Binary Stars as Critical Tools & Tests in Contemporary Astrophysics
Proceedings IAU Symposium No. 240, 2006
W.I. Hartkopf, E.F. Guinan & P. Harmanec, eds.

doi:10.1017/S1743921307006217

Discovery of a New Dwarf Nova, TSS J022216.4+412259.9: a WZ Sge-type Dwarf Nova Breaking the Shortest Superhump Period Record

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Abstract.
We report on time-resolved CCD photometry of the newly-discovered dwarf nova, TSS J022216.4+412259.9 during its outburst in 2005 November–December. The best-estimated superhump period was 0.0554 days, which is the shortest superhump period among WZ Sge-type dwarf novae ever known. Double-peaked humps were also detected with a period of 0.05487 days in the early stage of the outburst. A rebrightening exhibited after the end of the plateau phase. All of these observations indicate the WZ Sge nature of the system. We mainly discuss the rebrightening stage of the superoutburst, compared with other WZ Sge-type dwarf novae.

1. Introduction

TSS J022216.4+412259.9 (aliased J0222) was discovered as a candidate for a supernova on November 15, 2005, when the magnitude of the star was 15.5 in R. Soon after that, optical spectroscopy was carried out, by which the star turned out to be a dwarf nova. We performed optical photometry mainly using the Kyoto 40-cm Schmidt Cassegran telescope during the outburst of J0222.

WZ Sge stars are believed to be an ultimate descendant of SU UMa stars, due to the loss of mass and angular momentum of the system, resulting in a short-period system. Consequently, the system may have a degenerate secondary. The mass loss from the degenerate secondary makes the orbital period of the system long. Observationally, the turning point is around 78 min, which is called the "observational period minimum". Theoretically, on the other hand, the minimum is calculated as 64 min (the "theoretical period minimum"). This is a large discrepancy between theory and observation. So far, we do not know what is going on around the period minimum.

2. Observations and results

High speed CCD photometry was performed via the VSNET campaign from 2005 Nov. 21 to Dec. 20 at 4 sites using 25- to 60-cm telescopes. No filter was used during the run, which does not affect the following period analysis. We performed the PSF photometry. Figure 1 shows a finding chart of J0222; north is up and east is to the left. The variable and comparison stars are denoted by the letters V and C, respectively.

The light curve we obtained is displayed in Figure 2. The vertical axis denotes R mag. As can be seen in Figure 2, we undoubtedly caught rebrightenings of J0222, whose duration is about a week.

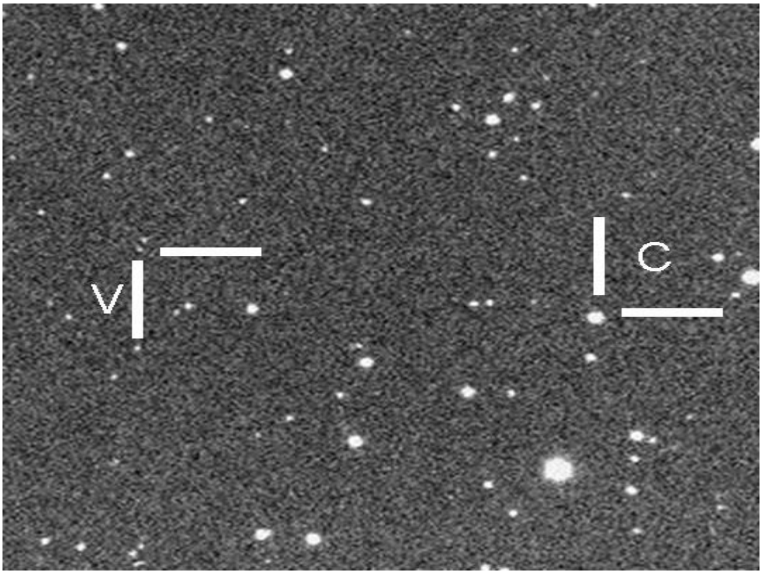

Figure 1. Finding chart.

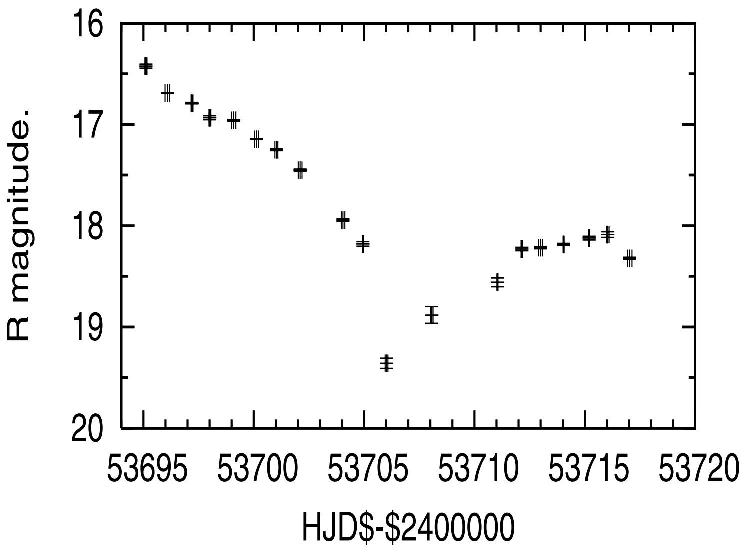

Figure 2. Light curve of the 2005 superoutburst of TSS J0222.

