV 4838. If we missed no superoutbursts, an estimated supercycle of NSV 4838 is about 340 d, which is a typical value for SU UMa-type dwarf novae. On the other hand, the total number of recorded normal outbursts is too small for the estimated supercycle of NSV 4838 (Osaki 1995). One possibility is that the normal outburst denied detection at the faint level of its maximum magnitude. If we did not overlook any normal outbursts, the event ratio of the normal outburst to the superoutburst is unusually small (see table 1 of Osaki 1995). Future continuous observations of this object are needed to clarify the activity of NSV 4838.

4.2. Distance

According to an empirical relation of Harrison et al. (2004), the absolute magnitude of dwarf nova at the maximum of the normal outburst is given as a function of its orbital period,

$$
M_V = 5.92 - 0.383 \times P_{orb},
$$

where $P_{orb}$ is measured in hours. According to multicolor photometry, the color index shows $V - R_C \sim 0$ near the bright maximum (Uemura et al. 2008). Thus, the maximum magnitude in the $V$ band may have almost the same value as that in the $R_C$ band. Since no filter is close to $R_C$, it is not unreasonable that we regard the magnitude in nonfilter as that in the $V$ band.

Extensive observations of SU UMa-type dwarf novae suggest that the maximum magnitude of the normal outburst is fainter than that of the superoutburst by about 0.5 mag (Warner 1995; Shafter et al. 2007). In conjunction with the above facts, including figure 8, the maximum magnitude of normal outburst for NSV 4838 is expected to be around 15.5 mag in the $V$ band. Using this value, we roughly estimated the distance to NSV 4838 to be 1.1 kpc.

4.3. Superhump-Period Change

The general consensus concerning the superhump-period change is that the majority of SU UMa-type dwarf novae show a decrease in superhump period during superoutburst (Uemura et al. 2005). Osaki (1985) suggested that this is possibly due to shrinkage of the disk radius, or a consequence of mass depletion from the accretion disk. Recently, it has been recognized that some SU UMa-type dwarf novae show an increasing superhump-period change during a plateau phase of a superoutburst (Semeniuk et al. 1997; Nogami et al. 1997). So far, we have confirmed this increase for about 15 SU UMa-type dwarf novae, most of which have superhump periods shorter than 0.065 d (Oizumi et al. 2007).

Based on a refined thermal-tidal instability model proposed by Osaki and Meyer (2003), the maximum radius during the superoutburst without a precursor is larger than that with a precursor. When the accretion disk reaches the tidal truncation radius (the maximum radius) at the onset of an outburst, the matter will be piled up at this radius, at which the stored matter works as a wall. This wall prevents a cooling wave from propagating inward because the continuous tidal dissipation at
the tidal truncation radius urges matter to infall. In this case, no precursor is observed at the onset of the superoutburst. On the other hand, when the accretion disk does not reach the tidal truncation radius at the onset of the outburst, the cooling wave can propagate from the outermost annulus, which is observed as a rapid decline, like a normal outburst. If the eccentricity of the accretion disk grows to some extent, the heating wave can again propagate from the outermost annulus, because the tidal torque enhancement supplies the gas to the inner annulus. This process is observed as a superoutburst with a precursor.

Recently, Uemura et al. (2005) studied superhump-period changes for the 2001 and 2004 superoutbursts of a short-period SU UMa-type dwarf nova, TV Crv. It was found that the 2001 superoutburst showed no evidence of a precursor, and the superhump period increased during the plateau phase. On the other hand, the 2004 superoutburst was accompanied by a precursor, and the superhump period remained almost constant during the plateau phase. Combining these observations with the refined thermal-tidal instability model, Uemura et al. (2005) suggested that sufficient propagation of the eccentric mode outside the 3:1 resonance radius may be observed as an increase in superhump period. Therefore, short-period SU UMa-type dwarf novae, in which there exists a large annulus between the 3:1 resonance radius and the tidal truncation radius, tend to show a positive-period derivative. On the other hand, long-period SU UMa-type dwarf novae and those with a precursor during superoutburst, in which the gap between the 3:1 resonance radius and the tidal truncation radius is small, tend to show negative- or zero-period derivatives.

Figure 9 illustrates a $P_{\dot{\text{dot}}}-P_{\text{sh}}$ diagram of SU UMa-type novae, in which we added the results of NSV 4838. It should be noted that NSV 4838 showed positive-period derivatives despite the fact that the superhump period of the system was as long as 0.070 d. In figure 9, one can notice that a few systems of $P_{\text{sh}} > 0.07$ d also show a positive $P_{\dot{\text{dot}}}$. They are VW CrB ($P_{\text{sh}} = 0.07287$ d, Nomoto et al. 2004), TT Boo ($P_{\text{sh}} = 0.07796$ d, Olech et al. 2004), and RZ Leo ($P_{\text{sh}} = 0.07853$ d, Ishioka et al. 2001). Interestingly, these systems commonly show long-lasting (exceeding 2 weeks), large-amplitude (exceeding 6 mag) superoutbursts and long supercycles. On the other hand, NSV 4838 exhibits a relatively small amplitude ($\sim$4 mag) and a moderate supercycle ($\sim$1 year). In addition, the negative $P_{\dot{\text{dot}}}$ was reported in the 1991 October superoutburst of EF Peg, which exhibited a long-lasting and large-amplitude superoutburst and a long-recurrence time (Howell et al. 1993; Kato 2002). Therefore, we suggest that these properties do not necessarily lead to a positive $P_{\dot{\text{dot}}}$.

