Follow-up Observations of SDSS and CRTS Candidate Cataclysmic Variables II*

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Received 2017 November 1; revised 2017 November 28; accepted 2017 November 29; published 2017 December 21

Abstract

Spectra of 38 candidate or known cataclysmic variables are presented. Most are candidate dwarf novae or systems containing possible highly magnetic white dwarfs, while a few (KR Aur, LS Peg, V380 Oph, and V694 Mon) are previously known objects caught in unusual states. Individual spectra are used to confirm a dwarf nova nature or other classification while radial velocities of 15 systems provide orbital periods and velocity amplitudes that aid in determining the nature of the objects. Our results substantiate a polar nature for four objects, find an eclipsing SW Sex star below the period gap, another as a likely intermediate polar, as well as two dwarf novae with periods in the middle of the gap.

Key words: novae, cataclysmic variables – techniques: spectroscopic

Supporting material: data behind figure

1. Introduction

This is the second paper in a series containing follow-up observations of candidate cataclysmic variables (CVs) found in various past and ongoing sky surveys such as the Sloan Digital Sky Survey (SDSS; York et al. 2000), the Catalina Real-Time Transient Survey (CRTS; Drake et al. 2009), the All Sky Automated Survey (ASAS; Pojmanski 1997), (ASAS-SN; Shappee et al. 2014), and the Mobile Astronomical System of the Telescope Robots (Lipunov et al. 2010). As described in Paper I (Szkody et al. 2014), the confirmation and properties of the candidates found in the photometric surveys require spectra and further orbital light curves. Most candidate objects are dwarf novae, which are easily discovered in the sky surveys because they undergo periodic outbursts due to a disk instability resulting from the accumulation of the mass transferred from the late-type companion onto an accretion disk that ultimately accretes onto the primary white dwarf star. Because the periods of the outbursts depend on the mass transfer rate, the highest transfer rate objects are preferentially found while the shortest orbital period systems, with outburst timescales of decades, can remain hidden until an outburst occurs. Thus, significant biases exist in the determination of the real CV population. Hidden among these CV systems are those that contain highly magnetic white dwarfs, the polars and intermediate polars (different types are reviewed in Warner 1995) and other nowalikes that undergo high and low states when the mass transfer is either on or off (SW Sex, VV Scl subtypes). These latter systems tend to have high excitation lines of He II present when they are active, thus requiring spectra to confirm their identity. Long-term photometry can suggest their nature due to the large amplitude orbital modulations that are present on orbital timescales of hours due to the different viewing perspectives of the magnetic accretion columns during the orbit.

Paper I presented spectra of 35 systems obtained from 2010 September to 2013 October, while this paper contains additional spectral data on 38 systems from 2014 March to 2017 March. When combined with spectra from other groups (Thorstensen & Skinner 2012; Breedt et al. 2014; Thorstensen et al. 2016), these data allow future global studies of a confirmed population of objects. For simplicity, we provide identification of all objects by their 2000 coordinates in Table 1 (allowing them to be found in their photometric databases), while we abbreviate those coordinate in the following sections.

2. Observations

The majority of the spectra were obtained with the Double Imaging Spectrograph on the Apache Point Observatory (APO) 3.5 m telescope. The high-resolution (0.6 Å pixel−1) gratings were used to simultaneously cover blue wavelengths of 3900–5000 Å and red wavelengths of 6000–7200 Å with a 1.5 arcsec slit (during 2015 September only the blue spectrograph was available). Flux standards and HeNeAr lamps were used to provide calibrated spectra and spectra were reduced using IRAF5 standard routines.

A few spectra in 2014 were obtained at the Kitt Peak National Observatory (KPNO) 4 m telescope with the RC Spectrograph, using grating KPC-22b in second order and a 1 arcsec slit to produce blue spectra from 3800 to 4900 Å with a resolution of 0.7 Å pixel−1. FeAr lamps and flux standards were used along with IRAF reductions to produce final calibrated spectra.

Table 1 summarizes all the spectra obtained while a sample blue spectrum of each object is shown in Figure 1. Table 2 shows the equivalent widths of the emission lines of Hα, Hβ, and He λ4686 as measured with the e routine in the IRAF splot package.