Light curves on the 2nd and 3rd nights are displayed in Figure 3. On the 2nd night, there are almost no features, suggesting that the superhumps did not grow. On the 3rd night, we can see a rapid rise and slow decline feature, characteristic of superhumps. We conjecture that the so-called early superhumps were observed on the first two nights.

In order to search for periodicity, we performed the PDM method applied to the first 2 nights of the run and the other plateau phase. For the first 2 nights, we found the strongest signal at 0.054868 days, while we found 0.055544 days for the rest of the plateau stage.

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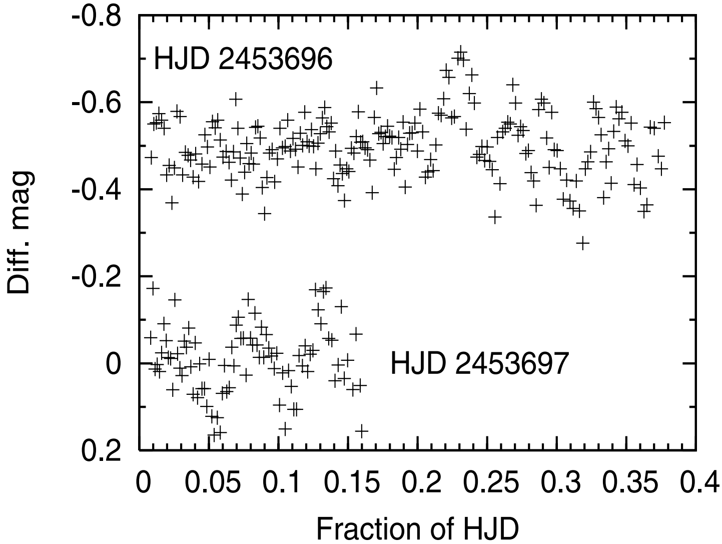

Figure 3. Enlarged light curves for the 2nd and 3rd nights. Superhumps are visible on HJD 2453697.

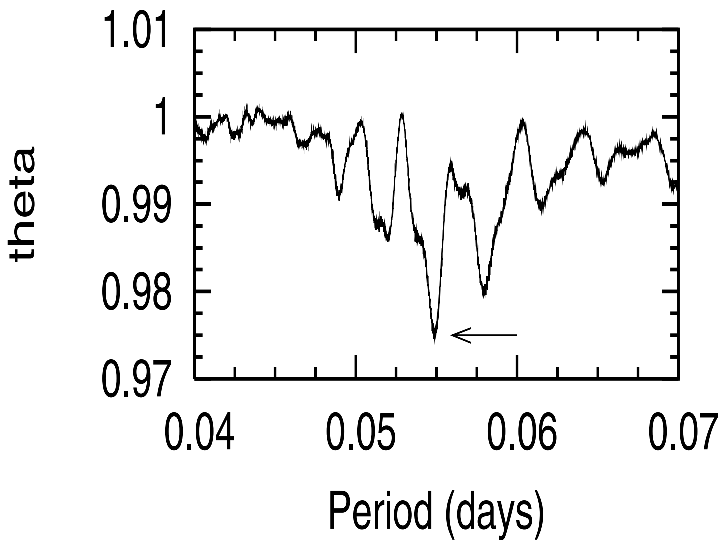

Figure 4. PDM analysis applied to the first 2 nights. The best estimated period is likely the early superhump period.

