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On the superhumps and mass ratio of CzeV404

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Abstract

CzeV404 is an SU UMa-type dwarf nova in the period gap. Kára et al. (2021) (arXiv:2107.02664) recently published photometric and spectroscopic observations and obtained a mass ratio q=0.16, which is in severe disagreement of q ~0.32 estimated from superhump observations (Bąkowska et al., 2014). I here present what analysis was wrong or outdated in Bąkowska et al. (2014) and provide a new value of q=0.247(5), consistent with the known behavior of superhumps and the evolution of cataclysmic variables. CzeV404 does not look like an unusual dwarf nova as suggested by Kára et al. (2021) and I discuss that the link between SW Sex and SU UMa systems suggested by Kára et al. (2021) is not supported.

CzeV404 is an SU UMa-type dwarf nova in the period gap (Bąkowska et al., 2014). Kára et al. (2021) recently published photometric and spectroscopic observations and obtained a mass ratio q=0.16, which is in severe disagreement of q ~0.32 estimated from superhump observations (Bąkowska et al., 2014).

Here I re-examined the superhump observations in Bąkowska et al. (2014) and solved the discrepancy. Bąkowska et al. (2014) used all the superhumps timing observations to derive a strongly negative $P_{\rm dot} = \dot{P}/P$. Such interpretations were common (e.g. Nogami et al. 2003; Kato et al. 2003; Olech et al. 2003; Rutkowski et al. 2007) before the establishment of the superhumps stages (A, B and C) in Kato et al. (2009) but are now outdated. In Kato et al. (2009), it was shown that all previously reported values of large negative $P_{\rm dot}$ simply reflected the stage transitions of superhumps rather than smooth, monotonous period variations.

CzeV404 (Bąkowska et al., 2014) was a textbook case of stage A-B transition. Their observations started on the rising branch of the superoutburst (HJD 2456856) and the earliest phase of the superhump development (stage A) was caught up to HJD 2456859. Looking at their light curve (in their figure 3), it is difficult to recognize superhumps on the first night (HJD 856), but growing superhumps were evidently caught on the second night (HJD 857). It is likely that their superhump detections for E=0, 1 on HJD 856 were spurious. Using their superhump maxima for 10≤ E ≤20, I obtained a period of 0.1060(1) d. This value corresponds to $\epsilon^* \equiv 1 - P_{\rm orb}/P_{\rm SH}$, where $P_{\rm orb}$ and $P_{\rm SH}$ represent orbital and superhump periods, respectively, of 0.075(1). Using the relation between ϵ^* and q in Kato and Osaki (2013), this value corresponds to q=0.247(5), which is a very reasonable value for a cataclysmic variable in the period gap (see e.g. Knigge et al. 2011).

The problems in the analysis by Bąkowska et al. (2014) were: (1) they used the entire phases of superoutbursts, without paying attention to superhump stages and (2) they used an inappropriate formula to estimate q, which is only applicable to stage B superhumps or novalike stars [but this formula does not consider the effect of the pressure effect and should be considered as an experimental formula; see Kato and Osaki (2013) for detailed discussions]. The statement in Bąkowska et al. (2014): "The tidal instability (Whitehurst 1988) of the disk starts to work effectively for binaries with a mass ratio q below 0.25. This assumption was used by Osaki (1989) in the TTI (thermal-tidal instability) model to explain the phenomenon of superoutburstsand superhumps. That is why such a high value of q in CzeV404 poses a serious problem for thesuperhump mechanism." is now unsubstantiated.

I must add, however, there is indeed a case of q=0.31–0.34 object, BO Cet, which showed a superoutburst and superhumps (Kato et al., 2021). q=0.25 is not an absolute limit.

Just for completeness, large negative P_{dot} of MN Dra mentioned in Bąkowska et al. (2014) was a result of stage A-B transition as clarified by Kato et al. (2016b) and Kato et al. (2016a).

The resultant q=0.247(5) for CzeV404 does not match q=0.16 from eclipse modeling in Kára et al. (2021). There must have been something wrong with the treatment in Kára et al. (2021) (for example, they assumed that the disk extends to the tidal truncation radius, which is clearly an overestimate). Eclipses analysis needs to be redone with better quality data. The statement in Kára et al. (2021): "This is lower than the value estimated from the superhump period applying different $\epsilon \sim q$ relationships. However, we note that a similar discrepancy is also observed in some other eclipsing systems (Kato & Osaki 2013)" is apparently a misunderstanding. There is no difference in the $\epsilon \sim q$ relationship between eclipsing and non-eclipsing systems.

Spectroscopy is outside the scope of this paper and I only make short comments. The spectroscopic results by Kára et al. (2021) needs to be treated with caution: (1) It was not clearly described whether they considered Jacobian in transforming the Doppler tomogram in the velocity space to real coordinates in obtaining their figure 12. If this was not considered, the resultant map gives an incorrect impression. (2) SW Sex phenomenon is generally considered to be seen in systems with high mass-transfer rates (novalike systems above the thermal stability) while the observations by Kára et al. (2021) were made in lower mass-transfer states. We showed that BO Cet, which had been considered as an SW Sex star (Rodríguez-Gil et al., 2007), had an orbital light curve not resembling that of an SW Sex star (Kato et al., 2021). The mass of the white dwarf in BO Cet was estimated to be larger than $1.0 M_{\odot}$. If the mass of the white dwarf in CzeV404 is indeed high ($\sim 1.0 M_{\odot}$, Kára et al. 2021), the features resembling those of SW Sex stars in CzeV404 may be a result of a massive white dwarf as in BO Cet.

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