3. Results on Systems with Time-resolved Spectra

For 18 of the systems in Table 1, five or more time-resolved spectra were obtained. The strongest Balmer lines (usually Hα and Hβ along with He λ4686 in a few cases) were used to

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* Based on observations obtained with the Apache Point Observatory (APO) 3.5 m telescope, which is owned and operated by the Astrophysical Research Consortium (ARC).

5 IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy, under cooperative agreement with the National Science Foundation.
determine the centroid positions and compute the velocities using the \( e \) routine in the IRAF splot package. For 0116+09 with strongly doubled lines, the Double-Gaussian method (Shafter 1983) was also used. The velocities were then fed into software programs to compute the best least-squares fit to a sinusoid, yielding \( \gamma \), semi-amplitude \( K \), period, and the total \( \sigma \) of the fit. Results were obtained for 15 of the systems, with fit parameters listed in Table 3, and the individual results are described below.

Examples of the radial velocity curves (for the strongest line with the best fit), are shown in Figure 2. Among the remaining three systems, 1545+01 (ASSASN-14 cm) was at outburst, so the broad absorption lines did not reveal the period. The weak lines in 0929+62 did not show any velocity change \( >31 \text{ km s}^{-1} \) during the 80 minutes of spectra. While the spectra of 2200+03 appear similar to dwarf novae, a satisfactory solution could not be obtained (likely due to insufficient time.
coverage during the 97 minutes of observation for what appears from the velocities to be a long orbital period of ∼160–200 minutes).

3.1. V677 And: Likely Polar

V677 And was reported as a flaring transient in CRTS as CSS080924:233423 +391423 by Mahabal et al. (2008) and spectroscopically identified as a likely dwarf nova by Quimby et al. (2008). Later photometry by Cook (2015) revealed a period near 100 minutes along with speculation that it could be a polar. Our 12 spectra obtained throughout 3 hr showed strong Balmer emission lines in the blue, along with He II 4686 line comparable to the strength of Hβ (Figure 1(b)). A large periodic velocity variation was evident throughout the time series and fits to a sine wave yielded periods of 105 minutes and very large K semi-amplitudes of 400 km s\(^{-1}\).
The short period, high K amplitude, combined with the 1.2 mag variations evident in photometry make it very likely that V677 And is a polar containing a highly magnetic white dwarf.

3.2. V380 Oph: SW Sex in Low State

This object was determined to be a novalike CV in a spectroscopic survey by Bond (1979) and was studied in more detail by Shafter (1985) who found a period of 3.8 hr and a radial velocity semi-amplitude of $100 \pm 14 \text{ km s}^{-1}$ when the system was at a magnitude of about 15.5. Shugarov et al. (2005) searched plate files and determined high and low states existed in a range from 14.5 to 17 mag. Rodriguez-Gil et al. (2007) accomplished a more thorough study at higher spectral resolution, improving the period to 3.69857 hr (221.9 minutes) and finding a K semi-amplitude of $207 \pm 5 \text{ km s}^{-1}$ when the system was at a comparable magnitude to the time when Shafter had observed. They concluded that V380 Oph was a
high mass transfer SW Sex type novalike\textsuperscript{6} and could be an IP, as they found a possible 47 minutes periodicity in their data, which could be the spin period of a magnetically accreting white dwarf. In 2015 July, V380 Oph began a low state near 17th mag, and we obtained spectral coverage of 0.76 of its orbit. Comparing our low-state spectra (Figure 1(b)) to those of Shafter (1985) and Rodriguez-Gil et al. (2007) during high states shows a much flatter blue continuum that has almost a factor of 10 less flux than the published high state spectra. The equivalent widths of our Balmer emission lines of H\textbeta{} of 22 Å (Table 2) are more than double those during the high state. Surprisingly, our K amplitude of 71 ± 3 (Table 3, Figure 2) is even lower than the value found by Shafter (1985) and almost three times lower than the value of Rodriguez-Gil et al. (2007). While determining masses from emission lines is unreliable, the differences between low and high states are consistent with a shrinking disk, allowing measurement of a more massive white dwarf than can be viewed during a high state.

