Survey of period variations of superhumps in SU UMa-type dwarf novae. VI.
The sixth year (2013–2014)


1 Department of Astronomy, Kyoto University, Kitashiyakawa-Oiwake-cho, Sakyu-ku, Kyoto, Kyoto 606-8502, Japan
2 Vihorlat Observatory, Mierova 4, Humenne, Slovakia
3 Groupe Européen d’Observations Stellaaires (GEOS), 23 Parc de Levesville, 28300 Bailleul l’Evêque, France
4 Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne (BAV), Munsterdamm 90, 12169 Berlin, Germany
5 Vereniging Voor Sterrenkunde (VVS), Oude Bleken 12, 2400 Mol, Belgium
6 Furzehill House, Ilston, Swansea, SA2 7LE, UK
7 Osaka Kyoiku University, 4-698-1 Asahigaoka, Kashiwara, Osaka 582-8582, Japan
8 Sendai Astronomical Observatory, Nishikigaoka, Aoba-ku, Sendai, Miyagi 989-3123, Japan

© The Author 2014. Published by Oxford University Press on behalf of the Astronomical Society of Japan.
All rights reserved. For Permissions, please email: journals.permissions@oup.com
Continuing the project undertaken by Kato et al. (2009), we collected times of superhump maxima for 56 SU UMa-type dwarf novae mainly observed during the 2013–2014 season and characterized these objects. We detected negative superhumps in VW Hyi and indicated that the low number of normal outbursts in some supercycles can be interpreted as a result of disk tilt. This finding, combined with the Kepler observation of V1504 Cyg and V344 Lyr, suggests that disk tilt is responsible for modulating the outburst pattern in SU UMa-type dwarf novae. We also studied the deeply eclipsing WZ Sge-type dwarf nova MASTER OT J005740.99+443101.5 and found evidence of a sharp eclipse during the phase of early superhumps. The profile can be reproduced by a combination of the eclipse of the axisymmetric disk and the uneclipsed light source of early superhumps. This finding shows the lack of evidence for a greatly enhanced hot spot during the early stage of WZ Sge-type outburst. We detected growing (stage A) superhumps in MN Dra and give a suggestion that some of SU UMa-type dwarf novae situated near the critical condition of tidal instability may show long-lasting stage A superhumps. The large negative period derivatives reported in such systems can be understood as a result of the combination of stage A and B superhumps. Two WZ Sge-type dwarf novae, AL Com and ASASSN-13ck, showed a long-lasting (plateau-type) rebrightening. In the early phase of their rebrightenings, both objects showed a precursor-like outburst, suggesting that the long-lasting rebrightening is triggered by a precursor outburst.

Key words: accretion, accretion disks — novae, cataclysmic variables — stars: dwarf novae
1 Introduction

Cataclysmic variables (CVs) are close binary systems transferring matter from a low-mass dwarf secondary to a white dwarf. The transferred matter forms an accretion disk. In dwarf novae (DNe), a class of CVs, thermal-viscous instability in the accretion disk causes outbursts. SU UMa-type dwarf novae, a subclass of DNe, show long outbursts (superoutburst) in addition to ordinary short outbursts, and semiperiodic modulations called superhumps are detected during the superoutbursts. The superhumps have periods a few percent longer than the orbital period. It is now widely believed that the 3:1 resonance in the accretion disk brings about the eccentric deformation of the disk, resulting in superhumps (tidal instability: Whitehurst 1988; Hirose & Osaki 1990; Lubow 1991). The superoutburst can be understood as a result of the increased tidal dissipation and the removal of the angular momentum when the tidal instability works [thermal tidal instability (TTI) model: Osaki 1989, 1996]. This process produces a relaxation oscillation in the total angular momentum of the disk, and superoutbursts recur. The interval between the successive superoutbursts is called a supercycle. For general information on CVs, DNe, SU UMa-type dwarf novae, and superhumps, see, e.g., Warner (1995).

In a series of papers, Kato et al. (2009, 2010, 2012b, 2013b, 2014a), we systematically surveyed SU UMa-type dwarf novae particularly on variations in the superhump period. The change in the superhump period reflects the precession angular velocity of the eccentric (or flexing) disk, and is expected to be an excellent probe for studying the structure of the accretion disk during dwarf nova outbursts. In a recent series of papers, we dealt with various topics related to SU UMa-type dwarf novae and superhumps; in Kato et al. (2012b), we also studied Kepler data and made a pilot study on variations in the superhump amplitude motivated by Smak (2010). In Kato et al. (2013b), we systematically studied ER UMa-type dwarf novae (a class of SU UMa-type dwarf novae with a very short supercycle, see, e.g., Kato & Kunjaya 1995; Robertson et al. 1995; Kato et al. 1999) and helium dwarf novae (AM CVn-type objects). In Kato et al. (2014a), we made a pilot study on the decline rate of the superoutburst motivated by Cannizzo et al. (2010) and studied negative superhumps (having periods shorter than the orbital period and being considered as a manifestation of a tilted disk, see, e.g., Harvey et al. 1995; Patterson et al. 1997; Wood & Burke 2007) particularly in BK Lyn, which displays two states: a nova-like variable (a thermally stable CV) and an ER UMa-type dwarf nova.

We continue this extended, comprehensive research of SU UMa-type dwarf novae and superhumps in general in this paper. Since most of the objects treated in this paper have been little documented in the past, and since a compilation from historical descriptions of dwarf novae has not been issued for a long time since Glasby (1970), we intend this series of papers to also be a compiled source of information as to individual dwarf novae.

The present advances in understanding superhump periods and their variations started with a new interpretation of the Kepler observation (Osaki & Kato 2013a), who used the negative superhump as a probe for the variation in the disk radius over a supercycle period, and confirmed the radius variation predicted by the TTI model. Combined with Osaki and Kato (2013b, 2014), the TTI model is currently the only viable model of the SU UMa-type phenomenon.

In Kato et al. (2009), we demonstrated that most of the $O - C$ diagrams of superhumps in SU UMa-type dwarf novae can be expressed by three distinct stages: an initial growing stage (stage A) with a long period, a fully developed stage (stage B) with a systematically varying period, and a later stage (stage C) with a shorter, almost constant period (see Kato et al. 2009 for the notation of stages A–B–C of superhumps). The origin of these three stages of superhumps was a mystery when it was documented in Kato et al. (2009). Through analysis of the Kepler data, Osaki and Kato (2013b) proposed that the appearance of the pressure effect is responsible for the transition from stage A to stage B. From this interpretation, stage A reflects the state of the 3:1 resonance that is confined to the resonance region. This interpretation allowed a new method for determining the mass ratio ($q = M_2/M_1$) only from superhump observations and the orbital period (Kato & Osaki 2013b). This method is particularly suitable for measuring mass ratios in WZ Sge-type dwarf nova (SU UMa-type dwarf novae with a very long supercycle, considered to be the terminal stage of the CV evolution) and for distinguishing hitherto very poorly known period bouncers (CVs which have passed the minimum orbital period in evolution) from ordinary CVs (Kato et al. 2013a; Nakata et al. 2013b). Superhumps are now not only a powerful tool for diagnosing the accretion disk, but also an important one for illuminating CV evolution.

Materials and methods of analyses are given in section 2; observations and analyses of individual objects, including short discussions on individual objects, are given in section 3; general discussion is described in section 4 and the summary in section 5.

2 Observation and analysis

The data were obtained in the campaign led by the VSNET Collaboration (Kato et al. 2004b). For some objects,
### Table 1. List of superoutbursts.

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Object</th>
<th>Year</th>
<th>Observers or references</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>FO And</td>
<td>2013</td>
<td>Aka</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>DH Aql</td>
<td>2000</td>
<td>Oud, Btw</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>BB Ari</td>
<td>2013</td>
<td>GFB, OkC, HaC, Mhh</td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>UZ Boo</td>
<td>2013</td>
<td>KU, GFB, DPV, RIT, Rui, Mhh, AAVSO, RPc, Kai, CRI, IMi, Mdy, Iak, Ioh</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>V342 Cam</td>
<td>2013</td>
<td>DPV</td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>V452 Cas</td>
<td>2013</td>
<td>IMi, RPc, DPV</td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>V359 Cen</td>
<td>2014</td>
<td>HaC</td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>YZ Cnc</td>
<td>2014</td>
<td>Aka, Mdy, HaC</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>BB Ari</td>
<td>2013</td>
<td>GFB, OkC, HaC, Mhh</td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>V359 Cen</td>
<td>2014</td>
<td>KU, GFB, DPV, RIT, Rui, Mhh, AAVSO, RPc,</td>
<td></td>
</tr>
<tr>
<td>3.11</td>
<td>AL Com</td>
<td>2013</td>
<td>OKU, Nka, KU, IRS, CRI, DKS, IMi, AAVSO</td>
<td></td>
</tr>
<tr>
<td>3.12</td>
<td>V503 Cyg</td>
<td>2013</td>
<td>RPc</td>
<td></td>
</tr>
<tr>
<td>3.13</td>
<td>IX Dra</td>
<td>2012</td>
<td>MEV, AAVSO, UJH</td>
<td></td>
</tr>
<tr>
<td>3.14</td>
<td>MN Dra</td>
<td>2012</td>
<td>Ast, CRI</td>
<td></td>
</tr>
<tr>
<td>3.15</td>
<td>CP Eri</td>
<td>2013</td>
<td>OkC, SWI</td>
<td></td>
</tr>
<tr>
<td>3.16</td>
<td>V1239 Her</td>
<td>2013</td>
<td>RPc, IMi</td>
<td></td>
</tr>
<tr>
<td>3.17</td>
<td>CT Hya</td>
<td>2014</td>
<td>Mdy</td>
<td></td>
</tr>
<tr>
<td>3.18</td>
<td>VW Hyi</td>
<td>2012</td>
<td>HaC, CTA, Han</td>
<td></td>
</tr>
<tr>
<td>3.19</td>
<td>WX Hyi</td>
<td>1977</td>
<td>Bailey (1979a)</td>
<td></td>
</tr>
<tr>
<td>3.20</td>
<td>AY Lyr</td>
<td>2013</td>
<td>Aka</td>
<td></td>
</tr>
<tr>
<td>3.21</td>
<td>AO Oct</td>
<td>2013</td>
<td>HaC</td>
<td></td>
</tr>
<tr>
<td>3.22</td>
<td>DT Oct</td>
<td>2014</td>
<td>OkC</td>
<td></td>
</tr>
<tr>
<td>3.23</td>
<td>V521 Peg</td>
<td>2013</td>
<td>KU, Mdy, Aka, DPV, RPc, IMi, Hsk, Mhh</td>
<td></td>
</tr>
<tr>
<td>3.24</td>
<td>TY Psc</td>
<td>2013</td>
<td>Aka</td>
<td></td>
</tr>
<tr>
<td>3.25</td>
<td>V893 Sco</td>
<td>2007</td>
<td>MLF, OKU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>GBo</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2010</td>
<td>GBo, OKU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2013</td>
<td>HaC, MLF</td>
<td></td>
</tr>
<tr>
<td>3.26</td>
<td>RZ Sge</td>
<td>2013</td>
<td>AAVSO, IMi, Rui</td>
<td></td>
</tr>
<tr>
<td>3.27</td>
<td>AW Sge</td>
<td>2013</td>
<td>Vol, SRI</td>
<td></td>
</tr>
<tr>
<td>3.28</td>
<td>V1265 Tau</td>
<td>2013</td>
<td>GFB, HaC, KU</td>
<td></td>
</tr>
<tr>
<td>3.29</td>
<td>SU UMa</td>
<td>2013</td>
<td>OKU, DPV, Kis, Iha</td>
<td></td>
</tr>
<tr>
<td>3.30</td>
<td>SS UMi</td>
<td>2013</td>
<td>DPV, Kai, Krv</td>
<td></td>
</tr>
<tr>
<td>3.31</td>
<td>CU Vel</td>
<td>2013</td>
<td>HaC, Ncl</td>
<td></td>
</tr>
<tr>
<td>3.32</td>
<td>1RXS J231935</td>
<td>2013</td>
<td>DPV</td>
<td>1RXS J231935.0+364705</td>
</tr>
<tr>
<td>3.33</td>
<td>ASAS J224349</td>
<td>2013</td>
<td>Krw, HaC, Mdy, DPV, Shu, IMi, Rui, Mhh</td>
<td>ASAS J224349+0809.5</td>
</tr>
<tr>
<td>3.34</td>
<td>ASASSN-13cf</td>
<td>2013</td>
<td>LCO, IMi, RPc</td>
<td></td>
</tr>
</tbody>
</table>

we used the public data from the AAVSO International Database.\(^1\)

The majority of the data were acquired by time-resolved CCD photometry by using telescopes in the 30 cm class located world-wide, and their observational details will be presented in future papers with analysis and discussion on individual objects of interest. The list of outbursts and observers is summarized in table 1. The data analysis was performed in the same way as described in Kato et al. (2009, 2014a), and we mainly used R software\(^2\) for data analysis. In de-trending the data, we used both lower (first- to fifth-order) polynomial fitting and locally weighted polynomial regression (LOWESS; Cleveland 1979). The times of superhump maxima were determined by such a template fitting method as is described in Kato et al. (2009). The times of all observations are expressed in Barycentric Julian Date (BJD).

The abbreviations used in this paper are the same as in Kato et al. (2014a); \(P_{\text{orb}}\) means the orbital

\(^1\) (http://www.aavso.org/data-download).

\(^2\) The R Foundation for Statistical Computing: (http://cran.r-project.org/).
period and \( \varepsilon \equiv P_{\text{SH}}/P_{\text{orb}} - 1 \) is the fractional superhump excess. Since Osaki and Kato (2013a), the alternative fractional superhump excess in the frequency unit, \( \varepsilon^* \equiv 1 - P_{\text{orb}}/P_{\text{SH}} = \varepsilon/(1 + \varepsilon) \), has been introduced because this fractional superhump excess can be directly compared to the precession rate. We therefore used \( \varepsilon^* \) for referring to the precession rate.

We used phase dispersion minimization (PDM; Stellingwerf 1978) for period analysis, and 1 \( \sigma \) errors for the PDM analysis were evaluated from the methods of Fernie (1989) and Kato et al. (2010). We also used the least absolute shrinkage and selection operator (Lasso) method (Tibshirani 1996; Kato & Uemura 2012), which has proved to be effective in yielding very sharp signals. In this paper, we used the two-dimensional Lasso power spectra, introduced in some analyses of the Kepler data such as Kato and Maehara (2013), Osaki and Kato (2013b), and Kato and Osaki (2013a). These two-dimensional Lasso power spectra have proved to be helpful in detecting negative superhumps (cf. Osaki & Kato 2013b) as well as positive superhumps with varying frequencies (cf. Kato & Maehara 2013). Although the application of two-dimensional Lasso power spectra to the Kepler data is limited to almost uniformly sampled data, we have demonstrated in Kato et al. (2014a) and Ohshima et al. (2014) that two-dimensional Lasso power spectra are also effective in detecting multiple signals and their variations in non-uniformly sampled ground-based data.

The resultant \( P_{\text{SH}}, P_{\text{orb}}, \) and other parameters are listed in table 2 in the same format as in Kato et al. (2009).
Table 2. Superhump periods and period derivatives.

<table>
<thead>
<tr>
<th>Object</th>
<th>Year</th>
<th>$P_1$(d)</th>
<th>Error*</th>
<th>$E_1$</th>
<th>$P_2$(d)</th>
<th>Error*</th>
<th>$E_2$*</th>
<th>$P_{orb}$(d)</th>
<th>Q*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO And</td>
<td>2013</td>
<td>0.074412</td>
<td>0.000070</td>
<td>1</td>
<td>70</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>DH Aql</td>
<td>2000</td>
<td>0.080005</td>
<td>0.000067</td>
<td>0</td>
<td>39</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>C</td>
</tr>
<tr>
<td>BB Ari</td>
<td>2013</td>
<td>0.072544</td>
<td>0.000097</td>
<td>0</td>
<td>42</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>C</td>
</tr>
<tr>
<td>UZ Boo</td>
<td>2013</td>
<td>0.062060</td>
<td>0.000029</td>
<td>15</td>
<td>85</td>
<td>5.1</td>
<td>5.1</td>
<td>—</td>
<td>B</td>
</tr>
<tr>
<td>V342 Cam</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>V452 Cas</td>
<td>2013</td>
<td>0.088596</td>
<td>0.000068</td>
<td>0</td>
<td>39</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>C</td>
</tr>
<tr>
<td>V359 Cen</td>
<td>2013</td>
<td>0.081064</td>
<td>0.000026</td>
<td>0</td>
<td>49</td>
<td>−6.3</td>
<td>4.2</td>
<td>0.08744</td>
<td>60</td>
</tr>
<tr>
<td>FZ Cer</td>
<td>2013</td>
<td>0.058547</td>
<td>0.000062</td>
<td>0</td>
<td>32</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>C</td>
</tr>
<tr>
<td>YZ Cnc</td>
<td>2013</td>
<td>0.090422</td>
<td>0.000097</td>
<td>0</td>
<td>42</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>GZ Cnc</td>
<td>2013</td>
<td>0.092699</td>
<td>0.000052</td>
<td>26</td>
<td>66</td>
<td>−14.8</td>
<td>9.5</td>
<td>0.092135</td>
<td>111</td>
</tr>
<tr>
<td>AL Com</td>
<td>2013</td>
<td>0.057323</td>
<td>0.000022</td>
<td>87</td>
<td>210</td>
<td>4.9</td>
<td>1.9</td>
<td>—</td>
<td>0.056669</td>
</tr>
<tr>
<td>IX Dra</td>
<td>2012</td>
<td>0.066955</td>
<td>0.000021</td>
<td>0</td>
<td>146</td>
<td>0.4</td>
<td>1.5</td>
<td>0.066178</td>
<td>87</td>
</tr>
<tr>
<td>MN Dra</td>
<td>2012</td>
<td>0.105299</td>
<td>0.000061</td>
<td>47</td>
<td>115</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>MN Dra</td>
<td>2013</td>
<td>0.105040</td>
<td>0.000026</td>
<td>26</td>
<td>66</td>
<td>−14.8</td>
<td>9.5</td>
<td>0.066178</td>
<td>87</td>
</tr>
<tr>
<td>CP Eri</td>
<td>2013</td>
<td>0.019897</td>
<td>0.000003</td>
<td>0</td>
<td>111</td>
<td>3.1</td>
<td>0.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CT Hya</td>
<td>2014</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VW Hyi</td>
<td>2012</td>
<td>0.076916</td>
<td>0.000014</td>
<td>11</td>
<td>90</td>
<td>2.9</td>
<td>1.3</td>
<td>0.076579</td>
<td>87</td>
</tr>
<tr>
<td>WX Hyi</td>
<td>1977</td>
<td>0.077612</td>
<td>0.000113</td>
<td>0</td>
<td>14</td>
<td>0.4</td>
<td>1.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>AO Oct</td>
<td>2013</td>
<td>0.067326</td>
<td>0.000046</td>
<td>0</td>
<td>59</td>
<td>19.6</td>
<td>6.4</td>
<td>0.066776</td>
<td>59</td>
</tr>
<tr>
<td>DT Oct</td>
<td>2014</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>V521 Peg</td>
<td>2013</td>
<td>0.061503</td>
<td>0.000032</td>
<td>0</td>
<td>67</td>
<td>13.8</td>
<td>5.8</td>
<td>0.061006</td>
<td>67</td>
</tr>
<tr>
<td>TY Psc</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>V893 Sco</td>
<td>2013</td>
<td>0.078675</td>
<td>0.000025</td>
<td>0</td>
<td>52</td>
<td>—</td>
<td>—</td>
<td>0.078288</td>
<td>51</td>
</tr>
<tr>
<td>RZ Sge</td>
<td>2013</td>
<td>0.070642</td>
<td>0.000026</td>
<td>0</td>
<td>58</td>
<td>11.5</td>
<td>4.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>AW Sge</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>V1265 Tau</td>
<td>2013</td>
<td>0.053428</td>
<td>0.000024</td>
<td>0</td>
<td>187</td>
<td>1.9</td>
<td>1.9</td>
<td>0.053086</td>
<td>186</td>
</tr>
<tr>
<td>SU UMa</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SS UMi</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CU Vel</td>
<td>2013</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASAS J224349</td>
<td>2013</td>
<td>0.069719</td>
<td>0.000048</td>
<td>0</td>
<td>55</td>
<td>25.2</td>
<td>7.5</td>
<td>0.069513</td>
<td>87</td>
</tr>
<tr>
<td>ASASSN-13cf</td>
<td>2013</td>
<td>0.058407</td>
<td>0.000028</td>
<td>0</td>
<td>115</td>
<td>7.1</td>
<td>1.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASASSN-13cg</td>
<td>2013</td>
<td>0.060228</td>
<td>0.000037</td>
<td>0</td>
<td>63</td>
<td>24.4</td>
<td>6.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASASSN-13ck</td>
<td>2013</td>
<td>0.056186</td>
<td>0.000010</td>
<td>35</td>
<td>185</td>
<td>5.6</td>
<td>0.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASASSN-13cz</td>
<td>2013</td>
<td>0.078977</td>
<td>0.000058</td>
<td>0</td>
<td>13</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASASSN-13da</td>
<td>2013</td>
<td>0.071781</td>
<td>0.000037</td>
<td>56</td>
<td>140</td>
<td>6.5</td>
<td>4.1</td>
<td>0.071259</td>
<td>154</td>
</tr>
<tr>
<td>ASASSN-14ac</td>
<td>2013</td>
<td>0.058350</td>
<td>0.000097</td>
<td>57</td>
<td>188</td>
<td>−1.7</td>
<td>1.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CSS J024354</td>
<td>2013</td>
<td>0.062076</td>
<td>0.000042</td>
<td>0</td>
<td>129</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

The definitions for parameters $P_1$, $P_2$, $E_1$, $E_2$, and $P_{dot}$ are the same as in Kato et al. (2009). We also presented comparisons of different superoutbursts in the $O-C$ diagram since this has been one of the motivations for these surveys (cf. Uemura et al. 2005) and it has been demonstrated that a combination of $O-C$ diagrams showing a comparison of different superoutbursts can better describe the overall pattern of the period variation (Kato et al. 2009). In drawing combined $O-C$ diagrams, we usually used $E=0$ for the start of a superoutburst, which is usually referred to the first positive detection of the outburst. This epoch usually has an accuracy of $\sim 1$ d for a well-observed object, and if the outburst was not sufficiently observed, we mentioned how to define $E=0$ in such an outburst. We also present representative $O-C$ diagrams and light curves, especially for WZ Sge-type dwarf novae, which are not expected to undergo outbursts in the near future. In all figures, the binned magnitude and $O-C$ value are accompanied by $1\sigma$ error bars, which are omitted when the error is smaller than the plotted mark.

We used the same terminology of superhumps as we summarized in Kato et al. (2012b). We especially call reader's attention to the term “late superhumps.” We only used “traditional” late superhumps when an $\sim 0.5$ phase shift is confirmed (Vogt 1983; see also table 1 in Kato et al. 2012b for various types of superhumps), since we suspect that many of the past claims of detections of “late
superhumps” were likely to be stage C superhumps—cf. Kato et al. (2009); note that the Kepler observation of V585 Lyr also demonstrated persistent stage C superhumps without a phase shift (Kato & Osaki 2013a).

Early superhumps are double-wave humps seen during the early stage of WZ Sge-type dwarf novae, and have a period close to the orbital period (Kato et al. 1996b; Kato 2002; Osaki & Meyer 2002). We used the period of early superhumps as the approximate orbital period. The validity of this assumption is also reviewed in this paper.

The same as in Kato et al. (2009), we used coordinate-based optical transient (OT) designations for some objects, such as Catalina Real-time Transient Survey (CRTS: Drake et al. 2009)3 transients, and listed the original identifiers in table 1. When available, we have preferred using the International Astronomical Union (IAU)-format names provided by the CRTS team in the public data release.4

\[ P_1 (P_2); \] (stage B); Error: the 1 \( \sigma \) error; \( E_1 \) \( (E_2) \); the interval used for calculating the period \( P_1 \) (period \( P_2 \)), corresponding to \( E \) in the superhump maxima table of section 3).

\[ P_{\text{dot}}: \] the period derivative in units of \( 10^{-5} \).

References: FO And (Thorstensen et al. 1996), V342 Cam (Shears et al. 2011b), YZ Cnc (Shafter & Hnessman 1988), GZ Cnc (Tappert & Bianchini 2003), Al. Com (this work), MIN Dra (Pavlenko et al. 2010), CP Eri (Armstrong et al. 2012), VW Hya (this work), WX Hya (Schoembs & Vogt 1981), AO Oct (Woudt et al. 2004), V521 Peg (Rodriguez-Gil et al. 2003), TY Psr (Thorstensen et al. 1996), V893 Sco (this work), RZ Sge (Patterson et al. 2003), SU UMa (Thorstensen et al. 1986), SS UMa (Thorstensen et al. 1996), CU Vel (this work), and ASASSN-13ck-TCP J233822 (this work).

Data quality and comments: A: excellent; B: partial coverage or slightly low quality, C: insufficient coverage or observations with large scatter, G: global period is a mixture of \( P_1 \) and \( P_2 \). The listed period may refer to \( P_1 \). \( P_2 \) refers to the period of early superhumps; \( P_{\text{orb}} \) refers to a shorter stable periodicity recorded in outburst.

### Table 2. (Continued)

<table>
<thead>
<tr>
<th>Object</th>
<th>Year</th>
<th>( P_1 ) (d)</th>
<th>Error*</th>
<th>( E_1 )</th>
<th>( P_{\text{dot}} )</th>
<th>Error</th>
<th>( P_2 ) (d)</th>
<th>Error*</th>
<th>( E_2 )</th>
<th>( P_{\text{orb}} ) (d)</th>
<th>Q^|</th>
</tr>
</thead>
<tbody>
<tr>
<td>MASTER J004527</td>
<td>2013</td>
<td>0.080365</td>
<td>0.000020</td>
<td>12</td>
<td>50</td>
<td>–3.8</td>
<td>4.8</td>
<td>0.080004</td>
<td>0.000012</td>
<td>50</td>
<td>144</td>
</tr>
<tr>
<td>MASTER J005740</td>
<td>2013</td>
<td>0.057067</td>
<td>0.000111</td>
<td>14</td>
<td>144</td>
<td>4.0</td>
<td>—</td>
<td>0.056190</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>MASTER J024847</td>
<td>2013</td>
<td>0.0644</td>
<td>0.0003</td>
<td>0</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>MASTER J061335</td>
<td>2013</td>
<td>0.036091</td>
<td>0.00021</td>
<td>61</td>
<td>269</td>
<td>5.1</td>
<td>0.6</td>
<td>0.055950</td>
<td>0.000072</td>
<td>268</td>
<td>321</td>
</tr>
<tr>
<td>MASTER J073208</td>
<td>2013</td>
<td>0.058836</td>
<td>0.000081</td>
<td>0</td>
<td>38</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>MASTER J162323</td>
<td>2013</td>
<td>0.088661</td>
<td>0.00020</td>
<td>33</td>
<td>192</td>
<td>3.9</td>
<td>0.9</td>
<td>0.05787</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>MASTER J234843</td>
<td>2013</td>
<td>0.032007</td>
<td>0.00005</td>
<td>0</td>
<td>255</td>
<td>1.3</td>
<td>0.5</td>
<td>0.031977</td>
<td>0.000010</td>
<td>249</td>
<td>438</td>
</tr>
<tr>
<td>OT J210016</td>
<td>2013</td>
<td>0.058502</td>
<td>0.000020</td>
<td>17</td>
<td>160</td>
<td>2.3</td>
<td>1.5</td>
<td>0.058176</td>
<td>0.000033</td>
<td>292</td>
<td>366</td>
</tr>
<tr>
<td>PNV J191501</td>
<td>2013</td>
<td>0.058382</td>
<td>0.000010</td>
<td>58</td>
<td>297</td>
<td>5.6</td>
<td>0.2</td>
<td>0.05782</td>
<td>0.000048</td>
<td>57</td>
<td>88</td>
</tr>
<tr>
<td>TCP J233822</td>
<td>2013</td>
<td>0.057868</td>
<td>0.000014</td>
<td>39</td>
<td>206</td>
<td>2.7</td>
<td>1.1</td>
<td>0.057255</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

\[ ^\ast P_1 \ (P_2): \] the superhump period during stage B (stage C); Error: the 1 \( \sigma \) error; \( E_1 \) \( (E_2) \); the interval used for calculating the period \( P_1 \) (period \( P_2 \)), corresponding to \( E \) in the superhump maxima table of section 3).

\[ ^1P_{\text{dot}}: \] the period derivative in units of \( 10^{-5} \).

### 3 Individual objects

#### 3.1 FO Andromedae

FO And was discovered to be a dwarf nova by Hoffmeister (1967). Meinunger (1984b) showed that its outbursts occur with intervals of 10–30 d, and there was probably already a superoutburst. Meinunger (1984a) reported on the detection of three superoutbursts and that the intervals between normal outbursts ranged from 15 to 23 d. This object has been monitored by amateur observers since 1982, and both AAVSO and VSOLJ observers detected superoutbursts. Bruch (1989) obtained a spectrum in quiescence and detected Balmer and He II emission lines. Szkody et al. (1989) reported on the time-resolved photometry in quiescence without detecting a significant period. According to Szkody et al. (1989), Grauer and Bond (1986) detected superhumps with a period of \( \sim 105 \) min, but this result was not published.

The first periodically printed matter of the superhumps in this object was Kato (1995b), whose result was refined in Kato et al. (2009). Thorstensen et al. (1996) determined the orbital period through a radial velocity study. Kato et al. (2012b) reported on superhumps in the 2010 and 2011 superoutbursts.

The 2013 November–December superoutburst was detected on November 24 by J. Ripero (vsnet-alert 16647). A time-series of observations started two nights later, and a total of three-night observations was obtained (vsnet-alert 16696). The times of superhump maxima are listed in table 3. A comparison of the \( O – C \) diagrams (figure 1) suggests that the obtained global period is a mixture of different stages.

#### 3.2 DH Aquilae

DH Aql was discovered to be a Mira-type variable (=HV 3899) with a range of 12.5 to fainter than 16 in the photographic magnitude (Cannon 1925). This...
Table 3. Superhump maxima of FO And (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max</th>
<th>Error</th>
<th>O − C</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56622.9587</td>
<td>0.0016</td>
<td>−0.0015</td>
<td>51</td>
</tr>
<tr>
<td>1</td>
<td>56623.0348</td>
<td>0.0006</td>
<td>0.0001</td>
<td>48</td>
</tr>
<tr>
<td>56</td>
<td>56627.1334</td>
<td>0.0019</td>
<td>0.0048</td>
<td>56</td>
</tr>
<tr>
<td>57</td>
<td>56627.2050</td>
<td>0.0018</td>
<td>0.0020</td>
<td>50</td>
</tr>
<tr>
<td>68</td>
<td>56628.0242</td>
<td>0.0030</td>
<td>−0.0018</td>
<td>56</td>
</tr>
<tr>
<td>69</td>
<td>56628.0944</td>
<td>0.0017</td>
<td>−0.0018</td>
<td>56</td>
</tr>
<tr>
<td>70</td>
<td>56628.1647</td>
<td>0.0028</td>
<td>−0.0060</td>
<td>55</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456622.9602 + 0.074435 E.
‡Number of points used to determine the maximum.

Fig. 1. Comparison of different superoutbursts of FO And in the O − C diagram. A period of 0.07451 d was used to draw this figure. Approximate cycle counts (E) after the start of the superoutburst were used.


Kato et al. (2009) reported on the observations of superoutbursts in 2002, 2003, and 2008. We found the data of the unreported 2000 superoutburst (vsnet-alert 5163) and summarize the result here. The times of superhump maxima are listed in table 4. This superoutburst was observed in relatively early phase, and stages B and C can be recognized. The resultant O − C diagram well agrees with the others (figure 2).

Table 4. Superhump maxima of DH Aql (2000).

<table>
<thead>
<tr>
<th>E</th>
<th>Max</th>
<th>Error</th>
<th>O − C</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>51759.1254</td>
<td>0.0005</td>
<td>−0.0030</td>
<td>101</td>
</tr>
<tr>
<td>1</td>
<td>51759.2027</td>
<td>0.0005</td>
<td>−0.0055</td>
<td>161</td>
</tr>
<tr>
<td>11</td>
<td>51760.0042</td>
<td>0.0002</td>
<td>−0.0019</td>
<td>171</td>
</tr>
<tr>
<td>12</td>
<td>51760.0842</td>
<td>0.0002</td>
<td>−0.0016</td>
<td>172</td>
</tr>
<tr>
<td>13</td>
<td>51760.1645</td>
<td>0.0003</td>
<td>−0.0012</td>
<td>122</td>
</tr>
<tr>
<td>14</td>
<td>51760.2479</td>
<td>0.0009</td>
<td>0.0025</td>
<td>49</td>
</tr>
<tr>
<td>24</td>
<td>51761.0444</td>
<td>0.0008</td>
<td>0.0011</td>
<td>174</td>
</tr>
<tr>
<td>25</td>
<td>51761.1217</td>
<td>0.0003</td>
<td>−0.0013</td>
<td>173</td>
</tr>
<tr>
<td>26</td>
<td>51761.2045</td>
<td>0.0011</td>
<td>0.0017</td>
<td>150</td>
</tr>
<tr>
<td>36</td>
<td>51762.0026</td>
<td>0.0002</td>
<td>0.0019</td>
<td>138</td>
</tr>
<tr>
<td>37</td>
<td>51762.0812</td>
<td>0.0003</td>
<td>0.0007</td>
<td>170</td>
</tr>
<tr>
<td>38</td>
<td>51762.1621</td>
<td>0.0004</td>
<td>0.0019</td>
<td>171</td>
</tr>
<tr>
<td>39</td>
<td>51762.2527</td>
<td>0.0011</td>
<td>0.0127</td>
<td>44</td>
</tr>
<tr>
<td>85</td>
<td>51765.9083</td>
<td>0.0011</td>
<td>−0.0017</td>
<td>54</td>
</tr>
<tr>
<td>86</td>
<td>51765.9838</td>
<td>0.0011</td>
<td>−0.0061</td>
<td>66</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2451759.1285 + 0.079783 E.
‡Number of points used to determine the maximum.

Fig. 2. Comparison of different superoutbursts of DH Aql in the O − C diagram. A period of 0.08000 d was used to draw this figure. Approximate cycle counts (E) after the start of the outburst were used.

3.3 BB Arietis

This object (= NSV 907) was suspected as a dwarf nova because this suspected variable is located close to a ROSAT X-ray source (vsnet-chat 3317). In 2004, two outbursts were detected by P. Schmeer, confirming the dwarf-nova-type nature. Superhumps were detected during the second outburst (Kato et al. 2009).

