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The search for SW Sex type stars

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Abstract. All eclipsing nova-likes in the 2.8–4 h orbital period range belong to the group of SW Sex stars, and as such experience very high mass transfer rates. Since the physical properties of a star should be independent of the inclination it is observed at, this suggests that all or at least a large fraction of the non- or weakly-magnetic cataclysmic variables in this period range are physically SW Sex stars.
We here present preliminary results of a large campaign to search for SW Sex characteristic features in the spectra of such stars. We find that 14 out of the 18 observed non-eclipsing cataclysmic variables belong to the group of SW Sex stars the classification of the other four is uncertain from our data. This confirms the domination of SW Sex stars in the period range of 2.8–4 h just above the period gap. Since all long-period systems need to cross this range before entering the gap, the SW Sex phenomenon is likely to be an evolutionary stage in the life of a cataclysmic variable.

1. Introduction

SW Sextantis stars are a sub-group of cataclysmic variables (CVs) that were originally characterised by Thorstensen, Ringwald, Wade, Schmidt & Norsworthy Thorstensen et al. (1991). They were defined as eclipsing nova–like stars with high velocity, emission line wings extending up to 4000 km/s, inconsistent with an origin in a standard accretion disc. They show narrow absorption features in the Balmer and He I lines near the inferior conjunction of the white dwarf, and large orbital phase offsets ($\sim$ 0.2 cycle) of the radial velocity curves with respect to the photometric ephemeris (Rodríguez-Gil, Gänsicke, Hagen, Araujo-Betancor, Aungwerojwit & et al.Rodríguez-Gil et al. 2007a). They also have large absolute magnitudes and hot white dwarfs, implying extremely high accretion rates exceeding the expected rates based on standard magnetic braking as angular momentum loss mechanism (Townsley & Gänsicke Townsley & Gänsicke 2009).

While SW Sex stars were considered rare objects at the beginning, later surveys (see Gänsicke (2005) for an overview) have shown that a surprisingly large number of the newly identified systems are deeply eclipsing SW Sextantis stars with orbital periods between 2.8 h and 4 h. Populating the upper edge of the orbital period gap makes them very interesting objects in the context of CV evolu-

Send offprint requests to: L. Schmidtobreick tion. In detail, 13 out of 48 nova-like systems in this period range – these are all the eclipsing ones – belong to the sub-class of SW Sex stars.

Since being an eclipsing system is not an intrinsic physical property of the star but rather depends on the angle under which the binary is observed, it appears entirely plausible that all non- or weakly-magnetic CVs just above the period gap are physically SW Sex stars, i.e. experience a very high mass transfer rate. This would be of major significance for the evolutionary theory of CVs, as all long-period CVs have to pass through this range before entering the period gap.

During the last years, we have conducted a project to test the hypothesis that all nova–like stars in the 2.8–4 h period regime are physical SW Sex type stars, even if they are not eclipsing. Examples for such stars are e.g. RR Pic (Schmidtobreick et al. 2003) or V533 Her (Rodríguez-Gil & Martínez-Pais 2002). We selected a sample of candidates: non-eclipsing nova-likes and old novae with an orbital period of 2.8–4 h that are sufficiently bright to perform time-series spectroscopy. We aim to analyse the emission lines of these stars searching for the presence of SW Sex characteristics such as broad line wings with large–amplitude radial velocity variations, single–peaked line profiles with phase-dependent central absorption, and phase lags between the radial velocity modulation in the line cores and wings. We also check for line flaring, an additional feature that is often observed in SW Sex stars but also in intermediate polars and that is manifested in fast oscillations of the emission line flux and velocity with periods around 10–20 min. First results of this campaign are discussed in Rodríguez-Gil et al. (2007b).

2. Data

In total, we have observed 18 non-eclipsing CVs with periods between 2.8 h and 4 h. Time series spectroscopy was done covering at least one orbit but most of the stars were followed over longer time ranges covering up to two orbits. The data of the first set are described in Rodríguez-Gil et al. (2007b).

The new set of candidate SW Sex stars were observed in January and December 2009 with EFOSC2 (Buzzoni et al. 1984) mounted at the NTT of the European Southern Observatory on La Silla, Chile. Grism # 20 centred on Hα was used to perform time-series spectroscopy covering at least one orbit for each system. The data were reduced using standard procedures in `PAMELA`[1] and `MOLLY`[1]. The wavelength calibration yielded a final FWHM resolution of 3.8 Å. All further analysis was done using `MIDAS`[2].

3. Preliminary results

In Figure 1 the average spectra of the new candidates are plotted. All of them are dominated by Hα in emission and also show the He I λ6678 line. As expected for SW Sex stars, most of them show single peak emission instead of the characteristic double-peak profile of lines originating in an accretion disc. The exceptions are AQ Men which shows a weak double-peak profile, KUV0358 which seems to show several components although part of them might rather be noise, and V382 Vel which still shows the shell of its 1999 nova outburst via two widely separated emission peaks bracketing the single-peaked emission line from the central binary.