3.3. 0038+25: DN

This g = 18.85 blue object found in Data Release 12 of the SDSS shows a steep blue continuum with strong doubled Balmer and He I lines as well as TiO band features from a red companion in the SDSS spectrum (Figure 1(a)). Our 10 blue spectra covering almost 2 hr reveal a typical short period CV (95 minutes) with a K value of 95 ± 13 km s\textsuperscript{−1} (Table 3, Figure 2).

3.4. 0116+09: DN

The CRTS discovered an outburst at 16 mag on 2008 December 20, while the SDSS g mag is 19.1. The long-term light curve shows several outbursts over a 10-year span. Our quiescent spectra show the broad doubled Balmer lines typical of a dwarf nova (Figure 1(a)). The doubled lines corroborate the photometric result of Coppejans et al. (2014) that 0116+09 is a deeply eclipsing CV system. Based on our 19 spectra at quiescence observed on 2014 September 2 with a spectral coverage of 2.45 orbits, the two trailed spectra of H\alpha{} and H\beta{} (Figure 3) clearly show evidence of an S-wave, which indicates the motion of a hot spot on the disk. Because the H\beta{} emission line is always deeply doubled throughout the whole orbit, the brighter H\alpha{} emission line was used to derive its orbital period. Using the Double-Gaussian method developed by Shafter (1983), our 19 quiescent spectra provide a radial velocity curve from H\alpha{} revealing a period of 93.6 ± 1.3 minutes and a K semi-amplitude of 78.3 ± 1.5 km s\textsuperscript{−1}. Using the e routine in IRAF to determine the centroids of H\alpha{} and H\beta{}, the derived velocity curves derive similar periods of 91.4 minutes and 87.9 minutes, respectively. Although the K semi-amplitude for H\alpha{} from the Double-Gaussian method is significantly smaller than that derived from the e routine (94.1 ± 4.5 km s\textsuperscript{−1}), it is consistent with the K semi-amplitude for H\beta{} (74.9 ± 0.3 km s\textsuperscript{−1}) derived from the e routine. The numbers are typical for a quiescent dwarf nova, which further corroborates its dwarf nova identification.

\textsuperscript{6} See D. W. Hoard’s Big List of SW Sextantis Stars at http://www.dwhoard.com/biglist (Hoard et al. 2003) for a complete discussion and current list of SW Sex stars.

3.5. 0333+33: Likely Polar

The CRTS first revealed an increased brightness of this object in 2011 November. The light curve reveals two states, a high one at about 17.5 and a low one about 20.5, with each state lasting years. During five nights of photometry in 2015, Littlefield et al. (2015) determined an orbital period of 111.5 minutes, with the light curve showing large periodic variations from V = 18 to 20.7 with double humps per orbit as well as a dip lasting for 0.4 of the orbit. They postulated a polar nature as the cause of the large variations. Our spectra obtained in 2015 December corroborate this classification. The narrow Balmer lines (Figure 1(a)), highly variable strength of He II throughout an orbit, and the very high K amplitudes (220−240 km s\textsuperscript{−1}) of the H\alpha{} and H\beta{} lines (Table 3, Figure 2) are all consistent with polar spectral characteristics.

3.6. 0411+23: DN

This object is listed in the CRTS archive as showing a range in magnitude from 15.5 to 18.5 with the comment of “not blue.” The KPNO and APO spectra (Figure 1(a)) show strong but fairly narrow Balmer emission lines. The 138 minutes of time-resolved spectra reveal a long period near 200 minutes with a low velocity amplitude (Table 3, Figure 2). These characteristics explain the color comment as well as the narrow