On 2013 August 3, the ASAS-SN (Shappee et al. 2014a) team detected this object in outburst (vsnet-alert 16111). Although the object faded rapidly, it brightened five days later and showed superhumps, and the initial ASAS-SN detection turned out to be a precursor outburst (vsnet-alert 16169, 16170). The times of superhump maxima...
Table 5. Superhump maxima of BB Ari (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max(^a)</th>
<th>Error</th>
<th>$O − C$(^b)</th>
<th>N(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56514.8763</td>
<td>0.0030</td>
<td>−0.0029</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>56514.9473</td>
<td>0.0009</td>
<td>−0.0042</td>
<td>24</td>
</tr>
<tr>
<td>14</td>
<td>56515.8916</td>
<td>0.0011</td>
<td>−0.0001</td>
<td>44</td>
</tr>
<tr>
<td>26</td>
<td>56516.7491</td>
<td>0.0020</td>
<td>−0.0104</td>
<td>25</td>
</tr>
<tr>
<td>27</td>
<td>56516.8349</td>
<td>0.0004</td>
<td>0.0031</td>
<td>71</td>
</tr>
<tr>
<td>28</td>
<td>56516.9093</td>
<td>0.0004</td>
<td>0.0053</td>
<td>99</td>
</tr>
<tr>
<td>33</td>
<td>56517.2702</td>
<td>0.0007</td>
<td>0.0046</td>
<td>69</td>
</tr>
<tr>
<td>40</td>
<td>56517.7760</td>
<td>0.0045</td>
<td>0.0042</td>
<td>24</td>
</tr>
<tr>
<td>41</td>
<td>56517.8507</td>
<td>0.0007</td>
<td>0.0086</td>
<td>58</td>
</tr>
<tr>
<td>42</td>
<td>56517.9228</td>
<td>0.0004</td>
<td>0.0064</td>
<td>74</td>
</tr>
<tr>
<td>55</td>
<td>56518.8595</td>
<td>0.0030</td>
<td>0.0029</td>
<td>110</td>
</tr>
<tr>
<td>56</td>
<td>56518.9332</td>
<td>0.0005</td>
<td>0.0043</td>
<td>35</td>
</tr>
<tr>
<td>69</td>
<td>56519.8723</td>
<td>0.0006</td>
<td>0.0033</td>
<td>52</td>
</tr>
<tr>
<td>70</td>
<td>56519.9441</td>
<td>0.0008</td>
<td>0.0029</td>
<td>25</td>
</tr>
<tr>
<td>82</td>
<td>56520.7971</td>
<td>0.0068</td>
<td>−0.0119</td>
<td>37</td>
</tr>
<tr>
<td>83</td>
<td>56520.8779</td>
<td>0.0004</td>
<td>−0.0035</td>
<td>121</td>
</tr>
<tr>
<td>84</td>
<td>56520.9595</td>
<td>0.0009</td>
<td>0.0059</td>
<td>8</td>
</tr>
<tr>
<td>96</td>
<td>56521.8184</td>
<td>0.0013</td>
<td>−0.0031</td>
<td>23</td>
</tr>
<tr>
<td>97</td>
<td>56521.8884</td>
<td>0.0011</td>
<td>−0.0054</td>
<td>27</td>
</tr>
<tr>
<td>110</td>
<td>56522.8258</td>
<td>0.0012</td>
<td>−0.0080</td>
<td>24</td>
</tr>
<tr>
<td>111</td>
<td>56522.9022</td>
<td>0.0011</td>
<td>−0.0040</td>
<td>47</td>
</tr>
<tr>
<td>124</td>
<td>56523.8165</td>
<td>0.0020</td>
<td>−0.0297</td>
<td>25</td>
</tr>
<tr>
<td>137</td>
<td>56524.8159</td>
<td>0.0032</td>
<td>0.0296</td>
<td>56</td>
</tr>
<tr>
<td>138</td>
<td>56524.8508</td>
<td>0.0076</td>
<td>−0.0079</td>
<td>67</td>
</tr>
<tr>
<td>166</td>
<td>56526.8955</td>
<td>0.0029</td>
<td>0.0120</td>
<td>48</td>
</tr>
</tbody>
</table>

\(^a\)BJD − 2400000.
\(^b\)Against max = 2456514.8792 + 0.072315 E.
\(^c\)Number of points used to determine the maximum.

during the main superoutburst are listed in table 5. There was a stage B–C transition in the $O − C$ data. Although stage A superhumps were probably recorded between the precursor and the main superoutburst, we could not determine the period due to the insufficiency of observations. The present determination of superhump period confirmed the suggestion that we observed only stage C superhumps in 2004 (Kato et al. 2009)—figure 3.

3.4 UZ Bootis

UZ Boo is renowned as an object of a small group of WZ Sge-type dwarf novae when this subclass was proposed (Bailey 1979b). Only a small number of outbursts were recorded: 1929 April, 1937 June, 1938 May, 1978 September (Richter 1986), 1994 August (Iida & York 1994), and 2003 December (Kato et al. 2009). Although superhumps were first recorded during the 1994 superoutburst, the period was only marginally estimated to be 0.0619 d (Kato et al. 2001a) under very unfavorable conditions. During the 2003 superoutburst, the superhump period was established as 0.06192(3) d (stage B, Kato et al. 2009) despite the unfavorable seasonal observing conditions. The presence of multiple post-superoutburst rebrightenings was suspected during the 1994 superoutburst (Kuulkers et al. 1996), although the detections of these rebrightenings were based on visual observations. It took us additional two years to establish the phenomenon of multiple post-superoutburst rebrightenings in dwarf novae (EG Cnc: cf. Osaki et al. 1997; Patterson et al. 1998; Kato et al. 2004a). During the 2003 superoutburst, UZ Boo showed four post-superoutburst rebrightenings (Kato et al. 2009) and its close resemblance to EG Cnc was highlighted.

The object was again detected in outburst on 2013 July 26 by C. Chiselbrook visually and confirmed by W. MacDonald II using a CCD. Since the object had not been detected by the same observer on July 25, the outburst appeared to be a young one. Although this outburst was supposed to provide an opportunity to detect early superhumps, no meaningful coherent period was detected (vsnet-alert 16064, 16065, 16075), partly due to the high air mass and the short visibility in the evening. Only three days after the outburst detection, likely growing ordinary superhumps were detected (vsnet-alert 16080, 16087). The duration in which early superhumps were present, if there were any, was very short when compared to other WZ Sge-type dwarf novae.

Since the comparison star was much redder than the variable and some observations were done at high air masses, we corrected observations by using the second-order atmospheric extinction whose coefficients were experimentally determined. The times of superhump maxima during the plateau phase are listed in table 6. The times of superhumps were not determined by the fitting method on 2013

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max*</th>
<th>Error</th>
<th>$O-C$</th>
<th>N†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56504.4170</td>
<td>0.0005</td>
<td>−0.0007</td>
<td>136</td>
</tr>
<tr>
<td>1</td>
<td>56504.4762</td>
<td>0.0006</td>
<td>−0.0034</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>56504.7297</td>
<td>0.0003</td>
<td>0.0020</td>
<td>90</td>
</tr>
<tr>
<td>15</td>
<td>56505.3481</td>
<td>0.0002</td>
<td>0.0004</td>
<td>106</td>
</tr>
<tr>
<td>16</td>
<td>56505.4120</td>
<td>0.0004</td>
<td>0.0024</td>
<td>52</td>
</tr>
<tr>
<td>21</td>
<td>56505.7209</td>
<td>0.0003</td>
<td>0.0013</td>
<td>91</td>
</tr>
<tr>
<td>26</td>
<td>56506.0283</td>
<td>0.0005</td>
<td>−0.0013</td>
<td>266</td>
</tr>
<tr>
<td>30</td>
<td>56506.2797</td>
<td>0.0004</td>
<td>0.0022</td>
<td>127</td>
</tr>
<tr>
<td>31</td>
<td>56506.3391</td>
<td>0.0006</td>
<td>−0.0004</td>
<td>125</td>
</tr>
<tr>
<td>32</td>
<td>56506.4039</td>
<td>0.0004</td>
<td>0.0024</td>
<td>222</td>
</tr>
<tr>
<td>33</td>
<td>56506.4631</td>
<td>0.0008</td>
<td>−0.0004</td>
<td>52</td>
</tr>
<tr>
<td>37</td>
<td>56506.7129</td>
<td>0.0004</td>
<td>0.0014</td>
<td>106</td>
</tr>
<tr>
<td>38</td>
<td>56506.7725</td>
<td>0.0006</td>
<td>−0.0010</td>
<td>58</td>
</tr>
<tr>
<td>41</td>
<td>56506.9606</td>
<td>0.0039</td>
<td>0.0011</td>
<td>117</td>
</tr>
<tr>
<td>42</td>
<td>56507.0198</td>
<td>0.0002</td>
<td>−0.0017</td>
<td>424</td>
</tr>
<tr>
<td>43</td>
<td>56507.0811</td>
<td>0.0003</td>
<td>−0.0024</td>
<td>445</td>
</tr>
<tr>
<td>53</td>
<td>56507.7009</td>
<td>0.0005</td>
<td>−0.0026</td>
<td>91</td>
</tr>
<tr>
<td>54</td>
<td>56507.7644</td>
<td>0.0006</td>
<td>−0.0011</td>
<td>62</td>
</tr>
<tr>
<td>58</td>
<td>56508.0069</td>
<td>0.0024</td>
<td>−0.0065</td>
<td>93</td>
</tr>
<tr>
<td>64</td>
<td>56508.3879</td>
<td>0.0019</td>
<td>0.0025</td>
<td>25</td>
</tr>
<tr>
<td>69</td>
<td>56508.7038</td>
<td>0.0015</td>
<td>0.0084</td>
<td>84</td>
</tr>
<tr>
<td>70</td>
<td>56508.7620</td>
<td>0.0011</td>
<td>0.0046</td>
<td>88</td>
</tr>
<tr>
<td>80</td>
<td>56509.3604</td>
<td>0.0015</td>
<td>−0.0169</td>
<td>28</td>
</tr>
<tr>
<td>81</td>
<td>56509.4368</td>
<td>0.0008</td>
<td>−0.0025</td>
<td>129</td>
</tr>
<tr>
<td>83</td>
<td>56509.5668</td>
<td>0.0021</td>
<td>0.0035</td>
<td>63</td>
</tr>
<tr>
<td>84</td>
<td>56509.6294</td>
<td>0.0015</td>
<td>0.0041</td>
<td>76</td>
</tr>
<tr>
<td>85</td>
<td>56509.6910</td>
<td>0.0009</td>
<td>0.0038</td>
<td>69</td>
</tr>
<tr>
<td>86</td>
<td>56509.7519</td>
<td>0.0009</td>
<td>0.0026</td>
<td>89</td>
</tr>
<tr>
<td>95</td>
<td>56510.3080</td>
<td>0.0035</td>
<td>0.0007</td>
<td>64</td>
</tr>
<tr>
<td>96</td>
<td>56510.3681</td>
<td>0.0008</td>
<td>−0.0011</td>
<td>132</td>
</tr>
<tr>
<td>97</td>
<td>56510.4276</td>
<td>0.0013</td>
<td>−0.0037</td>
<td>61</td>
</tr>
<tr>
<td>101</td>
<td>56510.6821</td>
<td>0.0032</td>
<td>0.0029</td>
<td>55</td>
</tr>
<tr>
<td>102</td>
<td>56510.7407</td>
<td>0.0021</td>
<td>−0.0005</td>
<td>67</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 56504.4177 + 0.0619954 $E$.
‡Number of points used to determine the maximum.

July 29 (JD 2456503). Although the amplitudes of superhumps grew during the initial three nights and they were likely stage A superhumps, the stages were not distinct on the $O-C$ diagram. This was probably due to the shortness of stage A itself and the limited observation. We used $E \geq 15$ for determining the period in Table 2 to avoid the inclusion of stage A superhumps. Using the data from BJD 2456503 to 2456506, we obtained a period of 0.062032 d by the PDM method. We regard it a likely period of stage A superhumps. The superhump period was almost constant during stage B and no clear transition to stage C was recorded.

After the rapid fading from the superoutburst, individual maximum times of superhumps could not be measured due to the faintness. We could, however, detect signals by the PDM method. During an observational interval between BJD 2456511−2456515 (the “dip” after the fading), we obtained a period of 0.0610(1) d. During the interval between BJD 2456515−2456522 (the first two rebrightenings), we detected a period of 0.06182(4) d. During the interval between BJD 2456522−2456532 (the last two rebrightenings), we detected a period of 0.06197(4) d. These periods suggest that superhumps persisted during the entire rebrightening phase.

The object underwent four post-superoutburst rebrightenings the same as in the 2003 superoutburst (figure 4). The object slightly brightened when superhumps appeared. This phenomenon is common to what was observed in objects with multiple rebrightenings—EG Cnc (Patterson et al. 1998), EZ Lyn (Kato et al. 2012b), MASTER OT J211258.65+242145.4 (Nakata et al. 2013b), and MASTER OT J203749.39+552210.3 (Nakata et al. 2013b); for a complete list, see Nakata et al. (2013b). It seems that this phenomenon is more apparent in systems with multiple rebrightenings.

The mean length of the supercycle has been updated; that is, 3170(110) d on the assumption that one superoutburst escaped detection around 1986.

3.5 V342 Camelopardalis

V342 Cam (=1RXS J042332+745300 =HS 0417+7445) was selected as a CV from ROSAT X-ray sources (Wu et al. 2001) and from a spectroscopic survey (Aungwerojwit et al. 2006). Kato et al. (2009, 2010) reported observations of superhumps during the 2008 and 2010 superoutbursts, respectively. Shears et al. (2011b) also presented an analysis of the 2008 superoutburst and examined the outburst behavior during the period from 2005 to 2010. Shears et al. (2011b) photometrically obtained an orbital period of 0.07531(8) d.
Table 7. Superhump maxima of V342 Cam (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56511.4451</td>
<td>0.0005</td>
<td>−0.0019</td>
<td>78</td>
</tr>
<tr>
<td>1</td>
<td>56511.5245</td>
<td>0.0005</td>
<td>−0.0006</td>
<td>72</td>
</tr>
<tr>
<td>12</td>
<td>56512.3914</td>
<td>0.0011</td>
<td>0.0076</td>
<td>70</td>
</tr>
<tr>
<td>13</td>
<td>56512.4645</td>
<td>0.0008</td>
<td>0.0025</td>
<td>78</td>
</tr>
<tr>
<td>14</td>
<td>56512.5410</td>
<td>0.0005</td>
<td>0.0010</td>
<td>70</td>
</tr>
<tr>
<td>25</td>
<td>56513.3975</td>
<td>0.0006</td>
<td>−0.0012</td>
<td>79</td>
</tr>
<tr>
<td>26</td>
<td>56513.4752</td>
<td>0.0006</td>
<td>−0.0016</td>
<td>73</td>
</tr>
<tr>
<td>27</td>
<td>56513.5465</td>
<td>0.0020</td>
<td>−0.0084</td>
<td>55</td>
</tr>
<tr>
<td>64</td>
<td>56516.4516</td>
<td>0.0022</td>
<td>0.0083</td>
<td>83</td>
</tr>
<tr>
<td>65</td>
<td>56516.5157</td>
<td>0.0016</td>
<td>−0.0057</td>
<td>83</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456511.4471 + 0.078067E.
‡Number of points used to determine the maximum.

Table 8. Superhump maxima of V452 Cas (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56616.2975</td>
<td>0.0004</td>
<td>−0.0086</td>
<td>117</td>
</tr>
<tr>
<td>23</td>
<td>56618.3469</td>
<td>0.0007</td>
<td>0.0031</td>
<td>92</td>
</tr>
<tr>
<td>24</td>
<td>56618.4347</td>
<td>0.0005</td>
<td>0.0023</td>
<td>131</td>
</tr>
<tr>
<td>25</td>
<td>56618.5273</td>
<td>0.0010</td>
<td>0.0063</td>
<td>69</td>
</tr>
<tr>
<td>91</td>
<td>56624.3651</td>
<td>0.0042</td>
<td>−0.0033</td>
<td>41</td>
</tr>
<tr>
<td>92</td>
<td>56624.4570</td>
<td>0.0029</td>
<td>0.0001</td>
<td>38</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456616.3061 + 0.088596E.
‡Number of points used to determine the maximum.

Fig. 5. Comparison of different superoutbursts of V342 Cam in the O − C diagram. A period of 0.07845 d was used to draw this figure. Approximate cycle counts (E) after the start of the superoutburst were used. Since the start of the 2013 superoutburst was not well constrained, we shifted the O − C diagram to best fit the others.

On 2013 August 1, ASAS-SN team detected an outburst (vsnet-alert 16096). The outburst was not young enough and only stage C superhumps were recorded (table 7). On the final night, the profile was double-humped. We show the maxima on the smooth extension of stage C superhumps in the table. A comparison of O − C diagrams of different superoutbursts is shown in figure 5.

3.6 V452 Cassiopeiae

V452 Cas was discovered to be a dwarf nova (= S10453) with a range of 14–17.5 (photographic magnitude) by Richter (1969). Bruch, Fischer, and Wilmsen (1987) also detected an outburst. Liu and Hu (2000) obtained a spectrum in quiescence and detected the Hα line in emission.

Although the object has been monitored visually by amateur observers since 1992, no secure outburst was detected until 1999 October 8, when P. Schmeer detected an outburst of 16.2 mag (unfiltered CCD; vsnet-alert 3561). P. Schmeer suspected that past possible visual detections were probably the close companion star rather than true outbursts. The object further brightened and attained to 15.52 mag on the next night. On 1999 November 9, P. Schmeer reported (private communication) a bright (∼15.0 mag) outburst and suspected that it is a superoutburst. This bright outburst was also confirmed visually at a magnitude of 14.7–14.9 (vsnet-alert 3684). P. Schmeer suspected that this object is an SU UMa-type dwarf nova with (rather) frequent small-amplitude outbursts (vsnet-alert 3687). P. Vannmunster detected superhumps with a period of 0.0891 d (vsnet-alert 3687). Superhumps were also detected during the 2000 September outburst (vsnet-alert 3687).

Shears et al. (2009) systematically studied this object during the period from 2005 to 2008, and obtained a supercycle length of 146 ± 16 d. Shears et al. (2009) also reported superhumps during the 2007 September superoutburst. The long-period superhumps detected in the early stage were likely stage A superhumps. An analysis of the 1999 and 2008 superoutbursts was reported in Kato et al. (2009).

I. Miller detected a superoutburst on 2013 November 19 and detected a superhump (vsnet-alert 16632). The times of superhump maxima are listed in table 8. On BJD 2456624, secondary maxima of superhumps became strong. In the table, we list the maxima which are on a smooth extension of earlier times of maxima. A comparison of O − C diagrams (figure 6) indicates that the evolution of superhumps during this superoutburst followed the trend previously recorded. The initial epoch probably indicated the time near the stage A–B transition. In table 2, a global $P_{dot}$ in all stages is given.

Preceding superoutbursts occurred in 2013 January and June (BJD 2456305 and 2456445). Supercycles in a series of these three superoutbursts were 140 and 171 d, suggesting that the supercycle significantly varies.
3.7 V359 Centauri

V359 Cen was originally discovered to be a possible nova by A. Opolski (originally in Lwów Contr. 4; Prager & Shapley 1941). The object was visible from 1930 April 20 to 1930 April 27, and its brightness declined from 13.8 to 15.0 mag. On the assumption of a typical absolute maximum for a nova, a large distance of 160 kpc was inferred (McLaughlin 1945). McLaughlin (1945) already discussed the possibility of a dwarf nova. Duerbeck (1987) proposed a 21.0 mag quiescent counterpart. Munari and Zwitter (1998) tried to find the proposed quiescent counterpart spectroscopically, but their attempt failed due to its faintness. Gill and O'Brien (1998) could not find a nova shell in a deep image.

The second historical outburst was recorded by R. Stubbing on 1999 July 13. Woudt and Warner (2001) obtained time-resolved CCD photometry following the 1999 July outburst and detected a period of 0.0779 d. The object underwent more outbursts in 2000 May, 2001 April, and 2002 June, and the object was recognized as an SU UMa-type dwarf nova. The detection of superhumps during the 1999 and 2002 superoutbursts was reported in Kato et al. (2002d).

The 2014 superoutburst was detected by R. Stubbing (see vsnet-alert 16941). Subsequent observations detected superhumps (vsnet-alert 16946, 16948, 16952). The times of superhump maxima are listed in table 9. The observation recorded the middle and latter parts of the superoutburst. The epochs for $E \geq 97$ correspond to the rapidly fading part of the superoutburst. The times of maxima and the identification of superhumps was not secure due to faintness of the object. The two $O - C$ diagrams of the 2002 and 2014 superoutbursts agree with each other (figure 7).

### Table 9. Superhump maxima of V359 Cen (2014).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max*</th>
<th>Error</th>
<th>$O - C$†</th>
<th>$N$‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56712.8358</td>
<td>0.0005</td>
<td>-0.0034</td>
<td>17</td>
</tr>
<tr>
<td>11</td>
<td>56713.7308</td>
<td>0.0006</td>
<td>-0.0009</td>
<td>19</td>
</tr>
<tr>
<td>12</td>
<td>56713.8097</td>
<td>0.0008</td>
<td>-0.0011</td>
<td>20</td>
</tr>
<tr>
<td>23</td>
<td>56714.7021</td>
<td>0.0006</td>
<td>-0.0077</td>
<td>16</td>
</tr>
<tr>
<td>24</td>
<td>56714.7848</td>
<td>0.0007</td>
<td>-0.0025</td>
<td>19</td>
</tr>
<tr>
<td>36</td>
<td>56715.7333</td>
<td>0.0009</td>
<td>-0.0014</td>
<td>20</td>
</tr>
<tr>
<td>37</td>
<td>56715.8362</td>
<td>0.0008</td>
<td>-0.0013</td>
<td>19</td>
</tr>
<tr>
<td>48</td>
<td>56716.7291</td>
<td>0.0006</td>
<td>-0.0307</td>
<td>20</td>
</tr>
<tr>
<td>49</td>
<td>56716.8086</td>
<td>0.0005</td>
<td>-0.0021</td>
<td>20</td>
</tr>
<tr>
<td>60</td>
<td>56717.6975</td>
<td>0.0006</td>
<td>-0.0004</td>
<td>17</td>
</tr>
<tr>
<td>61</td>
<td>56717.7794</td>
<td>0.0008</td>
<td>-0.0014</td>
<td>20</td>
</tr>
<tr>
<td>73</td>
<td>56718.7461</td>
<td>0.0006</td>
<td>-0.0034</td>
<td>20</td>
</tr>
<tr>
<td>74</td>
<td>56718.8274</td>
<td>0.0006</td>
<td>-0.0031</td>
<td>20</td>
</tr>
<tr>
<td>86</td>
<td>56719.7978</td>
<td>0.0011</td>
<td>-0.0042</td>
<td>20</td>
</tr>
<tr>
<td>97</td>
<td>56720.6940</td>
<td>0.0021</td>
<td>-0.0013</td>
<td>19</td>
</tr>
<tr>
<td>98</td>
<td>56720.7719</td>
<td>0.0016</td>
<td>-0.0017</td>
<td>19</td>
</tr>
<tr>
<td>99</td>
<td>56720.8513</td>
<td>0.0014</td>
<td>-0.0033</td>
<td>19</td>
</tr>
<tr>
<td>110</td>
<td>56721.7465</td>
<td>0.0035</td>
<td>-0.0013</td>
<td>20</td>
</tr>
<tr>
<td>111</td>
<td>56721.8175</td>
<td>0.0032</td>
<td>-0.0087</td>
<td>20</td>
</tr>
<tr>
<td>122</td>
<td>56722.7259</td>
<td>0.0079</td>
<td>0.0091</td>
<td>15</td>
</tr>
<tr>
<td>123</td>
<td>56722.8006</td>
<td>0.0054</td>
<td>0.0029</td>
<td>16</td>
</tr>
</tbody>
</table>

*BJD = 2400000.
†Against max = 2456712.8393 + 0.080963E.
‡Number of points used to determine the maximum.

3.8 FZ Ceti

This object was discovered to be a variable star of unknown type (= BV 1187, NSV 601) with a range of 12.2 to fainter than 14.4 in the photographic magnitude (Avery & Sievers 1968). The object was also selected as a faint blue star.

(=PHL 3637)\(^5\) with a photographic magnitude of 18.7 and a \((U-V)\) excess of −0.2. The identification in Demartino et al. (1996) was incorrect (Haro & Luyten 1962). S. Otero found in 2005 that this object is a dwarf nova based on ASAS-3 (Pojmański 2002) observations (vsnet-alert 8620). The ASAS-3 light curve immediately suggested that this object is an SU UMa-type dwarf nova showing superoutbursts (vsnet-alert 8621). The object was given the GCVS (General Catalogue of Variable Stars) name FZ Cet in Kazarovets et al. (2008). Despite its brightness in outburst, the two superoutbursts occurred in seasonally unfavorable conditions (2010 February and 2012 February) and their superhumps were not detected until 2014.

The 2014 outburst was detected by R. Stubbings on January 19 (vsnet-alert 16797). This outburst was in better seasonal conditions than the preceding two superoutbursts, and subsequent observations were useful for detecting superhumps (vsnet-alert 16803, 16808; figure 8). The times of superhump maxima are listed in table 10. The superoutburst lasted more than 11 d (vsnet-alert 16845).

\(^5\) The name in the Downes CV catalog (Downes et al. 2001) is incorrect.

### Table 10. Superhump maxima of FZ Cet (2014).

<table>
<thead>
<tr>
<th>E</th>
<th>Max(^a)</th>
<th>Error</th>
<th>O − C(^b)</th>
<th>N(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56678.0315</td>
<td>0.0002</td>
<td>0.0012</td>
<td>106</td>
</tr>
<tr>
<td>1</td>
<td>56678.0889</td>
<td>0.0003</td>
<td>0.0000</td>
<td>114</td>
</tr>
<tr>
<td>9</td>
<td>56678.5564</td>
<td>0.0006</td>
<td>−0.0008</td>
<td>17</td>
</tr>
<tr>
<td>17</td>
<td>56679.0233</td>
<td>0.0020</td>
<td>−0.0023</td>
<td>36</td>
</tr>
<tr>
<td>18</td>
<td>56679.0821</td>
<td>0.0003</td>
<td>−0.0020</td>
<td>107</td>
</tr>
<tr>
<td>19</td>
<td>56679.1463</td>
<td>0.0015</td>
<td>0.0036</td>
<td>33</td>
</tr>
<tr>
<td>43</td>
<td>56680.5482</td>
<td>0.0023</td>
<td>0.0004</td>
<td>12</td>
</tr>
</tbody>
</table>

\(^a\)BJD − 2400000.
\(^b\)Against max = 2456678.0303 + 0.058547 E.
\(^c\)Number of points used to determine the maximum.

### Table 11. Superhump maxima of YZ Cnc (2014).

<table>
<thead>
<tr>
<th>E</th>
<th>Max(^a)</th>
<th>Error</th>
<th>O − C(^b)</th>
<th>N(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56678.6122</td>
<td>0.0016</td>
<td>−0.0023</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>56678.7048</td>
<td>0.0011</td>
<td>−0.0001</td>
<td>21</td>
</tr>
<tr>
<td>16</td>
<td>56680.0624</td>
<td>0.0006</td>
<td>0.0011</td>
<td>100</td>
</tr>
<tr>
<td>17</td>
<td>56680.1538</td>
<td>0.0007</td>
<td>0.0021</td>
<td>201</td>
</tr>
<tr>
<td>18</td>
<td>56680.2434</td>
<td>0.0005</td>
<td>0.0013</td>
<td>201</td>
</tr>
<tr>
<td>19</td>
<td>56680.3353</td>
<td>0.0013</td>
<td>0.0029</td>
<td>48</td>
</tr>
<tr>
<td>22</td>
<td>56680.6079</td>
<td>0.0032</td>
<td>0.0041</td>
<td>21</td>
</tr>
<tr>
<td>23</td>
<td>56680.6916</td>
<td>0.0040</td>
<td>−0.0026</td>
<td>20</td>
</tr>
<tr>
<td>27</td>
<td>56681.0546</td>
<td>0.0011</td>
<td>−0.0013</td>
<td>100</td>
</tr>
<tr>
<td>28</td>
<td>56681.1417</td>
<td>0.0011</td>
<td>−0.0046</td>
<td>101</td>
</tr>
<tr>
<td>29</td>
<td>56681.2380</td>
<td>0.0011</td>
<td>0.0013</td>
<td>99</td>
</tr>
<tr>
<td>30</td>
<td>56681.3224</td>
<td>0.0009</td>
<td>−0.0047</td>
<td>82</td>
</tr>
<tr>
<td>38</td>
<td>56682.0489</td>
<td>0.0017</td>
<td>−0.0016</td>
<td>55</td>
</tr>
<tr>
<td>39</td>
<td>56682.1466</td>
<td>0.0018</td>
<td>0.0056</td>
<td>48</td>
</tr>
<tr>
<td>41</td>
<td>56682.3205</td>
<td>0.0018</td>
<td>−0.0013</td>
<td>38</td>
</tr>
</tbody>
</table>

\(^a\)BJD − 2400000.
\(^b\)Against max = 2456678.6145 + 0.090422 E.
\(^c\)Number of points used to determine the maximum.

### 3.9 YZ Cancri

YZ Cnc is a well-known active SU UMa-type dwarf nova (e.g., Szkody & Mattei 1984). Although Patterson (1979) detected superhumps, the identification of the period was incorrect (Kato et al. 2009). The 2007 superoutburst was reported in Kato et al. (2009). The 2011 superoutburst was reported in Kato et al. (2014a). We reported on a superoutburst in 2014 January here. The times of superhump maxima during the main superoutburst are listed in table 11. Since we could not determine whether there was a jump in the phase (the same as in traditional late superhumps) after the fading in the main superoutburst, we listed the times of superhumps after the superoutburst separately (table 12). A comparison of the \(O − C\) diagrams (figure 9) suggests that post-superoutburst superhumps in the 2014 superoutburst were indeed traditional late superhumps.

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max</th>
<th>Error</th>
<th>$O-C$</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56684.9658</td>
<td>0.0015</td>
<td>-0.0020</td>
<td>68</td>
</tr>
<tr>
<td>1</td>
<td>56685.0488</td>
<td>0.0021</td>
<td>-0.0098</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>56685.1507</td>
<td>0.0024</td>
<td>0.0011</td>
<td>66</td>
</tr>
<tr>
<td>3</td>
<td>56685.2422</td>
<td>0.0016</td>
<td>0.0017</td>
<td>68</td>
</tr>
<tr>
<td>7</td>
<td>56685.6098</td>
<td>0.0021</td>
<td>0.0056</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>56686.1433</td>
<td>0.0011</td>
<td>0.0038</td>
<td>22</td>
</tr>
<tr>
<td>13</td>
<td>56686.2429</td>
<td>0.0007</td>
<td>0.0027</td>
<td>19</td>
</tr>
<tr>
<td>14</td>
<td>56686.2429</td>
<td>0.0017</td>
<td>0.0011</td>
<td>66</td>
</tr>
<tr>
<td>18</td>
<td>56686.6070</td>
<td>0.0015</td>
<td>-0.0064</td>
<td>68</td>
</tr>
<tr>
<td>19</td>
<td>56686.6994</td>
<td>0.0011</td>
<td>0.0042</td>
<td>22</td>
</tr>
<tr>
<td>45</td>
<td>56689.0553</td>
<td>0.0010</td>
<td>0.0038</td>
<td>66</td>
</tr>
<tr>
<td>46</td>
<td>56689.1525</td>
<td>0.0015</td>
<td>0.0025</td>
<td>68</td>
</tr>
<tr>
<td>47</td>
<td>56689.2391</td>
<td>0.0012</td>
<td>-0.0019</td>
<td>67</td>
</tr>
</tbody>
</table>

Fig. 9. Comparison of different superoutbursts of YZ Cnc in the $O-C$ diagram. A period of 0.09050 d was used to draw this figure. Approximate cycle counts ($E$) after the start of the superoutburst were used (in the case of YZ Cnc, this refers to the precursor outburst). Since the start of the 2014 superoutburst was not well constrained, we shifted the $O-C$ diagram to best fit the others.

Table 13. Superhump maxima of GZ Cnc (2014).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max</th>
<th>Error</th>
<th>$O-C$</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56663.1487</td>
<td>0.0015</td>
<td>-0.0142</td>
<td>60</td>
</tr>
<tr>
<td>1</td>
<td>56663.2486</td>
<td>0.0003</td>
<td>-0.0073</td>
<td>181</td>
</tr>
<tr>
<td>2</td>
<td>56663.3478</td>
<td>0.0004</td>
<td>-0.0010</td>
<td>181</td>
</tr>
<tr>
<td>12</td>
<td>56664.2934</td>
<td>0.0005</td>
<td>0.0149</td>
<td>69</td>
</tr>
<tr>
<td>53</td>
<td>56668.1021</td>
<td>0.0004</td>
<td>0.0118</td>
<td>127</td>
</tr>
<tr>
<td>54</td>
<td>56668.1943</td>
<td>0.0004</td>
<td>0.0112</td>
<td>162</td>
</tr>
<tr>
<td>55</td>
<td>56668.2812</td>
<td>0.0018</td>
<td>0.0050</td>
<td>64</td>
</tr>
<tr>
<td>75</td>
<td>56670.1309</td>
<td>0.0008</td>
<td>-0.0048</td>
<td>160</td>
</tr>
<tr>
<td>79</td>
<td>56670.5059</td>
<td>0.0005</td>
<td>-0.0017</td>
<td>102</td>
</tr>
<tr>
<td>80</td>
<td>56670.5937</td>
<td>0.0008</td>
<td>-0.0068</td>
<td>76</td>
</tr>
<tr>
<td>90</td>
<td>56671.2561</td>
<td>0.0005</td>
<td>-0.0042</td>
<td>96</td>
</tr>
<tr>
<td>91</td>
<td>56671.6229</td>
<td>0.0006</td>
<td>-0.0002</td>
<td>91</td>
</tr>
<tr>
<td>92</td>
<td>56671.7136</td>
<td>0.0006</td>
<td>-0.0026</td>
<td>89</td>
</tr>
</tbody>
</table>

The 2014 January superoutburst was detected by R. Stubbings (vsnet-alert 16758). The bright magnitude immediately suggested a superoutburst. The initial observation recorded a long superhump period (vsnet-alert 16782). The times of superhump maxima are listed in table 13. The maxima $E \leq 2$ correspond to stage A superhumps (see also figures 10 and 11). A PDM analysis of this part of the data yielded a period of 0.0969(3) d (the period in vsnet-alert 16782 referred to $E \leq 12$). Due to the shortness of the run, the accuracy of this period of stage A superhumps is limited. This corresponds to $q = 0.30(2)$ (Kato & Osaki 2013b; see also subsection 4.2 of this paper). Although this estimate is based on a very limited observation, this observation seems to support that this object has a mass ratio near the border of the condition for the 3:1 resonance ($q$ range of 0.25–0.33 depending on simulations). The object is indeed likely a “borderline” SU UMa-type dwarf nova.

3.11 AL Comae Berenices

AL Com has been one of the most renowned high-amplitude dwarf novae since its discovery in 1962 by L. Rosino (Bertola 1964). Szkody (1987) showed a large amplitude variation with a period of $\sim 40$ min and suggested that AL Com may belong to either the DQ Her-type magnetic systems or AM CVn-type double degenerate systems. Further spectroscopic observations by Mukai et al. (1990) precluded any possibility of the latter system. More extensive photometry by Abbott et al. (1992) showed two distinct periodicities of 41 min and 87–90 min; the latter was suggested to be the orbital period, and the former the rotation period of the white dwarf. From these periods, Abbott et al. (1992) concluded that AL Com bears the properties of
both an enigmatic dwarf nova WZ Sge and a unique intermediate polar EX Hya. The 1995 superoutburst clarified that this object is a WZ Sge-type dwarf nova, and it shows double-wave modulations (now called early superhumps) during the early stage of the superoutburst (Kato et al. 1996b). Based on the outburst light curve and the orbital parameters, AL Com was considered as a “twin” of WZ Sge. This superoutburst was particularly well documented (Patterson et al. 1996; Howell et al. 1996; Nogami et al. 1997).

Another superoutburst was recorded in 2001 (Ishioka et al. 2002). A less-observed superoutburst in 2007 indicated that the post-superoutburst rebrightenings are different between different superoutbursts (Uemura et al. 2008). There was an outburst in 2003 detected in SDSS, which was missed by visual observers.

The 2013 superoutburst was detected on December 6 by C. Gualdoni (cvnet-outburst 5738). Subsequent observations detected early superhumps (vsnet-alert 16695, 16712). The evolution of superhumps in the early stage was well observed (vsnet-alert 16718, 16724).