Although the exact mechanism causing superhump-period changes still remains unknown, the present results imply that an additional physical parameter on the accretion disk should be required for explaining the observed diversity of the superhump-period changes. In order to clarify the nature of the superhump-period changes, we should collect further samples.

5 In dwarf novae during quiescence, $V$ magnitude is close to $g$ (e.g., Szkody et al. 2005). From this, $V$ magnitude in quiescence may be around 18.8, which corresponds to 3.7 in figure 1.
5. Summary

In this paper, we have presented CCD photometry of the dwarf nova NSV 4838 during the two superoutbursts in 2005 June and 2007 February and the long-term behavior of the system. During the 2007 February superoutburst, the best-estimated superhump period was $P_{\text{sh}} = 0.069824(83)$ days. We also examined superhump-period changes and concluded that the superhump period increased with $P_{\text{sh}} = P_{\text{sh}} + 7(\pm 3, -4) \times 10^{-5}$. In the late phase of the superoutburst, the mean superhump period became almost constant at $0.06954(1)$ days. Based on the long-term light curve, we found four superoutbursts since 2005 June and estimated a supercycle of NSV 4838 to be about 340 days. On the other hand, we detected at most two normal outbursts. If we did not miss any normal outburst, the event ratio of the normal outburst to the superoutburst is unusually small for this supercycle. Using the empirical relations, we estimated the distance to NSV 4838 and the mass ratio to be $\sim 1.1$ kpc and 0.13, respectively. We plotted the obtained values of NSV 4838 in the $P_{\text{dot}}$ vs. $P_{\text{sh}}$ plane, finding that the positions in the plane deviate from the general trend. In order to understand the observed diversity of the superhump-period change, additional physics should be invoked. This should be clarified in future observations by collecting further information on superhump-period changes.

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References

Baba, H., Kato, T., Nogami, D., Hirata, R., Matsumoto, K., & Sadakane, K. 2000, PASJ, 52, 429
Berger, J., & Fringant, A.-M. 1977, A&AS, 28, 123
Berry, R., & Burnell, J. 2000, The Handbook of Astronomical Image Processing (Richmond, VA: Willmann-Bell)
Cannizzo, J. K., Shafter, A. W., & Wheeler, J. C. 1988, ApJ, 333, 227
Common Smith, R. 2007 (astro-ph/0701654)
Downes, R. A., Webbink, R. F., & Shara, M. M. 1997, PASP, 109, 345
Downes, R. A., Webbink, R. F., Shara, M. M., Ritter, H., Kolb, U., & Duerbeck, H. W. 2001, PASP, 113, 764
Fernie, J. D. 1989, PASP, 101, 225
Gänsicke, B. T. 2005, ASP Conf. Ser., 330, 3
Harrison, T. E., Johnson, J. J., McArthur, B. E., Benedict, G. F., Szkody, P., Howell, S. B., & Gelino, D. M. 2004, AJ, 127, 460
Hellier, C. 2001, Cataclysmic Variable Stars: how and why they vary (Berlin: Springer-Verlag)
Hirose, M., & Osaki, Y. 1990, PASJ, 42, 135
Höflich, P. 1979, Prog. Theor. Phys., 61, 1307
Howell, S. B., Schmidt, R., DeYoung, J. A., Fried, R., Schmeer, P., & Stellingwerf, R. 1978, ApJ, 224, 953
Ishioka, R., et al. 2001, PASJ, 53, 905
Kato, T. 2002, PASJ, 54, 87
Knie, C. 2006, MNRAS, 373, 484
Meinunger, L. 1981, Inf. Bull. Variable Stars, 2001
Murray, J. R. 1998, MNRAS, 297, 323
Nogami, D., Kato, T., Baba, H., Matsumoto, K., Arimoto, J., Tanabe, K., & Ishikawa, K. 1997, ApJ, 490, 840
Nogami, D., Uemura, M., Ishioka, R., Kato, T., & Pietz, J. 2004, PASJ, 56, S155
Ozumi, S., et al. 2007, PASJ, 59, 643
Olech, A., Cook, L. M., Złoczewski, K., Mularczyk, K., Kędzierski, P., Udalski, A., & Wiśniewski, M. 2004, Acta Astron., 54, 233
Osaki, Y. 1985, A&A, 144, 369
Osaki, Y. 1989, PASJ, 41, 1005
Osaki, Y. 1995, PASJ, 47, 47
Osaki, Y. 1996, PASP, 108, 39
Osaki, Y. 2005, Proc. Japan Acad., Ser. B, 81, 291
Osaki, Y., & Meyer, F. 2003, A&A, 401, 325
Patterson, J. 1998, PASP, 110, 1132
Patterson, J., et al. 2000, PASP, 112, 1584
Patterson, J., et al. 2005, PASP, 117, 1204
Ritter, H., & Kolb, U. 2003, A&A, 404, 301
Semeniuk, I., Olech, A., Kwart, T., & Należyty, M. 1997, Acta Astron., 47, 201
Shafter, A. W., Coelho, E. A., & Reed, J. K. 2007, PASP, 119, 388
Smith, A. J., Haswell, C. A., Murray, J. R., Truss, M. R., & Foulkes, S. B. 2007, MNRAS, 378, 875
Steffen, M. R. 1978, ApJ, 224, 953
Szkody, P., et al. 2005, AJ, 129, 2386
Uemura, M., et al. 2005, A&A, 432, 261
Uemura, M., et al. 2008, PASJ, 60, 227
Warner, B. 1995, Cataclysmic Variable Stars (Cambridge: Cambridge University Press)
Whitehurst, R. 1988, MNRAS, 232, 35
Yanagisawa, K., et al. 2006, SPIE, 6269, 62693Q