\begin{table}[h]
\centering
\caption{Equivalent Widths of Emission Lines (Å)}
\begin{tabular}{|c|c|c|c|}
\hline
Object & H\beta{} & H\alpha{} & He II \\
\hline
0033+38 & 59 & 59 & ... \\
0038+25 & 53 & ... & ... \\
0116+09 & 77 & ... & ... \\
0150+33 & 78 & ... & 10 \\
0206+20 & 96 & ... & ... \\
0309+26 & 4 & 28 & ... \\
0333+33 & 5 & 16 & 3 \\
0359+17 & 34 & ... & ... \\
0411+23 & 24 & 30 & ... \\
0422+33 & 25 & ... & ... \\
0501+20 & 27 & 37 & ... \\
KR Aur & 65 & 113 & 9 \\
0648+06 & 96 & 94 & ... \\
V694 Mon & 14 & 81 & 0.2 \\
0853+48 & 39 & 60 & ... \\
0929+62 & 10 & 11 & ... \\
1005+69 & 78 & 64 & 48 \\
1055+68 & 9 & 21 & ... \\
1245+07 & 57 & 74 & ... \\
1325+08 & 12 & 25 & ... \\
1432+19 & 17 & 24 & 29 \\
1626+33 & 37 & 51 & ... \\
V380 Oph & 22 & ... & ... \\
1853+42 & 27 & 54 & ... \\
2059+09 & 9 & 22 & 11 \\
2112+06 & 11 & 11 & 2 \\
LS Peg & 9 & 22 & 1 \\
2200+25 & 68 & ... & ... \\
2200+03 & 37 & 34 & ... \\
2246+06 & 61 & ... & ... \\
2319+08 & 4 & 6 & ... \\
2319+33 & 58 & 72 & ... \\
V677 And & 21 & 14 & 13 \\
2342+34 & 59 & ... & 6 \\
2350+28 & 5 & 11 & ... \\
\hline
\end{tabular}
\end{table}
Note. 

* Period fixed at this value.

lines if the inclination is low. Further data are needed to obtain a more precise period.

3.7. 0501+20: DN

The CRTS discovered this dwarf nova when it went into outburst in 2009 October. The long-term light curve shows a quiescent magnitude near 17.8 and many outbursts with amplitude about 3 mag. Our quiescent spectra taken over a 2 hr interval show typical broad Balmer emission lines (Figure 1(a)), while the radial velocities indicate a short orbital period of 108 minutes and typical K semi-amplitudes of 84 ± 5 and 51 ± 19 for the Hα and Hβ lines (Table 3, Figure 2).

3.8. 0648+06: DN in Period Gap

A large brightness change from 18 to 11.5 mag reported in the vsnet-alerts in 2014 November 22 (Schmeer 2014) resulted in a possible nova variable designation for this object. A spectrum by Maehara (2014) near the same time was more consistent with a dwarf nova at outburst than a nova. Our spectra three weeks later (Figure 1(a)) confirm this identification, with strong broad Balmer emission lines typical of a quiescent dwarf nova. Our 2.5 hr of spectral coverage reveal a period of 2.4 hr squarely in the middle of the period gap in the orbital period distribution of CVs (Warner 1995). The K semi-amplitudes of 70 km s⁻¹ are typical for dwarf novae (Table 3, Figure 2).

3.9. 0853+48: DN in Period Gap

This CV found in SDSS DR12 also reveals a period in the middle of the gap (142 minutes). The SDSS g magnitude is 18.9, and the SDSS spectrum shows strong Balmer and HeI emission as well as a TiO and red flux from its late-type companion. Our time-resolved spectra show the Balmer emission lines are broad and at times very doubled in appearance (Figure 1(a)). This, together with K amplitudes near 100 km s⁻¹, imply a higher inclination than for 0648+06 (Table 3, Figure 2).

