Discovery of a Promising Candidate of WZ Sge-Type Dwarf Novae, ASAS 160048-4846.2: Evidence for Double-Peaked Humps

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Abstract

We report on time-resolved CCD photometry during the 2005 June outburst of a dwarf nova, ASAS160048-4846.2. The observed light curves unambiguously showed embryonic humps with a period of 0.063381(41) days, after which genuine superhumps emerged with a period of 0.064927(3) days. Based on evidence for double-peaked humps in the earlier stage of the outburst, this object might be qualified as the seventh member of WZ Sge-type dwarf novae after Var Her 04. If the former period is the same as, or very close to the orbital period of the system, as in other WZ Sge systems, the fractional superhump excess is about 2.4%. This value is unexpectedly larger than that of other WZ Sge-type dwarf novae.

Key words: accretion, accretion disks — stars: dwarf novae — stars: individual (ASAS 160048-4846.2) — stars: novae, cataclysmic variables — stars: oscillations

1. introduction

Recently, extensive monitoring of dwarf novae has revealed that SU UMa stars have diversity of the behavior. WZ Sge stars, an extreme subclass of SU UMa stars, exhibit peculiarities compared to well-observed SU UMa stars (Kato et al. 2001). Main properties of WZ Sge stars are that (1) they have very long recurrence times, sometimes in excess of decades, (2) the amplitude of these systems exceeds 6 mag instead about 4−5 mag for many SU UMa stars, (3) one outburst or repetitive ones take place after the termination of the main superoutburst, and (4) double-peaked humps, with a periodicity of almost the same as the orbital period of the system (Osaki, Meyer 2002; Patterson et al. 2002; Kato 2002), are observed on the early phase of superoutbursts. Especially, the last one is of particular interest because there are only 6 systems that showed double-peaked humps: AL Com (Kato et al. 1996, Patterson et al. 1996, EG Cnc (Patterson et al. 1998), RZ Leo (Ishioka et al. 2001), HV Vir (Ishioka et al. 2003), Var Her 04 (Price 2004), and WZ Sge itself (Kato et al. 2004).

There are three competing models concerning the double-peaked humps at the early phase of the superoutburst for WZ Sge stars since the 2001 superoutburst of WZ Sge itself. Osaki, Meyer (2002) proposed that the double-peaked humps are most likely a manifestation of the 2:1 resonance radius in the accretion disk in these systems with extremely low mass ratios. Kato (2002) suggested that irradiation of the elevated surface of the accretion disk caused by vertical tidal deformation well represents the observations. On the other hand, Patterson et al. (2002) proposed that enhanced-mass transfer from the secondary causes more luminous hot-spot on the accretion disk, resulting in double-peaked humps. The presence of the double-peaked humps is now regarded as a criterion for WZ Sge stars (Imada 2005). Many works have been performed both from theoretical and observational sides in order to decipher the nature of double-peaked humps, as well as other properties (Lasota et al. 1995; Osaki, Meyer 2003. However, there are many problems left behind our understanding.

ASAS 160048-4846.2 (hereafter ASAS 1600) was discovered as an eruptive object by All Sky Automated Survey (Pojmanski 2002) on June 9 2005. This is the first recorded superoutburst in the survey. Astrometry on the UCAC2 frames yields the coordinate of the variable with 16h00m47s.43, −48°46′07″.6.

In this letter, we mainly focus on the variation of hump profiles. Detailed analysis will be published in the forthcoming paper.

2. observation

Time-resolved CCD photometries were performed with a 32 cm telescope at Tiegemploort (South Africa) for 12 consecutive nights between 2005 June 9 and June 20. The exposure time during the run was 30 seconds. The total data points amounted to 10511. After dark subtraction and flat fielding on the acquisitions, we analyzed the target, a comparison star, and a check star by aperture photometry. For a comparison star and check star, we chose UCAC2 160053.1-484433 (R = 11.9) and UCAC2 160043.6-484628 (R = 12.8), respectively. Heliocentric corrections to the observed times were applied before the following analysis.
3. results

3.1. light curve

Figure 2 shows the whole light curves obtained during our run. The plateau stage lasted more than 12 days with a declining rate of 0.12 mag d$^{-1}$. During a plateau stage, some WZ Sge stars show steep decline just after the maximum at a rate of 0.5 mag d$^{-1}$ (e.g., WZ Sge), or a brightening up to 0.2 mag at the middle of the plateau phase (e.g., EG Cnc, (Matsumoto et al. 1998)). As for ASAS 1600, such features could not be detected during our run.

After the termination of the plateau phase, ASAS 1600 underwent a rebrightening outburst on HJD 2453547 detected by R. Stubbings (vsnet-outburst 6503) with $V \sim 14.5$. We have no other information about the rebrightening.

3.2. superhumps

Superhump features were prominent from HJD 2453534, the fourth day of our run. After subtracting a declining trend of the plateau stage, we carried out the PDM method (Stellingwerf 1978) from HJD 2453534 to HJD 2453542. Figure 2 represents the theta diagram of this stage, from which we can conclude that the mean superhump period is 0.064927(3) days with 1-$\sigma$ error. The error was calculated by the Lafler-Kinman methods (Fernie 1989). Notice that this period is much longer than those of known WZ Sge stars, e.g., 0.05721 days for AL Com (Nogami et al. 1997), 0.05820 days for HV Vir (Ishioka et al. 2003). This value is quite similar to that of a promising candidate of WZ Sge star, ASAS 153616-0837.1 (Patterson et al. 2005). No other periodicity was found during the span.