The period of early superhumps was found to be 0.056660(8) d by the PDM method from the observations before BJD 2456639.5. This value is in complete agreement with the 2001 measurement of early superhumps (figure 12; see subsection 4.4). The commonly accepted mechanism of early superhumps (cf. Osaki & Meyer 2002) suggests that the phases of early superhumps are constant in different superoutbursts (which is defined by the orientation of the observer against the binary’s orbit). Assuming that the phases of early superhumps are the same during the
1995, 2001, and 2013 superoutbursts, we can determine the orbital period. A refined orbital period of 0.056668589(9) d are well fitted to all the observations. An alias by one cycle is 0.056667180(9) d and is not favored if we believe the identification of the period by Patterson et al. (1996).

The times of superhump maxima during the plateau phase of the superoutburst are listed in table 14. Stage A superhumps were better detected during the 2013 superoutburst than during the previous ones. The 2013 superoutburst showed a positive \( P'_{\text{dot}} \) of \( +4.9(19) \times 10^{-5} \). This value is larger than the 1995 and 2001 measurements. A comparison of \( O - C \) diagrams of different superoutbursts is presented in figure 14.

The times of superhump maxima after the rapid fading are listed in table 15. A PDM analysis of the combined data in this interval yielded a period of 0.05733 d was used for drawing this figure. Lower: Light curve. The observations were binned to 0.011 d.

dip was almost flat in the 1995 superoutburst, and it was associated with an initial small dip in the 2013. The 2007 superoutburst was more structured, as reported in Uemura et al. (2008), but it is still unlike discrete brightenings such as EG Cnc showed (Patterson et al. 1998; Kato et al. 2004a). We consider that the 2007 superoutburst resembled the 2001 superoutburst of WZ Sge, though with small brightenings with amplitudes less than 1 mag. Although the duration of the rebrightening plateau in the 2001 superoutburst appears longer than those in other superoutbursts, this part of the observation was of low quality and it needs to be interpreted carefully. A variation in the rebrightening was also observed in EZ Lyn (Kato et al. 2012b) and suspected in WZ Sge (Patterson et al. 1981). Although there
is a subtle difference between patterns of rebrightening in the same object, the present comparison of the light curves in AL Com suggests that the pattern of rebrightening is generally reproducible.

The known outbursts of AL Com are listed in table 16. The supercycle appears to be 6–7 yr. Since the 2003 outburst escaped detection under visual observer’s observations, the true frequency of normal outbursts may be higher than what this table suggests.

3.12 V503 Cygni

This SU UMa-type dwarf nova is notable for its unusually short (89 d) supercycle and the occasional presence of negative superhumps (Harvey et al. 1995). Kato, Ishioka, and Uemura (2002a) reported on a dramatic variation in the number of normal outbursts, and this finding led to the discovery of the state with negative superhumps suppressing the number of normal outbursts (Ohshima et al. 2012; Zemko et al. 2013; Osaki & Kato 2013a, 2013b).

The superoutburst in 2013 August was observed only for two nights during its final part. We obtained maxima of BJD 2456527.4717(11) (N = 88), 2456527.5580(27) (N = 47), 2456532.3896(20) (N = 67), and 2456532.4696(13) (N = 63). Since the phases of the last two maxima are different from the earlier ones by a phase of ~0.5, they may be traditional late superhumps.

3.13 IX Draconis

IX Dra was selected as an ultraviolet-excess object (K = KUV 18126+6704) by Noguchi, Maehara, and Kondo (1980). Noguchi, Yutani, and Maehara (1982) detected its variability. Wegner and McMahan (1988) spectroscopically classified the object as a B subdwarf. Liu et al. (1999) classified the object as a dwarf nova by spectroscopy. Klose (1995) detected the variability of this object on photographic plates and obtained a period of ~45.7 d, although it was not strictly periodic. T. Vanmunster detected superhumps in 2000 (vsnet-alert 5368, 5369). Ishioka et al. (2001) studied this object and revealed that it is a new ER UMa-type dwarf nova with a supercycle of 53 d. Olech et al. (2004) studied the 2003 superoutburst and suggested a period of 0.06646(6) d, which they considered to be an orbital period. This period led to a very small fractional superhump excess, from which Olech et al. (2004) suggested that IX Dra is a period bouncer. Otulakowska-Hypka et al. (2013) further studied this object and found a longer supercycle. Otulakowska-Hypka et al. (2013) discussed the secular increase of supercycles in ER UMa-type dwarf novae. The identification of the orbital period, however, was less convincing the same as in Olech et al. (2004), and there is a possibility of another period which places IX Dra in a region of ordinary dwarf nova before the period minimum. Kato et al. (2013b) did not regard the orbital period by Otulakowska-Hypka et al. (2013) as a true orbital one based on a close similarity of IX Dra to ER UMa.

We analyzed the superoutburst in 2012 July–August. The times of superhump maxima are listed in table 17. The resultant O − C data indicate that the superhumps can be expressed by a single period without a strong period variation. Such a phase reversal as can be seen in ER UMa (Kato et al. 1996a) was not apparent. Olech et al. (2004) also reported on only small period variations. Although Kato et al. (2009) recognized stages B and C in the data...
Table 16. Outbursts of AL Com.

<table>
<thead>
<tr>
<th>Date</th>
<th>Maximum</th>
<th>Type</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1892 April 26</td>
<td>14.3p</td>
<td>—</td>
<td>Bertola (1964)</td>
</tr>
<tr>
<td>1941 June 25</td>
<td>13.8p</td>
<td>—</td>
<td>Lucchetti and Usher (1972)</td>
</tr>
<tr>
<td>1961 November 17–December 20</td>
<td>13.8p</td>
<td>super</td>
<td>Rosino (1961); Bertola (1964)</td>
</tr>
<tr>
<td>1963 March 26–27</td>
<td>13.4p</td>
<td>super</td>
<td>Zwicky (1965); Bertola (1965)</td>
</tr>
<tr>
<td>1974 April 19–20</td>
<td>14.1v</td>
<td>normal?</td>
<td>AAVSO</td>
</tr>
<tr>
<td>1975 March 16–June 29</td>
<td>12.8v</td>
<td>super (two outbursts?)</td>
<td>AAVSO</td>
</tr>
<tr>
<td>1995 April 5–May 19</td>
<td>12.4v</td>
<td>super</td>
<td>Patterson et al. (1996); Nogami et al. (1997)</td>
</tr>
<tr>
<td>2003 January 28</td>
<td>15.5g</td>
<td>normal</td>
<td>SDSS</td>
</tr>
<tr>
<td>2007 November 6–24</td>
<td>15.4v</td>
<td>super</td>
<td>Uemura et al. (2008)</td>
</tr>
<tr>
<td>2013 December 6–2014 January 15</td>
<td>12.7v</td>
<td>super</td>
<td>this work</td>
</tr>
</tbody>
</table>

*For modern data, the end date refers to the end of the (second) plateau phase.
†p: photographic, v: visual, g: green in the SDSS system.
‡Rebrightening part only.

Table 17. Superhump maxima of IX Dra (2012).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56130.7403</td>
<td>0.0003</td>
<td>−0.0017</td>
<td>58</td>
</tr>
<tr>
<td>1</td>
<td>56130.8082</td>
<td>0.0003</td>
<td>−0.0007</td>
<td>56</td>
</tr>
<tr>
<td>25</td>
<td>56132.4161</td>
<td>0.0003</td>
<td>0.0002</td>
<td>126</td>
</tr>
<tr>
<td>26</td>
<td>56132.4832</td>
<td>0.0003</td>
<td>0.0003</td>
<td>144</td>
</tr>
<tr>
<td>27</td>
<td>56132.5466</td>
<td>0.0003</td>
<td>−0.0032</td>
<td>144</td>
</tr>
<tr>
<td>28</td>
<td>56132.6215</td>
<td>0.0019</td>
<td>0.0047</td>
<td>45</td>
</tr>
<tr>
<td>40</td>
<td>56133.4199</td>
<td>0.0005</td>
<td>−0.0003</td>
<td>75</td>
</tr>
<tr>
<td>54</td>
<td>56134.3624</td>
<td>0.0109</td>
<td>0.0048</td>
<td>24</td>
</tr>
<tr>
<td>55</td>
<td>56134.4228</td>
<td>0.0006</td>
<td>−0.0018</td>
<td>70</td>
</tr>
<tr>
<td>56</td>
<td>56134.4939</td>
<td>0.0005</td>
<td>0.0024</td>
<td>75</td>
</tr>
<tr>
<td>57</td>
<td>56134.5590</td>
<td>0.0008</td>
<td>0.0005</td>
<td>75</td>
</tr>
<tr>
<td>58</td>
<td>56134.6268</td>
<td>0.0019</td>
<td>0.0013</td>
<td>58</td>
</tr>
<tr>
<td>59</td>
<td>56134.6898</td>
<td>0.0016</td>
<td>−0.0026</td>
<td>44</td>
</tr>
<tr>
<td>70</td>
<td>56135.4323</td>
<td>0.0019</td>
<td>0.0034</td>
<td>75</td>
</tr>
<tr>
<td>71</td>
<td>56135.4944</td>
<td>0.0006</td>
<td>−0.0015</td>
<td>66</td>
</tr>
<tr>
<td>105</td>
<td>56137.7717</td>
<td>0.0017</td>
<td>−0.0006</td>
<td>66</td>
</tr>
<tr>
<td>106</td>
<td>56137.8364</td>
<td>0.0011</td>
<td>−0.0029</td>
<td>68</td>
</tr>
<tr>
<td>107</td>
<td>56137.9039</td>
<td>0.0013</td>
<td>−0.0023</td>
<td>68</td>
</tr>
<tr>
<td>121</td>
<td>56138.8408</td>
<td>0.0011</td>
<td>−0.0028</td>
<td>88</td>
</tr>
<tr>
<td>130</td>
<td>56139.4364</td>
<td>0.0008</td>
<td>−0.0098</td>
<td>70</td>
</tr>
<tr>
<td>131</td>
<td>56139.5149</td>
<td>0.0024</td>
<td>0.0017</td>
<td>75</td>
</tr>
<tr>
<td>145</td>
<td>56140.4481</td>
<td>0.0012</td>
<td>−0.0025</td>
<td>61</td>
</tr>
<tr>
<td>146</td>
<td>56140.5307</td>
<td>0.0032</td>
<td>0.0132</td>
<td>59</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456130.7420 + 0.066955 E.
‡Number of points used to determine the maximum.

of Olech et al. (2004), the present data did not show any strong sign of a stage transition (see also figure 16).

3.14 MN Draconis

This object is an SU UMa-type dwarf nova in the period gap (Antipin & Pavlenko 2002; Nogami et al. 2003). It is well-known that this object showed negative superhumps in quiescence (Pavlenko et al. 2010; Samsonov et al. 2010).

The 2012 July–August superoutburst was observed from the growing stage of superhumps. The times of superhump maxima are listed in table 18. Although the individual times of maxima were not well determined before $E = 10$, the $O − C$ diagram suggests that the interval $E ≤ 39$ was stage A (figure 17). A PDM analysis of this segment yielded a period of 0.10993(9) d.

The 2013 November superoutburst (vsnet-alert 16611) was observed for eight nights. The times of superhump maxima are listed in table 19. A large variation of period was detected. Up to $E = 18$, the amplitudes of superhumps grew, and stage A superhumps were most likely recorded (figure 18). Although we identified the following phase as stage B, the identification for $E = 95$ is uncertain due to
### Table 18. Superhump maxima of MN Dra (2012).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56130.3597</td>
<td>0.0048</td>
<td>−0.0239</td>
<td>42</td>
</tr>
<tr>
<td>1</td>
<td>56130.4483</td>
<td>0.0030</td>
<td>−0.0420</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>56130.5274</td>
<td>0.0017</td>
<td>−0.0696</td>
<td>56</td>
</tr>
<tr>
<td>10</td>
<td>56131.4246</td>
<td>0.0026</td>
<td>−0.0261</td>
<td>80</td>
</tr>
<tr>
<td>36</td>
<td>56134.2857</td>
<td>0.0011</td>
<td>0.0608</td>
<td>30</td>
</tr>
<tr>
<td>38</td>
<td>56134.4995</td>
<td>0.0006</td>
<td>0.0612</td>
<td>28</td>
</tr>
<tr>
<td>46</td>
<td>56135.3539</td>
<td>0.0015</td>
<td>0.0619</td>
<td>28</td>
</tr>
<tr>
<td>47</td>
<td>56135.4674</td>
<td>0.0012</td>
<td>0.0688</td>
<td>27</td>
</tr>
<tr>
<td>94</td>
<td>56140.4101</td>
<td>0.0017</td>
<td>−0.0035</td>
<td>27</td>
</tr>
<tr>
<td>95</td>
<td>56140.5155</td>
<td>0.0027</td>
<td>−0.0049</td>
<td>21</td>
</tr>
<tr>
<td>112</td>
<td>56142.3134</td>
<td>0.0042</td>
<td>−0.0209</td>
<td>32</td>
</tr>
<tr>
<td>113</td>
<td>56142.4136</td>
<td>0.0036</td>
<td>−0.0274</td>
<td>30</td>
</tr>
<tr>
<td>114</td>
<td>56142.5133</td>
<td>0.0045</td>
<td>−0.0344</td>
<td>28</td>
</tr>
</tbody>
</table>

$^*$BJD − 2400000.

$^\dagger$Against max = 2456130.3836 + 0.106703 $E$.

$^\ddagger$Number of points used to determine the maximum.

### Table 19. Superhump maxima of MN Dra (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56602.2479</td>
<td>0.0011</td>
<td>−0.0287</td>
<td>114</td>
</tr>
<tr>
<td>1</td>
<td>56602.3594</td>
<td>0.0010</td>
<td>−0.0231</td>
<td>116</td>
</tr>
<tr>
<td>9</td>
<td>56603.2248</td>
<td>0.0004</td>
<td>−0.0042</td>
<td>198</td>
</tr>
<tr>
<td>10</td>
<td>56603.3341</td>
<td>0.0014</td>
<td>−0.0007</td>
<td>90</td>
</tr>
<tr>
<td>18</td>
<td>56604.1967</td>
<td>0.0019</td>
<td>0.0154</td>
<td>13</td>
</tr>
<tr>
<td>26</td>
<td>56605.0438</td>
<td>0.0088</td>
<td>0.0159</td>
<td>99</td>
</tr>
<tr>
<td>27</td>
<td>56605.1550</td>
<td>0.0034</td>
<td>0.0213</td>
<td>166</td>
</tr>
<tr>
<td>28</td>
<td>56605.2595</td>
<td>0.0015</td>
<td>0.0200</td>
<td>20</td>
</tr>
<tr>
<td>46</td>
<td>56607.1492</td>
<td>0.0011</td>
<td>0.0051</td>
<td>64</td>
</tr>
<tr>
<td>47</td>
<td>56607.2544</td>
<td>0.0006</td>
<td>0.0044</td>
<td>106</td>
</tr>
<tr>
<td>48</td>
<td>56607.3611</td>
<td>0.0007</td>
<td>0.0053</td>
<td>131</td>
</tr>
<tr>
<td>57</td>
<td>56608.3064</td>
<td>0.0037</td>
<td>−0.0018</td>
<td>59</td>
</tr>
<tr>
<td>66</td>
<td>56609.2469</td>
<td>0.0012</td>
<td>−0.0136</td>
<td>95</td>
</tr>
<tr>
<td>95</td>
<td>56612.3137</td>
<td>0.0043</td>
<td>−0.0153</td>
<td>37</td>
</tr>
</tbody>
</table>

$^*$BJD − 2400000.

$^\dagger$Against max = 2456602.2767 + 0.105815 $E$.

$^\ddagger$Number of points used to determine the maximum.

---

the lower quality of the data. In table 2, we list the period derived from the data between $26 \leq E \leq 66$.

Assuming that the orbital period is $0.0998(2)\,d$ (Pavlenko et al. 2010), the values of $\varepsilon^*$ for stage A superhumps are $0.092(2)$ for 2012 which corresponds to $q=0.327(5)$ and $0.078(1)$ for 2013 to $q=0.258(5)$. Since both observations were not ideal (due to lack of well-measured maxima for the 2012 observation and to lack of data for the early stage of the 2013), we simply take an average of these two values to obtain $q=0.29(5)$. A comparison of $O−C$ diagrams of different superoutbursts (figure 19) suggests that the large negative $P_{\dot{\nu}}$ in the 2002b...
superoutburst reported in Nogami et al. (2003) and Kato et al. (2009) reflected stage A–B transition.

### 3.15 CP Eridani

CP Eri was discovered to be a faint blue variable showing an outburst (Luyten & Haro 1959). Szkody et al. (1989) obtained a time-series of photometry in quiescence and detected sporadic variations of 0.2–0.4 mag without clear periodicity. Howell et al. (1991) observed this object again in quiescence and detected modulations with a period of 28.6–29.5 min. Due to its shortness, Howell et al. (1991) considered this period to be the spin period of the magnetic white dwarf. Abbott et al. (1992) obtained a time-series of higher quality photometry and identified a period of 1724(4) s (28.6 min). Furthermore, Abbott et al. (1992) obtained spectra in both high and low states, and revealed that this object lacks hydrogen lines. The helium lines were in emission in a low state and in absorption in a high state, and this behavior was very similar to that of CR Boo (Wood et al. 1987). Abbott et al. (1992) concluded that CP Eri is an interacting binary white dwarf (IBWD, or AM CVn-type star). Patterson et al. (1993), however, suggested that this photometric period is the superhump period since most AM CVn-type stars show superhumps. Zwitter and Munari (1995) obtained a spectrum with a featureless blue continuum.

Although this object was discovered to be an outbursting one, its outburst behavior was not clarified for a long time. Although J. Patterson (cbainfo message on 1998 January 1) reported an outburst of 16.5 mag and its 0.2 mag superhumps, the result was published only in Armstrong, Patterson, and Kemp (2012). Since 2003, B. Monard regularly monitored this object and detected several outbursts between 16.0 and 17.5 mag. More recently, CRTS data suggested a cycle length of \( \sim 100 \) d (Kato et al. 2012b). Ramsay et al. (2012) presented the result of long-term monitoring of AM CVn-type stars and detected three outbursts in CP Eri. The duration of the outbursts was 15 d and the outburst duty cycle was 27%. Judging from the duration, these outbursts were likely superoutbursts.

Armstrong, Patterson, and Kemp (2012), following the interpretation in Patterson et al. (1993), identified the orbital and superhump periods from the 1998 data. According to this interpretation, the orbital modulation of 1701.4(2) s doubly humped.

On 2013 October 3, the ASAS-SN team detected an outburst of CP Eri (vsnet-alert 16501). Subsequent observations recorded its superhumps (vsnet-alert 16510, 16515). This outbursting state near the peak was observed for three nights (the outburst lasted at least 5 d including the ASAS-SN detection) and followed by a dip (vsnet-alert 16526). After the dip, the superhump signal at first became weaker, but then became detectable again (vsnet-alert 16530, 16537). The later part of the outburst consisted of oscillations as reported in Armstrong, Patterson, and Kemp (2012).

The times of superhump maxima during the initial peak are listed in table 20. A positive \( P_{\text{dot}} \) of \( +3.1(9) \times 10^{-5} \) was for the first time recorded in CP Eri. Superhumps after the dip had a shorter period—0.019752(4) d by the PDM method. The times of maxima of these superhumps are listed in table 21. The interpretation of these superhumps (whether they are the same superhumps as in the initial peak or “traditional” late superhumps) is not clear. It was, however, likely that these superhumps were excited again after the dip phenomenon. The combined \( O–C \) diagram (figure 20) may suggest that the phase of the superhumps was continuous if the superhump period continued to increase the same as in stage B of hydrogen-rich dwarf novae.

### 3.16 V1239 Herculis

This object (SDSS J170213.26+322954.1) is an eclipsing SU UMa-type dwarf nova in the period gap (Boyd et al. 2006; Littlefair et al. 2006). The 2005 and 2011 superoutbursts were reported in Boyd, Oksanen, and Henden (2006) and Kato et al. (2009) and in Kato et al. (2013b), respectively. On 2013 September 26, another outburst was reported (vsnet-alert 16462; also vsnet-alert 16464). Although this outburst was probably a superoutburst, only a single-night observation covering an eclipse was reported.

---

**Fig. 19.** Comparison of different superoutbursts of MN Dra in the \( O–C \) diagram. A period of 0.1050 d was used to draw this figure. Approximate cycle counts (\( E \)) after the start of the outburst were used (2012). Since the start of the other superoutbursts was not well constrained, we shifted the \( O–C \) diagrams to best fit the 2012 one.
By using these observations, we refined an ephemeris of

\[
\text{Min}(\text{BJD}) = 2453648.23651(1) + 0.1000822137(7)E
\]

using the Markov-chain Monte Carlo (MCMC) modeling introduced in Kato et al. (2013b). This ephemeris supersedes the one reported in Kato et al. (2013b) which was determined by the traditional minimum finding method.

### 3.17 CT Hydrea

CT Hya was discovered to be a dwarf nova (\(=\text{AN 114.1936}\)) with a photographic range of 14.5 to fainter than 16.5 by Hoffmeister (1936). Hoffmeister (1936) recorded four outbursts during the period from 1929 to 1934. The finding chart was published in Hoffmeister (1957). Vogt and Bateson (1982) presented a photographic chart and identified the quiescent counterpart. The first secure outburst since the discovery was reported on 1995 February 22 from CCD observations by M. Iida (VSOLJ). Iida observed the object on the subsequent night and detected variations compatible with superhumps. The

---

### Table 20. Superhump maxima of CP Eri (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max</th>
<th>Error</th>
<th>O – C</th>
<th>N⁠†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56570.6649</td>
<td>0.0008</td>
<td>−0.0001</td>
<td>14</td>
</tr>
<tr>
<td>1</td>
<td>56570.6854</td>
<td>0.0003</td>
<td>0.0005</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>56570.7060</td>
<td>0.0002</td>
<td>0.0012</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>56570.7253</td>
<td>0.0003</td>
<td>0.0006</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>56570.7452</td>
<td>0.0003</td>
<td>0.0006</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>56570.7649</td>
<td>0.0003</td>
<td>0.0004</td>
<td>19</td>
</tr>
<tr>
<td>6</td>
<td>56570.7841</td>
<td>0.0003</td>
<td>0.0003</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>56570.8050</td>
<td>0.0003</td>
<td>0.0007</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>56570.8250</td>
<td>0.0003</td>
<td>0.0008</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>56570.8439</td>
<td>0.0006</td>
<td>0.0002</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>56570.8640</td>
<td>0.0003</td>
<td>0.0006</td>
<td>19</td>
</tr>
<tr>
<td>11</td>
<td>56570.8836</td>
<td>0.0012</td>
<td>−0.0002</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>56570.9029</td>
<td>0.0005</td>
<td>−0.0003</td>
<td>21</td>
</tr>
<tr>
<td>13</td>
<td>56570.9217</td>
<td>0.0006</td>
<td>−0.0019</td>
<td>21</td>
</tr>
<tr>
<td>14</td>
<td>56570.9446</td>
<td>0.0006</td>
<td>0.0010</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>56570.9634</td>
<td>0.0004</td>
<td>−0.0001</td>
<td>21</td>
</tr>
<tr>
<td>16</td>
<td>56570.7790</td>
<td>0.0007</td>
<td>−0.0008</td>
<td>15</td>
</tr>
<tr>
<td>17</td>
<td>56570.7999</td>
<td>0.0005</td>
<td>0.0003</td>
<td>15</td>
</tr>
<tr>
<td>18</td>
<td>56570.8186</td>
<td>0.0010</td>
<td>−0.0005</td>
<td>14</td>
</tr>
<tr>
<td>19</td>
<td>56570.8378</td>
<td>0.0011</td>
<td>−0.0012</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>56570.8587</td>
<td>0.0005</td>
<td>−0.0001</td>
<td>19</td>
</tr>
<tr>
<td>21</td>
<td>56570.8780</td>
<td>0.0004</td>
<td>−0.0008</td>
<td>32</td>
</tr>
<tr>
<td>22</td>
<td>56570.8975</td>
<td>0.0005</td>
<td>−0.0011</td>
<td>19</td>
</tr>
<tr>
<td>23</td>
<td>56570.9172</td>
<td>0.0004</td>
<td>−0.0013</td>
<td>14</td>
</tr>
<tr>
<td>24</td>
<td>56570.9380</td>
<td>0.0006</td>
<td>−0.0004</td>
<td>14</td>
</tr>
<tr>
<td>25</td>
<td>56570.9584</td>
<td>0.0013</td>
<td>0.0001</td>
<td>14</td>
</tr>
<tr>
<td>26</td>
<td>56570.9779</td>
<td>0.0008</td>
<td>−0.0003</td>
<td>11</td>
</tr>
<tr>
<td>27</td>
<td>56572.7142</td>
<td>0.0004</td>
<td>−0.0002</td>
<td>19</td>
</tr>
<tr>
<td>28</td>
<td>56572.7344</td>
<td>0.0004</td>
<td>0.0001</td>
<td>20</td>
</tr>
<tr>
<td>29</td>
<td>56572.7540</td>
<td>0.0005</td>
<td>−0.0002</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>56572.7750</td>
<td>0.0004</td>
<td>0.0009</td>
<td>18</td>
</tr>
<tr>
<td>31</td>
<td>56572.7948</td>
<td>0.0004</td>
<td>0.0008</td>
<td>20</td>
</tr>
<tr>
<td>32</td>
<td>56572.8139</td>
<td>0.0004</td>
<td>0.0000</td>
<td>19</td>
</tr>
<tr>
<td>33</td>
<td>56572.8340</td>
<td>0.0003</td>
<td>0.0002</td>
<td>20</td>
</tr>
<tr>
<td>34</td>
<td>56572.8547</td>
<td>0.0004</td>
<td>0.0011</td>
<td>19</td>
</tr>
<tr>
<td>35</td>
<td>56572.8737</td>
<td>0.0008</td>
<td>0.0002</td>
<td>17</td>
</tr>
</tbody>
</table>

* BJ D – 2400000.
† Against max = 2456570.6650 + 0.019897E.
‡ Number of points used to determine the maximum.

---

### Table 21. Superhump maxima of CP Eri (2013) (after the dip).

<table>
<thead>
<tr>
<th>E</th>
<th>Max</th>
<th>Error</th>
<th>O – C</th>
<th>N⁠†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56576.7433</td>
<td>0.0018</td>
<td>0.0013</td>
<td>19</td>
</tr>
<tr>
<td>1</td>
<td>56576.7615</td>
<td>0.0011</td>
<td>−0.0003</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>56576.7835</td>
<td>0.0003</td>
<td>0.0019</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>56576.7996</td>
<td>0.0006</td>
<td>−0.0017</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>56576.8203</td>
<td>0.0007</td>
<td>−0.0007</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>56576.8401</td>
<td>0.0006</td>
<td>−0.0007</td>
<td>19</td>
</tr>
<tr>
<td>6</td>
<td>56576.8609</td>
<td>0.0005</td>
<td>0.0003</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>56576.8804</td>
<td>0.0008</td>
<td>0.0001</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>56577.7487</td>
<td>0.0026</td>
<td>−0.0009</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>56577.7670</td>
<td>0.0010</td>
<td>−0.0024</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>56577.7869</td>
<td>0.0006</td>
<td>−0.0022</td>
<td>20</td>
</tr>
<tr>
<td>11</td>
<td>56577.8047</td>
<td>0.0013</td>
<td>0.0047</td>
<td>17</td>
</tr>
<tr>
<td>12</td>
<td>56577.8222</td>
<td>0.0011</td>
<td>0.0052</td>
<td>19</td>
</tr>
<tr>
<td>13</td>
<td>56577.8009</td>
<td>0.0024</td>
<td>0.0042</td>
<td>19</td>
</tr>
<tr>
<td>14</td>
<td>56580.7519</td>
<td>0.0007</td>
<td>−0.0007</td>
<td>17</td>
</tr>
<tr>
<td>15</td>
<td>56580.8114</td>
<td>0.0009</td>
<td>−0.0006</td>
<td>19</td>
</tr>
<tr>
<td>16</td>
<td>56580.8308</td>
<td>0.0004</td>
<td>−0.0009</td>
<td>19</td>
</tr>
<tr>
<td>17</td>
<td>56580.8489</td>
<td>0.0007</td>
<td>−0.0025</td>
<td>19</td>
</tr>
<tr>
<td>18</td>
<td>56580.8715</td>
<td>0.0018</td>
<td>0.0003</td>
<td>19</td>
</tr>
</tbody>
</table>

* BJ D – 2400000.
† Against max = 2456576.7420 + 0.019757E.
‡ Number of points used to determine the maximum.

---

Fig. 20. \(O – C\) diagram of superhumps in CP Eri (2013). Upper: \(O – C\) diagram. A period of 0.019897 d was used for drawing this figure. Lower: Light curve. The observations were binned to 0.004 d.
Table 22. Superhump maxima of CT Hya (2014).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56708.1208</td>
<td>0.0004</td>
<td>0.0024</td>
<td>134</td>
</tr>
<tr>
<td>1</td>
<td>56708.1860</td>
<td>0.0004</td>
<td>0.0015</td>
<td>133</td>
</tr>
<tr>
<td>2</td>
<td>56708.2468</td>
<td>0.0012</td>
<td>−0.0039</td>
<td>123</td>
</tr>
<tr>
<td>45</td>
<td>56711.0947</td>
<td>0.0011</td>
<td>−0.0017</td>
<td>28</td>
</tr>
<tr>
<td>46</td>
<td>56711.1644</td>
<td>0.0007</td>
<td>0.0018</td>
<td>38</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456708.1184 + 0.066178 E.
‡Number of points used to determine the maximum.

The same outburst was observed by Nogami, Kato, and Hirata (1996), who reported on the detection of superhumps. In Kato et al. (2009), superoutbursts in 1999, 2000, 2002 (two superoutbursts), and 2009 were reported. In Kato et al. (2010), another superoutburst in 2010 was reported.

The 2014 superoutburst was detected by CRTS (see vsnet-alert 16926) and observations on two nights were obtained. The times of superhump maxima are listed in table 22. The observation probably detected stage C superhumps (see figure 21).

3.18 VW Hydri

We observed the 2012 November–December superoutburst of this famous SU UMa-type dwarf nova. By using the 2011–2012 data, we have determined that the orbital period is 0.0742705(1) d and that the mean epoch of the maximum is BJD 2456116.7250(1). Combined these values with the ephemeris of Vogt (1974), we have obtained an updated ephemeris of

Max(BJD) = 2456116.7250(1) + 0.074271061(4)E.

The times of superhump maxima during the superoutburst plateau are listed in table 23. Although the evolution of superhumps was similar to that in 2011 (Kato et al. 2013b), stage A superhumps were not well observed in the 2012 superoutburst. The precursor was not as apparent as that in the 2011 superoutburst. During the rapidly fading phase from the superoutburst, an ∼0.5 phase jump was observed the same as in 2011. These superhumps can be interpreted as “traditional” late superhumps. The times of these post-superoutburst superhumps were determined after the subtraction of the mean orbital profile (table 24).

A comparison between the 2011 (Kato et al. 2013b) and 2012 superoutbursts in the O − C diagram shows a slight difference in the curvature of the O − C diagram during the superoutburst plateau. Although the times of post-superoutburst superhumps in the 2012 superoutburst were given only before the next normal outburst, the signal remained detectable for ∼40 d after the termination of the superoutburst by the PDM method. The resultant periods in 5 d intervals are listed in table 25.

The detection of negative superhumps in this object is discussed in subsection 4.8.

3.19 WX Hydri

WX Hyi was originally discovered to be a variable star (= AN 9.1932) with a magnitude range of 10.7 to 14.2 (photographic scale at that time) by Luyten (1932).

Fig. 22. Comparison of different superoutbursts of VW Hya in the O−C diagram. A period of 0.076914 d was used to draw this figure. Approximate cycle counts (E) after the maximum of the superoutburst were used.
Hoffmeister (1949) classified the object as a Mira-type variable (also Kukarkin et al. 1969). Philip (1971) noted its blue color, rapid light variations, and an emission-line spectrum on a low-dispersion objective-prism plate. Kukarkin (1971) suggested that the variable is either a dwarf nova or symbiotic object, not a Mira such as was originally proposed. Fisher et al. (1971) communicated UBV and visual observations giving a range (visual and V) of 11.5–14.73. The blue color and variation were incompatible with the Mira-type variable. This object has been recognized as a dwarf nova. Splittgerber (1971) also reported on the detection of two outbursts.

Amateur observers (particularly Royal Astronomical Society of New Zealand members) started visual observations in 1971 April. Bateson (1976) suggested the SU UMa-type dwarf nova based on the presence of superoutbursts detected by visual observations. Walker, Marino, and Freeth (1976) reported on the detection of superhumps by photoelectric photometry. The reported period was 0.0783 d based on the two nights’ observation. Walker, Marino, and Freeth (1976) also reported on a period of 0.0749 d, and suggested it is the orbital period. Sanduleak (1976) reported on a spectrum showing Balmer lines in emission, which is typical for a dwarf nova. Bailey (1979a) reported on high-speed photometry both in superoutburst and in quiescence. Using observations on four successive nights in 1977 December, Bailey (1979a) derived a superhump period of 0.07737 d. This observation corresponded to the middle part of the superoutburst. In contrast to Walker, Marino, and Freeth (1976), Bailey (1979a) could not detect orbital modulations in quiescence (also J. Bailey 1979 unpublished; see Schoembs & Vogt 1981). Schoembs and Vogt (1981) obtained high time-resolution spectroscopy and determined that the orbital period is 0.0748134(2) d. Pretorius, Warner, and Woudt (2006) reported on the detection of quasi-periodic oscillations (QPOs) in quiescence.

Identifying this object as a dwarf nova led to a suggestion that some SU UMa-type dwarf novae could be misclassified as Mira-type variables (Vogt 1980). DH Aql (Tsesevich 1969; Nogami & Kato 1995), SY Cap (Kato et al. 2009), and FQ Mon (vsnet-chat 3063, 3066; Kato et al. 2009) are indeed such objects. Despite the fact that WX Hya is a well-known SU UMa-type dwarf nova, the listed set of literature...
was probably the last published observation of superhumps before this paper.

Our 2014 January–February observation started after the detection of a bright outburst on January 27 by S. Hovell and R. Stubbings (the start of the outburst was on January 25). From the observations on January 30 fully grown superhumps were detected and the subsequent evolution was observed (vsnet-alert 16851, 16868, 16904). The times of superhump maxima are listed in table 26, which includes post-superoutburst observations.

A comparison of O−C diagrams (figure 23) suggests that Schoembs and Vogt (1981) recorded stage B superhumps on the first two nights and stage C superhumps on the last two nights (since both superoutbursts began with a precursor, we used the maximum which was easier to


<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56268.5388</td>
<td>0.0073</td>
<td>−0.0124</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>56268.6241</td>
<td>0.0061</td>
<td>−0.0033</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>56268.6976</td>
<td>0.0011</td>
<td>−0.0061</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>56268.7775</td>
<td>0.0014</td>
<td>−0.0025</td>
<td>37</td>
</tr>
<tr>
<td>19</td>
<td>56269.9944</td>
<td>0.0009</td>
<td>−0.0004</td>
<td>113</td>
</tr>
<tr>
<td>20</td>
<td>56270.0744</td>
<td>0.0006</td>
<td>−0.0016</td>
<td>162</td>
</tr>
<tr>
<td>21</td>
<td>56270.1533</td>
<td>0.0006</td>
<td>0.0010</td>
<td>164</td>
</tr>
<tr>
<td>22</td>
<td>56270.2348</td>
<td>0.0009</td>
<td>0.0062</td>
<td>170</td>
</tr>
<tr>
<td>19</td>
<td>56270.9944</td>
<td>0.0009</td>
<td>−0.0054</td>
<td>113</td>
</tr>
<tr>
<td>20</td>
<td>56270.0744</td>
<td>0.0006</td>
<td>−0.0016</td>
<td>162</td>
</tr>
<tr>
<td>21</td>
<td>56270.1533</td>
<td>0.0006</td>
<td>0.0010</td>
<td>164</td>
</tr>
<tr>
<td>22</td>
<td>56270.2348</td>
<td>0.0009</td>
<td>0.0062</td>
<td>170</td>
</tr>
</tbody>
</table>

*BJD = 2400000.
†Against max = 2456268.5512 + 0.076242 E.
‡Number of points used to determine the maximum.