3.10. 1005+69: Likely IP

The first spectrum of 1005+69 was obtained by the SDSS and suggested a possible IP nature due to the presence of strong HeII (Szkody et al. 2011). We accomplished three time-resolved spectroscopic observations in 2014 March 23, May 4, and 6. The details are listed in Table 1. All spectra show strong single-peaked and asymmetrical Balmer emission lines in the red and blue, along with strong HeII comparable to the strength of Hβ and several weak HeI emission lines (Figure 1(a)). The five spectra covering almost 1 hr obtained in the first two observations show a velocity variation larger than 100 km s⁻¹. All the blue spectra show a relatively flat continuum flux like the SW Sex star V380 Oph in a low state, the large radial velocity semi-amplitude of 211 km s⁻¹ for Hα is typical for a CV with a magnetic white dwarf. The phases of the Hα and Hβ velocity curves are nearly the same as those of HeII. Moreover, the common spectral feature of an SW Sex star of a central absorption in the Balmer lines and HeII4471 near phase 0.3–0.5 is not evident in the layout of all the blue spectra (Figure 4). Thus, we postulate 1005+69 to be an IP with a moderately strong HeII emission.
magnetic white dwarf. The finding of a spin period of the white dwarf in further better time-resolved photometry can corroborate its plausible IP identification.

3.11. 1245-07: DN

This object was detected at about 14.5 mag in 2015 May by both CRTS and ASAS-SN (as ASASSN-15iq). It exists in the SDSS archive with a $g$ mag of 19.8 and very blue $u - g$ color of $-0.05$. The CRTS lists it as a possible polar. Our APO spectra (Figure 1(a)) disputes this possibility as the lines clearly show doubling from an accretion disk. Our 109 minutes of spectral coverage indicate a period near 118 minutes and a $K$ value of 60 km s$^{-1}$ (Table 3, Figure 2), which are typical for a dwarf nova.

3.12. 1432+19: Eclipsing SW Sex

By using an outlier-mining method to pick up unusual objects in the SDSS DR8, Wei et al. (2013) found this 18.4 mag CV. The SDSS spectrum shows a very blue continuum and He II much stronger than H$\beta$. While our spectra (Figure 1(b)) show a similar enhancement of He II, the continuum flux is about a factor of three larger. Our time-resolved spectra over 2 hr show several changes in the line shapes, fluxes, and velocities. The radial velocity curve (Figure 2) shows large red and blue deviations from a sine wave in two consecutive 10 minutes spectra, indicative of an eclipse (the Rossiter–McLaughlin effect). The continuum drops during these two spectra, corroborating an eclipse. The radial velocity curve for He II shows the red to blue crossing at this
time as well. While the \( \text{H} \beta \) velocity curve is noisier, the phases are offset by about +0.1 from the \( \text{He} \) \( \text{II} \) one. Furthermore, at phases 0.1–0.3, the Balmer and \( \text{He} \) \( \text{II} \) lines show a central absorption, while they are single-peaked at other phases. All of these characteristics are the signature of an SW Sex star. However, the period determined is much shorter than the usual SW Sex systems, which are between 3–4 hr.\(^7\) There are only two objects with orbital periods below 2 hr (EX Hya and SDSS J210131.26+105251.5), and these two are merely listed as possible, not definite. Because our spectra only cover 115 minutes and the eclipse removes two of these from a solution, further spectra and photometry will be needed to determine a better period. If this short period is determined to be real, then this could be a very interesting test case for SW Sex accretion phenomena.

3.13. 2112–06: Likely Polar

ASAS-SN reported this object on 2016 October 27 as ASASSN-16me, a CV candidate with an SDSS \( g \) mag = 19.7 and an unusual CRTS light curve. Littlefield et al. (2016) obtained time-resolved photometry and a low-resolution spectrum and classified it as a deeply eclipsing polar with a period of 95.7 minutes. They commented that their single spectrum showed surprisingly weak \( \text{He} \) \( \text{II} \) but did not know if this was just due to the orbital phase. Our spectra (Figure 1(b)), which cover 0.84 of an orbit, show a similar weak flux for this high excitation line, with the line actually disappearing for part of the orbit. Our radial velocity curve finds a very high \( K \) value (359 km s\(^{-1}\)) for \( \text{H}\)\(\alpha\) (Table 3, Figure 2), consistent with a polar system.

3.14. 2319+33: DN

This object is listed in the CRTS CV candidate list of Drake et al. (2014). Its light curve shows outbursts to about 16.4 mag, and possible low states to 18.7. The SDSS lists \( g = 17.79 \) and a very blue color of \( u – g = −0.34 \). The two hours of spectroscopic coverage provide about 0.74 of the orbital period determined from the radial velocities to be 171 minutes. This period places it just inside the upper edge of the period gap. The broad Balmer emission lines (Figure 1(b)) and average \( K \) value of 55 km\(^{-1}\) (Table 3, Figure 2) are typical for a dwarf nova.