Phase-averaged light curves folded by 0.064927 days are depicted in figure 3, in which one can see the “textbook” feature of superhumps with an amplitude of about 0.2 mag. There is no sign of an eclipse, indicating a low inclination of the system.

3.3. early stage of the outburst

At the earlier stage of the superoutburst, the light curve showed ambiguous humps of variable shapes. Judging from our run, such modulations lasted 3 days. Figure 4 represents enlarged light curves of this phase. In order to search for a periodicity, we performed the PDM method (Stellingwerf 1978) over the first two days after subtracting the declining trend. Figure 5 demonstrates the theta diagram for the search, for which we found a periodicity of 0.063381(41) days. This period is certainly not an alias, but the period of this stage. As is often observed in other WZ Sge stars, this period might be the same as, or very close to the orbital period of the system. However, spec-
Fig. 4. Enlarged light curves on the first 3 days of our run. On HJD 2453533, one can see four humps in the figure. Note, that the amplitude of the hump increased with time, but the less than 0.1 mag, suggesting we are the witness of the growth of superhumps.

Fig. 5. Period search for the first 2 days of the observations. The theta diagram show the periodicity of 0.063381(41) days, which we interpret as the period of early superhumps seen in WZ Sge-type dwarf novae.

Fig. 6. Mean humps on the first 2 days of our run, folded by 0.063381 days. The abscissa and the ordinate denote the phase and relative magnitude, respectively. The epoch was arbitrary set. Note, that the profiles are not single-peaked, but double-peaked. Such features are characteristic of WZ Sge stars on the earlier stage of superoutburst.

trosopic observations for the object should be performed to confirm this.

We also made phase-averaged light curves folded by the period (figure 6). Note that the profile fairly represents a double-peaked feature as is observed in other WZ Sge stars. This results could allow us to suggest that ASAS 1600 may be a promising candidate for WZ Sge-type dwarf novae.

The right panel of figure 4 shows the light curves on HJD 2453533 in which we detected the transition from ambiguous humps to genuine superhumps. Although the amplitude of the humps is as less as 0.1 mag, it can be obviously seen the growing humps.

4. discussion

As mentioned above, WZ Sge stars rarely exhibit a superoutburst, which has hampered us from qualification of a new member of the systems, although a possible candidate for WZ Sge stars amounts to a few tens (Kato et al. 2001; Szkody 2003). Our observations proved that ASAS 160048-4846.2 is the seventh member of WZ Sge stars after detection of double-peaked humps and a rebrightening. The outburst properties were similar to a long-period WZ Sge star, RZ Leo, in terms of profiles of humps features.

As for double-peaked humps at the early stage of the superoutburst, we detected a periodicity of 0.063381(41) days. This period is slightly shorter than the superhump period of 0.064927(3) days. If we could interpret the former period as the orbital period of the system, the fractional superhump excess is 0.024(1), and we can roughly estimate the mass ratio of the system using an empirical relation as follows (Patterson 1998),

$$\epsilon = \frac{0.23q}{1 + 0.27q},$$  \hspace{1cm} (1)

where $\epsilon$ and $q$ are the fractional superhump excess and mass ratio, respectively. With a little algebra, we can determine the value of $q$ with 0.109(4). Compared to other WZ Sge stars, this value is slightly large. In conjunction with the obtained values, it is likely that the secondary of ASAS 1600 is not a degenerated brown dwarf, but a normal M-type star. (Patterson et al. 2005) recently suggests that a possible dwarf nova, RE 1255+266, may be a promising candidate for “period bouncer”, whose secondary star has a very low mass and is degenerated. Patterson et al. (2005) further derived that the mass ratio of RE 1255+266 to be less than 0.06. If the obtained
period of double-peaked humps does indeed correspond to the orbital period of the system, we might exclude the possibility that ASAS 1600 is "period bouncer". This also implies that WZ Sge stars are not restricted to systems having a low mass secondary star, which is strongly supported by the observations of RZ Leo, the longest period of WZ Sge stars ever known. The mass ratio of RZ Leo is estimated to be 0.14 using the above equation (Ishioka et al. 2001), indicating a normal secondary of the object. This is consistent with a spectroscopic observation by Mennickent et al. (1999).

Spectroscopic observations should be performed in order to determine the precise orbital period of the system, which will yield the accurate value of superhump excess.

We also detected the transition from double-peaked humps to genuine superhumps on HJD 2453533. This phenomena are difficult to observe because this may rapidly occur. During this, the magnitude of systems increases by $\sim 0.2$ mag, which is observed in EG Cnc (Matsumoto et al. 1998), AL Com (Patterson et al. 1996; Howell et al. 1996) Var Her 04 (Price 2004). On the other hand, ASAS 1600 showed no resumption of the magnitude (Patterson et al. 2002). So far, we cannot specify the reason why EG Cnc and Var Her 04 took place and ASAS 1600 did not. Further observations during the transition will improve our understanding of this phenomenon.

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