Table 25. Post-superoutburst superhumps in VW Hyi (2012).

<table>
<thead>
<tr>
<th>JD*−2400000</th>
<th>Period (d)</th>
<th>Error (d)</th>
<th>Amplitude (mag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56270–56275</td>
<td>0.07623</td>
<td>0.00001</td>
<td>0.33</td>
</tr>
<tr>
<td>56275–56280</td>
<td>0.07584</td>
<td>0.00004</td>
<td>0.36</td>
</tr>
<tr>
<td>56280–56285</td>
<td>0.07732</td>
<td>0.00011</td>
<td>0.08</td>
</tr>
<tr>
<td>56285–56290</td>
<td>0.07615</td>
<td>0.00014</td>
<td>0.13</td>
</tr>
<tr>
<td>56290–56295</td>
<td>0.07600</td>
<td>0.00005</td>
<td>0.15</td>
</tr>
<tr>
<td>56295–56300</td>
<td>0.07586</td>
<td>0.00005</td>
<td>0.07</td>
</tr>
<tr>
<td>56300–56305</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>56305–56310</td>
<td>0.07712</td>
<td>0.00013</td>
<td>0.08</td>
</tr>
</tbody>
</table>

*BJD = 2400000.
†Against max = 2456687.5640 + 0.077499 E.
‡Number of points used to determine the maximum.

Fig. 23. Comparison of different superoutbursts of WX Hyi in the O−C diagram. A period of 0.07765 d was used to draw this figure. Approximate cycle counts (E) after the maximum of the superoutburst were used.
The resultant period of stage B is in agreement with the value of Walker, Marino, and Freeth (1976), who reported on an early part of the superoutburst. We list the periods estimated from this interpretation in table 2.

3.20 AY Lyrae

Observations of this well-known SU UMa-type dwarf nova were performed on only two nights in 2013 August. The times of superhump maxima are listed in table 27.

3.21 AO Octantis

Due to the large outburst amplitude (7.5 mag) listed in Kholopov et al. (1985), this object has long been considered as a candidate for a WZ Sge-type dwarf nova (Downes 1990; Howell & Szkody 1990; O’Donoghue et al. 1991; Kato et al. 2001a). Although Howell et al. (1991) observed this object in quiescence, no orbital modulation was detected. Mason and Howell (2003) obtained a spectrum in quiescence, which was typical of dwarf novae with a low mass-transfer rate but not so extreme as a WZ Sge-type dwarf nova. Patterson et al. (2003) observed the 2000 September outburst and obtained a superhump period of 0.06716(13)d and an orbital period of 0.06557(13)d. Woudt, Warner, and Pretorius (2004) obtained time-resolved photometry in quiescence and detected an orbital modulation with a period of 0.065345(15)d. The presence of the orbital modulation appears to be consistent with the relatively broad emission lines in Mason and Howell (2003).

The 2013 superoutburst of AO Oct was detected by R. Stubbings (vsnet-alert 16376). From subsequent observations superhumps were detected (vsnet-alert 16388, 16396, 16411; figure 24). The times of superhump maxima are listed in table 28. Stages B and C were clearly present. A large $P_{\text{dot}}$ of $+19(6) \times 10^{-5}$ for stage B superhumps is typical for this $P_{\text{orb}}$.

According to Woudt, Warner, and Pretorius (2004), the maximum magnitude of 13.5 in Kholopov et al. (1985) was probably a typographical error of 15.3 based on the discovery paper (von Gessner & Meinunger 1974). The

### Table 27. Superhump maxima of AY Lyr (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max*</th>
<th>Error</th>
<th>$O - C$</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56533.0467</td>
<td>0.0007</td>
<td>-0.0000</td>
<td>84</td>
</tr>
<tr>
<td>1</td>
<td>56533.1221</td>
<td>0.0005</td>
<td>-0.0007</td>
<td>79</td>
</tr>
<tr>
<td>2</td>
<td>56533.1996</td>
<td>0.0008</td>
<td>-0.0008</td>
<td>55</td>
</tr>
<tr>
<td>14</td>
<td>56534.1116</td>
<td>0.0006</td>
<td>-0.0001</td>
<td>39</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max = 2456533.0467 + 0.076064 $E$.
‡Number of points used to determine the maximum.

### Table 28. Superhump maxima of AO Oct (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max*</th>
<th>Error</th>
<th>$O - C$</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56545.5712</td>
<td>0.0006</td>
<td>0.0003</td>
<td>29</td>
</tr>
<tr>
<td>1</td>
<td>56545.6371</td>
<td>0.0007</td>
<td>-0.0011</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>56545.7043</td>
<td>0.0021</td>
<td>-0.0011</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>56545.7744</td>
<td>0.0016</td>
<td>0.0017</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>56546.5113</td>
<td>0.0009</td>
<td>-0.0011</td>
<td>22</td>
</tr>
<tr>
<td>15</td>
<td>56546.5781</td>
<td>0.0011</td>
<td>-0.0015</td>
<td>28</td>
</tr>
<tr>
<td>16</td>
<td>56546.6466</td>
<td>0.0012</td>
<td>-0.0002</td>
<td>15</td>
</tr>
<tr>
<td>17</td>
<td>56546.7126</td>
<td>0.0009</td>
<td>-0.0015</td>
<td>15</td>
</tr>
<tr>
<td>29</td>
<td>56547.5202</td>
<td>0.0011</td>
<td>-0.0007</td>
<td>26</td>
</tr>
<tr>
<td>45</td>
<td>56548.5933</td>
<td>0.0066</td>
<td>-0.0035</td>
<td>10</td>
</tr>
<tr>
<td>46</td>
<td>56548.6664</td>
<td>0.0014</td>
<td>0.0024</td>
<td>13</td>
</tr>
<tr>
<td>59</td>
<td>56549.5480</td>
<td>0.0011</td>
<td>0.0099</td>
<td>27</td>
</tr>
<tr>
<td>75</td>
<td>56550.6161</td>
<td>0.0012</td>
<td>0.0022</td>
<td>25</td>
</tr>
<tr>
<td>76</td>
<td>56550.6872</td>
<td>0.0032</td>
<td>0.0061</td>
<td>12</td>
</tr>
<tr>
<td>89</td>
<td>56551.5518</td>
<td>0.0020</td>
<td>-0.0035</td>
<td>27</td>
</tr>
<tr>
<td>90</td>
<td>56551.6183</td>
<td>0.0052</td>
<td>-0.0043</td>
<td>12</td>
</tr>
<tr>
<td>91</td>
<td>56551.6855</td>
<td>0.0019</td>
<td>-0.0042</td>
<td>14</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max = 2456545.5710 + 0.067240 $E$.
‡Number of points used to determine the maximum.
Table 29. Superhump maxima of DT Oct (2014).

<table>
<thead>
<tr>
<th>E</th>
<th>Max±</th>
<th>Error</th>
<th>O−C</th>
<th>N1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56696.7567</td>
<td>0.0008</td>
<td>−0.0020</td>
<td>83</td>
</tr>
<tr>
<td>54</td>
<td>56700.7787</td>
<td>0.0006</td>
<td>0.0031</td>
<td>119</td>
</tr>
<tr>
<td>65</td>
<td>56701.5969</td>
<td>0.0037</td>
<td>0.0031</td>
<td>35</td>
</tr>
<tr>
<td>66</td>
<td>56701.6714</td>
<td>0.0007</td>
<td>0.0032</td>
<td>66</td>
</tr>
<tr>
<td>67</td>
<td>56701.7412</td>
<td>0.0006</td>
<td>−0.0014</td>
<td>80</td>
</tr>
<tr>
<td>68</td>
<td>56701.8170</td>
<td>0.0014</td>
<td>0.0000</td>
<td>63</td>
</tr>
<tr>
<td>81</td>
<td>56702.7779</td>
<td>0.0011</td>
<td>−0.0061</td>
<td>70</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456696.7587 + 0.074386E.
‡Number of points used to determine the maximum.

object, however, has been detected to be as bright as 14.2 (visual magnitude) in outbursts several times. The true range of variability can be regarded as 14.2–20.9, where the minimum magnitude is taken from Woudt, Warner, and Pretorius (2004). Considering the supercycle of ∼300 d, this outburst amplitude is indeed slightly too large for this intermediate length of supercycle. Although TV Crv was reported to have similar parameters (cf. table 1 in Nogami et al. 1997), the maximum magnitude of TV Crv was probably overestimated, since recent magnitudes of superoutbursts only reach 13.0. AO Oct apparently deserves further study for its rather unusual outburst parameters.

3.22 DT Octantis

This object was discovered to be a variable star (= BV 966) with a large amplitude (11.2 to fainter than 15.0 in photographic magnitudes: Knigge & Bauernfeind 1967). Kato et al. (2002c) noticed the identification with a bright ROSAT source and suggested that this object is a cataclysmic variable. Kato et al. (2002c) detected multiple outbursts upon this suggestion. Although Kato et al. (2002c) initially suggested that these may be outbursts in an intermediate polar, Kato et al. (2004c) detected superhumps during the 2003 January outburst. DT Oct was thus recognized as an SU UMa-type dwarf nova. Kato et al. (2009) further studied another superoutburst in 2003 November and a superoutburst in 2008.

The 2014 superoutburst was detected by R. Stubbings (cf. vsnet-alert 16892) and the latter part of the superoutburst was observed. The times of superhump maxima are listed in table 29. The data mostly covered stage C superhumps (figure 25).

Using the near-quiescent data in 2013 (by A. Oksanen, BJD 2456380–2456445), we have obtained a possible orbital signal of 0.072707(5) d with a mean amplitude of 0.16 mag. This period is adopted in table 2. The e±value for stage A superhumps—0.050(2)—in 2003 (Kato et al. 2009) corresponds to q = 0.147(7).

Fig. 25. Comparison of different superoutbursts of DT Oct in the O−C diagram. A period of 0.07485 d was used to draw this figure. Approximate cycle counts (E) after the start of the superoutburst were used.

3.23 V521 Pegasi

This object (= HS 2219+1824) is a dwarf nova which was reported in Rodriguez-Gil et al. (2005). Although Rodriguez-Gil et al. (2005) reported on the detection of superhumps and a likely orbital modulation, subsequent superoutbursts occurred in seasonally unsuitable conditions, and it was only in 2012 when we succeeded in obtaining the superhump period (Kato et al. 2014a).

The 2013 superoutburst was detected by the ASAS-SN team (vsnet-alert 16093). K. Wenzel also reported on the outburst detection before the ASAS-SN detection. From subsequent observations superhumps were detected (vsnet-alert 16121, 16129, 16134). After rapidly fading from the
superhump period during the 2005 and 2008 superoutbursts. Thorstensen et al. (1996) determined the orbital period by a radial velocity study.

The 2013 December superoutburst was detected by Kyoto and Kiso Wide-field Survey (KWS; vsnet-alert 16682) and was observed for three nights. The times of superhump maxima are listed in table 31. From the observation stage B–C transition was apparently detected. This identification is confirmed by a comparison of $O - C$ diagrams (figure 27). Also note that the figure in Kato et al. (2009), based on the period of stage C superhumps rather than that of stage B superhumps, may give the reader a different impression from figure 27.

### Table 30. Superhump maxima of V521 Peg (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>$Max^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56507.0874</td>
<td>0.0009</td>
<td>−0.0139</td>
<td>44</td>
</tr>
<tr>
<td>1</td>
<td>56507.1507</td>
<td>0.0006</td>
<td>−0.0118</td>
<td>66</td>
</tr>
<tr>
<td>2</td>
<td>56507.2734</td>
<td>0.0005</td>
<td>−0.0114</td>
<td>63</td>
</tr>
<tr>
<td>18</td>
<td>56508.1942</td>
<td>0.0007</td>
<td>−0.0074</td>
<td>70</td>
</tr>
<tr>
<td>19</td>
<td>56508.2575</td>
<td>0.0007</td>
<td>−0.0052</td>
<td>67</td>
</tr>
<tr>
<td>34</td>
<td>56509.1753</td>
<td>0.0006</td>
<td>−0.0043</td>
<td>40</td>
</tr>
<tr>
<td>50</td>
<td>56510.1601</td>
<td>0.0004</td>
<td>0.0026</td>
<td>91</td>
</tr>
<tr>
<td>51</td>
<td>56510.2223</td>
<td>0.0008</td>
<td>−0.0118</td>
<td>66</td>
</tr>
<tr>
<td>52</td>
<td>56510.2848</td>
<td>0.0005</td>
<td>−0.0114</td>
<td>63</td>
</tr>
<tr>
<td>53</td>
<td>56510.3497</td>
<td>0.0011</td>
<td>0.0005</td>
<td>40</td>
</tr>
<tr>
<td>56</td>
<td>56510.5899</td>
<td>0.0012</td>
<td>0.0045</td>
<td>28</td>
</tr>
<tr>
<td>67</td>
<td>56511.2146</td>
<td>0.0016</td>
<td>0.0179</td>
<td>63</td>
</tr>
<tr>
<td>68</td>
<td>56511.2718</td>
<td>0.0009</td>
<td>0.0140</td>
<td>62</td>
</tr>
<tr>
<td>72</td>
<td>56511.5129</td>
<td>0.0003</td>
<td>0.0106</td>
<td>47</td>
</tr>
<tr>
<td>87</td>
<td>56512.4234</td>
<td>0.0008</td>
<td>0.0042</td>
<td>52</td>
</tr>
<tr>
<td>88</td>
<td>56512.4840</td>
<td>0.0015</td>
<td>0.0037</td>
<td>159</td>
</tr>
<tr>
<td>89</td>
<td>56512.5469</td>
<td>0.0030</td>
<td>0.0055</td>
<td>211</td>
</tr>
<tr>
<td>134</td>
<td>56515.2792</td>
<td>0.0016</td>
<td>−0.0128</td>
<td>123</td>
</tr>
<tr>
<td>148</td>
<td>56516.1433</td>
<td>0.0014</td>
<td>−0.0044</td>
<td>113</td>
</tr>
<tr>
<td>149</td>
<td>56516.2033</td>
<td>0.0009</td>
<td>−0.0055</td>
<td>230</td>
</tr>
<tr>
<td>150</td>
<td>56516.2645</td>
<td>0.0012</td>
<td>−0.0054</td>
<td>226</td>
</tr>
<tr>
<td>164</td>
<td>56517.1278</td>
<td>0.0006</td>
<td>0.0021</td>
<td>80</td>
</tr>
<tr>
<td>165</td>
<td>56517.1885</td>
<td>0.0008</td>
<td>0.0017</td>
<td>128</td>
</tr>
<tr>
<td>170</td>
<td>56517.4937</td>
<td>0.0004</td>
<td>0.0013</td>
<td>54</td>
</tr>
<tr>
<td>182</td>
<td>56518.2226</td>
<td>0.0006</td>
<td>−0.0034</td>
<td>82</td>
</tr>
<tr>
<td>183</td>
<td>56518.2853</td>
<td>0.0006</td>
<td>−0.0018</td>
<td>125</td>
</tr>
<tr>
<td>198</td>
<td>56519.2022</td>
<td>0.0011</td>
<td>−0.0017</td>
<td>126</td>
</tr>
<tr>
<td>199</td>
<td>56519.2599</td>
<td>0.0012</td>
<td>−0.0051</td>
<td>120</td>
</tr>
</tbody>
</table>

$^\ast BJ D - 2400000.$

$^\dagger Against max = 2456507.1013 + 0.061124 \times E.$

$^\dagger Number of points used to determine the maximum.$

---

**Table 31. Superhump maxima of TY Psc (2013).**

<table>
<thead>
<tr>
<th>$E$</th>
<th>$Max^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56635.0415</td>
<td>0.0006</td>
<td>−0.0012</td>
<td>91</td>
</tr>
<tr>
<td>1</td>
<td>56635.1110</td>
<td>0.0004</td>
<td>−0.0023</td>
<td>130</td>
</tr>
<tr>
<td>2</td>
<td>56635.1812</td>
<td>0.0005</td>
<td>−0.0027</td>
<td>109</td>
</tr>
<tr>
<td>27</td>
<td>56636.9499</td>
<td>0.0012</td>
<td>0.0018</td>
<td>25</td>
</tr>
<tr>
<td>28</td>
<td>56637.0230</td>
<td>0.0012</td>
<td>0.0043</td>
<td>46</td>
</tr>
<tr>
<td>29</td>
<td>56637.0924</td>
<td>0.0006</td>
<td>0.0031</td>
<td>63</td>
</tr>
<tr>
<td>30</td>
<td>56637.1630</td>
<td>0.0009</td>
<td>0.0032</td>
<td>47</td>
</tr>
<tr>
<td>55</td>
<td>56638.9234</td>
<td>0.0016</td>
<td>−0.0007</td>
<td>52</td>
</tr>
<tr>
<td>56</td>
<td>56638.9920</td>
<td>0.0008</td>
<td>−0.0026</td>
<td>52</td>
</tr>
<tr>
<td>57</td>
<td>56639.0622</td>
<td>0.0008</td>
<td>−0.0029</td>
<td>101</td>
</tr>
</tbody>
</table>

$^\ast BJ D - 2400000.$

$^\dagger Against max = 2456635.0428 + 0.070569 \times E.$

$^\dagger Number of points used to determine the maximum.$

---

**Fig. 27. Comparison of different superoutbursts of TY Psc in the $O - C$ diagram. A period of 0.07066 d was used to draw this figure. Approximate cycle counts ($E$) after the start of the superoutburst were used. Since the start of the 2013 superoutburst was not well constrained, we shifted the $O - C$ diagram to best fit the others.**
3.25 V893 Scorpii

V893 Sco was discovered to be a variable star (= SVS 1772) by Satyvoldiev (1972). Since this object is located in the region of the Scorpius T1 association, Satyvoldiev (1982) classified this object as a rapid irregular variable of InSF type (object normally in faint states with occasional brightenings up to 3 mag) according to the classification scheme by Filin and Satyvoldiev (1975). This classification corresponded to “RWF” type (RW Aur type in Tseveich & Dragomiretskaya 1973). Around this time, the RW Aur type or “In” type (irregular, nebular; see Kholopov et al. 1985) referred to pre-main sequence variables. It is apparent that Satyvoldiev (1982) considered this variable as a pre-main sequence variable. In Kholopov et al. (1985), however, the object was reclassified as a dwarf nova, probably based on the published light curve.

The finding chart in this discovery article was interchanged with that of a different star, and this bright dwarf nova remained virtually “lost” for a long time (cf. Downes et al. 1997). The light curves presented in Filin and Satyvoldiev (1975) and Satyvoldiev (1982) were, however, so characteristic of a dwarf nova (and at least two outbursts may be attributed to a superoutburst due to its long duration) that this object has attracted amateur astronomers (particularly VSOLJ members) since the late 1980s. Despite the high potentiality of being a bright SU UMa-type dwarf nova, all attempts (visually watching for the nominal position and photographic searches) to recover this variable were unsuccessful.

In 1998, K. Haseda reported on a detection of one transient object near the catalog position of V893 Sco, and this object was readily identified as a ROSAT X-ray source. A search for the plate collections at the time of observations of Satyvoldiev (1982) clarified that this outbursting object is indeed V893 Sco. This rediscovery was reported in Kato et al. (1998a).

Thorstensen (1999) spectroscopically confirmed that this object is indeed a dwarf nova, and obtained an orbital period of 0.0760 d. This short orbital period strengthened the suggestion that this object belongs to the SU UMa-type dwarf nova. Thorstensen (1999) also measured a large proper motion, implying a nearby object.

Since 1998, this object has been regularly monitored by amateur observers, and outbursts reaching ~ 12 mag were recorded. During the observation in 1999, the group led by K. Matsumoto clarified that this object is a grazing eclipsing dwarf nova below the period gap (vsnet-alert 3432, announced on 1999 September 2). Bruch, Steiner, and Gneiding (2000) independently reached the same conclusion and submitted a paper on 1999 September 11. The result of the former research was published as Matsumoto, Mennickent, and Kato (2000).

Although Bruch, Steiner, and Gneiding (2000) mentioned that V893 Sco cannot be an ER UMa-type dwarf nova, Mason et al. (2001) suggested that it is an ER UMa-type dwarf nova by demonstrating their new Doppler tomosgrams. Kato, Matsumoto, and Uemura (2002b) explained that this object cannot be an ER UMa-type dwarf nova.

Such a confusion apparently comes from the lack of a definite superoutburst, despite the fact that its existence has been expected for the short orbital period. Although there have been a number of possible detections of “slightly brighter” outbursts, none of them were confirmed to be a genuine superoutburst until 2013.

On 2013 August 27, R. Stubbings reported on a bright (11.6 mag) outburst (vsnet-alert 16276; figure 28). Subsequent observation of this outburst finally confirmed the presence of superhumps (vsnet-alert 16315; figure 29). We observed this superoutburst and report the result here.

Since the eclipse ephemeris by Bruch, Steiner, and Gneiding (2000) was not fitted to modern observations (Mukai et al. 2009), we first refined the eclipse ephemeris. Since the white dwarf is partially eclipsed (Mukai et al. 2009), we used outburst observations in which the central part of the accretion disk is expected to be eclipsed, and the times of minima are expected to be close to the center of eclipse of the white dwarf. We used a combined set of the 2007 data (B. Monard and Osaka Kyoiku Univ. data), 2008 data (G. Bolt data), 2010 data (G. Bolt and Osaka Kyoiku Univ. data), and the present data. All observational data other than the 2013 data were obtained during the normal outbursts. We obtained an ephemeris of

\[ \text{Min(BJD)} = 2454173.3030(4) + 0.0759614614(18)E \]  

using the MCMC modeling described in Kato et al. (2013b). This orbital period is in agreement with Mukai, Zietsman,
and Still (2009), suggesting that the original orbital period derived by Bruch, Steiner, and Gneiding (2000) was systematically too long.

The times of superhump maxima after subtracting the mean orbital modulations were determined outside the eclipses (orbital phase 0.07–0.93; table 32). Although some superhumps were visible in the light curve, some of the times of maxima could not be determined because the superhump maxima coincided with eclipses. These superhumps were not included in table 32. We identified stages B and C and give the measured periods in table 2.

As mentioned in Bruch, Steiner, and Gneiding (2000), it is surprising that such a bright dwarf nova defied detection of nova searches. This may have been a chance coincidence for superoutbursts occurring in unfavorable seasonal conditions before modern CCD-based search became popular. In table 33, we list the possible superoutbursts in modern observations. Except the 2013 one, all suspected superoutbursts in the late 1990s and 2000s could not be observed due to lying near the Sun. The relatively small outburst amplitude is probably a result of the high inclination of the system. It was also likely that the magnitude scale in Satyvoldiev (1982) was ~1 mag brighter than the modern scale.

### 3.26 RZ Sagittae

RZ Sge has long been known as a dwarf nova with a long cycle length (e.g., Petit 1956). Bond, Kemper, and Mattei (1982) reported on the detection of superhumps during the 1981 October outburst. Retrospective examination of the past visual observation also clarified a number of superoutbursts in the 1970s (Bond et al. 1982). Kato (1996) and Semeniuk et al. (1997) reported on observations of superhumps during the 1994 and 1996 superoutbursts, respectively. Although both Kato (1996) and Semeniuk et al. (1997) resulted in a global negative $P_{\text{dot}}$ of $\sim -10 \times 10^{-5}$, Kato et al. (2009) considered that this is a result of stage B–C transition and that $P_{\text{dot}}$ for stage B can be positive. Patterson et al. (2003) also reported on the 1996 superoutburst and the detection of the photometric orbital period in 1999.

We observed the 2013 superoutburst, which was detected in relatively early phase (vsnet-alert 16326). The times of superhump maxima are listed in table 34. The present data suggest a positive $P_{\text{dot}}$ (the data for $E = 58$ was better than for $E = 57$, and the positive $O - C$ for $E = 58$ appears to be real). The $O - C$ values of present and past

### Table 32. Superhump maxima of V893 Sco (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max</th>
<th>Error</th>
<th>$O - C$</th>
<th>phase</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56532.5397</td>
<td>0.0008</td>
<td>-0.0073</td>
<td>0.34</td>
<td>43</td>
</tr>
<tr>
<td>1</td>
<td>56532.6179</td>
<td>0.0010</td>
<td>-0.0075</td>
<td>0.37</td>
<td>45</td>
</tr>
<tr>
<td>38</td>
<td>56535.5283</td>
<td>0.0013</td>
<td>0.0032</td>
<td>0.68</td>
<td>42</td>
</tr>
<tr>
<td>39</td>
<td>56535.6098</td>
<td>0.0028</td>
<td>0.0063</td>
<td>0.76</td>
<td>36</td>
</tr>
<tr>
<td>51</td>
<td>56536.5526</td>
<td>0.0007</td>
<td>0.0087</td>
<td>0.17</td>
<td>36</td>
</tr>
<tr>
<td>52</td>
<td>56536.6294</td>
<td>0.0012</td>
<td>0.0071</td>
<td>0.18</td>
<td>15</td>
</tr>
<tr>
<td>89</td>
<td>56539.5270</td>
<td>0.0016</td>
<td>0.0050</td>
<td>0.32</td>
<td>40</td>
</tr>
<tr>
<td>99</td>
<td>56540.3013</td>
<td>0.0009</td>
<td>-0.0041</td>
<td>0.52</td>
<td>136</td>
</tr>
<tr>
<td>102</td>
<td>56540.5296</td>
<td>0.0005</td>
<td>-0.0111</td>
<td>0.52</td>
<td>41</td>
</tr>
<tr>
<td>128</td>
<td>56542.5793</td>
<td>0.0013</td>
<td>0.0009</td>
<td>0.57</td>
<td>47</td>
</tr>
<tr>
<td>140</td>
<td>56543.5208</td>
<td>0.0010</td>
<td>0.0020</td>
<td>0.90</td>
<td>36</td>
</tr>
<tr>
<td>141</td>
<td>56543.5975</td>
<td>0.0013</td>
<td>0.0003</td>
<td>0.91</td>
<td>35</td>
</tr>
<tr>
<td>153</td>
<td>56544.5343</td>
<td>0.0066</td>
<td>-0.0034</td>
<td>0.24</td>
<td>24</td>
</tr>
</tbody>
</table>

*BJD − 2400000.

| Table 33. Possible superoutbursts of V893 Sco. |
|------|------|------|------|
| JD   | Date            | Maximum | Duration (d) |
| 2454883 | 2009 February 20 | 11.7 | >8 |
| 2455975 | 2012 February 17 | 12.0 | >4 |
| 2456332 | 2013 August 27  | 11.6 | >8*|

*Confirmed superoutburst.

<Fig. 29. Superhumps in V893 Sco after subtracting the orbital modulation (2013). Upper: PDM analysis. Lower: Phase-averaged profile.>
superhumps can be well described as stage B and stage C (figure 30).

### 3.27 AW Sagittae

AW Sge was discovered to be a dwarf nova by Wolf and Wolf (1906). The 2000 and 2006 superoutbursts were reported in Kato et al. (2009). Kato et al. (2014a) further reported on the best observed 2012 superoutburst. On 2013 October 6, R. Stubbings detected another likely superoutburst (vsnet-alert 16512). This outburst was independently detected several hours early by AAVSO observers. On the night of this detection, no superhumps were detected. On the next night, a developing superhump was detected. There was a 4 d gap after these observations. The times of superhump maxima are listed in table 35. The epoch $E = 0$ was given a cycle count assuming that this was a stage A superhump with a longer period. A comparison of the period for $E \geq 62$ indicated that they are stage C superhumps. This identification was confirmed by a comparison of $O-C$ diagrams (figure 31). The negative detection of the outburst on 2013 October 3 could constrain the growth time of superhumps 3.5 d at the most.

### 3.28 V1265 Tauri

V1265 Tau was originally detected to be an optical transient (Skvarc & Palcic 2006). Shafter, Coelho, and Reed (2007) studied this object and detected short-period [0.053394(7) d] superhumps, which has been one of the shortest known superhump periods in classical SU UMa-type dwarf novae.

On 2013 August 4, the ASAS-SN team detected this object again in outburst (vsnet-alert 16120). The outburst...
was detected sufficiently early to follow the early evolution of the superhumps. On the first night of the observation, superhumps have already been detected (vsnet-alert 16137). This observation has confirmed that V1265 Tau has no characteristics of WZ Sge-type dwarf novae, such as the existence of early superhumps, despite its very short superhump period.

The times of superhump maxima are listed in table 36. Due to the faintness (~16 mag) of the object, the errors in the time of superhump maxima were relatively large. We could determine a $P_{\text{dot}}$ of $+1.9(1.9) \times 10^{-5}$ for stage B superhumps. This value is consistent with $P_{\text{dot}} = +2.1(0.8) \times 10^{-5}$ reported by Skvarc and Palcic (2006). This value of period derivative is small for an ordinary SU UMa-type dwarf nova with a short superhump period. After BJD 2456520, the object apparently showed a stage B–C transition. Since the measured times of superhump maxima during the late stage of the superoutburst were noisy, we determined the period by the PDM method — 0.05309(4) d, which is adopted in table 2.

This unusually short-period system is not similar to other systems with a similar short superhump period in which this object has neither WZ Sge-type characteristics nor a large positive $P_{\text{dot}}$ as in a non-WZ Sge-type short-period system, V844 Her (Oizumi et al. 2007; Kato et al. 2009, 2013b). The evolution of superhumps was more similar to those in ER UMa-type dwarf novae such as RZ LMi (Olech et al. 2008; Kato et al. 2013b), although this object does not show frequent outbursts such as ER UMa-type dwarf novae do. Further study is needed to clarify the unusual nature of this object.

### 3.29 SU Ursae Majoris

We observed this “prototype” SU UMa-type dwarf nova (Udalski 1990a) during the late stage of the 2013 November superoutburst. The times of superhump maxima (table 37) also include the first two nights of post-superoutburst state. The resultant period of the stage C superhump is in agreement with the 1989 and 1999 observations (Kato et al. 2009).

### 3.30 SS Ursae Minoris

SS UMi was originally discovered to be the optical counterpart (dwarf nova) of the X-ray source E 1551+718 (Mason et al. 1982). This object was also selected as a CV by the Palomer Green survey (Green et al. 1982). Andronov (1986) reported on variations with a period of 127 min, which was considered to be the orbital period. Richter (1989) studied the behavior of this object and found that the mean cycle length is 30–48 d. Amateur astronomers also started

---

**Table 36. Superhump maxima of V1265 Tau (2013).**

<table>
<thead>
<tr>
<th>$E$</th>
<th>$Max^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56509.9538</td>
<td>0.0016</td>
<td>−0.0052</td>
<td>25</td>
</tr>
<tr>
<td>1</td>
<td>56510.0132</td>
<td>0.0024</td>
<td>0.0008</td>
<td>11</td>
</tr>
<tr>
<td>37</td>
<td>56511.9444</td>
<td>0.0045</td>
<td>0.0100</td>
<td>16</td>
</tr>
<tr>
<td>38</td>
<td>56511.9844</td>
<td>0.0004</td>
<td>−0.0034</td>
<td>37</td>
</tr>
<tr>
<td>56</td>
<td>56512.9464</td>
<td>0.0025</td>
<td>−0.0024</td>
<td>30</td>
</tr>
<tr>
<td>57</td>
<td>56512.9894</td>
<td>0.0025</td>
<td>−0.0128</td>
<td>24</td>
</tr>
<tr>
<td>94</td>
<td>56514.9731</td>
<td>0.0008</td>
<td>−0.0046</td>
<td>48</td>
</tr>
<tr>
<td>113</td>
<td>56515.9901</td>
<td>0.0012</td>
<td>−0.0019</td>
<td>32</td>
</tr>
<tr>
<td>131</td>
<td>56516.9515</td>
<td>0.0013</td>
<td>−0.0016</td>
<td>35</td>
</tr>
<tr>
<td>148</td>
<td>56517.8658</td>
<td>0.0031</td>
<td>0.0050</td>
<td>28</td>
</tr>
<tr>
<td>149</td>
<td>56517.9275</td>
<td>0.0015</td>
<td>0.0134</td>
<td>8</td>
</tr>
<tr>
<td>150</td>
<td>56517.9660</td>
<td>0.0065</td>
<td>−0.0015</td>
<td>49</td>
</tr>
<tr>
<td>167</td>
<td>56518.8748</td>
<td>0.0021</td>
<td>0.0003</td>
<td>28</td>
</tr>
<tr>
<td>168</td>
<td>56518.9290</td>
<td>0.0049</td>
<td>0.0005</td>
<td>12</td>
</tr>
<tr>
<td>186</td>
<td>56519.8959</td>
<td>0.0028</td>
<td>0.0063</td>
<td>19</td>
</tr>
<tr>
<td>187</td>
<td>56519.9481</td>
<td>0.0019</td>
<td>0.0052</td>
<td>31</td>
</tr>
<tr>
<td>204</td>
<td>56520.8559</td>
<td>0.0014</td>
<td>0.0053</td>
<td>28</td>
</tr>
<tr>
<td>205</td>
<td>56520.9085</td>
<td>0.0056</td>
<td>0.0046</td>
<td>11</td>
</tr>
<tr>
<td>206</td>
<td>56520.9582</td>
<td>0.0007</td>
<td>0.0009</td>
<td>45</td>
</tr>
<tr>
<td>222</td>
<td>56521.8086</td>
<td>0.0033</td>
<td>−0.0030</td>
<td>14</td>
</tr>
<tr>
<td>223</td>
<td>56521.8692</td>
<td>0.0016</td>
<td>0.0042</td>
<td>25</td>
</tr>
<tr>
<td>260</td>
<td>56523.8356</td>
<td>0.0033</td>
<td>−0.0048</td>
<td>25</td>
</tr>
<tr>
<td>261</td>
<td>56523.8818</td>
<td>0.0013</td>
<td>−0.0120</td>
<td>23</td>
</tr>
<tr>
<td>278</td>
<td>56524.7991</td>
<td>0.0096</td>
<td>0.0024</td>
<td>10</td>
</tr>
<tr>
<td>279</td>
<td>56524.8469</td>
<td>0.0023</td>
<td>0.00120</td>
<td>18</td>
</tr>
<tr>
<td>297</td>
<td>56525.8170</td>
<td>0.0104</td>
<td>0.0011</td>
<td>13</td>
</tr>
<tr>
<td>305</td>
<td>56526.4747</td>
<td>0.0089</td>
<td>0.0044</td>
<td>63</td>
</tr>
<tr>
<td>319</td>
<td>56526.9728</td>
<td>0.0041</td>
<td>−0.0177</td>
<td>35</td>
</tr>
</tbody>
</table>

$^\dagger$BJD − 2400000.

$^\ast$Against $max = 245662.72931 + 0.078775 E$.

Number of points used to determine the maximum.