3.15. 2350+28: DN near \( P \) Minimum

This Gaia discovered object (Gaia14ade) was confirmed as a CV with a low-resolution spectrum by Wevers et al. (2014). While our best five spectra in 2015 December only cover about 85 minutes and the Balmer emission is weak (Figure 1(b)), the \( \text{H}\)\(\alpha\) velocities undergo a smooth sinusoid during this time (Figure 2) yielding a very short period of 77 minutes, which is near the observational period minimum for dwarf novae (Gänsicke et al. 2009). The \( K \) amplitude is typical for a dwarf nova.

4. Spectra at Outburst

Spectra of four of the systems shown in Figure 1 were obtained at outburst (0626+24, 1545+01, 1647+62, and V694 Mon). The first three show the typical Balmer absorption lines that are evidence of a dominant thick accretion disk near outburst peak. The last system is the symbiotic star (previously known as MWC560), which had a previous outburst in 1990. Munari et al. (2016) summarize their photometric observations of the 2016 outburst as well as a long-term light curve from 1928–2016. They found that the 2016 outburst was about 0.2 mag brighter in \( B \) than the 1990 one. The 2016 outburst had two peaks (February 7 and April 3) at \( B = 9.2 \), so the spectrum in Figure 1(a) was obtained midway between these peaks. Broad P Cygni profiles are apparent, but only extending to a blue velocity of 2780 km s\(^{-1}\), much smaller than the 6000 km s\(^{-1}\) during the 1990 outburst (Szkody et al. 1990). These absorptions have been interpreted as jet ejections in this binary, which contains an M4.5 giant and a likely magnetic

\(^7\) http://www.dwhoard.com/biglist
white dwarf (Tomov et al. 1992). This picture is substantiated by the detection of radio emission during the outburst on 2016 April 5 (Lucy et al. 2016).

5. Systems with Strong He II

Five objects in Figure 1 show noticeable He II: V677 And, 0333+33, 1005+69, 1432+19, and 2112–06 and, as discussed in the previous section, all show velocities and periods consistent with having a magnetic white dwarf. Of these, V677 And, 1005+69, and 1432+19 have this high excitation line stronger than Hβ at some portion of their orbits. The long period system 1005+69 is likely an IP, whereas the other two are likely polars. Of the two weaker lined systems, 2112–06 is a known eclipsing polar and 0333+33 is likely a polar as well.

6. Comments on Remaining Spectra

6.1. Unusual States

Besides the symbiotic V694 Mon at outburst that was described in the previous section, and V380 Oph in a low state discussed in Section 3.2, there are two other systems shown in Figure 1 that were observed due to notifications that they were in unusual states. These are KR Aur, which was coming out of a low state, and LS Peg, which was in one of its fainter observed states.

KR Aur is a novalike variable with a period of 3.9 hr that varies between high and low states of 11–18th mag, with most of the time between mag 12–14 (Shafter 1983). The AAVSO light curves show that it was at 16.8 in 2017 January and about 15.7 in March when the APO spectrum was obtained. Shafter obtained a spectrum when KR Aur was at $V = 15.5$ in 1982 January–February. Our spectrum in Figure 1(a) is 2–3 times brighter than that shown in Shafter (1983) and is considerably bluer. This is unexpected, as the mass transfer rate and the disk emission is thought to be lower at low states. It is likely that Shafter’s data were also obtained during the rise to a high state, as a minimum at 17 mag was reported at the end of 1981 December (Popov 1982). Thus, it seems that the optical magnitude is not sufficient to determine the state of accretion and the disk contribution.