3. Discussion

3.1. *Light curves*

J0222 showed three stages of its light curves: (1) plateau stage, (2) dip, and (3) long-lasting rebrightenings. Further, the plateau stage is divided into two phases: presence or absence of superhumps. All of these properties are satisfied with the criteria for WZ Sge-type stars. The periodicity that we detected in the earliest stage of the light curve is the likely period of early superhumps, as is observed among other WZ Sge-type stars. If the

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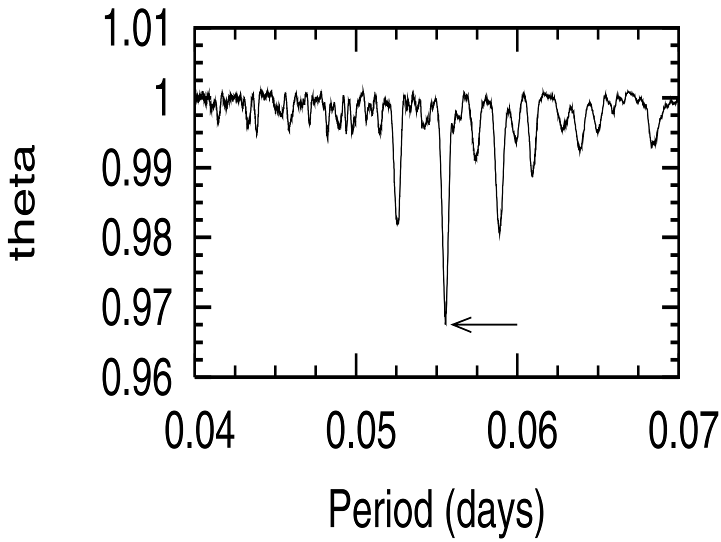

Figure 5. PDM analysis applied to the rest of the plateau stage. The best estimated period is likely the genuine superhump period.

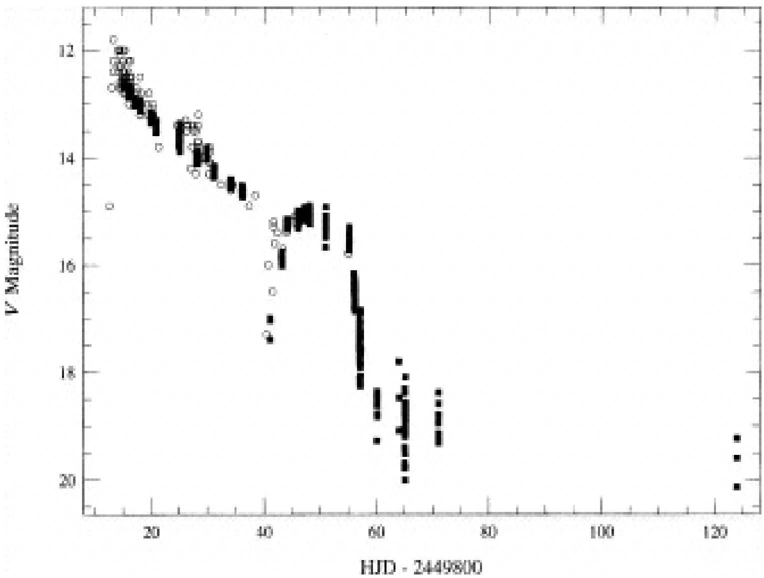

Figure 6. AL Com. This is what we call type A+ rebrightening. This figure is taken from Nogami *et al.* (1997).

observed period is identical with the orbital period of J0222, we can estimate crudely the mass ratio using the conventional Patterson's law, $\epsilon = 0.23q/1{+}0.27q$. Thus we determine that the mass ratio of the system is as small as 0.05. This value is comparable to those of AL Com and WZ Sge itself. Thus we conclude the system parameter is similar to that of WZ Sge-type stars.

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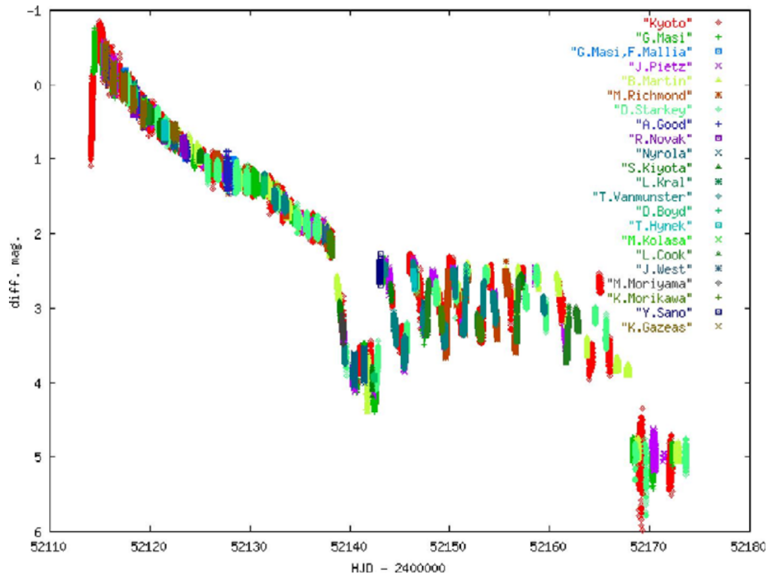

Figure 7. WZ Sge. Rebrightenings are distinguishable. We call this type A-. This figure is taken from Kato *et al.* (2004b).