---

**Table 37. Superhump maxima of SU UMa (2013).**

<table>
<thead>
<tr>
<th>$E$</th>
<th>$Max^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56627.2982</td>
<td>0.0011</td>
<td>0.0051</td>
<td>127</td>
</tr>
<tr>
<td>1</td>
<td>56627.3712</td>
<td>0.0029</td>
<td>−0.0007</td>
<td>83</td>
</tr>
<tr>
<td>10</td>
<td>56628.0796</td>
<td>0.0013</td>
<td>−0.0013</td>
<td>45</td>
</tr>
<tr>
<td>11</td>
<td>56628.1626</td>
<td>0.0007</td>
<td>0.0030</td>
<td>198</td>
</tr>
<tr>
<td>12</td>
<td>56628.2401</td>
<td>0.0009</td>
<td>0.0017</td>
<td>85</td>
</tr>
<tr>
<td>13</td>
<td>56628.3141</td>
<td>0.0009</td>
<td>−0.0031</td>
<td>85</td>
</tr>
<tr>
<td>23</td>
<td>56629.1012</td>
<td>0.0010</td>
<td>−0.0037</td>
<td>13</td>
</tr>
<tr>
<td>24</td>
<td>56629.1703</td>
<td>0.0032</td>
<td>−0.0135</td>
<td>8</td>
</tr>
<tr>
<td>25</td>
<td>56629.2622</td>
<td>0.0014</td>
<td>−0.0003</td>
<td>86</td>
</tr>
<tr>
<td>26</td>
<td>56629.3573</td>
<td>0.0008</td>
<td>0.0160</td>
<td>111</td>
</tr>
<tr>
<td>27</td>
<td>56629.4194</td>
<td>0.0009</td>
<td>−0.0007</td>
<td>79</td>
</tr>
<tr>
<td>28</td>
<td>56629.4999</td>
<td>0.0007</td>
<td>0.0011</td>
<td>69</td>
</tr>
<tr>
<td>29</td>
<td>56629.5701</td>
<td>0.0016</td>
<td>−0.0075</td>
<td>50</td>
</tr>
<tr>
<td>38</td>
<td>56630.2856</td>
<td>0.0036</td>
<td>−0.0010</td>
<td>54</td>
</tr>
<tr>
<td>51</td>
<td>56631.3153</td>
<td>0.0009</td>
<td>0.0047</td>
<td>86</td>
</tr>
</tbody>
</table>

$^\dagger$BJD − 2400000.

$^\ast$Against $max = 245662.72931 + 0.078775 E$.

Number of points used to determine the maximum.
observations of this object in 1987 and recorded frequent outbursts with a cycle length as short as $\sim 10$ d.

Udalski (1990b) observed this object and reported that the orbital period is much longer (probably 6.8 hr) in contrast to Andronov (1986). This contradiction between observations was resolved by the detection of superhumps with a period of 101 min (Chen et al. 1991). Neither Andronov (1986) nor Udalski (1990b) turned out to be correct. Kato et al. (1998b) also reported on observations of superhumps.

This object began to receive attention because of its high frequency of outbursts. Kato et al. (2000) clarified that the supercycle of this object is 84.7 d, one of the shortest known supercycles in ordinary SU UMa-type dwarf novae—note that this object was not classified as an ER Uma-type dwarf nova in this reference; see also Kato et al. (2001b) for the similar case of BF Ara. Olech et al. (2006) reported that the supercycle lengthened to 197 d in 2004. Olech et al. (2006) also reported on the development of superhumps. Kato et al. (2013b) also studied the 2012 superoutburst. A supercycle being as short as 84.7 d has never been recorded convincingly in recent decades.

We observed the final part of the superoutburst in 2003 August–September (the early part of this superoutburst was probably missed). The times of superhump maxima are listed in table 38. The times for $E \geq 29$ were obtained after the rapid fading from the superoutburst. Although these epochs of maxima could be expressed without a phase jump from those for $E \leq 3$, the identification of the phase was not complete due to the gap in the observation.

### Table 38. Superhump maxima of SS UMi (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O – C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56540.3119</td>
<td>0.0010</td>
<td>0.0008</td>
<td>53</td>
</tr>
<tr>
<td>1</td>
<td>56540.3717</td>
<td>0.0012</td>
<td>0.00092</td>
<td>77</td>
</tr>
<tr>
<td>2</td>
<td>56540.4451</td>
<td>0.0012</td>
<td>0.00058</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>56540.5170</td>
<td>0.0008</td>
<td>0.00038</td>
<td>77</td>
</tr>
<tr>
<td>29</td>
<td>56542.3524</td>
<td>0.0010</td>
<td>0.0032</td>
<td>73</td>
</tr>
<tr>
<td>30</td>
<td>56542.4149</td>
<td>0.0008</td>
<td>0.0038</td>
<td>33</td>
</tr>
<tr>
<td>31</td>
<td>56542.4847</td>
<td>0.0005</td>
<td>0.0056</td>
<td>77</td>
</tr>
<tr>
<td>32</td>
<td>56542.5575</td>
<td>0.0006</td>
<td>0.0085</td>
<td>70</td>
</tr>
<tr>
<td>33</td>
<td>56542.6244</td>
<td>0.002</td>
<td>0.0004</td>
<td>41</td>
</tr>
<tr>
<td>42</td>
<td>56543.123</td>
<td>0.0008</td>
<td>0.0060</td>
<td>33</td>
</tr>
<tr>
<td>44</td>
<td>56543.3922</td>
<td>0.0015</td>
<td>0.0039</td>
<td>37</td>
</tr>
<tr>
<td>57</td>
<td>56544.2931</td>
<td>0.0008</td>
<td>0.0043</td>
<td>38</td>
</tr>
<tr>
<td>58</td>
<td>56544.3588</td>
<td>0.0021</td>
<td>0.0085</td>
<td>35</td>
</tr>
<tr>
<td>59</td>
<td>56544.4318</td>
<td>0.0030</td>
<td>0.0055</td>
<td>22</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max $= 2456640.3111 + 0.069936 E$.
‡Number of points used to determine the maximum.

### Table 39. Superhump maxima of CU Vel (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O – C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56627.7714</td>
<td>0.0013</td>
<td>0.0004</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>56627.8531</td>
<td>0.0052</td>
<td>0.0016</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>56628.7378</td>
<td>0.0008</td>
<td>0.0001</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>56628.8233</td>
<td>0.0011</td>
<td>0.0038</td>
<td>17</td>
</tr>
<tr>
<td>24</td>
<td>56629.6989</td>
<td>0.0077</td>
<td>0.00059</td>
<td>6</td>
</tr>
<tr>
<td>25</td>
<td>56629.7856</td>
<td>0.0007</td>
<td>0.0003</td>
<td>17</td>
</tr>
<tr>
<td>37</td>
<td>56630.7515</td>
<td>0.0015</td>
<td>0.0007</td>
<td>17</td>
</tr>
<tr>
<td>38</td>
<td>56630.8298</td>
<td>0.0017</td>
<td>0.00029</td>
<td>15</td>
</tr>
<tr>
<td>62</td>
<td>56632.7684</td>
<td>0.0010</td>
<td>0.0019</td>
<td>17</td>
</tr>
<tr>
<td>63</td>
<td>56632.8488</td>
<td>0.0036</td>
<td>0.0017</td>
<td>10</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max $= 2456627.7710 + 0.080573 E$.
‡Number of points used to determine the maximum.

#### 3.31 CU Velorum

Although CU Vel is a well-known SU UMa-type dwarf nova, only a limited amount of information has been published (Vogt 1980; Menickent & Diaz 1996). We reported on observations of the 2002 superoutburst in Kato et al. (2009).

The 2013 superoutburst was detected on November 25 (vsnet-alert 16648), but the actual start of the superoutburst must have been several days earlier, as later shown in the comparison of the $O – C$ diagrams. The 2013 observation, however, well covered the post-superoutburst state.

The times of superhump maxima during the plateau phase are listed in table 39. These superhumps are likely stage C superhumps since they were observed during the late stage of the superoutburst. A comparison of the $O – C$ diagrams supports this identification (figure 33).

Since orbital modulations are clearly seen in the light curve, we refined the orbital period by using observations around quiescence. The 2013–2014 data after the 2013 November superoutburst yielded a period of 0.078043(5) d. The 2013 January data (P. Nelson and F.-J. Hardsh) yielded a period of 0.07805(4) d. Using the combined data set, we selected a period of 0.0780543(3) d. The resultant profile (figure 32) showed two maxima of different amplitudes. This feature of double maxima is to some extent similar to WZ Sge-type dwarf novae in quiescence (e.g., Patterson et al. 1998; Araujo-Betancor et al. 2005). CU Vel may be intermediate between ordinary SU UMa-type dwarf novae and WZ Sge-type dwarf novae.

We subtracted the mean orbital light curve from the post-superoutburst light curve. A PDM analysis yielded a strong signal at 0.079906(4) d. The times of these post-superoutburst superhumps are listed in table 40. The $O – C$ diagram (figure 34) indicates that the superhump phase was continuous before and after the rapid fading from the superoutburst. There was a decrease in period...
after $E = 110$ (after the rapid fading) and this period was almost constant at least until $E = 400$. Both the signals of superhumps and orbital period are clearly seen in the Lasso power spectrum (figure 35). The post-superoutburst superhumps survived at least 30 d after the fading.

Fig. 32. Orbital variation of CU Vel in quiescence.

Fig. 33. Comparison of different superoutbursts of CU Vel in the $O - C$ diagram. A period of 0.08100 d was used to draw this figure. Approximate cycle counts ($E$) after the start of the superoutburst were used. Since the start of the 2013 superoutburst was not well constrained, we shifted the $O - C$ diagram to best fit the 2002 one.

Table 40. Superhump maxima of CU Vel in (2013) (post-superoutburst).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O - C$</th>
<th>$N^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56636.8003</td>
<td>0.0026</td>
<td>-0.0013</td>
<td>17</td>
</tr>
<tr>
<td>12</td>
<td>56637.7592</td>
<td>0.0021</td>
<td>-0.0014</td>
<td>15</td>
</tr>
<tr>
<td>13</td>
<td>56637.8416</td>
<td>0.0023</td>
<td>0.0010</td>
<td>10</td>
</tr>
<tr>
<td>24</td>
<td>56638.7266</td>
<td>0.0037</td>
<td>0.0070</td>
<td>16</td>
</tr>
<tr>
<td>25</td>
<td>56638.8052</td>
<td>0.0027</td>
<td>0.0057</td>
<td>16</td>
</tr>
<tr>
<td>36</td>
<td>56639.6797</td>
<td>0.0160</td>
<td>0.0011</td>
<td>8</td>
</tr>
<tr>
<td>37</td>
<td>56639.7645</td>
<td>0.0063</td>
<td>0.0060</td>
<td>15</td>
</tr>
<tr>
<td>38</td>
<td>56639.8600</td>
<td>0.0028</td>
<td>0.0215</td>
<td>7</td>
</tr>
<tr>
<td>75</td>
<td>56642.7844</td>
<td>0.0106</td>
<td>-0.0109</td>
<td>15</td>
</tr>
<tr>
<td>87</td>
<td>56643.7411</td>
<td>0.0017</td>
<td>-0.0133</td>
<td>8</td>
</tr>
<tr>
<td>88</td>
<td>56643.8264</td>
<td>0.0048</td>
<td>-0.0079</td>
<td>11</td>
</tr>
<tr>
<td>99</td>
<td>56644.7034</td>
<td>0.0057</td>
<td>-0.0099</td>
<td>13</td>
</tr>
<tr>
<td>100</td>
<td>56644.7798</td>
<td>0.0033</td>
<td>-0.0134</td>
<td>15</td>
</tr>
<tr>
<td>111</td>
<td>56645.6772</td>
<td>0.0112</td>
<td>0.0049</td>
<td>10</td>
</tr>
<tr>
<td>112</td>
<td>56645.7496</td>
<td>0.0016</td>
<td>-0.0026</td>
<td>14</td>
</tr>
<tr>
<td>113</td>
<td>56645.8343</td>
<td>0.0017</td>
<td>0.0021</td>
<td>15</td>
</tr>
<tr>
<td>124</td>
<td>56646.7064</td>
<td>0.0039</td>
<td>-0.0048</td>
<td>14</td>
</tr>
<tr>
<td>125</td>
<td>56646.7885</td>
<td>0.0016</td>
<td>-0.0027</td>
<td>17</td>
</tr>
<tr>
<td>126</td>
<td>56646.8770</td>
<td>0.0049</td>
<td>0.0059</td>
<td>6</td>
</tr>
<tr>
<td>136</td>
<td>56647.6679</td>
<td>0.0028</td>
<td>-0.0023</td>
<td>9</td>
</tr>
<tr>
<td>137</td>
<td>56647.7395</td>
<td>0.0043</td>
<td>-0.0106</td>
<td>13</td>
</tr>
<tr>
<td>138</td>
<td>56647.8254</td>
<td>0.0021</td>
<td>-0.0047</td>
<td>20</td>
</tr>
<tr>
<td>149</td>
<td>56648.7093</td>
<td>0.0032</td>
<td>0.0002</td>
<td>14</td>
</tr>
<tr>
<td>150</td>
<td>56648.7870</td>
<td>0.0016</td>
<td>-0.0020</td>
<td>17</td>
</tr>
<tr>
<td>151</td>
<td>56648.8610</td>
<td>0.0024</td>
<td>-0.0080</td>
<td>12</td>
</tr>
<tr>
<td>161</td>
<td>56649.6647</td>
<td>0.0022</td>
<td>-0.0034</td>
<td>9</td>
</tr>
<tr>
<td>162</td>
<td>56649.7443</td>
<td>0.0012</td>
<td>-0.0037</td>
<td>13</td>
</tr>
<tr>
<td>163</td>
<td>56649.8291</td>
<td>0.0018</td>
<td>0.0012</td>
<td>20</td>
</tr>
</tbody>
</table>

$^\ast$BJD $- 2400000$.

$^\dagger$Against max = 2456636.8016 + 0.079916 $E$.

$^\ddagger$Number of points used to determine the maximum.
3.32 1RXS J231935.0+364705

This object (hereafter 1RXS J231935) was selected as a variable star (= DDE 8, probably a dwarf nova) during the course of identification of the ROSAT sources (Denisenko & Sokolovsky 2011). There was a well-observed superoutburst in 2011 (Kato et al. 2013b). D. Denisenko detected a new outburst on 2013 September 27 (vsnet-alert 16460). This outburst turned out to be a superoutburst. Only a single superhump maximum of BJD 2456565.5851(18) (N=19) was obtained during the observation on two nights.

3.33 ASAS J224349+0809.5

This dwarf nova (hereafter ASAS J224349) was selected by P. Wils (see Shears et al. 2011a). There was one well-recorded outburst (superoutburst) in the ASAS data in 2005 October–November. The outburst in 2009 October was well observed, and superhumps were detected (Kato et al. 2010; Shears et al. 2011a). Although there was another superoutburst in 2011 June, the outburst was observed only for two nights (Kato et al. 2013b).

On 2013 August 14, the ASAS-SN team detected another outburst (vsnet-alert 16197). This outburst turned out to be a superoutburst, and stages B and C were well recorded (table 41). This superoutburst was followed by one post-superoutburst rebrightening 4 d later than the rapid fading from the plateau phase (figure 36). This interval was rather short for an ordinary SU UMa-type dwarf nova. As in the 2009 superoutburst, a definitely positive $P_{dot}$ was recorded during stage B. The $O-C$ diagrams in the two superoutbursts were very similar (figure 37). Although the coincidence in cycle count between two superoutbursts was by chance, the 2013 superoutburst was confirmed to be detected sufficiently early (vsnet-alert 16207, within 3 d of the start of the outburst).

3.34 ASASSN-13cf

This object was discovered by the ASAS-SN survey on 2013 August 24 (vsnet-alert 16261). The coordinates are 21°55′12.76 and +27°41′18.9. One previous outburst was detected in the CRTS data and another outburst was recorded on a Palomar quick-V plate (D. Denisenko, vsnet-alert 16263). From subsequent observations superhumps were detected (vsnet-alert 16284, 16308; figure 38). The times of superhump maxima are listed in table 42. A positive $P_{dot}$ of $+7.1(1.9) \times 10^{-5}$, characteristic of this short superhump period, was obtained.

3.35 ASASSN-13cg

This object was discovered by the ASAS-SN survey on 2013 August 27. The coordinates are 20°52′52.74 and −02°39′53.0. This object attracted attention because
it has a very blue ($u-g=-0.2$) SDSS color (vsnet-alert 16280). It also has an X-ray counterpart of 1RXS J205252.1−023952. By time-resolved photometry superhumps and possible shallow eclipses were detected (vsnet-alert 16302; figures 39 and 40). These eclipse-like fadings were not recorded on later nights and we could not determine its period. The reality of the eclipses requires future observations. The times of superhump maxima are listed in table 43, which clearly shows a positive $P_{\text{dot}}$.

Table 41. Superhump maxima of ASAS J224349 (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O-C^\dagger$</th>
<th>$N^\ddagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56521.4291</td>
<td>0.0002</td>
<td>0.0027</td>
<td>116</td>
</tr>
<tr>
<td>1</td>
<td>56521.4990</td>
<td>0.0003</td>
<td>0.0028</td>
<td>146</td>
</tr>
<tr>
<td>4</td>
<td>56521.7072</td>
<td>0.0007</td>
<td>0.0019</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>56521.7753</td>
<td>0.0006</td>
<td>0.0002</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>56522.2618</td>
<td>0.0007</td>
<td>−0.0013</td>
<td>45</td>
</tr>
<tr>
<td>16</td>
<td>56522.3392</td>
<td>0.0004</td>
<td>−0.0028</td>
<td>123</td>
</tr>
<tr>
<td>17</td>
<td>56522.6095</td>
<td>0.0003</td>
<td>−0.0022</td>
<td>142</td>
</tr>
<tr>
<td>18</td>
<td>56522.6911</td>
<td>0.0011</td>
<td>0.0097</td>
<td>40</td>
</tr>
<tr>
<td>25</td>
<td>56523.1618</td>
<td>0.0006</td>
<td>−0.0013</td>
<td>45</td>
</tr>
<tr>
<td>26</td>
<td>56523.2355</td>
<td>0.0004</td>
<td>−0.0028</td>
<td>57</td>
</tr>
<tr>
<td>27</td>
<td>56523.3054</td>
<td>0.0003</td>
<td>−0.0036</td>
<td>65</td>
</tr>
<tr>
<td>29</td>
<td>56523.4459</td>
<td>0.0003</td>
<td>−0.0024</td>
<td>134</td>
</tr>
<tr>
<td>30</td>
<td>56523.5129</td>
<td>0.0006</td>
<td>−0.0050</td>
<td>143</td>
</tr>
<tr>
<td>33</td>
<td>56523.7255</td>
<td>0.0008</td>
<td>−0.0016</td>
<td>22</td>
</tr>
<tr>
<td>34</td>
<td>56523.7957</td>
<td>0.0012</td>
<td>−0.0011</td>
<td>17</td>
</tr>
<tr>
<td>39</td>
<td>56524.1445</td>
<td>0.0003</td>
<td>−0.0009</td>
<td>125</td>
</tr>
<tr>
<td>40</td>
<td>56524.2130</td>
<td>0.0009</td>
<td>−0.0021</td>
<td>66</td>
</tr>
<tr>
<td>41</td>
<td>56524.2801</td>
<td>0.0006</td>
<td>−0.0048</td>
<td>68</td>
</tr>
<tr>
<td>42</td>
<td>56524.3491</td>
<td>0.0022</td>
<td>−0.0055</td>
<td>86</td>
</tr>
<tr>
<td>43</td>
<td>56524.4241</td>
<td>0.0005</td>
<td>−0.0002</td>
<td>143</td>
</tr>
<tr>
<td>44</td>
<td>56524.4934</td>
<td>0.0004</td>
<td>−0.0006</td>
<td>139</td>
</tr>
<tr>
<td>45</td>
<td>56524.5630</td>
<td>0.0004</td>
<td>−0.0007</td>
<td>142</td>
</tr>
<tr>
<td>46</td>
<td>56524.6398</td>
<td>0.0008</td>
<td>0.0065</td>
<td>29</td>
</tr>
<tr>
<td>47</td>
<td>56524.7039</td>
<td>0.0011</td>
<td>0.0008</td>
<td>33</td>
</tr>
<tr>
<td>48</td>
<td>56525.2003</td>
<td>0.0037</td>
<td>0.0092</td>
<td>61</td>
</tr>
<tr>
<td>49</td>
<td>56525.2620</td>
<td>0.0024</td>
<td>0.0012</td>
<td>22</td>
</tr>
<tr>
<td>57</td>
<td>56527.4994</td>
<td>0.0010</td>
<td>0.0077</td>
<td>49</td>
</tr>
<tr>
<td>88</td>
<td>56527.5680</td>
<td>0.0011</td>
<td>0.0066</td>
<td>39</td>
</tr>
<tr>
<td>114</td>
<td>56529.3777</td>
<td>0.0004</td>
<td>0.0036</td>
<td>136</td>
</tr>
<tr>
<td>115</td>
<td>56529.4478</td>
<td>0.0004</td>
<td>0.0041</td>
<td>138</td>
</tr>
<tr>
<td>116</td>
<td>56529.5159</td>
<td>0.0005</td>
<td>0.0025</td>
<td>154</td>
</tr>
<tr>
<td>117</td>
<td>56529.5861</td>
<td>0.0006</td>
<td>0.0030</td>
<td>138</td>
</tr>
<tr>
<td>129</td>
<td>56530.4187</td>
<td>0.0029</td>
<td>−0.0010</td>
<td>53</td>
</tr>
<tr>
<td>130</td>
<td>56530.4886</td>
<td>0.0015</td>
<td>−0.0009</td>
<td>58</td>
</tr>
<tr>
<td>131</td>
<td>56530.5579</td>
<td>0.0020</td>
<td>−0.0013</td>
<td>66</td>
</tr>
<tr>
<td>132</td>
<td>56530.6269</td>
<td>0.0019</td>
<td>−0.0020</td>
<td>43</td>
</tr>
<tr>
<td>133</td>
<td>56530.6970</td>
<td>0.0025</td>
<td>−0.0016</td>
<td>17</td>
</tr>
<tr>
<td>134</td>
<td>56530.7656</td>
<td>0.0015</td>
<td>−0.0028</td>
<td>17</td>
</tr>
<tr>
<td>135</td>
<td>56531.6697</td>
<td>0.0020</td>
<td>−0.0050</td>
<td>23</td>
</tr>
</tbody>
</table>

$^*$BJD − 2400000.
$^\dagger$Against max = 2456521.4265 + 0.069715 E.
$^\ddagger$Number of points used to determine the maximum.

Fig. 36. $O-C$ diagram of superhumps in ASAS J2243 (2013). Upper: $O-C$ diagram. A period of 0.069715 d was used for drawing this figure. Lower: Light curve. The observations were binned to 0.014 d.

Fig. 37. Comparison of different superoutbursts of ASAS J2243 in the $O-C$ diagram. A period of 0.06975 d was used to draw this figure. Approximate cycle counts ($E$) after the start of the superoutburst were used. The coincidence in cycle count between two superoutbursts was by chance.

Table 42. Superhump maxima of ASASSN-13cf (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O-C^\dagger$</th>
<th>$N^\ddagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56529.7208</td>
<td>0.0008</td>
<td>0.0007</td>
<td>101</td>
</tr>
<tr>
<td>1</td>
<td>56529.7839</td>
<td>0.0013</td>
<td>0.0054</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>56529.8388</td>
<td>0.0007</td>
<td>0.0018</td>
<td>96</td>
</tr>
<tr>
<td>29</td>
<td>56531.4116</td>
<td>0.0028</td>
<td>−0.0026</td>
<td>27</td>
</tr>
<tr>
<td>48</td>
<td>56532.5201</td>
<td>0.0004</td>
<td>−0.0040</td>
<td>100</td>
</tr>
<tr>
<td>49</td>
<td>56532.5772</td>
<td>0.0007</td>
<td>−0.0053</td>
<td>65</td>
</tr>
<tr>
<td>98</td>
<td>56534.4447</td>
<td>0.0012</td>
<td>−0.0002</td>
<td>52</td>
</tr>
<tr>
<td>114</td>
<td>56536.3780</td>
<td>0.0020</td>
<td>−0.0016</td>
<td>40</td>
</tr>
<tr>
<td>115</td>
<td>56536.4419</td>
<td>0.0015</td>
<td>0.0039</td>
<td>43</td>
</tr>
<tr>
<td>149</td>
<td>56538.4257</td>
<td>0.0015</td>
<td>0.0015</td>
<td>63</td>
</tr>
<tr>
<td>150</td>
<td>56538.4828</td>
<td>0.0011</td>
<td>0.0002</td>
<td>64</td>
</tr>
</tbody>
</table>

$^*$BJD − 2400000.
$^\dagger$Against max = 2456529.7201 + 0.058715 E.
$^\ddagger$Number of points used to determine the maximum.
3.36 ASASSN-13ck

This object was discovered by the ASAS-SN survey on 2013 August 29 (vsnet-alert 16303). The coordinates are 00$^\text{h}$11$^\text{m}$33.71 and +04$^\circ$51'23.0. The object had a blue SDSS counterpart (g = 20.8) and its outburst amplitude immediately suggested a WZ Sge-type dwarf nova.

From subsequent observations early superhumps were recorded (vsnet-alert 16307, 16309, 16313, 16314, 16332, 16368; figure 41). Ten days after the outburst detection, ordinary superhumps grew (vsnet-alert 16370, 16374, 16375, 16385; figure 42). Judging from the evolution of superhumps, the outburst of this object was detected sufficiently early.

The times of superhump maxima during the superoutburst plateau are listed in table 44. Clear stages A and B can be recognized as seen in many WZ Sge-type dwarf novae (figure 43). The last point ($E = 202$) was obtained during the stage of fading branch of the superoutburst, and its large

Table 43. Superhump maxima of ASASSN-13cg (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^a$</th>
<th>Error</th>
<th>$O - C$</th>
<th>N$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56533.6131</td>
<td>0.0003</td>
<td>0.0013</td>
<td>132</td>
</tr>
<tr>
<td>1</td>
<td>56533.6735</td>
<td>0.0004</td>
<td>0.0015</td>
<td>138</td>
</tr>
<tr>
<td>2</td>
<td>56533.7326</td>
<td>0.0005</td>
<td>0.0003</td>
<td>140</td>
</tr>
<tr>
<td>12</td>
<td>56534.3338</td>
<td>0.0008</td>
<td>−0.0008</td>
<td>23</td>
</tr>
<tr>
<td>13</td>
<td>56534.3939</td>
<td>0.0013</td>
<td>−0.0009</td>
<td>23</td>
</tr>
<tr>
<td>46</td>
<td>56536.3759</td>
<td>0.0020</td>
<td>−0.0064</td>
<td>21</td>
</tr>
<tr>
<td>61</td>
<td>56537.2850</td>
<td>0.0021</td>
<td>−0.0007</td>
<td>22</td>
</tr>
<tr>
<td>62</td>
<td>56537.3490</td>
<td>0.0012</td>
<td>0.0031</td>
<td>23</td>
</tr>
<tr>
<td>63</td>
<td>56537.4088</td>
<td>0.0030</td>
<td>0.0026</td>
<td>23</td>
</tr>
</tbody>
</table>

$^a$BJD − 2400000.

$^b$Against max = 2456533.6118 + 0.060228$E$.

$^c$Number of points used to determine the maximum.
positive $O-C$ probably reflects a decrease in pressure effect (cf. Nakata et al. 2013b). This maximum was not used for determining $P_{\text{dot}}$ at stage B. As in many WZ Sge-type dwarf novae, this object did not show a marked transition to the stage C superhump.

Five days after the rapid fading, the object showed a short rebrightening (September 23, BJD 2456558.5). The object showed another rebrightening (September 26, BJD 2456561.7), which served as a precursor outburst to the second plateau phase. This second plateau phase lasted 6 d (figure 43). During the second plateau phase, superhumps were also present. The mean superhump period during this phase was 0.056172(14) d, indicating that this precession rate was smaller than that in the main superoutburst. This smaller precession rate can be considered as a result of a smaller disk radius.

The pattern of rebrightening was like a “hybrid” between a long-lasting plateau (type A rebrightening in Kato et al. 2009) and distinct repetitive rebrightenings (type B rebrightening in Kato et al. 2009). There appears to be a smooth transition from one of these types to the other type. The presence of a precursor outburst in the second plateau is also intriguing. Such a precursor was also recorded in AL Com in 1995 (see Nogami et al. 1997; also subsection 3.11 of this paper). It is likely that a normal outburst triggered the second plateau phase (second superoutburst) as in ordinary SU UMa-type dwarf novae (Osaki 1989).

A two-dimensional Lasso analysis is presented in figure 44. The orbital signal was only present during the stage of early superhumps. The signal of (positive) superhumps showed a decrease in frequency (increase in period) during the superoutburst plateau. The superhumps appeared with slightly higher frequencies during the rebrightening plateau.

### 3.37 ASASSN-13cv

This object was discovered by the ASAS-SN survey on 2013 September 5 (vsnet-alert 16303). The coordinates are $22^\text{h}10^\text{m}25^\text{s}24$ and $+30^\circ46'06''.9$. Although the quiescent counterpart was not listed in the photometric catalog of SDSS (vsnet-alert 16354), Version 2.3.2 of the Guide Star Catalog (GSC) has an object with 21.4 mag. GALEX (Martin et al. 2005) also has an ultraviolet counterpart within 1”—near-UV and far-UV magnitudes are 22.07(3) and 21.6(4), respectively.

We obtained a single-night observation of this object (vsnet-alert 16364; figure 45). Three superhump maxima were obtained: BJD 2456541.3818(7) ($N = 37$), 2456541.4441(2) ($N = 66$), and 2456541.5072(6)
(N = 36). The best period by the PDM method is 0.0607(2) d.

### 3.38 ASASSN-13cz

This object was discovered by the ASAS-SN survey on 2013 September 14 (vsnet-alert 16401). The coordinates are 15\textdegree 27\textminus 55\textsec and +63\textdeg 27\arcmin 53\arcsec. From subsequent observations superhumps were detected (vsnet-alert 16405; figure 46). The times of superhump maxima are listed in table 45. The period shown in table 2 is a result of the PDM analysis.

### 3.39 ASASSN-13da

This object was discovered by the ASAS-SN survey on 2013 September 20 (vsnet-alert 16426). The coordinates are 19\textdeg 59\textmin 18\textsec 03 and −18\textdeg 33\arcmin 31\arcsec. The quiescent counterpart is a 21 mag object in CRTS. On the first three nights, only low-amplitude modulations were detected. Four days after the detection, fully grown superhumps appeared (vsnet-alert 16494; figure 47). This growth of superhumps was associated with an increase in the system’s brightness. The times of superhump maxima are listed in table 46. The times for $E \leq 29$ were those for superhumps in the growing stage—they are likely stage A superhumps. Cycle counts
Fig. 43. $O-C$ diagram of superhumps in ASASSN-13ck (2013). Upper: $O-C$ diagram. A period of 0.056238 d was used for drawing this figure. Lower: Light curve. The observations were binned to 0.012 d.

Fig. 44. Lasso analysis of ASASSN-13ck (2013). Upper: Light curve. The data were binned to 0.02 d. Middle: First overtones of the superhump and orbital signals. Lower: Fundamentals of the superhump and the orbital signal. The orbital signal was present both in the fundamental and in the first overtone during the earliest phase (early superhumps). The signal of (positive) superhumps with a variable frequency was recorded during the superoutburst plateau. No indication of negative superhump was present. The parameter $\log \lambda = -8.8$ was used. The width of the sliding window and the time step used are 8 d and 0.6 d, respectively.

Fig. 45. Superhumps in ASASSN-13cv on 2013 September 5.

Fig. 46. Superhumps in ASASSN-13cz (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

Table 45. Superhump maxima of ASASSN-13cz (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max†</th>
<th>Error</th>
<th>$O-C$‡</th>
<th>N§</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56550.3610</td>
<td>0.0004</td>
<td>0.0003</td>
<td>86</td>
</tr>
<tr>
<td>1</td>
<td>56550.4407</td>
<td>0.0004</td>
<td>0.0002</td>
<td>81</td>
</tr>
<tr>
<td>2</td>
<td>56550.5198</td>
<td>0.0005</td>
<td>-0.0006</td>
<td>82</td>
</tr>
<tr>
<td>13</td>
<td>56551.3986</td>
<td>0.0006</td>
<td>0.0001</td>
<td>50</td>
</tr>
</tbody>
</table>

*BJD = 2400000.
†Against max = 2456550.3607 + 0.079834 E.
‡Number of points used to determine the maximum.

for these maxima are uncertain. Although a PDM analysis of this segment yielded a possible period of 0.07300(5) d, this value was not included in table 2 due to its uncertainty. The decrease in $O-C$ for $E \geq 153$ suggests a stage B–C transition.
Fig. 47. Superhumps in ASASSN-13da (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

Table 46. Superhump maxima of ASASSN-13da (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O – C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56556.5090</td>
<td>0.0025</td>
<td>0.0017</td>
<td>19</td>
</tr>
<tr>
<td>1</td>
<td>56556.5161</td>
<td>0.0047</td>
<td>0.0079</td>
<td>20</td>
</tr>
<tr>
<td>29</td>
<td>56558.5871</td>
<td>0.0048</td>
<td>0.0002</td>
<td>17</td>
</tr>
<tr>
<td>56</td>
<td>56560.5208</td>
<td>0.0010</td>
<td>0.0032</td>
<td>19</td>
</tr>
<tr>
<td>57</td>
<td>56560.5976</td>
<td>0.0012</td>
<td>0.0019</td>
<td>20</td>
</tr>
<tr>
<td>70</td>
<td>56561.5317</td>
<td>0.0009</td>
<td>0.0036</td>
<td>19</td>
</tr>
<tr>
<td>71</td>
<td>56561.6015</td>
<td>0.0007</td>
<td>0.0016</td>
<td>19</td>
</tr>
<tr>
<td>98</td>
<td>56563.5360</td>
<td>0.0015</td>
<td>0.0006</td>
<td>19</td>
</tr>
<tr>
<td>99</td>
<td>56563.6082</td>
<td>0.0014</td>
<td>0.0001</td>
<td>15</td>
</tr>
<tr>
<td>112</td>
<td>56564.3530</td>
<td>0.0011</td>
<td>0.0057</td>
<td>24</td>
</tr>
<tr>
<td>113</td>
<td>56564.6136</td>
<td>0.0021</td>
<td>0.0011</td>
<td>17</td>
</tr>
<tr>
<td>126</td>
<td>56565.5111</td>
<td>0.0016</td>
<td>0.0062</td>
<td>21</td>
</tr>
<tr>
<td>139</td>
<td>56566.4829</td>
<td>0.0111</td>
<td>0.0055</td>
<td>9</td>
</tr>
<tr>
<td>140</td>
<td>56566.5555</td>
<td>0.0018</td>
<td>0.0065</td>
<td>25</td>
</tr>
<tr>
<td>153</td>
<td>56567.4878</td>
<td>0.0212</td>
<td>0.0062</td>
<td>10</td>
</tr>
<tr>
<td>154</td>
<td>56567.5563</td>
<td>0.0010</td>
<td>0.0031</td>
<td>25</td>
</tr>
<tr>
<td>168</td>
<td>56568.5571</td>
<td>0.0014</td>
<td>0.0004</td>
<td>26</td>
</tr>
<tr>
<td>181</td>
<td>56569.4737</td>
<td>0.0045</td>
<td>0.0016</td>
<td>6</td>
</tr>
<tr>
<td>182</td>
<td>56569.5585</td>
<td>0.0024</td>
<td>0.0031</td>
<td>26</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max = 2456556.5072 + 0.071728E.
‡Number of points used to determine the maximum.

3.40 ASASSN-14ac

This object was discovered by the ASAS-SN survey on 2014 January 18 (Shappee et al. 2014b). The coordinates are 07h52m54.9 and +53°05′31″.2. The large outburst amplitude (∼7 mag) and the blue SDSS counterpart (u – g = −0.3) was suggestive of a WZ Sge-type dwarf nova (vsnet-alert 16794). Although subsequent observations showed some low-amplitude modulations (vsnet-alert 16823, 16830), no distinct period was obtained. The object started to show ordinary superhumps 14 d after the discovery (vsnet-alert 16880, 16895; figure 48). The times of superhump maxima are listed in table 47. The early part of the observation clearly revealed stage A superhumps. The global light curve showed systematic brightening associated with the appearance of superhumps (see also figure 49). Although the latter part of the superoutburst was not very well recorded, the $P_{\text{dot}}$ of stage B superhumps was not strongly positive. The object started rapidly fading from the plateau stage on February 17 (30 d after the discovery).