LS Peg is another nova-like system that spends most of its time at a high state ($V = 12$) with a high mass transfer rate and high velocity emission line wings (Garnavich & Szkody 1992; Taylor et al. 1999), with occasional drops to a low state near 14. Because of some indications of a period near 20 minutes, it has been postulated as an IP, and X-ray spectra concur with this classification even though no stable spin period was detected (Ramsay et al. 2008). The AAVSO light curves show LS Peg was at 13.4 in 2015 July and 12.5 in August so it was coming out of a low state when our spectrum was obtained at the end of June. Our spectrum in Figure 1(b) compared to the Taylor et al. (1999) data (obtained in 1996–1997 when LS Peg was in its high state) is 2–3 times fainter in the continuum and line fluxes.

6.2. Typical Dwarf Novae

About half of the remaining systems in Figure 1 have spectra that look like typical dwarf novae with broad Balmer emission lines and a flat Balmer decrement. These objects include 0033+38, 0150+33, 0206+20, 0359+17, 0422+33, 1853+42, 2246+06, and 2342+34. 0359+17 shows moderate to strong doubled lines, indicative of moderate to high inclination. A couple of others show a narrow component superposed, which is likely a hot spot: 0206+20, 0422+33, 2319+33.

6.3. Weak or Narrow Lines

Four objects in Figure 1 have weaker lines than is normal for a typical CV. These objects are 0309+26, 1055+66, 1325–08, and 2059–09. They may have been observed before they returned to their quiescent state. There are also three systems with very narrow lines: 1626+33, 2200+25, and 2319+08. The first object (1626+33) was identified as a potential polar in the SDSS due to its very strong He II line (Szkody et al. 2004). Our three spectra obtained in 2015 June are about a factor of 5 fainter than the SDSS spectrum and have He II weak to nonexistent (Figure 1(b)). It is likely this object was in a low state.

Figure 4. The 2014 May 6 spectra of 1005+69 showing the changing line shapes throughout its orbit.
during our observations, and the rapidly changing strength of the \( \text{He}\,\text{II} \) line during the three exposures indicates that a polar classification is more likely than an IP. The second object (2200+25) has had four outbursts in the CRTS database and is listed as a faint (\( g = 20.9 \)) blue object in SDSS DR12. While the continuum is very faint, the Balmer emission lines are very strong, similar to V380 Oph in its low state. The third object 2319+08 was observed as part of a list of ellipsoidal variables with periods below 0.22 day and blue \textit{GALEX} colors that could be hidden CVs (Denisenko 2016). It was listed with a period of 0.107760 day (in the period gap). Our spectra in 2016 November and December show prominent TiO bands in the red and narrow Balmer emission, so this is likely an irradiated M star system, which could be a pre-CV.

7. Conclusions

Our follow-up spectra have shown several systems with interesting properties that merit further detailed study. Three systems (V677 And, 0333+33, and 2112–06) are likely polars because they show the presence of He\( \text{II} \) and high velocity amplitudes throughout their orbital periods. In addition, 1626+33 appears much fainter in its continuum and He\( \text{II} \) line strength than during the SDSS spectrum and is likely a polar that had gone into a low state. These objects merit circular polarimetry to confirm a high magnetic field strength for the white dwarfs. The system 1005+69 appears to be an IP and requires high speed photometry to search for a spin period, while 1432+19 is likely an eclipsing SW Sex star with a period below the gap. Photometry of the latter can confirm this short period and determine an inclination from the eclipse. Two dwarf novae (0648+06 and 0853+48) appear to have periods in the period gap, adding to the small number of systems within this range. Spectra of three known novalike systems (V380 Oph, KR Aur, and LS Peg) observed during low states are presented, while the symbiotic V694 Mon was caught during an outburst, showing P Cygni profiles indicative of jet ejections similar to the 1990 outburst. The information gathered for these 38 objects over a span of almost 4 yr shows the large amount of effort that will be needed to sort out object types in the forthcoming deluge of transients that will appear in ZTF and LSST.

P.S. and D.S.G. acknowledge support from NSF grant AST-1514737. Z.D. acknowledges support from CAS Light of West China Program and the Science Foundation of Yunnan Province (No. 2016FB007). The students in Astro 497, 499 are acknowledged for their help in obtaining spectra on the nights of 2016 April 21 (David Bordenave, Nicholas Huntley, Tessa Wilkinson) and 2017 March 5 (Ellis Avallone).

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