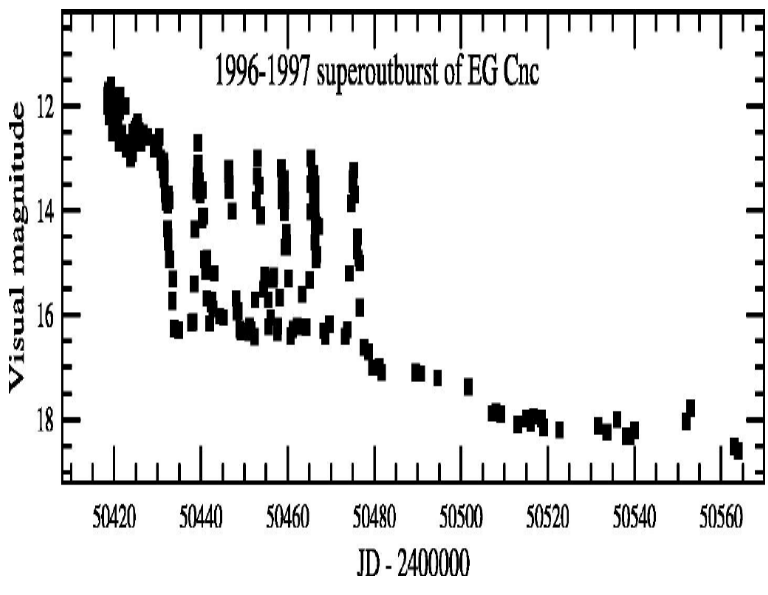

Figure 8. EG Cnc. Discrete rebrightenings. We call this type B. This figure is taken from Kato *et al.* (2004a).

3.2. *Rebrightenings*

One of the puzzling (and interesting) results is that the light curve of the rebrightenings is peculiar. That is, J0222 did not show several rebrightenings like EG Cnc, not vigorously modulating like WZ Sge or SDSS 0804 (see poster by E. Pavlenko), not short duration like RZ Leo, but the feature is flat (see Figure 2)! The flat rebrightening was previously observed in AL Com during 1995 and 2001 superoutbursts.

Obviously, these differences originated from different physical mechanism, presumably

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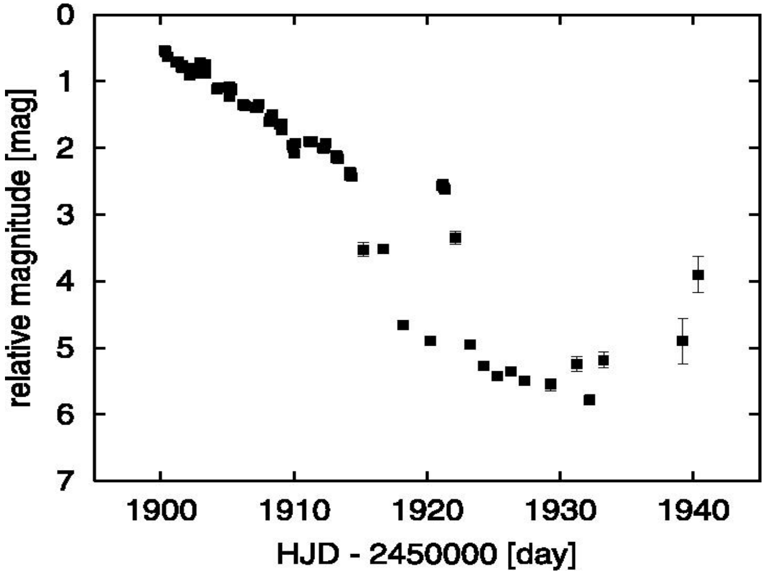

Figure 9. RZ Leo, exhibiting only once. We call the rebrightening type C. This figure is taken from Ishioka *et al.* (2001).

due to the difference in α_c during the cold state. In the future, we need to collect more samples during rebrightenings in order to elucidate the rebrightening mechanism. We also hope researchers use our type-definition of rebrightenings mentioned above in their future papers.

Acknowledgements

This work is supported by Grants-in-Aid for the 21st Century COE "Center for Diversity and Universality in Physics" from the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

References

Ishioka, R., *et al.* 2001, *PASJ*, 53, 905

Kato, T., Uemura, M., Ishioka, R., Nogami, D., Kunjaya, C., Baba, H., & Yamaoka, H. 2004b, *PASJ*, 56S, 1

Kato, T., Nogami, D., Matsumoto, K., & Baba, H. 2004a, *PASJ*, 56, S109

Nogami, D., Kato, T., Baba, H., Matsumoto, K., Arimoto, J., Tanabe, K., & Ishikawa, K. 1997, *ApJ*, 490, 840