On March 1, E. Muyllaert recorded the object at 17.2 mag (unfiltered CCD magnitude), which appeared to be a post-superoutburst rebrightening. The type of the rebrightening, however, could not be determined.
Table 47. Superhump maxima of ASASSN-14ac (2014).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O – C</th>
<th>N²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56689.1105</td>
<td>0.0023</td>
<td>0.0364</td>
<td>43</td>
</tr>
<tr>
<td>1</td>
<td>56689.1686</td>
<td>0.0016</td>
<td>0.0370</td>
<td>42</td>
</tr>
<tr>
<td>15</td>
<td>56690.0034</td>
<td>0.0006</td>
<td>0.0245</td>
<td>32</td>
</tr>
<tr>
<td>52</td>
<td>56692.2034</td>
<td>0.0029</td>
<td>0.0023</td>
<td>17</td>
</tr>
<tr>
<td>53</td>
<td>56692.2656</td>
<td>0.0006</td>
<td>0.0058</td>
<td>31</td>
</tr>
<tr>
<td>54</td>
<td>56692.3279</td>
<td>0.0010</td>
<td>0.0094</td>
<td>31</td>
</tr>
<tr>
<td>55</td>
<td>56692.3847</td>
<td>0.0003</td>
<td>0.0074</td>
<td>24</td>
</tr>
<tr>
<td>56</td>
<td>56692.4400</td>
<td>0.0010</td>
<td>0.0040</td>
<td>23</td>
</tr>
<tr>
<td>57</td>
<td>56692.5074</td>
<td>0.0006</td>
<td>0.0127</td>
<td>31</td>
</tr>
<tr>
<td>58</td>
<td>56692.5630</td>
<td>0.0006</td>
<td>0.0096</td>
<td>30</td>
</tr>
<tr>
<td>68</td>
<td>56693.1495</td>
<td>0.0007</td>
<td>0.0087</td>
<td>25</td>
</tr>
<tr>
<td>69</td>
<td>56693.2077</td>
<td>0.0014</td>
<td>0.0081</td>
<td>39</td>
</tr>
<tr>
<td>70</td>
<td>56693.2673</td>
<td>0.0008</td>
<td>0.0090</td>
<td>47</td>
</tr>
<tr>
<td>71</td>
<td>56693.3261</td>
<td>0.0005</td>
<td>0.0091</td>
<td>31</td>
</tr>
<tr>
<td>72</td>
<td>56693.3863</td>
<td>0.0004</td>
<td>0.0106</td>
<td>32</td>
</tr>
<tr>
<td>83</td>
<td>56694.0294</td>
<td>0.0004</td>
<td>0.0076</td>
<td>42</td>
</tr>
<tr>
<td>84</td>
<td>56694.0876</td>
<td>0.0006</td>
<td>0.0071</td>
<td>42</td>
</tr>
<tr>
<td>85</td>
<td>56694.1463</td>
<td>0.0004</td>
<td>0.0070</td>
<td>42</td>
</tr>
<tr>
<td>86</td>
<td>56694.2066</td>
<td>0.0007</td>
<td>0.0086</td>
<td>50</td>
</tr>
<tr>
<td>87</td>
<td>56694.2665</td>
<td>0.0010</td>
<td>0.0098</td>
<td>42</td>
</tr>
<tr>
<td>88</td>
<td>56694.3246</td>
<td>0.0006</td>
<td>0.0091</td>
<td>31</td>
</tr>
<tr>
<td>89</td>
<td>56694.3837</td>
<td>0.0007</td>
<td>0.0095</td>
<td>31</td>
</tr>
<tr>
<td>90</td>
<td>56694.4332</td>
<td>0.0007</td>
<td>0.0053</td>
<td>18</td>
</tr>
<tr>
<td>151</td>
<td>56698.0078</td>
<td>0.0008</td>
<td>0.0079</td>
<td>56</td>
</tr>
<tr>
<td>152</td>
<td>56698.0692</td>
<td>0.0010</td>
<td>0.0052</td>
<td>50</td>
</tr>
<tr>
<td>153</td>
<td>56698.1300</td>
<td>0.0018</td>
<td>0.0032</td>
<td>56</td>
</tr>
<tr>
<td>185</td>
<td>56700.0049</td>
<td>0.0009</td>
<td>0.0077</td>
<td>38</td>
</tr>
<tr>
<td>186</td>
<td>56700.0388</td>
<td>0.0008</td>
<td>0.0126</td>
<td>61</td>
</tr>
<tr>
<td>187</td>
<td>56700.1190</td>
<td>0.0016</td>
<td>0.0111</td>
<td>61</td>
</tr>
<tr>
<td>188</td>
<td>56700.1737</td>
<td>0.0012</td>
<td>0.0151</td>
<td>60</td>
</tr>
</tbody>
</table>

*BJD – 2400000.
†Against max = 2456689.1469 + 0.058734 E.
‡Number of points used to determine the maximum.

Since the stage A superhumps of this object are well established, determination of the orbital period in quiescence is desired to estimate the mass ratio.

3.41 CSS J024354.0−160314

This object (CSS131026:024354−160314, hereafter CSS J024354) was detected to be a large-amplitude dwarf nova by CRTS on 2013 October 26 (vsnet-alert 16564). From subsequent observations superhumps were detected (vsnet-alert 16600; figure 50). The times of superhump maxima are listed in table 48.
3.42 DDE 31

This dwarf nova was discovered by D. Denisenko in outburst (16.3 mag; all magnitudes for this object are unfiltered CCD magnitudes) on 2012 October 15 (vsnet-alert 15007). The coordinates are 02h13m17.18s and +46°06′03″.4. On the next night, the object faded to 17.7 mag (B. Staels). On 2012 December 15, D. Denisenko again detected this object in outburst (16.2 mag) and reported on a previous outburst on 2012 September 14 (17.0 mag, vsnet-alert 15170).

On 2014 January 4, D. Denisenko reported on a brighter outburst (15.3 mag, vsnet-alert 16757). From time-resolved observations modulations resembling a superoutburst were detected (figure 51). Although a period of 0.073(3) d was inferred, the outburst faded rapidly (≈1 mag d$^{-1}$) and the object was not detected to be brighter than 18.2 mag five nights later. This behavior was unusual for a superoutburst. Furthermore, an analysis of the SDSS colors (Kato et al. 2012a) yielded an expected orbital period longer than 0.1 d (it is also likely that these SDSS observations were not obtained in true quiescence, cf. vsnet-alert 15170). We should therefore await another outburst to clarify the classification of this object.

3.43 MASTER OT J004527.52+503213.8

This object (hereafter MASTER J004527) was detected to be a bright (12.5 mag) transient by the MASTER network (Gorbovskoy et al. 2013) on 2013 September 17 (Denisenko et al. 2013c). The object has an 18–19 mag quiescent counterpart and its large outburst amplitude suggested a WZ Sge-type dwarf nova. The last non-detection observation prior to the outburst was announced on September 13 (fainter than 18.5; vsnet-alert 16422).

From subsequent observations superhumps were immediately detected (vsnet-alert 16423). The long (≈0.081 d) superhump period, however, was not compatible with the suggested WZ Sge-type classification (vsnet-alert 16425).

Later observations yielded a slightly shorter superhump period (vsnet-alert 16433, 16434, 16459). A further decrease in the superhump period was announced on September 22 (vsnet-alert 16463, 16497). The object showed a single post-superoutburst rebrightening on October 6 (vsnet-alert 16513; figure 52).

The times of superhump maxima are listed in table 49. The decrease in period around September 22 ($E \sim 50$; figure 52) may be attributed to either stage B–C transition (such as is observed in ordinary SU UMa-type dwarf novae) or stage A–B transition [such as are reported in likely period bouncers: SSS J122221.7–311523 (Kato et al. 2013a) and OT J075418.7+381225 and OT J230425.8+062546 (Nakata et al. 2014)]. Since the large outburst amplitude of MASTER J004527 suggested the WZ Sge-type dwarf nova, the second possibility would deserve consideration. We consider that the former interpretation is more probable for several reasons: (1) The difference between periods before and after the transition was 0.5%, which is typical of stage B–C transition (e.g., Kato et al. 2009), but is smaller than in stage A–B transition (1.0%–1.5%, cf. Nakata et al. 2013b). (2) There was a phase with a longer superhump period ($E \leq 7$), which can be considered as stage A. (3) The amplitudes of superhumps were much larger (0.2–0.3 mag; figure 53) than those in likely period bouncers (e.g., Kato et al. 2013a). We list the periods based on the former interpretation in table 2.

Following this interpretation of the superhump stages, the object can be recognized as an SU UMa-type dwarf nova (not a period bouncer) with a long orbital period and infrequent, large-amplitude outbursts. The object may resemble V1251 Cyg (Kato 1995a; Kato et al. 2009) or QY Per (Kato et al. 2009). Future monitoring of outbursts would be helpful in identifying the supercycle.
### Table 49. Superhump maxima of MASTER J004527 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56554.3649</td>
<td>0.0003</td>
<td>−0.0181</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>56554.6902</td>
<td>0.0002</td>
<td>−0.0132</td>
<td>226</td>
</tr>
<tr>
<td>5</td>
<td>56554.7735</td>
<td>0.0002</td>
<td>−0.0101</td>
<td>147</td>
</tr>
<tr>
<td>6</td>
<td>56554.8558</td>
<td>0.0002</td>
<td>−0.0079</td>
<td>124</td>
</tr>
<tr>
<td>7</td>
<td>56554.9406</td>
<td>0.0008</td>
<td>−0.0031</td>
<td>73</td>
</tr>
<tr>
<td>12</td>
<td>56555.3398</td>
<td>0.0002</td>
<td>−0.0045</td>
<td>197</td>
</tr>
<tr>
<td>13</td>
<td>56555.4214</td>
<td>0.0001</td>
<td>−0.0030</td>
<td>292</td>
</tr>
<tr>
<td>14</td>
<td>56555.5005</td>
<td>0.0001</td>
<td>−0.0040</td>
<td>386</td>
</tr>
<tr>
<td>15</td>
<td>56555.5804</td>
<td>0.0001</td>
<td>−0.0042</td>
<td>305</td>
</tr>
<tr>
<td>16</td>
<td>56555.6610</td>
<td>0.0002</td>
<td>−0.0037</td>
<td>310</td>
</tr>
<tr>
<td>19</td>
<td>56555.9016</td>
<td>0.0004</td>
<td>−0.0035</td>
<td>63</td>
</tr>
<tr>
<td>20</td>
<td>56555.9821</td>
<td>0.0003</td>
<td>−0.0030</td>
<td>59</td>
</tr>
<tr>
<td>25</td>
<td>56556.3838</td>
<td>0.0002</td>
<td>−0.0019</td>
<td>279</td>
</tr>
<tr>
<td>26</td>
<td>56556.4649</td>
<td>0.0002</td>
<td>−0.0009</td>
<td>279</td>
</tr>
<tr>
<td>27</td>
<td>56556.5459</td>
<td>0.0002</td>
<td>0.0000</td>
<td>171</td>
</tr>
<tr>
<td>28</td>
<td>56556.6266</td>
<td>0.0002</td>
<td>0.0006</td>
<td>202</td>
</tr>
<tr>
<td>29</td>
<td>56556.7080</td>
<td>0.0003</td>
<td>0.0019</td>
<td>190</td>
</tr>
<tr>
<td>30</td>
<td>56556.7859</td>
<td>0.0004</td>
<td>−0.0003</td>
<td>186</td>
</tr>
<tr>
<td>31</td>
<td>56556.8672</td>
<td>0.0003</td>
<td>0.0009</td>
<td>197</td>
</tr>
<tr>
<td>32</td>
<td>56556.9491</td>
<td>0.0006</td>
<td>0.0027</td>
<td>52</td>
</tr>
<tr>
<td>36</td>
<td>56557.2702</td>
<td>0.0003</td>
<td>0.0033</td>
<td>312</td>
</tr>
<tr>
<td>40</td>
<td>56557.5902</td>
<td>0.0006</td>
<td>0.0030</td>
<td>62</td>
</tr>
<tr>
<td>41</td>
<td>56557.6700</td>
<td>0.0004</td>
<td>0.0026</td>
<td>69</td>
</tr>
<tr>
<td>42</td>
<td>56557.7514</td>
<td>0.0005</td>
<td>0.0039</td>
<td>61</td>
</tr>
<tr>
<td>43</td>
<td>56557.8294</td>
<td>0.0005</td>
<td>0.0018</td>
<td>71</td>
</tr>
<tr>
<td>44</td>
<td>56557.9109</td>
<td>0.0005</td>
<td>0.0032</td>
<td>71</td>
</tr>
<tr>
<td>47</td>
<td>56558.1502</td>
<td>0.0004</td>
<td>0.0022</td>
<td>125</td>
</tr>
<tr>
<td>48</td>
<td>56558.2338</td>
<td>0.0003</td>
<td>0.0057</td>
<td>212</td>
</tr>
<tr>
<td>49</td>
<td>56558.3160</td>
<td>0.0003</td>
<td>0.0078</td>
<td>227</td>
</tr>
<tr>
<td>50</td>
<td>56558.3929</td>
<td>0.0003</td>
<td>0.0046</td>
<td>187</td>
</tr>
<tr>
<td>51</td>
<td>56558.4730</td>
<td>0.0003</td>
<td>0.0046</td>
<td>196</td>
</tr>
<tr>
<td>52</td>
<td>56558.5527</td>
<td>0.0003</td>
<td>0.0041</td>
<td>225</td>
</tr>
<tr>
<td>53</td>
<td>56558.6324</td>
<td>0.0003</td>
<td>0.0037</td>
<td>256</td>
</tr>
<tr>
<td>54</td>
<td>56558.7136</td>
<td>0.0004</td>
<td>0.0049</td>
<td>130</td>
</tr>
<tr>
<td>55</td>
<td>56558.7924</td>
<td>0.0005</td>
<td>0.0036</td>
<td>61</td>
</tr>
<tr>
<td>57</td>
<td>56558.9552</td>
<td>0.0011</td>
<td>0.0061</td>
<td>24</td>
</tr>
<tr>
<td>60</td>
<td>56559.1944</td>
<td>0.0002</td>
<td>0.0050</td>
<td>209</td>
</tr>
<tr>
<td>61</td>
<td>56559.2731</td>
<td>0.0002</td>
<td>0.0037</td>
<td>263</td>
</tr>
<tr>
<td>62</td>
<td>56559.3533</td>
<td>0.0002</td>
<td>0.0037</td>
<td>144</td>
</tr>
<tr>
<td>63</td>
<td>56559.4352</td>
<td>0.0003</td>
<td>0.0055</td>
<td>128</td>
</tr>
<tr>
<td>64</td>
<td>56559.5145</td>
<td>0.0003</td>
<td>0.0047</td>
<td>169</td>
</tr>
<tr>
<td>65</td>
<td>56559.5930</td>
<td>0.0004</td>
<td>0.0031</td>
<td>66</td>
</tr>
<tr>
<td>66</td>
<td>56559.6741</td>
<td>0.0003</td>
<td>0.0041</td>
<td>206</td>
</tr>
<tr>
<td>67</td>
<td>56559.7535</td>
<td>0.0002</td>
<td>0.0034</td>
<td>188</td>
</tr>
<tr>
<td>68</td>
<td>56559.8333</td>
<td>0.0003</td>
<td>0.0030</td>
<td>68</td>
</tr>
<tr>
<td>69</td>
<td>56559.9127</td>
<td>0.0005</td>
<td>0.0024</td>
<td>70</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456554.3830 + 0.080106 E.
‡Number of points used to determine the maximum.

### 3.44 MASTER OT J005740.99+443101.5

This object (hereafter MASTER J005740) was detected to be a transient by the MASTER network on 2013 November 6 (Balanutsa et al. 2013a). From subsequent observations early superhumps were immediately detected (vsnet-alert 16603, 16606, 16609). The large amplitude (0.4 mag) of early superhumps suggested a high inclination. There was also an eclipse-like feature in the light curve.
Fig. 53. Superhumps in MASTER J004527 (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

(vsnet-alert 16614; see also vsnet-alert 16603). On November 12–13, ordinary superhumps began to appear, and were accompanied by eclipses (vsnet-alert 16624; figure 54). After the light curve faded away on the plateau, the eclipses became deeper (∼1 mag, vsnet-alert 16640), implying that the white dwarf is eclipsed. This object became the first candidate for the WZ Sge-type dwarf nova showing the eclipse of the white dwarf.

We first obtained the eclipse ephemeris using the observations in the phases other than early superhumps, since the profile of early superhumps is similar to, but known to be different from, that of the eclipse (cf. Uemura et al. 2012). We obtained the following ephemeris:

\[
\text{Min}(\text{BJD}) = 2456617.36772(4) + 0.05619043(3)E,
\]

by using MCMC modeling the same as in V893 Sco. Note that this ephemeris is not intended as a long-term prediction of eclipses, in contrast to other eclipsing dwarf novae treated in this paper, since the eclipse profile is strongly affected by the varying superhumps and systematic variations in relation to the system brightness. The errors given in equation (4) are formal statistic ones, and the actual errors are expected to be larger due to the systematic error.

The times of superhump maxima, determined after removing the data within 0.07 orbital phases of eclipse, are listed in table 50. The \(O-C\) diagram is presented in figure 57. The maxima for \(E < 14\) are stage A superhumps with growing amplitude. The maxima for \(14 \leq E \leq 144\) are stage B superhumps. The times for \(144 < E < 245\) were not well determined because the amplitude of superhumps became smaller and the profile was difficult of detection due to the orbital modulation. After \(E = 245\), the amplitude of superhumps grew again. These superhumps can be identified as stage C superhumps, which are not usually seen in WZ Sge-type dwarf novae (see Kato et al. 2009).

The period of early superhump by the PDM method was 0.056169(3) d (figure 55), which is 0.04% shorter than the orbital period. A summary of the comparison between periods of early superhumps and orbital periods in various WZ Sge-type dwarf novae is given in subsection 4.4. The zero epoch in this figure is based on the ephemeris equation (4). Since the period of early superhumps and the orbital period are very slightly different, we used the eclipse center nearest to the center of observation of early superhumps. The period used for phase-averaging is that of early superhumps. The profile of these early superhumps and its implication are discussed in subsection 4.5.
The mean profile of stage B superhumps is shown in figure 56. Since the times of superhumps during the growing stage (stage A) were difficult of determination due to the orbital modulation, we also measured the period for the interval BJD 2456608–2456610 by PDM. The resultant period was 0.05783(3) d. This value is slightly different from that of the $O-C$ analysis [0.05758(19) d, $E \leq 14$], which was probably more affected by the shorter period close to stage B. We therefore chose the former period as the representative period of stage A. The resultant $\varepsilon^*$ of 0.028(5) corresponds to $q = 0.076(16)$.

A two-dimensional Lasso analysis is presented in figure 58. As in the eclipsing WZ Sge-type dwarf nova WZ Sge (Kato et al. 2014a), the orbital signal was continuously seen. The superhump signal with a decreasing frequency (increasing period) during the plateau phase of the superoutburst is also clearly visible.

3.45 MASTER OT J024847.86+501239.7

This object (hereafter MASTER J024847) was detected to be a transient by the MASTER network on 2013
November 11 (Denisenko et al. 2013a). From subsequent observations superhumps were detected immediately (vsnet-alert 16619; figure 59). A single-night observation yielded the following times of superhump maxima: BJD 2456609.3402(7) \((E = 62)\), 2456609.4043(8) \((E = 62)\), and 2456609.4683(12) \((E = 65)\). A PDM analysis yielded a period of 0.0644(3) d.

3.46 MASTER OT J061335.30+395714.7

This object (hereafter MASTER J061335) was detected to be a bright \((14.2 \text{mag})\) transient by the MASTER network on 2013 October 15 (Vladimirov et al. 2013). After a period without strong modulations, growing superhumps were detected (vsnet-alert 16554, 16555, 16556, 16563, 16567; figure 60). The times of superhump maxima are listed in table 51. There are well-defined stages A–B–C (figure 61), although the period of stage A superhumps was not determined. Although early superhumps were potentially present for the first two nights, we could not detect their period due to the shortness of the observation. There was significant brightening around the stage B–C transition (figure 61).

3.47 MASTER OT J073208.11+064149.5

This object (hereafter MASTER J073208) was detected to be a large-amplitude \((\sim 7 \text{mag})\) transient by the MASTER network on 2013 December 29 (Balanutsa et al. 2013b). The object indeed showed short-period superhumps (vsnet-alert 16747, 16756). The times of superhump maxima are listed in table 52. Although a PDM analysis favors a
Fig. 58. Lasso analysis of MASTER J005740 (2013). Upper: Light curve. The data were binned to 0.02 d. Middle: First overtones of the superhump and orbital signals. Lower: Fundamentals of the superhump and the orbital signal. The orbital signal was present both in the fundamental and in the first overtone. The signal of (positive) superhumps with variable frequency was recorded during the superoutburst plateau. No indication of negative superhump was present. The parameter $\log \lambda = -8.7$ was used. The width of the sliding window and the time step used were 6 d and 0.3 d, respectively.

period of 0.05878(2) d, a shorter alias of 0.05722(2) d is not excluded (figure 62).

3.48 MASTER OT J095018.04−063921.9

This object (hereafter MASTER J095018) was detected to be a 14.1 mag transient by the MASTER network on 2013 November 11 (Rufanov et al. 2013). From subsequent observations superhumps were detected immediately (vsnet-alert 16631, 16659; figure 63). Although a period of 0.06681(3) d was initially reported, a reanalysis of the data clarified that this is double the value of the true variation (see also figure 63). A PDM analysis of all data yielded a period of 0.033409(4) d (figure 64). The profile, however, is not similar to that of ordinary superhumps, but resembles that of early superhumps with double maxima (cf. Kato 2002). An $O-C$ analysis did not show significant period variation.

The period suggests a system with a compact, evolved secondary such as SBS 1108+574 (Kato et al. 2013b; Littlefield et al. 2013; Carter et al. 2013). If the present variation is indeed due to early superhumps, data from the present observation are the first to reveal early superhumps in such systems. We preserve this possibility for future observations since we could not follow the latter stage, when its ordinary superhumps were expected. On the last two nights (November 24 and 25), the double-wave modulation became less apparent and waves with a period of $\sim 0.08$ d seemed to appear. We, however, were not confident of presence of this periodicity due to the limited signal-to-noise ratio of this faint object.
Table 51. Superhump maxima of MASTER J061335 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O−C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56587.2100</td>
<td>0.0013</td>
<td>0.0042</td>
<td>119</td>
</tr>
<tr>
<td>1</td>
<td>56587.2635</td>
<td>0.0007</td>
<td>0.0016</td>
<td>167</td>
</tr>
<tr>
<td>61</td>
<td>56590.6387</td>
<td>0.0007</td>
<td>0.0099</td>
<td>56</td>
</tr>
<tr>
<td>62</td>
<td>56590.6942</td>
<td>0.0009</td>
<td>0.0094</td>
<td>37</td>
</tr>
<tr>
<td>76</td>
<td>56591.4781</td>
<td>0.0015</td>
<td>0.0076</td>
<td>32</td>
</tr>
<tr>
<td>77</td>
<td>56591.5312</td>
<td>0.0010</td>
<td>0.0047</td>
<td>31</td>
</tr>
<tr>
<td>78</td>
<td>56591.5864</td>
<td>0.0009</td>
<td>0.0038</td>
<td>30</td>
</tr>
<tr>
<td>79</td>
<td>56591.6400</td>
<td>0.0013</td>
<td>0.0047</td>
<td>30</td>
</tr>
<tr>
<td>80</td>
<td>56591.6942</td>
<td>0.0009</td>
<td>0.0094</td>
<td>37</td>
</tr>
<tr>
<td>86</td>
<td>56592.2572</td>
<td>0.0008</td>
<td>0.0012</td>
<td>41</td>
</tr>
<tr>
<td>90</td>
<td>56592.3116</td>
<td>0.0007</td>
<td>0.0006</td>
<td>41</td>
</tr>
<tr>
<td>93</td>
<td>56592.4240</td>
<td>0.0007</td>
<td>0.0004</td>
<td>35</td>
</tr>
<tr>
<td>94</td>
<td>56592.4804</td>
<td>0.0007</td>
<td>0.0001</td>
<td>90</td>
</tr>
<tr>
<td>95</td>
<td>56592.5368</td>
<td>0.0007</td>
<td>0.0002</td>
<td>74</td>
</tr>
<tr>
<td>96</td>
<td>56592.5916</td>
<td>0.0015</td>
<td>0.0011</td>
<td>30</td>
</tr>
<tr>
<td>108</td>
<td>56593.2630</td>
<td>0.0009</td>
<td>0.0031</td>
<td>46</td>
</tr>
<tr>
<td>109</td>
<td>56593.3207</td>
<td>0.0006</td>
<td>0.0015</td>
<td>101</td>
</tr>
<tr>
<td>110</td>
<td>56593.3777</td>
<td>0.0004</td>
<td>0.0006</td>
<td>51</td>
</tr>
<tr>
<td>143</td>
<td>56595.2393</td>
<td>0.0080</td>
<td>0.0093</td>
<td>36</td>
</tr>
<tr>
<td>144</td>
<td>56595.2768</td>
<td>0.0053</td>
<td>0.0094</td>
<td>33</td>
</tr>
<tr>
<td>146</td>
<td>56595.3958</td>
<td>0.0019</td>
<td>0.0026</td>
<td>31</td>
</tr>
<tr>
<td>162</td>
<td>56596.2882</td>
<td>0.0012</td>
<td>0.0080</td>
<td>58</td>
</tr>
<tr>
<td>163</td>
<td>56596.3477</td>
<td>0.0008</td>
<td>0.0046</td>
<td>95</td>
</tr>
<tr>
<td>164</td>
<td>56596.3997</td>
<td>0.0065</td>
<td>0.0087</td>
<td>27</td>
</tr>
<tr>
<td>165</td>
<td>56596.4576</td>
<td>0.0006</td>
<td>0.0069</td>
<td>67</td>
</tr>
<tr>
<td>166</td>
<td>56596.5147</td>
<td>0.0005</td>
<td>0.0060</td>
<td>77</td>
</tr>
<tr>
<td>167</td>
<td>56596.5675</td>
<td>0.0010</td>
<td>0.0092</td>
<td>39</td>
</tr>
<tr>
<td>179</td>
<td>56597.2461</td>
<td>0.0026</td>
<td>0.0040</td>
<td>35</td>
</tr>
<tr>
<td>180</td>
<td>56597.3000</td>
<td>0.0025</td>
<td>0.0063</td>
<td>41</td>
</tr>
<tr>
<td>181</td>
<td>56597.3606</td>
<td>0.0106</td>
<td>0.0018</td>
<td>20</td>
</tr>
<tr>
<td>185</td>
<td>56597.5773</td>
<td>0.0025</td>
<td>0.0095</td>
<td>23</td>
</tr>
<tr>
<td>186</td>
<td>56597.6408</td>
<td>0.0019</td>
<td>0.0021</td>
<td>19</td>
</tr>
<tr>
<td>197</td>
<td>56598.2544</td>
<td>0.0037</td>
<td>0.0057</td>
<td>50</td>
</tr>
<tr>
<td>268</td>
<td>56602.2595</td>
<td>0.0067</td>
<td>0.0153</td>
<td>41</td>
</tr>
<tr>
<td>269</td>
<td>56602.3072</td>
<td>0.0057</td>
<td>0.0068</td>
<td>40</td>
</tr>
<tr>
<td>303</td>
<td>56604.2153</td>
<td>0.0027</td>
<td>0.0071</td>
<td>36</td>
</tr>
<tr>
<td>304</td>
<td>56604.2665</td>
<td>0.0014</td>
<td>0.0022</td>
<td>41</td>
</tr>
<tr>
<td>305</td>
<td>56604.3244</td>
<td>0.0023</td>
<td>0.0040</td>
<td>41</td>
</tr>
<tr>
<td>321</td>
<td>56605.2218</td>
<td>0.0054</td>
<td>0.0036</td>
<td>44</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456587.2058 + 0.056114 E.
‡Number of points used to determine the maximum.

### 3.49 MASTER OT J141143.46+262051.5

This object (hereafter MASTER J141143) was detected to be a transient (15.4 mag) by the MASTER network on 2013 February 13 (Shumkov et al. 2013). The object was again detected in outburst on 2014 January 30. The outburst was caught in the early stage (vsnet-alert 16852). The only available observation on February 5 showed superhumps with an amplitude of 0.15 mag (vsnet-alert 16881; figure 65). The period was determined by the PDM method—0.064(1)d. The times of superhump maxima were BJD 2456693.5806(9) (N = 35) and 2456693.6466(9) (N = 33).

### 3.50 MASTER OT J162323.48+782603.3

This object (hereafter MASTER J162323) was detected to be a bright (13.0 mag) transient by the MASTER network on 2013 December 9 (Denisenko et al. 2013b). There were a number of past ROSAT chance observations, showing a relatively soft source with variable intensity (vsnet-alert 16698). From subsequent observations modulations were detected immediately modulations were...
Table 52. Superhump maxima of MASTER J073208 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max</th>
<th>Error</th>
<th>O−C</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56658.3918</td>
<td>0.0018</td>
<td>−0.0028</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>56658.4553</td>
<td>0.0006</td>
<td>0.0018</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>56658.5134</td>
<td>0.0007</td>
<td>0.0010</td>
<td>23</td>
</tr>
<tr>
<td>37</td>
<td>56660.5747</td>
<td>0.0007</td>
<td>0.0031</td>
<td>20</td>
</tr>
<tr>
<td>38</td>
<td>56660.6273</td>
<td>0.0011</td>
<td>−0.0031</td>
<td>42</td>
</tr>
</tbody>
</table>

 BJ2400000.
†Against max = 2456658.3947 + 0.058836 E.
‡Number of points used to determine the maximum.

Fig. 63. Example of (early?) superhumps in MASTER J095018 on two nights.

detected immediately (vsnet-alert 16703) and were followed by growing superhumps (vsnet-alert 16706, 16716, 16717, 16723; figure 66). The times of superhump maxima are listed in table 53. There were clear stages A and B. There was no variation of the superhump period around the rapid fading. There was an apparent decrease in period 5 d after the fading (around E = 200). We interpret the superhumps up to E = 192 as stage B superhumps and list the period in table 2. The resultant ̂P ̂\_\text{dot} of +3.9 ± 8 10^-5 for stage B again offers another example of the positive ̂P ̂\_\text{dot} in the long-\text{P ̂_\text{orb}} system—such examples include GX Cas (Kato et al. 2012b), V1239 Her, OT J145921.8+354806, OT J214738.4+244553 (Kato et al. 2013b), V444 Peg, CSS J203937.7−042907, and MASTER OT J212624.16+253827.2 (Kato et al. 2014a).

The quiescent SDSS colors suggest an orbital period of 0.072 d based on Kato, Maehara, and Uemura (2012a).

This relatively long orbital period for an SU UMa-type dwarf nova is in agreement with the present observation. The object was twice detected in outburst in 2012 by the MASTER network (Denisenko et al. 2013b). The supercycle appears to be less than 1 yr. Since the object is bright and frequently outbursting, future observations, including the determination of the orbital period, will be promising.

3.51 MASTER OT J234843.23+250250.4

This object (hereafter MASTER J234843) was detected to be a 14.4 mag transient by the MASTER network on 2013
Fig. 66. Superhumps in MASTER J162323 during the superoutburst plateau (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

October 29 (Shurpakov et al. 2013). The object has a faint, blue ($g = 20.2$, $g - r = -0.1$) SDSS counterpart. Five previous outbursts were recorded by CRTS. From subsequent observations modulations resembling early superhumps were detected (vsnet-alert 16577, 16578). Later observations, however, indicated that their period was half what was initially suggested (figure 67), and the object was recognized as a CV below the period minimum (vsnet-alert 16608; the superhump profile is shown in figure 68). The times of superhump maxima based on this interpretation are listed in table 54. Although the data were not sufficient, the $O - C$ values suggest that there was a stage B–C transition around $E = 252$ as in SBS 1108+574, a similar ultrashort-$P_{\text{orb}}$ dwarf nova (Kato et al. 2013b).

The outburst light curve and $O - C$ diagram are shown in figure 69.

Although spectroscopic observation is needed to see whether this object is hydrogen-rich or not, we suspect that this object is a binary containing hydrogen in the secondary with an evolved core rather than a hydrogen-depleted AM CVn-type binary, since the known AM CVn-type objects with this $P_{\text{orb}}$ do not show outbursts (cf. Solheim 2010; Ramsay et al. 2012). Further detailed observations will clarify the nature of this object.

### Table 53. Superhump maxima of MASTER J162323 (2013).

<table>
<thead>
<tr>
<th>$E$</th>
<th>Max$^*$</th>
<th>Error</th>
<th>$O - C$$^\dagger$</th>
<th>N$^\ddagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56637.5690</td>
<td>0.0011</td>
<td>-0.0542</td>
<td>94</td>
</tr>
<tr>
<td>1</td>
<td>56637.6655</td>
<td>0.0020</td>
<td>-0.0464</td>
<td>86</td>
</tr>
<tr>
<td>2</td>
<td>56637.7684</td>
<td>0.0012</td>
<td>-0.0323</td>
<td>46</td>
</tr>
<tr>
<td>19</td>
<td>56639.3104</td>
<td>0.0006</td>
<td>0.0021</td>
<td>40</td>
</tr>
<tr>
<td>20</td>
<td>56639.3987</td>
<td>0.0002</td>
<td>0.0017</td>
<td>177</td>
</tr>
<tr>
<td>21</td>
<td>56639.4874</td>
<td>0.0003</td>
<td>0.0017</td>
<td>157</td>
</tr>
<tr>
<td>22</td>
<td>56639.5749</td>
<td>0.0008</td>
<td>0.0005</td>
<td>12</td>
</tr>
<tr>
<td>23</td>
<td>56639.6642</td>
<td>0.0007</td>
<td>0.0011</td>
<td>12</td>
</tr>
<tr>
<td>30</td>
<td>56640.2879</td>
<td>0.0010</td>
<td>0.0040</td>
<td>17</td>
</tr>
<tr>
<td>31</td>
<td>56640.3795</td>
<td>0.0002</td>
<td>0.0069</td>
<td>159</td>
</tr>
<tr>
<td>32</td>
<td>56640.4681</td>
<td>0.0003</td>
<td>0.0068</td>
<td>165</td>
</tr>
<tr>
<td>33</td>
<td>56640.5578</td>
<td>0.0003</td>
<td>0.0078</td>
<td>112</td>
</tr>
<tr>
<td>35</td>
<td>56640.7456</td>
<td>0.0014</td>
<td>0.0182</td>
<td>9</td>
</tr>
<tr>
<td>39</td>
<td>56641.3661</td>
<td>0.0028</td>
<td>0.0179</td>
<td>24</td>
</tr>
<tr>
<td>44</td>
<td>56641.5352</td>
<td>0.0003</td>
<td>0.0096</td>
<td>66</td>
</tr>
<tr>
<td>45</td>
<td>56641.6238</td>
<td>0.0008</td>
<td>0.0095</td>
<td>25</td>
</tr>
<tr>
<td>46</td>
<td>56641.7088</td>
<td>0.0009</td>
<td>0.0059</td>
<td>12</td>
</tr>
<tr>
<td>56</td>
<td>56642.6015</td>
<td>0.0007</td>
<td>0.0116</td>
<td>56</td>
</tr>
<tr>
<td>57</td>
<td>56642.6897</td>
<td>0.0015</td>
<td>0.0112</td>
<td>16</td>
</tr>
<tr>
<td>67</td>
<td>56643.5716</td>
<td>0.0012</td>
<td>0.0062</td>
<td>10</td>
</tr>
<tr>
<td>68</td>
<td>56643.6643</td>
<td>0.0019</td>
<td>0.0102</td>
<td>15</td>
</tr>
<tr>
<td>79</td>
<td>56644.6320</td>
<td>0.0031</td>
<td>0.0023</td>
<td>15</td>
</tr>
<tr>
<td>98</td>
<td>56646.3168</td>
<td>0.0005</td>
<td>0.0020</td>
<td>73</td>
</tr>
<tr>
<td>99</td>
<td>56646.4037</td>
<td>0.0005</td>
<td>0.0003</td>
<td>112</td>
</tr>
<tr>
<td>101</td>
<td>56646.5840</td>
<td>0.0018</td>
<td>0.0032</td>
<td>12</td>
</tr>
<tr>
<td>102</td>
<td>56646.6708</td>
<td>0.0010</td>
<td>0.0012</td>
<td>15</td>
</tr>
<tr>
<td>135</td>
<td>56649.5986</td>
<td>0.0057</td>
<td>0.0024</td>
<td>16</td>
</tr>
<tr>
<td>136</td>
<td>56649.6894</td>
<td>0.0021</td>
<td>0.0044</td>
<td>16</td>
</tr>
<tr>
<td>143</td>
<td>56650.3106</td>
<td>0.0012</td>
<td>0.0048</td>
<td>44</td>
</tr>
<tr>
<td>153</td>
<td>56651.2012</td>
<td>0.0035</td>
<td>0.0086</td>
<td>28</td>
</tr>
<tr>
<td>154</td>
<td>56651.2825</td>
<td>0.0012</td>
<td>0.0012</td>
<td>50</td>
</tr>
<tr>
<td>155</td>
<td>56651.3732</td>
<td>0.0011</td>
<td>0.0031</td>
<td>50</td>
</tr>
<tr>
<td>156</td>
<td>56651.4641</td>
<td>0.0063</td>
<td>0.0053</td>
<td>13</td>
</tr>
<tr>
<td>180</td>
<td>56653.5948</td>
<td>0.0027</td>
<td>0.0075</td>
<td>13</td>
</tr>
<tr>
<td>181</td>
<td>56653.6807</td>
<td>0.0100</td>
<td>0.0047</td>
<td>13</td>
</tr>
<tr>
<td>187</td>
<td>56654.2236</td>
<td>0.0044</td>
<td>0.0155</td>
<td>18</td>
</tr>
<tr>
<td>188</td>
<td>56654.3132</td>
<td>0.0028</td>
<td>0.0164</td>
<td>13</td>
</tr>
<tr>
<td>192</td>
<td>56654.6519</td>
<td>0.0030</td>
<td>0.0004</td>
<td>21</td>
</tr>
<tr>
<td>223</td>
<td>56657.3771</td>
<td>0.0015</td>
<td>-0.0238</td>
<td>30</td>
</tr>
<tr>
<td>224</td>
<td>56657.4603</td>
<td>0.0018</td>
<td>-0.0293</td>
<td>28</td>
</tr>
<tr>
<td>244</td>
<td>56659.2330</td>
<td>0.0013</td>
<td>-0.0304</td>
<td>14</td>
</tr>
</tbody>
</table>

$^*$BJD – 2400000.