A first analysis of the radial velocities and trailed spectra shows that all new systems seem to experience the high velocity S–wave, one of the main characteristics of SW Sex stars (see Fig. 2 for examples). Also a central absorption feature at a specific phase is present for all these stars. For V382 Vel, these results are less secure as the lines from the nova shell muddle the outer wings of the central line and a careful analysis is needed for confirmation. The phase lag has not yet been found for all stars mainly because a more thorough study of the different components in the emission line is needed to determine the correct zero-phase. Also the

[1] Tom Marsh's packages PAMELA and MOLLY are available at `http://deneb.astro.warwick.ac.uk/phsaap/software/`

[2] MIDAS is distributed by ESO at `http://www.eso.org/sci/software/esomidas/`

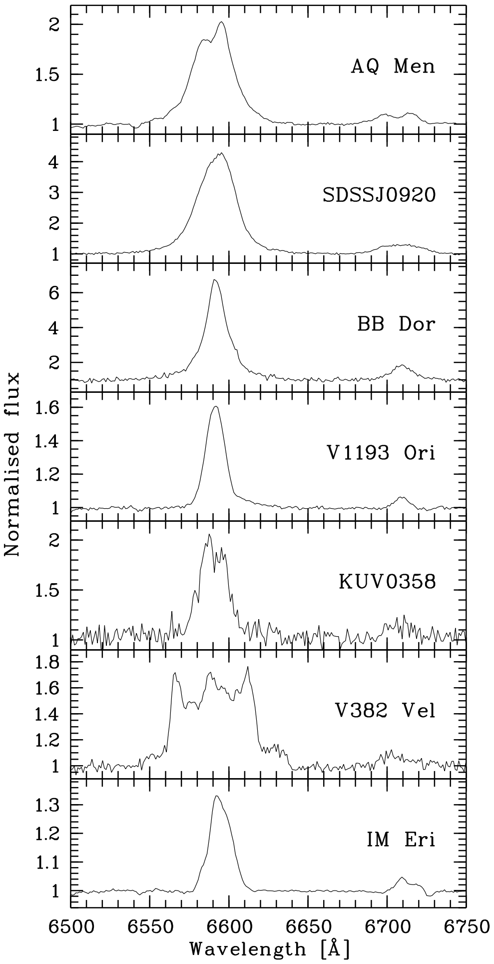

Fig. 1. Averaged normalised spectra of the new set of SW Sex candidate stars.

flaring has not yet been checked for in any of the new stars. We leave these results for a later paper. Still, with the presence of the S–wave as well as the central absorption we are pretty confident that all our new candidates are in fact SW Sex stars.

Thus, from the 18 observed nova-likes in the orbital period range of 2.8–4 h, 14 belong to the group of SW Sex stars, see Table 1 for details. The data for V849 Her and V393 Hya are rather poor and do not allow a conclusive classification. LQ Peg is of very low inclination and much higher spectral resolution is needed

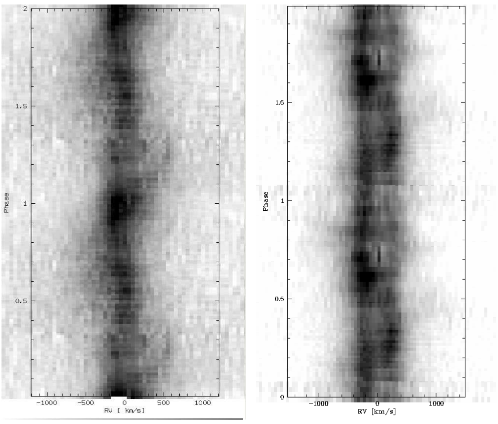

Fig. 2. Trailed spectra of the Hα line of BB Dor (left) and KUV03580+0614 (right). The phase for BB Dor is determined using the ephemeris of Rodríguez-Gil et al. (2011) which has sufficient accuracy to be extrapolated to our observations. The orbital period P = 0.143 d for KUV03580+0614 was taken from Szkody et al. (2001) the zero phase was set arbitrary.

to find any features in the emission line. The spectrum of V992 Sco is still dominated by the nova outburst and does not yet show any signature of the binary.

4. Conclusions

With the results so far, we have shown that the mayority of the nova-like stars in the 2.8–4 h period range are of SW Sex nature. There might be the one or other oddball among the CVs in this range, but the population in clearly dominated by SW Sex stars. On the other hand, due to angular momentum loss, a CV that started with a long orbital period will eventually cross the 2.8–4 h period range. Our findings imply that these CVs will turn into an SW Sex star during this phase of their lifetime. Therefore, the SW Sex phenomenon can be no longer considered a feature of individual stars but rather an evolutionary stage of the CV population.

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Table 1. The observed SW Sex characteristics and the final classification for all candidates

System	single peak	S–wave	0.5–abs.	phases	flaring	SW Sex?
HL Aqr*	√[a]	√	√	√	x	yes
BO Cet*	√	√	√	√	√	yes
BB Dor**	√	√	√	√	?	yes
IM Eri**	√	√	√	√	?	yes
V849 Her*	√	x	x	x	x	no [c]
V393 Hya*	x	x	x	x	x	no [c]
AQ Men**	x	√	√	?	?	yes
AH Men*	√	√	√	√	x	yes
KQ Mon**	√	√	√	√	√	yes
V380 Oph*	√	√	√	√	√	yes
V1193 Ori**	√	√	√	√	?	yes
LQ Peg*	√	x	x	x	x	no [c]
AH Pic*	√[a]	√	x	√	x	yes
V992 Sco*	-	-	-	-	-	- [b]
LN UMa*	√	√	√	√	x	yes
V382 Vel**	x[b]	√	√	√	?	yes
SDSS J0920+0043**	√	√	√	√	?	yes
KUV 03580+0614**	x	√	√	√	?	yes

[a]in absorption.; [b]spectrum still dominated by shell emission from nova explosion;
[c] need higher quality data
* Rodríguez-Gil et al. (2007b); **Schmidtobreick et al. (2011)

collected at ESO, La Silla, Chile under program IDs 082.D-0138 and 084.D-0646.

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