$^\dagger$Against max = 2456637.6232 + 0.088689 $E$.

$^\ddagger$Number of points used to determine the maximum.

### 3.52 OT J013741.1+220312

This object was detected to be an unknown type of transient by CRTS (= CSS140104:013741+220312, hereafter OT J013741) on 2014 January 4. There was no previous outburst detection in CRTS. From subsequent observations double-wave early superhumps with a mean period of 0.05854(2) d were detected (vsnet-alert 16765,
Fig. 67. Example of superhumps in MASTER J234843 on two nights. (16769; figure 70). Only the stage of early superhumps was observed.

3.53 OT J210016.0−024258

This object was detected to be a transient by CRTS (= CSS130905:210016−024258, hereafter OT J210016) on 2013 September 5. The quiescent counterpart has an SDSS magnitude of $g = 19.9$, implying a dwarf nova with a large outburst amplitude (vsnet-alert 16347).

Low-amplitude modulations resembling early superhumps were recorded until September 12 (vsnet-alert 16362; figure 71). From September 16, ordinary superhumps appeared (vsnet-alert 16420, 16430; figure 72). The times of ordinary superhumps are listed in table 55. Although observational data at the earliest epochs may contain stage A superhumps, we could not convincingly detect stage A. Since $E = 0$ and $E = 1$ were probably obtained during the growing stage of superhumps, we excluded these epochs when determining $P_{\text{dot}}$ of stage B superhumps.

The object rapidly faded on the superoutburst plateau on September 29. It showed a post-superoutburst rebrightening on October 6 (around 17.4 mag—all magnitudes during this rebrightening were unfiltered CCD ones; vsnet-alert 16525). The snapshot CCD observations indicate that this object was already bright on October 1 (16.86 mag) and October 4 (17.55 mag). These observations indicate that the faint state following the superoutburst plateau lasted less than 2 d. This fading was probably a “dip” type between the main superoutburst and long rebrightening as seen in the WZ Sge-type dwarf nova AL Com (1995, cf. Nogami et al. 1997). The WZ Sge-type nature is supported by the likely presence of early superhumps, the large outburst amplitude, and the lack of past outburst detections in the CRTS data.

3.54 PNV J19150199+0719471

This object (hereafter PNV J191501) was detected to be a possible nova of 10.8 mag on 2013 May 31.5974 UT (Itagaki et al. 2013). The object was detected at 9.8 mag on May 30.721 UT by T. Kojima. The object was identified as an Hα emission object IPHAS J191502.09+071947.6 ($r = 18.503$, Drew et al. 2005), and its color and large proper motion suggested the object as a dwarf nova rather than a classical nova (vsnet-alert 15768). The object was then regarded as a likely candidate for a WZ Sge-type dwarf nova (vsnet-alert 15776). Although data of subsequent observations revealed small variations suggesting early superhumps (vsnet-alert 15778, 15785, 15788), the period was difficult of determination due to the low amplitude. We will deal with this issue later.

6 See also ⟨http://www.cbat.eps.harvard.edu/unconf/followups/J19150199+0719471.html⟩.
In the meantime, low-resolution spectra confirmed that the object is classified as a type of dwarf nova (vsnet-alert 15779). The spectrum showed double-peak Hβ emission line and a C III/N III emission line, suggesting that this object is a WZ Sge-type dwarf nova with a moderate inclination (vsnet-alert 15782). Further spectroscopic observations were also reported (vsnet-alert 15787, 15800). The latter spectrum showed Balmer series in absorption with emission cores in Hα and Hβ. Nakata et al. (2013a) also reported on a UV spectrum taken by the Swift satellite.

Six days after the discovery, modulations suggesting growing superhumps appeared (vsnet-alert 15815; the actual variations could be detected two days before). The times of superhump maxima during the superoutburst plateau are listed in table 56. The profile is shown in figure 73. There were remarkably well-sampled stages B and C. The existence of stage C in a WZ Sge-type dwarf nova is rather exceptional. Although stage A was detected, a lack of observations for 1 d due to bad weather hindered us from measuring the period of stage A superhumps from the O − C analysis. A PDM analysis during the interval of BJD 2456449–2456452 yielded a period of 0.05883(6) d with an amplitude of 0.015 mag.

After the superoutburst rapidly faded, the superhump signal became strong again. The times of these post-superoutburst superhumps are listed in table 57. The data indicate that there was a phase jump of ∼ 0.5 between

### Table 54. Superhump maxima of MASTER J234843 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Max Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56595.2868</td>
<td>0.0025</td>
<td>0.0032</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>56595.3167</td>
<td>0.0005</td>
<td>0.0011</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>56595.3480</td>
<td>0.0004</td>
<td>0.0005</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>56595.3803</td>
<td>0.0004</td>
<td>0.0008</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>56595.4106</td>
<td>0.0005</td>
<td>−0.0009</td>
<td>29</td>
</tr>
<tr>
<td>5</td>
<td>56595.4431</td>
<td>0.0005</td>
<td>−0.0011</td>
<td>26</td>
</tr>
<tr>
<td>54</td>
<td>56597.0157</td>
<td>0.0012</td>
<td>0.0015</td>
<td>22</td>
</tr>
<tr>
<td>55</td>
<td>56597.0420</td>
<td>0.0007</td>
<td>−0.0014</td>
<td>23</td>
</tr>
<tr>
<td>56</td>
<td>56597.0747</td>
<td>0.0010</td>
<td>−0.0007</td>
<td>23</td>
</tr>
<tr>
<td>57</td>
<td>56597.1052</td>
<td>0.0007</td>
<td>−0.0021</td>
<td>23</td>
</tr>
<tr>
<td>58</td>
<td>56597.1358</td>
<td>0.0007</td>
<td>−0.0036</td>
<td>23</td>
</tr>
<tr>
<td>59</td>
<td>56597.2998</td>
<td>0.0019</td>
<td>0.0043</td>
<td>15</td>
</tr>
<tr>
<td>84</td>
<td>56603.2836</td>
<td>0.0017</td>
<td>0.0007</td>
<td>28</td>
</tr>
<tr>
<td>85</td>
<td>56603.3156</td>
<td>0.0019</td>
<td>0.0008</td>
<td>28</td>
</tr>
<tr>
<td>86</td>
<td>56603.3543</td>
<td>0.0014</td>
<td>0.0075</td>
<td>19</td>
</tr>
<tr>
<td>87</td>
<td>56603.3825</td>
<td>0.0016</td>
<td>0.0037</td>
<td>26</td>
</tr>
<tr>
<td>88</td>
<td>56603.4137</td>
<td>0.0019</td>
<td>0.0028</td>
<td>28</td>
</tr>
<tr>
<td>89</td>
<td>56603.4427</td>
<td>0.0018</td>
<td>−0.0001</td>
<td>28</td>
</tr>
<tr>
<td>249</td>
<td>56604.0826</td>
<td>0.0017</td>
<td>−0.0002</td>
<td>23</td>
</tr>
<tr>
<td>250</td>
<td>56604.1165</td>
<td>0.0038</td>
<td>0.0017</td>
<td>22</td>
</tr>
<tr>
<td>277</td>
<td>56604.1430</td>
<td>0.0011</td>
<td>−0.0038</td>
<td>24</td>
</tr>
<tr>
<td>436</td>
<td>56609.2325</td>
<td>0.0018</td>
<td>−0.0018</td>
<td>15</td>
</tr>
<tr>
<td>437</td>
<td>56609.2655</td>
<td>0.0053</td>
<td>−0.0008</td>
<td>17</td>
</tr>
<tr>
<td>438</td>
<td>56609.2952</td>
<td>0.0034</td>
<td>−0.0030</td>
<td>16</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456595.2835 + 0.031997 E.
‡Number of points used to determine the maximum.
Fig. 71. Possible early superhumps in OT J210016 (2013). Upper: PDM analysis. The rejection rate for bootstraping was reduced to 0.3. Lower: Phase-averaged profile.

Fig. 72. Ordinary superhumps in OT J210016 (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

Table 55. Superhump maxima of OT J210016 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56552.0076</td>
<td>0.0014</td>
<td>−0.0070</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>56552.0764</td>
<td>0.0018</td>
<td>0.0033</td>
<td>61</td>
</tr>
<tr>
<td>17</td>
<td>56553.0093</td>
<td>0.0007</td>
<td>−0.0001</td>
<td>60</td>
</tr>
<tr>
<td>18</td>
<td>56553.0705</td>
<td>0.0006</td>
<td>0.0027</td>
<td>61</td>
</tr>
<tr>
<td>34</td>
<td>56554.0039</td>
<td>0.0014</td>
<td>−0.0002</td>
<td>47</td>
</tr>
<tr>
<td>35</td>
<td>56554.0678</td>
<td>0.0014</td>
<td>0.0032</td>
<td>47</td>
</tr>
<tr>
<td>57</td>
<td>56555.3469</td>
<td>0.0013</td>
<td>−0.0030</td>
<td>47</td>
</tr>
<tr>
<td>58</td>
<td>56555.4057</td>
<td>0.0010</td>
<td>−0.0027</td>
<td>46</td>
</tr>
<tr>
<td>59</td>
<td>56555.4675</td>
<td>0.0015</td>
<td>0.0006</td>
<td>47</td>
</tr>
<tr>
<td>60</td>
<td>56555.5296</td>
<td>0.0030</td>
<td>0.0042</td>
<td>17</td>
</tr>
<tr>
<td>108</td>
<td>56558.3312</td>
<td>0.0109</td>
<td>−0.0030</td>
<td>17</td>
</tr>
<tr>
<td>109</td>
<td>56558.3908</td>
<td>0.0008</td>
<td>−0.0019</td>
<td>44</td>
</tr>
<tr>
<td>110</td>
<td>56558.4503</td>
<td>0.0010</td>
<td>−0.0008</td>
<td>45</td>
</tr>
<tr>
<td>160</td>
<td>56561.3796</td>
<td>0.0012</td>
<td>0.0027</td>
<td>31</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456552.0146 + 0.058514E.
‡Number of points used to determine the maximum.

BJD 2456472.295 and BJD 2456472.688. A combined O − C diagram (figure 74), however, indicates that the superhumps in the post-superoutburst stage are on a smooth extension of stage C superhumps. The signal of reversed phases (likely corresponding to “traditional” late superhumps) appeared only briefly near the rapid fading.

The signal of early superhumps was very weak and the period of 0.05706(2) d is the only candidate in the region of the period of early superhumps expected from the superhump period (figure 75). Although the fractional excess of stage A superhumps based on the O − C analysis corresponds to $q = 0.095(4)$, this measurement suffers from uncertainties arising from the low amplitudes of both early superhumps and stage A superhumps. Future determination of the orbital period will be necessary for confirming this value.

A two-dimensional Lasso analysis is presented in figure 76. The superhumps with increasing frequencies (decreasing periods) after the superoutburst are clearly seen. The overall behavior resembles that of an SU UMa-type dwarf nova rather than an extreme WZ Sge-type dwarf nova (cf. WZ Sge in Kato et al. 2014a), except for the possible presence of early superhumps.

3.55 SSS J094327.3−272038

This object (= SSS111226:094327−272039, hereafter SSS J094327) was discovered to be a transient object by the CRTS Siding Spring Survey (SSS) on 2011 December 26 at an unfiltered CCD magnitude of 16.6. The object, however, showed several outbursts reaching $V = 12.8$ mag in ASAS-3 data (vsnet-alert 14013). There is also an X-ray
Table 56. Superhump maxima of PNV J191501 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max t</th>
<th>Error</th>
<th>O − Cl</th>
<th>Ni</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56449.3764</td>
<td>0.0010</td>
<td>−0.0056</td>
<td>221</td>
</tr>
<tr>
<td>1</td>
<td>56449.4229</td>
<td>0.0025</td>
<td>−0.0175</td>
<td>222</td>
</tr>
<tr>
<td>2</td>
<td>56449.4826</td>
<td>0.0010</td>
<td>−0.1620</td>
<td>211</td>
</tr>
<tr>
<td>7</td>
<td>56449.7761</td>
<td>0.0018</td>
<td>−0.0146</td>
<td>64</td>
</tr>
<tr>
<td>8</td>
<td>56449.8298</td>
<td>0.0012</td>
<td>−0.1931</td>
<td>313</td>
</tr>
<tr>
<td>24</td>
<td>56450.7898</td>
<td>0.0009</td>
<td>0.0646</td>
<td>124</td>
</tr>
<tr>
<td>25</td>
<td>56450.8453</td>
<td>0.0019</td>
<td>0.0355</td>
<td>154</td>
</tr>
<tr>
<td>30</td>
<td>56451.1402</td>
<td>0.0006</td>
<td>0.0656</td>
<td>784</td>
</tr>
<tr>
<td>48</td>
<td>56452.1993</td>
<td>0.0005</td>
<td>0.0146</td>
<td>98</td>
</tr>
<tr>
<td>49</td>
<td>56452.2646</td>
<td>0.0009</td>
<td>0.0215</td>
<td>126</td>
</tr>
<tr>
<td>58</td>
<td>56452.7916</td>
<td>0.0005</td>
<td>0.0230</td>
<td>32</td>
</tr>
<tr>
<td>59</td>
<td>56452.8486</td>
<td>0.0002</td>
<td>0.0217</td>
<td>51</td>
</tr>
<tr>
<td>71</td>
<td>56453.5446</td>
<td>0.0002</td>
<td>0.0170</td>
<td>63</td>
</tr>
<tr>
<td>74</td>
<td>56453.7190</td>
<td>0.0003</td>
<td>0.0162</td>
<td>38</td>
</tr>
<tr>
<td>75</td>
<td>56453.7754</td>
<td>0.0003</td>
<td>0.0142</td>
<td>53</td>
</tr>
<tr>
<td>76</td>
<td>56453.8347</td>
<td>0.0003</td>
<td>0.0151</td>
<td>89</td>
</tr>
<tr>
<td>77</td>
<td>56453.8929</td>
<td>0.0002</td>
<td>0.0150</td>
<td>99</td>
</tr>
<tr>
<td>104</td>
<td>56455.4592</td>
<td>0.0014</td>
<td>0.0048</td>
<td>45</td>
</tr>
<tr>
<td>105</td>
<td>56455.5171</td>
<td>0.0002</td>
<td>0.0042</td>
<td>92</td>
</tr>
<tr>
<td>106</td>
<td>56455.5754</td>
<td>0.0002</td>
<td>0.0042</td>
<td>92</td>
</tr>
<tr>
<td>107</td>
<td>56455.6345</td>
<td>0.0003</td>
<td>0.0049</td>
<td>108</td>
</tr>
<tr>
<td>109</td>
<td>56455.7499</td>
<td>0.0002</td>
<td>0.0035</td>
<td>97</td>
</tr>
<tr>
<td>110</td>
<td>56455.8079</td>
<td>0.0002</td>
<td>0.0031</td>
<td>114</td>
</tr>
<tr>
<td>111</td>
<td>56455.8665</td>
<td>0.0001</td>
<td>0.0033</td>
<td>113</td>
</tr>
<tr>
<td>112</td>
<td>56455.9241</td>
<td>0.0002</td>
<td>0.0025</td>
<td>113</td>
</tr>
<tr>
<td>116</td>
<td>56456.1595</td>
<td>0.0003</td>
<td>0.0044</td>
<td>651</td>
</tr>
<tr>
<td>122</td>
<td>56456.5059</td>
<td>0.0003</td>
<td>0.0005</td>
<td>181</td>
</tr>
<tr>
<td>123</td>
<td>56456.5645</td>
<td>0.0003</td>
<td>0.0006</td>
<td>101</td>
</tr>
<tr>
<td>124</td>
<td>56456.6218</td>
<td>0.0003</td>
<td>−0.0004</td>
<td>89</td>
</tr>
<tr>
<td>132</td>
<td>56457.0887</td>
<td>0.0002</td>
<td>−0.0007</td>
<td>238</td>
</tr>
<tr>
<td>133</td>
<td>56457.1520</td>
<td>0.0030</td>
<td>0.0043</td>
<td>183</td>
</tr>
<tr>
<td>134</td>
<td>56457.2050</td>
<td>0.0001</td>
<td>−0.0011</td>
<td>586</td>
</tr>
<tr>
<td>135</td>
<td>56457.2618</td>
<td>0.0001</td>
<td>−0.0027</td>
<td>566</td>
</tr>
<tr>
<td>136</td>
<td>56457.3217</td>
<td>0.0002</td>
<td>−0.0112</td>
<td>79</td>
</tr>
<tr>
<td>137</td>
<td>56457.3803</td>
<td>0.0003</td>
<td>−0.0010</td>
<td>192</td>
</tr>
<tr>
<td>138</td>
<td>56457.4391</td>
<td>0.0003</td>
<td>−0.0006</td>
<td>221</td>
</tr>
<tr>
<td>139</td>
<td>56457.4958</td>
<td>0.0002</td>
<td>−0.0022</td>
<td>303</td>
</tr>
<tr>
<td>140</td>
<td>56457.5550</td>
<td>0.0003</td>
<td>−0.0015</td>
<td>121</td>
</tr>
<tr>
<td>141</td>
<td>56457.6122</td>
<td>0.0002</td>
<td>−0.0026</td>
<td>105</td>
</tr>
<tr>
<td>143</td>
<td>56457.7287</td>
<td>0.0003</td>
<td>−0.0029</td>
<td>132</td>
</tr>
<tr>
<td>144</td>
<td>56457.7872</td>
<td>0.0002</td>
<td>−0.0028</td>
<td>156</td>
</tr>
<tr>
<td>145</td>
<td>56457.8430</td>
<td>0.0002</td>
<td>−0.0034</td>
<td>163</td>
</tr>
<tr>
<td>146</td>
<td>56457.9028</td>
<td>0.0002</td>
<td>−0.0040</td>
<td>124</td>
</tr>
<tr>
<td>150</td>
<td>56458.1365</td>
<td>0.0004</td>
<td>−0.0039</td>
<td>234</td>
</tr>
<tr>
<td>151</td>
<td>56458.1950</td>
<td>0.0004</td>
<td>−0.0037</td>
<td>394</td>
</tr>
<tr>
<td>152</td>
<td>56458.2567</td>
<td>0.0009</td>
<td>−0.0004</td>
<td>77</td>
</tr>
<tr>
<td>155</td>
<td>56458.4271</td>
<td>0.0003</td>
<td>−0.0052</td>
<td>44</td>
</tr>
<tr>
<td>156</td>
<td>56458.4866</td>
<td>0.0005</td>
<td>−0.0041</td>
<td>33</td>
</tr>
<tr>
<td>157</td>
<td>56458.5451</td>
<td>0.0003</td>
<td>−0.0039</td>
<td>66</td>
</tr>
<tr>
<td>161</td>
<td>56458.7791</td>
<td>0.0003</td>
<td>−0.0035</td>
<td>137</td>
</tr>
<tr>
<td>162</td>
<td>56458.8365</td>
<td>0.0003</td>
<td>−0.0045</td>
<td>183</td>
</tr>
<tr>
<td>163</td>
<td>56458.8933</td>
<td>0.0003</td>
<td>−0.0061</td>
<td>180</td>
</tr>
<tr>
<td>164</td>
<td>56458.9516</td>
<td>0.0003</td>
<td>−0.0062</td>
<td>98</td>
</tr>
</tbody>
</table>
In table 56 we summarize the past outbursts from the ASAS-3 data. Many of the detected outbursts were superoutbursts and the shortest interval between two superoutbursts was \( \sim 390 \) d.

### 3.56 TCP J23382254—2049518

This object (hereafter TCP J233822) was discovered to be a transient object by K. Itagaki on 2013 September 28 at an unfiltered CCD magnitude of 13.6. The object is identical with a blue SDSS object (\( g = 21.5, g - r = -0.2 \)) and a GALEX ultraviolet source, GALEX J233822.5—204951 (vsnet-alert 16468). The large outburst amplitude already suggested a WZ Sge-type dwarf nova.

![Downloaded from https://academic.oup.com/pasj/article-abstract/66/5/90/2588753 by guest on 30 November 2018](http://www.cbat.eps.harvard.edu/unconf/followups/J23382254-2049518.html)
Fig. 73. Ordinary superhumps in PNV J191501 (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

The object initially showed early superhumps (vsnet-alert 16486, 16489, 16496, 16528; figure 78). Twelve days after the discovery, the object started to show ordinary superhumps (vsnet-alert 16520, 16529, 16532, 16536; figure 79). The times of superhump maxima are listed in table 60, in which the stage A–B transition is clearly seen (also figure 80). For the epochs \( E \geq 222 \), there was some evidence that its period shortened. This part may correspond to stage C superhumps.

The fractional superhump excess (in frequency) for stage A superhumps was \( \varepsilon^* = 0.0231(14) \). This value corresponds to \( q = 0.061(4) \), suggesting that the object is near the period minimum or somewhat past the period minimum.

The object showed two post-superoutburst rebrightenings (figure 80). It is rare to observe multiple post-superoutburst rebrightenings in such a short-\( P_{\text{orb}} \) system (cf. Nakata et al. 2013b).

4 Discussion

We first report in this section general statistical properties of the sample together with the earlier sample the same as in Kato et al. (2014a), and then deal with new topics which arose in this paper.

4.1 Period derivatives during stage B

Figure 81 represents the updated relation between \( P_{\text{dot}} \) during stage B and \( P_{\text{orb}} \). Most of the objects with \( P_{\text{orb}} < 0.085 \text{ d} \) followed the general trend reported in Kato et al. (2013b). Some objects with \( P_{\text{orb}} \) longer than 0.085 d show a negative \( P_{\text{dot}} \), while some others show a large positive \( P_{\text{dot}} \) (as we see in subsection 4.7, some of them may have been contaminated by stage A superhumps). We could add a new sample, MASTER J162323, to the latter group. We can say that most of objects \( P_{\text{orb}} < 0.080 \text{ d} \) have a positive \( P_{\text{dot}} \) during stage B.

4.2 Mass ratios from stage A superhumps

It has been proposed that the binary’s mass ratio superhumps can be estimated from the stage A superhumps, which are considered to reflect the dynamical precession rate at the radius of the 3:1 resonance (Kato & Osaki 2013b). Stage A superhumps recorded in the present study are listed in table 61. In table 62, we list the new estimates of mass ratios from this paper. An updated summary of \( q \) estimates is shown in figure 82, in which measurements in Nakata et al. (2013b) are also included. The Kepler DNe shown in this figure are V516 Lyr (Kato & Osaki 2013a), KIC 7524178 (Kato & Osaki 2013c), and the unusual short-\( P_{\text{orb}} \) object GALEX J194419.33+491257.0 in the field of KIC 11412044 (Kato & Osaki 2014)—located at \( P_{\text{orb}}=0.05282 \text{ d}, q = 0.14 \).

4.3 WZ Sge-type stars

The WZ Sge-type dwarf novae in this study are listed in table 63. In figure 83, we show the relation between \( P_{\text{dot}} \) and \( P_{\text{orb}} \) for the entire set of WZ Sge-type dwarf novae. This figure is an updated version of figure 86 of Kato et al. (2014a). We use here the types of superoutburst in terms of rebrightenings as introduced in Imada et al. (2006) and Kato et al. (2009): type-A outburst (a long-duration rebrightening), type-B outburst (multiple discrete rebrightenings), type-C outburst (a single rebrightening), and type-D outburst (no rebrightening) (see, e.g., figure 35 in Kato et al. 2009). The type-E outburst (superoutburst with early superhumps and another superoutburst with ordinary superhumps) has been introduced since Kato et al. (2014a). The new data have confirmed the trend that each subtype of rebrightening pattern appears in a cluster in this diagram. Objects with type-B outburst have a high concentration around \( P_{\text{orb}} = 0.060 \text{ d} \). Nakata et al. (2013b) indicated that at least two objects with type-B outburst are not period bouncers but lie on the ordinary track of CV evolution before the period minimum. If this interpretation is

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C1</th>
<th>N1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56471.7401</td>
<td>0.0018</td>
<td>−0.0068</td>
<td>185</td>
</tr>
<tr>
<td>1</td>
<td>56471.8019</td>
<td>0.0026</td>
<td>−0.0030</td>
<td>210</td>
</tr>
<tr>
<td>7</td>
<td>56472.1209</td>
<td>0.0024</td>
<td>−0.0322</td>
<td>61</td>
</tr>
<tr>
<td>8</td>
<td>56472.1853</td>
<td>0.0086</td>
<td>−0.0258</td>
<td>62</td>
</tr>
<tr>
<td>9</td>
<td>56472.2412</td>
<td>0.0021</td>
<td>−0.0280</td>
<td>62</td>
</tr>
<tr>
<td>10</td>
<td>56472.2953</td>
<td>0.0011</td>
<td>−0.0319</td>
<td>77</td>
</tr>
<tr>
<td>16</td>
<td>56472.6877</td>
<td>0.0090</td>
<td>0.0124</td>
<td>23</td>
</tr>
<tr>
<td>17</td>
<td>56472.7242</td>
<td>0.0029</td>
<td>−0.0991</td>
<td>84</td>
</tr>
<tr>
<td>18</td>
<td>56472.7908</td>
<td>0.0019</td>
<td>−0.0005</td>
<td>224</td>
</tr>
<tr>
<td>19</td>
<td>56472.8465</td>
<td>0.0006</td>
<td>−0.0292</td>
<td>202</td>
</tr>
<tr>
<td>24</td>
<td>56473.1319</td>
<td>0.0020</td>
<td>−0.0076</td>
<td>59</td>
</tr>
<tr>
<td>25</td>
<td>56473.1993</td>
<td>0.0004</td>
<td>0.0018</td>
<td>123</td>
</tr>
<tr>
<td>26</td>
<td>56473.2578</td>
<td>0.0008</td>
<td>0.0023</td>
<td>119</td>
</tr>
<tr>
<td>32</td>
<td>56473.6053</td>
<td>0.0069</td>
<td>0.0017</td>
<td>27</td>
</tr>
<tr>
<td>33</td>
<td>56473.6628</td>
<td>0.0014</td>
<td>0.0012</td>
<td>50</td>
</tr>
<tr>
<td>34</td>
<td>56473.7212</td>
<td>0.0013</td>
<td>0.0015</td>
<td>56</td>
</tr>
<tr>
<td>35</td>
<td>56473.7793</td>
<td>0.0004</td>
<td>0.0016</td>
<td>125</td>
</tr>
<tr>
<td>46</td>
<td>56474.4220</td>
<td>0.0005</td>
<td>0.0061</td>
<td>84</td>
</tr>
<tr>
<td>47</td>
<td>56474.4768</td>
<td>0.0006</td>
<td>0.0028</td>
<td>104</td>
</tr>
<tr>
<td>48</td>
<td>56474.5360</td>
<td>0.0004</td>
<td>0.0041</td>
<td>108</td>
</tr>
<tr>
<td>49</td>
<td>56474.5906</td>
<td>0.0009</td>
<td>0.0006</td>
<td>116</td>
</tr>
<tr>
<td>50</td>
<td>56474.6537</td>
<td>0.0022</td>
<td>0.0057</td>
<td>86</td>
</tr>
<tr>
<td>51</td>
<td>56474.7087</td>
<td>0.0006</td>
<td>0.0027</td>
<td>104</td>
</tr>
<tr>
<td>52</td>
<td>56474.7671</td>
<td>0.0004</td>
<td>0.0031</td>
<td>161</td>
</tr>
<tr>
<td>54</td>
<td>56474.8831</td>
<td>0.0004</td>
<td>0.0030</td>
<td>184</td>
</tr>
<tr>
<td>63</td>
<td>56475.4060</td>
<td>0.0006</td>
<td>0.0038</td>
<td>28</td>
</tr>
<tr>
<td>64</td>
<td>56475.4634</td>
<td>0.0003</td>
<td>0.0031</td>
<td>77</td>
</tr>
<tr>
<td>65</td>
<td>56475.5192</td>
<td>0.0004</td>
<td>0.0009</td>
<td>65</td>
</tr>
<tr>
<td>67</td>
<td>56475.6335</td>
<td>0.0044</td>
<td>−0.0009</td>
<td>20</td>
</tr>
<tr>
<td>68</td>
<td>56475.6953</td>
<td>0.0015</td>
<td>0.0030</td>
<td>51</td>
</tr>
<tr>
<td>69</td>
<td>56475.7551</td>
<td>0.0006</td>
<td>0.0047</td>
<td>103</td>
</tr>
<tr>
<td>70</td>
<td>56475.8115</td>
<td>0.0004</td>
<td>0.0030</td>
<td>133</td>
</tr>
<tr>
<td>71</td>
<td>56475.8702</td>
<td>0.0003</td>
<td>0.0037</td>
<td>138</td>
</tr>
<tr>
<td>80</td>
<td>56476.3910</td>
<td>0.0013</td>
<td>0.0024</td>
<td>20</td>
</tr>
<tr>
<td>81</td>
<td>56476.4493</td>
<td>0.0004</td>
<td>0.0027</td>
<td>63</td>
</tr>
<tr>
<td>82</td>
<td>56476.5068</td>
<td>0.0005</td>
<td>0.0022</td>
<td>54</td>
</tr>
<tr>
<td>85</td>
<td>56476.6795</td>
<td>0.0015</td>
<td>0.0008</td>
<td>18</td>
</tr>
<tr>
<td>86</td>
<td>56476.7401</td>
<td>0.0005</td>
<td>0.0034</td>
<td>73</td>
</tr>
<tr>
<td>87</td>
<td>56476.7928</td>
<td>0.0008</td>
<td>−0.0020</td>
<td>135</td>
</tr>
<tr>
<td>88</td>
<td>56476.8527</td>
<td>0.0009</td>
<td>−0.0000</td>
<td>128</td>
</tr>
<tr>
<td>97</td>
<td>56477.3801</td>
<td>0.0007</td>
<td>0.0052</td>
<td>42</td>
</tr>
<tr>
<td>98</td>
<td>56477.4338</td>
<td>0.0005</td>
<td>0.0008</td>
<td>63</td>
</tr>
<tr>
<td>99</td>
<td>56477.4919</td>
<td>0.0014</td>
<td>0.0009</td>
<td>69</td>
</tr>
<tr>
<td>100</td>
<td>56477.5498</td>
<td>0.0004</td>
<td>0.0008</td>
<td>45</td>
</tr>
<tr>
<td>101</td>
<td>56477.6096</td>
<td>0.0006</td>
<td>0.0026</td>
<td>62</td>
</tr>
<tr>
<td>102</td>
<td>56477.6669</td>
<td>0.0003</td>
<td>0.0018</td>
<td>95</td>
</tr>
<tr>
<td>103</td>
<td>56477.7214</td>
<td>0.0009</td>
<td>−0.0017</td>
<td>125</td>
</tr>
<tr>
<td>104</td>
<td>56477.7859</td>
<td>0.0005</td>
<td>0.0048</td>
<td>97</td>
</tr>
<tr>
<td>109</td>
<td>56478.0779</td>
<td>0.0013</td>
<td>0.0066</td>
<td>44</td>
</tr>
<tr>
<td>110</td>
<td>56478.1357</td>
<td>0.0009</td>
<td>0.0064</td>
<td>60</td>
</tr>
<tr>
<td>111</td>
<td>56478.1905</td>
<td>0.0006</td>
<td>0.0032</td>
<td>62</td>
</tr>
<tr>
<td>112</td>
<td>56478.2476</td>
<td>0.0008</td>
<td>0.0023</td>
<td>63</td>
</tr>
<tr>
<td>113</td>
<td>56478.3054</td>
<td>0.0007</td>
<td>0.0021</td>
<td>62</td>
</tr>
</tbody>
</table>
4.4 A comparison between periods of early superhumps and orbital periods

Although early superhumps have been reported (e.g., Kato et al. 1996b, 2001a; Patterson et al. 1996, 2002; Ishioka et al. 2002; Kato 2002) as double-wave modulations having a period very close to the orbital period, there has been no summary of comparisons between the period of early superhumps and the orbital period. We therefore make a study of the WZ Sge-type dwarf novae with a well-established orbital period.

The periods of early superhumps of AL Com (2001) and HV Vir (2008) were estimated from the data in Ishioka et al. (2002) and Kato et al. (2009), respectively. The orbital period of BW Scl has been refined by using quiescent observations (B. Monard, F.-J. Hambsch, P. Starr, and AAVSO data during the period from 2004 September to 2013 September, 14070 measurements). The orbital period of EZ Lyn is a revised one by using post-superoutburst eclipses reported in Kato et al. (2012b). The orbital period of AL Com is an updated one using observations of early superhumps in three superoutbursts (subsection 3.11).

The result is summarized in table 64. Although all the objects showed statistically significant negative $\varepsilon$ for early
Fig. 75. Possible early superhumps in PNV J191501 (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

Fig. 76. Lasso analysis of PNV J191501 (2013). Upper: Light curve. The data were binned to 0.02 d. Middle: First overtones of the superhump and possible orbital signals. Lower: Fundamentals of the superhump and the possible orbital signal. The orbital signal was present only in the initial part of the outburst. The signal of (positive) superhumps with variable frequency was recorded during the superoutburst plateau and post-superoutburst stage. No indication of negative superhump was present. The parameter $\log \lambda = -8.0$ was used. The width of the sliding window and the time step used are 10 d and 0.5 d, respectively.

Fig. 77. Superhumps in SSS J094327 (2014). Upper: PDM analysis. Lower: Phase-averaged profile.

Table 58. Outbursts of SSS J094327.

<table>
<thead>
<tr>
<th>JD−2400000</th>
<th>Maximum (V)</th>
<th>Duration</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>51926</td>
<td>13.1</td>
<td>12</td>
<td>Super</td>
</tr>
<tr>
<td>52440</td>
<td>12.8</td>
<td>&gt;3</td>
<td>Super?</td>
</tr>
<tr>
<td>53005</td>
<td>13.8</td>
<td>1*</td>
<td>Normal?</td>
</tr>
<tr>
<td>53385</td>
<td>12.8</td>
<td>11</td>
<td>Super</td>
</tr>
<tr>
<td>53776</td>
<td>13.0</td>
<td>&gt;7</td>
<td>Super</td>
</tr>
<tr>
<td>54182</td>
<td>13.1</td>
<td>&gt;8</td>
<td>Super</td>
</tr>
<tr>
<td>54667</td>
<td>13.6</td>
<td>2</td>
<td>Normal</td>
</tr>
<tr>
<td>54796</td>
<td>13.3</td>
<td>1*</td>
<td>Normal?</td>
</tr>
</tbody>
</table>

*Single detection.

Superhumps, the period deficit is very small (of the order of 0.05%). This result has confirmed the finding in Ishioka et al. (2002). Since the period deficit is very small, the period of early superhumps can be considered as the orbital period with accuracy of 0.1%. If more accuracy is needed and the orbital period is not known, we propose to estimate the orbital period by assuming $\varepsilon$ of $-0.05\%$.

4.5 Eclipses during the phase of early superhumps

In the light curve of early superhumps in MASTER J005740 (figure 55), there are sharp structures (kinks in the light

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56689.0954</td>
<td>0.0013</td>
<td>−0.0073</td>
<td>123</td>
</tr>
<tr>
<td>1</td>
<td>56689.1697</td>
<td>0.0010</td>
<td>−0.0036</td>
<td>112</td>
</tr>
<tr>
<td>14</td>
<td>56690.0889</td>
<td>0.0003</td>
<td>0.0000</td>
<td>140</td>
</tr>
<tr>
<td>15</td>
<td>56690.1581</td>
<td>0.0003</td>
<td>−0.0012</td>
<td>142</td>
</tr>
<tr>
<td>16</td>
<td>56690.2310</td>
<td>0.0003</td>
<td>0.0012</td>
<td>142</td>
</tr>
<tr>
<td>17</td>
<td>56690.3007</td>
<td>0.0003</td>
<td>0.0005</td>
<td>140</td>
</tr>
<tr>
<td>18</td>
<td>56690.3716</td>
<td>0.0005</td>
<td>0.0009</td>
<td>81</td>
</tr>
<tr>
<td>28</td>
<td>56691.0753</td>
<td>0.0004</td>
<td>0.0002</td>
<td>136</td>
</tr>
<tr>
<td>29</td>
<td>56691.1462</td>
<td>0.0003</td>
<td>0.0006</td>
<td>141</td>
</tr>
<tr>
<td>43</td>
<td>56692.1327</td>
<td>0.0003</td>
<td>0.0010</td>
<td>142</td>
</tr>
<tr>
<td>44</td>
<td>56692.2032</td>
<td>0.0005</td>
<td>0.0010</td>
<td>142</td>
</tr>
<tr>
<td>45</td>
<td>56692.2741</td>
<td>0.0004</td>
<td>0.0015</td>
<td>141</td>
</tr>
<tr>
<td>46</td>
<td>56692.3434</td>
<td>0.0005</td>
<td>0.0004</td>
<td>138</td>
</tr>
<tr>
<td>50</td>
<td>56692.6270</td>
<td>0.0009</td>
<td>0.0023</td>
<td>22</td>
</tr>
<tr>
<td>51</td>
<td>56692.6971</td>
<td>0.0007</td>
<td>0.0019</td>
<td>24</td>
</tr>
<tr>
<td>52</td>
<td>56692.7674</td>
<td>0.0009</td>
<td>0.0018</td>
<td>19</td>
</tr>
<tr>
<td>53</td>
<td>56692.8385</td>
<td>0.0015</td>
<td>0.0024</td>
<td>22</td>
</tr>
<tr>
<td>57</td>
<td>56693.1213</td>
<td>0.0006</td>
<td>0.0035</td>
<td>142</td>
</tr>
<tr>
<td>58</td>
<td>56693.1913</td>
<td>0.0006</td>
<td>0.0030</td>
<td>143</td>
</tr>
<tr>
<td>59</td>
<td>56693.2610</td>
<td>0.0010</td>
<td>0.0022</td>
<td>141</td>
</tr>
<tr>
<td>60</td>
<td>56693.3325</td>
<td>0.0006</td>
<td>0.0034</td>
<td>132</td>
</tr>
<tr>
<td>65</td>
<td>56693.6825</td>
<td>0.0009</td>
<td>0.0012</td>
<td>23</td>
</tr>
<tr>
<td>66</td>
<td>56693.7536</td>
<td>0.0009</td>
<td>0.0018</td>
<td>19</td>
</tr>
<tr>
<td>72</td>
<td>56694.1758</td>
<td>0.0031</td>
<td>0.0014</td>
<td>76</td>
</tr>
<tr>
<td>78</td>
<td>56694.5904</td>
<td>0.0032</td>
<td>−0.0067</td>
<td>11</td>
</tr>
<tr>
<td>79</td>
<td>56694.6640</td>
<td>0.0011</td>
<td>−0.0036</td>
<td>23</td>
</tr>
<tr>
<td>80</td>
<td>56694.7388</td>
<td>0.0013</td>
<td>0.0008</td>
<td>20</td>
</tr>
<tr>
<td>81</td>
<td>56694.8097</td>
<td>0.0016</td>
<td>0.0013</td>
<td>21</td>
</tr>
<tr>
<td>82</td>
<td>56694.8773</td>
<td>0.0021</td>
<td>−0.0016</td>
<td>16</td>
</tr>
<tr>
<td>85</td>
<td>56695.0884</td>
<td>0.0012</td>
<td>−0.0018</td>
<td>137</td>
</tr>
<tr>
<td>86</td>
<td>56695.1567</td>
<td>0.0012</td>
<td>−0.0039</td>
<td>141</td>
</tr>
<tr>
<td>87</td>
<td>56695.2272</td>
<td>0.0011</td>
<td>−0.0038</td>
<td>142</td>
</tr>
<tr>
<td>88</td>
<td>56695.3007</td>
<td>0.0016</td>
<td>−0.0008</td>
<td>78</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456689.1028 + 0.070440 E.
‡Number of points used to determine the maximum.

curve) around orbital phases of −0.15 and 0.15. They suggest that the phases between −0.15 and 0.15 were affected by the eclipse. We can propose a hypothetical uneclipsed hump structure (assuming that larger and smaller humps are separated equally) as the dashed line in figure 55.

It has been a mystery why eclipses are not evident during the stage of early superhumps in such a high-inclination system as WZ Sge (Patterson et al. 2002), despite the fact that eclipses appear more strongly after the appearance of ordinary superhumps. While Patterson et al. (2002) suggested the enhanced hot spot as the origin of eclipses during the phase of ordinary superhumps, Osaki and Meyer (2003) suggested that what is eclipsed is the superhump light source rather than the enhanced hot spot. In the interpretation of Osaki and Meyer (2003), the source of early superhumps, which Osaki and Meyer (2002) interpret as the two-armed

Fig. 78. Early superhumps in TCP J233822 (2013). Upper: PDM analysis. Lower: Phase-averaged profile.

Fig. 79. Ordinary superhumps in TCP J233822 (2013). The data of BJD 2456577.6–2456593 was used. Upper: PDM analysis. Lower: Phase-averaged profile.
Table 60. Superhump maxima of TCP J233822 (2013).

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>56575.7668</td>
<td>0.0016</td>
<td>−0.0178</td>
<td>28</td>
</tr>
<tr>
<td>15</td>
<td>56576.6453</td>
<td>0.0017</td>
<td>−0.0079</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>56576.7008</td>
<td>0.0017</td>
<td>−0.0103</td>
<td>15</td>
</tr>
<tr>
<td>17</td>
<td>56576.7607</td>
<td>0.0010</td>
<td>−0.0083</td>
<td>28</td>
</tr>
<tr>
<td>22</td>
<td>56577.0364</td>
<td>0.0007</td>
<td>−0.0023</td>
<td>28</td>
</tr>
<tr>
<td>23</td>
<td>56577.1140</td>
<td>0.0009</td>
<td>−0.0026</td>
<td>37</td>
</tr>
<tr>
<td>24</td>
<td>56577.1786</td>
<td>0.0028</td>
<td>0.0041</td>
<td>15</td>
</tr>
<tr>
<td>32</td>
<td>56577.6414</td>
<td>0.0006</td>
<td>0.0037</td>
<td>13</td>
</tr>
<tr>
<td>33</td>
<td>56577.6995</td>
<td>0.0007</td>
<td>0.0038</td>
<td>14</td>
</tr>
<tr>
<td>34</td>
<td>56577.7575</td>
<td>0.0005</td>
<td>0.0039</td>
<td>27</td>
</tr>
<tr>
<td>39</td>
<td>56578.0499</td>
<td>0.0008</td>
<td>0.0068</td>
<td>20</td>
</tr>
<tr>
<td>50</td>
<td>56578.6861</td>
<td>0.0008</td>
<td>0.0058</td>
<td>18</td>
</tr>
<tr>
<td>51</td>
<td>56578.7437</td>
<td>0.0006</td>
<td>0.0056</td>
<td>25</td>
</tr>
<tr>
<td>60</td>
<td>56579.2642</td>
<td>0.0004</td>
<td>0.0048</td>
<td>124</td>
</tr>
<tr>
<td>61</td>
<td>56579.3229</td>
<td>0.0006</td>
<td>0.0056</td>
<td>123</td>
</tr>
<tr>
<td>62</td>
<td>56579.3795</td>
<td>0.0004</td>
<td>0.0043</td>
<td>133</td>
</tr>
<tr>
<td>63</td>
<td>56579.4388</td>
<td>0.0007</td>
<td>0.0057</td>
<td>134</td>
</tr>
<tr>
<td>64</td>
<td>56579.4949</td>
<td>0.0008</td>
<td>0.0039</td>
<td>133</td>
</tr>
<tr>
<td>65</td>
<td>56579.5320</td>
<td>0.0007</td>
<td>0.0030</td>
<td>133</td>
</tr>
<tr>
<td>86</td>
<td>56580.7644</td>
<td>0.0017</td>
<td>−0.0007</td>
<td>30</td>
</tr>
<tr>
<td>91</td>
<td>56581.0576</td>
<td>0.0007</td>
<td>0.0030</td>
<td>11</td>
</tr>
<tr>
<td>92</td>
<td>56581.1159</td>
<td>0.0010</td>
<td>0.0034</td>
<td>15</td>
</tr>
<tr>
<td>101</td>
<td>56581.6412</td>
<td>0.0022</td>
<td>0.0074</td>
<td>13</td>
</tr>
<tr>
<td>102</td>
<td>56581.6880</td>
<td>0.0021</td>
<td>−0.0037</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E</th>
<th>Max*</th>
<th>Error</th>
<th>O − C†</th>
<th>N‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>56581.7476</td>
<td>0.0011</td>
<td>−0.0020</td>
<td>28</td>
</tr>
<tr>
<td>118</td>
<td>56582.6154</td>
<td>0.0063</td>
<td>−0.0029</td>
<td>12</td>
</tr>
<tr>
<td>119</td>
<td>56582.6782</td>
<td>0.0017</td>
<td>0.0020</td>
<td>13</td>
</tr>
<tr>
<td>120</td>
<td>56582.7293</td>
<td>0.0014</td>
<td>−0.0048</td>
<td>21</td>
</tr>
<tr>
<td>133</td>
<td>56584.6426</td>
<td>0.0024</td>
<td>−0.0027</td>
<td>19</td>
</tr>
<tr>
<td>134</td>
<td>56584.7083</td>
<td>0.0028</td>
<td>0.0051</td>
<td>29</td>
</tr>
<tr>
<td>135</td>
<td>56584.7562</td>
<td>0.0013</td>
<td>−0.0049</td>
<td>72</td>
</tr>
<tr>
<td>139</td>
<td>56584.9939</td>
<td>0.0022</td>
<td>0.0012</td>
<td>12</td>
</tr>
<tr>
<td>160</td>
<td>56585.0535</td>
<td>0.0022</td>
<td>0.0029</td>
<td>15</td>
</tr>
<tr>
<td>161</td>
<td>56585.1065</td>
<td>0.0045</td>
<td>−0.0021</td>
<td>11</td>
</tr>
<tr>
<td>162</td>
<td>56585.1671</td>
<td>0.0027</td>
<td>0.0006</td>
<td>15</td>
</tr>
<tr>
<td>170</td>
<td>56585.6263</td>
<td>0.0024</td>
<td>−0.0035</td>
<td>15</td>
</tr>
<tr>
<td>172</td>
<td>56585.7438</td>
<td>0.0015</td>
<td>−0.0018</td>
<td>31</td>
</tr>
<tr>
<td>187</td>
<td>56586.6078</td>
<td>0.0019</td>
<td>−0.0065</td>
<td>14</td>
</tr>
<tr>
<td>188</td>
<td>56586.6706</td>
<td>0.0023</td>
<td>−0.0017</td>
<td>13</td>
</tr>
<tr>
<td>189</td>
<td>56586.7244</td>
<td>0.0017</td>
<td>−0.0058</td>
<td>22</td>
</tr>
<tr>
<td>206</td>
<td>56587.8241</td>
<td>0.0030</td>
<td>0.0094</td>
<td>23</td>
</tr>
<tr>
<td>222</td>
<td>56588.6437</td>
<td>0.0016</td>
<td>0.0024</td>
<td>13</td>
</tr>
<tr>
<td>223</td>
<td>56588.6979</td>
<td>0.0028</td>
<td>−0.0013</td>
<td>17</td>
</tr>
<tr>
<td>224</td>
<td>56588.7606</td>
<td>0.0019</td>
<td>0.0034</td>
<td>19</td>
</tr>
<tr>
<td>233</td>
<td>56589.2765</td>
<td>0.0027</td>
<td>−0.0018</td>
<td>133</td>
</tr>
<tr>
<td>234</td>
<td>56589.3336</td>
<td>0.0016</td>
<td>−0.0027</td>
<td>134</td>
</tr>
<tr>
<td>235</td>
<td>56589.3905</td>
<td>0.0024</td>
<td>−0.0037</td>
<td>132</td>
</tr>
</tbody>
</table>

*BJD − 2400000.
†Against max = 2456575.7845 + 0.057913 E.
‡Number of points used to determine the maximum.

Fig. 80. O − C diagram of superhumps in TCP J233822 (2013). Upper: O − C diagram. A period of 0.057913 d was used for drawing this figure. Lower: Light curve. The observations were binned to 0.011 d.

dissipation pattern of the 2:1 Lindblad resonance, cannot be eclipsed because this pattern is located azimuthally far away from the secondary star. The present observation indicates that the broad eclipse was located close to the expected eclipse center, which suggests that (the axisymmetric component of) the bright disk, rather than the enhanced hot spot, is eclipsed. This picture smoothly fits in with the interpretation by Osaki and Meyer (2003), and the mystery of the apparent absence of the eclipse during the phase of early superhumps is solved.

In Uemura et al. (2012), the eclipse of the disk was considered in the model. This effect, however, was not so large in the model parameters of V455 And, which apparently has a lower inclination than MASTER J005740, and it was difficult to distinguish its effect from the un eclipsed light curve of early superhumps. Our new observation in a system of higher inclination now presents more convincing evidence against the greatly increased mass-transfer in the WZ Sge-type outburst.

4.6 Model of the eclipse during early superhumps

We further studied whether or not a simple model can reproduce the depth of the eclipse in MASTER J005740 during the phase of early superhumps. We adopted \( q = 0.076 \) from our measurement using stage A superhumps (it is well known that there is a strong relation in modeling the eclipse light curve between its \( q \) and inclination, and the
Fig. 81. $P_\text{dot}$ for stage B versus $P_{\text{orb}}$. The filled circles, filled diamonds, filled triangles, filled squares, filled lower-pointed triangles, and filled stars represent samples in Kato et al. (2009, 2010, 2012b, 2013b, 2014a), and this paper, respectively. The curve represents the spline-smoothed global trend.

Table 61. New estimates for the binary’s mass ratio from stage A superhumps.

<table>
<thead>
<tr>
<th>Object</th>
<th>$e^\ast$(stage A)</th>
<th>$q$ from stage A</th>
</tr>
</thead>
<tbody>
<tr>
<td>GZ Cnc</td>
<td>0.089(7)</td>
<td>0.30(2)</td>
</tr>
<tr>
<td>MN Dra (2012, 2013)</td>
<td>0.078, 0.092</td>
<td>0.29(5)</td>
</tr>
<tr>
<td>DT Oct</td>
<td>0.050(2)</td>
<td>0.147(7)</td>
</tr>
<tr>
<td>MASTER J005740</td>
<td>0.028(5)</td>
<td>0.076(16)</td>
</tr>
<tr>
<td>PNV J191501</td>
<td>0.0344(12)</td>
<td>0.095(4)</td>
</tr>
<tr>
<td>TCP J233822</td>
<td>0.0231(14)</td>
<td>0.061(4)</td>
</tr>
</tbody>
</table>

Table 62. Superhump periods during stage A.

<table>
<thead>
<tr>
<th>Object</th>
<th>Year</th>
<th>Period (d)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>UZ Boo</td>
<td>2013</td>
<td>0.06210</td>
<td>0.00005</td>
</tr>
<tr>
<td>GZ Cnc</td>
<td>2014</td>
<td>0.09690</td>
<td>0.00030</td>
</tr>
<tr>
<td>AL Com</td>
<td>2013</td>
<td>0.05859</td>
<td>0.00009</td>
</tr>
<tr>
<td>MN Dra</td>
<td>2012</td>
<td>0.10993</td>
<td>0.00009</td>
</tr>
<tr>
<td>DT Oct</td>
<td>2014</td>
<td>0.07271</td>
<td>—</td>
</tr>
<tr>
<td>ASASSN-13ck</td>
<td>2013</td>
<td>0.05700</td>
<td>0.00010</td>
</tr>
<tr>
<td>ASASSN-14ac</td>
<td>2014</td>
<td>0.05952</td>
<td>0.00003</td>
</tr>
<tr>
<td>MASTER J004527</td>
<td>2013</td>
<td>0.08210</td>
<td>0.00035</td>
</tr>
<tr>
<td>MASTER J005740</td>
<td>2013</td>
<td>0.05783</td>
<td>0.00034</td>
</tr>
<tr>
<td>MASTER J162323</td>
<td>2013</td>
<td>0.09134</td>
<td>0.00055</td>
</tr>
<tr>
<td>PNV J191501</td>
<td>2013</td>
<td>0.05909</td>
<td>0.00008</td>
</tr>
<tr>
<td>TCP J233822</td>
<td>2013</td>
<td>0.05861</td>
<td>0.00008</td>
</tr>
</tbody>
</table>

The uncertainty in $q$ can be reasonably neglected by allowing a free selection of the inclination. We assumed that the disk radius is the radius of the 2:1 resonance (0.615 $A$ in the case of $q = 0.076$). We assumed flat and axisymmetric geometry and a standard disk having a surface luminosity with a radial dependence $\propto r^{-3/4}$ (assuming that we observed the Rayleigh–Jeans tail of the emission from the hot disk). Although all of these assumptions are rough, they will not seriously affect the results. We constructed the eclipse light curve using the Roche geometry. We could reproduce the eclipse depth of 0.16 mag from the assumed secondary maximum of early superhumps and the bottom of the eclipse (as seen from figure 55) by assuming an inclination of $81.5\pm 0.5$. The total duration of the eclipse was 0.28 binary phase, which is in agreement with the observation. Under these parameters, the white dwarf is marginally eclipsed, which is also in agreement with the observational suggestion.

The model light curve is shown in figure 84. In this model, it is assumed that the standard disk is eclipsed by the secondary and the light source of early superhumps is simply added to the light curve (i.e., we assume that the light source of early superhumps is not eclipsed). The two maxima of early superhumps are approximated by...
sine curves having different amplitudes (the secondary maximum is assumed to have a half amplitude of the primary maximum). The resultant light curve appears to well reproduce the basic characteristics of the observation (figure 55). The sharp minimum around a phase of 0.0 reflects the eclipse of the central part of the disk; the less clear appearance of this feature in observations may have been the result of the self-obscuration of the central part of the disk.

4.7 Stage A superhumps in long-period systems

In subsections 3.14 and 3.10, likely stage A superhumps were detected in the long-\(P_{orb}\) systems MN Dra and GZ Cnc. The identification of stage A superhumps in the former system is almost certain because growing amplitudes of the superhumps were detected.

This finding appears to contradict the earlier interpretation that stage A superhumps reflecting the radius of the
3:1 resonance in high-\(q\) systems are difficult of detection because the tidal effect is stronger in higher-\(q\) systems and their eccentric region spreads more quickly than in low-\(q\) systems (Kato & Osaki 2013b). In MN Dra and GZ Cnc, however, the \(q\) values are probably critically close to the condition in which the 3:1 resonance occurs, and the resonance may be weak enough to be confined to the radius of the 3:1 resonance for a longer time than in ordinary SU UMa-type dwarf novae. This possibility needs to be studied further. Although some of the objects recorded in our past study with a long \(P_{\text{orb}}\) and large negative \(P_{\text{dot}}\) may have been similar ones, we could not find as convincing a case as MN Dra. Since almost all of these systems lack determination of the orbital period, future measurements of the orbital periods may provide a clue to interpreting this phenomenon.

### Table 64. Periods of early superhumps.

<table>
<thead>
<tr>
<th>Object</th>
<th>(P_{\text{orb}}) (d)</th>
<th>(P_{\text{ESH}}) (d)(^*)</th>
<th>(\varepsilon_{\text{ESH}})(^\dagger)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>V455 And (2007)</td>
<td>0.05630921(1)</td>
<td>0.0562675(18)</td>
<td>−0.00074(3)</td>
<td>Kato et al. (2009)</td>
</tr>
<tr>
<td>AL Com (1995)</td>
<td>0.056668589(9)</td>
<td>0.05666(2)</td>
<td>−0.0002(4)</td>
<td>this work; Kato et al. (1996b)</td>
</tr>
<tr>
<td>AL Com (2001)</td>
<td>0.056668589(9)</td>
<td>0.056660(4)</td>
<td>−0.00015(7)</td>
<td>this work</td>
</tr>
<tr>
<td>AL Com (2013)</td>
<td>0.056668589(9)</td>
<td>0.056660(8)</td>
<td>−0.00015(14)</td>
<td>this work</td>
</tr>
<tr>
<td>EZ Lyn (2010)</td>
<td>0.05900495(3)</td>
<td>0.058973(6)</td>
<td>−0.00054(10)</td>
<td>Kato et al. (2012b)</td>
</tr>
<tr>
<td>BW Scl (2011)</td>
<td>0.05432391(1)</td>
<td>0.054308(2)</td>
<td>−0.00029(4)</td>
<td>this work; Kato et al. (2013b)</td>
</tr>
<tr>
<td>WZ Sge (2001)</td>
<td>0.056687846(3)</td>
<td>0.056656(2)</td>
<td>−0.000357(4)</td>
<td>Patterson et al. (2002); Ishioka et al. (2002).</td>
</tr>
<tr>
<td>HV Vir (1992)</td>
<td>0.057069(6)</td>
<td>0.05698(8)</td>
<td>−0.0016(14)</td>
<td>Patterson et al. (2003); Kato et al. (2001a)</td>
</tr>
<tr>
<td>HV Vir (2008)</td>
<td>0.057069(6)</td>
<td>0.056991(7)</td>
<td>−0.0014(1)</td>
<td>this work</td>
</tr>
<tr>
<td>MASTER J005740 (2013)</td>
<td>0.0561904(3)</td>
<td>0.056169(3)</td>
<td>−0.0038(5)</td>
<td>this work</td>
</tr>
</tbody>
</table>

\(^*\) Period of early superhumps.

\(^\dagger\) Fractional excess of early superhumps.
Fig. 84. Model light curve of the early superhump and eclipse of MASTER J005740.

Table 65. Period of negative superhumps in VW Hyi (2012).

<table>
<thead>
<tr>
<th>JD$^{*}$−2400000</th>
<th>Period (d)</th>
<th>Error (d)</th>
<th>Amplitude (mag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56229–56239</td>
<td>0.07252</td>
<td>0.00003</td>
<td>0.05</td>
</tr>
<tr>
<td>56240–56254</td>
<td>0.07266</td>
<td>0.00002</td>
<td>0.04</td>
</tr>
<tr>
<td>56269–56279</td>
<td>0.07261</td>
<td>0.00003</td>
<td>0.10</td>
</tr>
<tr>
<td>56285–56302</td>
<td>0.07279</td>
<td>0.00003</td>
<td>0.07</td>
</tr>
<tr>
<td>56305–56327</td>
<td>0.07275</td>
<td>0.00002</td>
<td>0.07</td>
</tr>
<tr>
<td>56339–56361</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>56365–56374</td>
<td>0.07271</td>
<td>0.00005</td>
<td>0.05</td>
</tr>
</tbody>
</table>

$^{*}$Julian day number.

4.8 Negative superhumps in VW Hydri

In a recent series of papers (Osaki & Kato 2013a, 2013b, 2014), it has been demonstrated by using the Kepler data that the state with negative superhumps tends to suppress normal outbursts in V1504 Cyg and V344 Lyr. The same phenomenon is also reported in ER UMa (Ohshima et al. 2012, 2014; Zemko et al. 2013). This phenomenon has been interpreted as a result of the decreased mass supply to the outermost part of the accretion disk when the disk is tilted, thereby reducing the occurrence of thermal instability in the outer part of the disk (Osaki & Kato 2013a; Ohshima et al. 2014). Osaki & Kato (2013a) called the supercycle type S (short intervals between normal outbursts) or type L (long intervals between normal outbursts), according to the nomenclature originally introduced by Smak (1985) for VW Hyi. Although the result in V1504 Cyg and V344 Lyr suggests that the same mechanism is responsible for type S and L supercycles in VW Hyi, this has not yet been demonstrated observationally.

We conducted an intensive campaign on VW Hyi in 2012–2013 to test this possibility. Since the start of the campaign on 2012 October 29, no outburst was detected (for a duration of 25 d) until the next superoutburst starting on November 23 (the superoutburst reported in subsection 3.18). Although the observations were not as dense as our CCD campaign, visual observations by the AAVSO observers did not reveal an outburst until the last recorded outburst on September 9. If there was no outburst from September 10 through November 22, the interval of normal outbursts may be as long as ∼70 d. Since VW Hyi undergoes normal outbursts as frequently as every 11–23 d in type S supercycles (cf. Smak 1985), in which intervals shorter than 23 d were considered as type S and those longer than ∼30 d were type L), the state before the 2012 superoutburst was most likely in type L.

A PDM analysis of the observation from BJD 2456229 to 2456254 (quiescence before the 2012 superoutburst) after subtracting the mean orbital variation yielded a period of 0.07265(3) d, by 2.2% shorter than the orbital period. Another candidate period is 0.07829(3) d, which is a one-day alias of the 0.07265 d period. Although there remains a possibility that 0.07829 d is the true period and the 0.07265 d period is a one-day alias signal, we consider this possibility less likely because a similar signal was also observed after the superoutburst (figure 86). In this interval, the negative superhump was the strongest signal after subtracting the orbital modulations, and there is no remaining...
ambiguity of a one-day alias. The periods of negative superhumps determined for different segments of the data after subtraction of the orbital signal are listed in table 65. During the superoutburst, the period of negative superhumps could not be determined because it was located close to the one-day alias of the (positive) superhump period.

The mean profile (figure 83) is also characteristic of negative superhumps (cf. Osaki & Kato 2013a, 2013b) with a slower rise to the maximum and a faster decline to the minimum. The coexistence of orbital humps and negative superhumps, which is also recorded in both V1504 Cyg and V344 Lyr, suggests that some part of the stream hits the outermost part of the disk to produce the hot spot while some part of the stream reaches the inner disk to produce negative superhumps (cf. Wood & Burke 2007).

A two-dimensional Lasso analysis (figure 87) shows a signal of negative superhumps with a frequency of $\sim 13.75$ cycles d$^{-1}$ before the superoutburst. A possible signal of negative superhumps with a frequency of $\sim 13.65$–13.70 cycles d$^{-1}$ was also detected after the superoutburst. The decrease in the frequency (also evident as an increase in period is shown in table 65) is compatible with the shrinkage of the accretion disk after the superoutburst. As reported in Osaki and Kato (2013a), the precession frequency of a tilted disk can be expressed as follows (Larwood 1998):

$$\nu_{\text{NSH}}/\nu_{\text{orb}} = 1 + \frac{q}{7} \frac{q}{\sqrt[3]{1+q}} \cos \theta \left(\frac{R_d}{A}\right)^{3/2},$$

(5)

where $\nu_{\text{NSH}}$ and $\nu_{\text{orb}}$ are the frequency for the negative superhump and the binary’s orbital frequency, respectively; $R_d$ is the disk radius, $A$ the binary separation, and $\theta$ the tilt angle of the disk to the binary’s orbital plane. The smallest $|\varepsilon^*|$ (equivalent to $\nu_{\text{NSH}}/\nu_{\text{orb}}$) before the superoutburst was 0.024 and the largest $|\varepsilon^*|$ after the superoutburst was 0.020. This difference can be explained from a 13% shrinkage of the disk radius after the superoutburst. Assuming $q = 0.21(2)$ (from the radial velocity study by Smith et al. 2006) and a small tilt angle ($\cos \theta \sim 1$), these two values of $|\varepsilon^*|$ correspond to disk radii of 0.42(1)$A$ and 0.39(1)$A$, respectively.\(^8\)

\(^8\) Smith, Haswell, and Hynes (2006) suggested that this q value is highly insecure. We used this value since there is no other direct determination of q value, and the q determined from stage B superhumps (Patterson et al. 2005) has some unknown uncertainty.
For comparison, a two-dimensional Lasso analysis of the 2011 superoutburst is also shown in figure 88. No clear signal of negative superhumps was detected, although the analysis is noisy due to the poorer data coverage than in the 2012 superoutburst and to the persistence of positive superhumps which interferes with the detection of other signals when the data are sparse.

We conclude that the type L supercycle in VW Hyi (reduced number of normal outbursts) is associated with the presence of negative superhumps as in V1504 Cyg and V344 Lyr, and the tilt in the disk can be regarded as a cause of the varying frequency of normal outbursts.

5 Summary

In addition to basic data of superhumps of the objects dealt with in this paper, the major findings we obtained can be summarized as follows.

(i) We report on the detection of negative superhumps in quiescence of VW Hyi in 2012. We conclude that the type L supercycle in VW Hyi (reduced number of normal outbursts) is associated with the presence of negative superhumps as in V1504 Cyg and V344 Lyr, and the tilt in the disk can be regarded as a cause of the varying frequency of normal outbursts.

(ii) MASTER J005740 is the first eclipsing WZ Sge-type dwarf nova showing the probable eclipse of the white dwarf. The sharp structure in the profile of early superhumps is interpreted as an eclipse of the accretion disk, and it has been difficult to distinguish the eclipse from the profile of the early superhump itself in other WZ Sge-type dwarf novae. The symmetric profile of the eclipse indicates that the disk itself, not the enhanced hot spot, is eclipsed. This finding provides observational support for Osaki and Meyer (2003) who interpreted that the source of early superhumps is not the hot spot such as is explained by an enhanced mass-transfer model (Patterson et al. 1981). We also carried out a model calculation of the eclipse light curve of this object during the phase of early superhumps.

(iii) We detected stage A superhumps with growing amplitude in MN Dra and likely stage A (from the $O-C$ diagram) in GZ Cnc, both of which have a long orbital period. The stage A superhump in these systems lasted longer than expected. We interpreted that the 3:1 resonance was confined to the region of excitation because these objects have a mass ratio critically close to the condition in which tidal instability occurs. This may provide an interpretation of large negative-period derivatives recorded in the past in the system with a long orbital period.

(iv) The 2013 superoutburst of UZ Boo was followed by four post-superoutburst rebrightenings, the same as in the 2003 superoutburst. This observation suggests that the pattern of rebrightening is inclined to be reproducible in the same object.

(v) The WZ Sge-type dwarf novae AL Com and ASASSN-13ck showed a long-lasting (plateau-type) rebrightening. In the early phase of the rebrightening, both objects showed a precursor-like outburst, suggesting that the long-lasting rebrightening is triggered by a precursor outburst. Both objects showed small dip(s) during the rebrightening.

(vi) We have reviewed the observation of early superhumps of WZ Sge-type dwarf novae and found that the fractional superhump excess for early superhumps has a typical value of $-0.05\%$.

(vii) We have succeeded in detecting a positive period derivative of superhumps in the helium CV CP Eri. This object also showed an oscillation-type rebrightening.

(viii) We have established the long-sought superoutburst of the eclipsing dwarf nova V893 Sco. It was 15 years after its rediscovery.

Note added in proof (2014 October 2):
Most recent study indicates that AM CVn-type objects having orbital periods as long as $\sim 0.034 \text{ d}$ show dwarf
nova-type outbursts (Kato et al. 2014b; Woudt et al. 2013). MASTER J234843 may also fit this category.

Acknowledgments

This work was supported by a Grant-in-Aid “Initiative for High-Dimensional Data-Driven Science through Deepening of Sparse Modeling” from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The authors are grateful to observers of VSNET Collaboration and to VSOLJ observers who supplied vital data. We acknowledge with thanks the variable star observations from the AAVSO International Database, which are contributed by observers world-wide and used in this research. This work is deeply indebted to outburst detections and announcement by a number of variable star observers worldwide, including participants of CVNET and BAA VSS alert. We thank Dr. Brian Skiff for making historical materials about WX Hyi available for our use. The CCD operation of the Bronberg Observatory is partly sponsored by the Center for Backyard Astrophysics. The CCD operation by Peter Nelson is on loan from the AAVSO, funded by the Curry Foundation. We are grateful to the Catalina Real-time Transient Survey team for making their real-time detection of transient objects available for the public use.

References

Petit, M. 1956, Journal des Observateurs, 39, 37
Philip, A. G. D. 1971, IAU Circ., 2308
Richter, G. A. 1990b, IBVS, 3425
Rosino, L. 1961, IAU Circ., 1782
Sandrauk, N. 1976, IBVS, 1218
Satyvoldiev, V. 1972, Astron. Tsirk., 711, 7
Shappee, B. J., et al. 2014b, Astron. Telegram, 5775
Shumkov, V., et al. 2013, Astron. Telegram, 4814
Shurpakov, S., et al. 2013, Astron. Telegram, 5526
Smak, J. 2010, Acta Astron., 60, 357
Splitberger, R. 1971, IBVS, 578
Thorstensen, J. R. 1999, IBVS, 4749
Tsevech, V. P. 1969, Astron. Tsirk., 529, 7
Tsevech, V. P., & Dragomiretskaia, B. A. 1973, Zvezdy tipa RW Voznichego: fotograficheskie nabliydeniya bleska (Naukova dumka: Kiev)
Udalski, A. 2000a, AJ, 100, 226
Udalski, A. 1990b, IBVS, 3425
Umura, M., et al. 2008, IBVS, 5815
Umura, M., Kato, T., Ohshima, T., & Maehara, H. 2012, PASJ, 64, 92
Walker, W. S. G., Marino, B. F., & Freeth, G. 1976, IBVS, 1185
Zhuov, G. V., Solov'ev, V. Y., & Solovjev, V. Y. 1972, Astron. Tsirk., 729, 8
Zwicky, F. 1965, IAU Circ., 1902
Zwitter, T., & Munari, U. 1995, AAS, 114, 575