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An Update on Pulsations in Accreting White Dwarfs

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Abstract

Since the last white dwarf workshop, there is continuing evidence that long (hrs to days) periodicities are being found in white dwarfs that are undergoing accretion in close binary systems. Pulsation modes remain a possible explanation but proof remains elusive. We will compare the known properties of accreting, pulsating white dwarfs with those in ZZ Ceti stars. While sky surveys continue to proliferate, the discovery of accreting pulsators is not rising proportionally. Reasons for this discrepancy as well as future needs are discussed.

1 Background

The pulsating white dwarfs in accreting close binary systems differ from single ZZ Ceti stars in several ways (Szkody et al., 2013a, 2015; Mukadam et al., 2017). They rotate faster (about 200 sec rather than days), they are hotter due to the accretion from their companions (12,000 – 16,000 K), they have mixed compositions due to the mass transfer (models generally use 0.1 solar composition of their atmospheres) and they are more massive than single white dwarfs (0.8 $M_{\odot}$ versus 0.6 $M_{\odot}$). These differences result in changes in the location of the instability strip and in the pulsational properties.

2 The Current List

There are currently 18 accreting white dwarfs that have exhibited pulsations. These are listed in Table 1 below with their original and current names, their discovery date, orbital period, temperature, pulsation periods at quiescence and other longer periods observed. The properties of these 18 systems lead to the following questions.

3 Why Do Pulsations Stop?

The instability strip for accreting pulsators ranges from 10,000 – 16,000K, much wider than that for ZZ Ceti objects (Szkody et al., 2010). Within this temperature range are many objects which are not known to pulsate. It is expected that the white dwarfs in dwarf novae will be heated by a dwarf nova outburst and move out of the instability strip until the white dwarf cools back to its quiescent temperature. Several accreting white dwarfs are known to have had outbursts (Table 2), and four have been observed both before and after outburst. Of these 4, two (EQ Lyn and V455 And) returned to their quiescent temperatures and pulsation periods within a few years after outburst (Mukadam et al., 2011; Szkody et al., 2013b). The other two (GW Lib and EZ Lyn) are peculiar in that GW Lib has remained hot for more than 10 years after its outburst in 2007 and continues to show different pulsations from those at quiescence (Szkody et al., 2016; Toloza et al., 2016, see also Gänsicke et al. this conference), while EZ Lyn only shows pulsations after outburst (Pavlenko et al., 2014). In addition, 6 systems (Table 3) have been observed to stop their pulsations at times during quiescence when no outburst has occurred and there has been no change in optical magnitude (Mukadam et al., 2013). These 6 systems have a range in temperatures, so the cause cannot be that they are at the edge of the instability strip. In contrast, V386 Ser has been observed for 10 years (2004 – 2014) and always shows the same pulsation spectrum.

4 Are Pulsations Related to Disk Superhumps?

In 2 of the accreting pulsators (EQ Lyn and GW Lib), the pulsation has been observed to turn off and be replaced with an orbital modulation that is close to the superhump period (Mukadam et al., 2013; Chote et al., 2017). The short period (non-confirmed pulsator SW UMa) also shows this behavior (Shafter et al., 1986). This transition occurs without any change in the quiescent magnitude. Since superhumps are related to an eccentric disk caused by the disk growing to the 3:1

Table 1: Current Systems with Accreting Pulsating White Dwarfs.

Object	Date	P_{orb}(min)	T (K)	P_{puls}(sec)	P_{long}(min)
GW Lib	1998	76.8	15,000	236,376,648	18,83,240
V455 And	2004	81.5	10,500	320-370	83
GY Cet (SDSS0131-09)	2004	81.5	14,500	335,581,595	
V386 Ser	2004	80.5	14,500	221,304,345,607	
SDSS2205+11	2004	82.8	15,000	330,475,575	
EQ Lyn (SDSS0745+45)	2005	77.8	15,100	1192-1230	86
PQ And	2005	80.6	12,000	1358,1967,1988	
LV Cnc (SDSS0919-08)	2005	81.3	13,500	214,260	
MT Com (RE1255+266)	2005	119.5	12,000	668,1236,344	
V355 UMa (SDSS1339+48)	2006	82.5	12,500	641,1065	320
PP Boo (SDSS1514+45)	2006	88.8	10,000	559	
OV Boo (SDSS1507+52)	2008	66.6	14,200	500,660,1140	
EZ Lyn (SDSS0804+51)	2008	85.0	13,000	256,756	86, 32 days?
DY CMi (SDSS0747+06)	2011	85.6		238,684	
BW Scl	2012	78.2	14,800	618,1242	87
SDSS1457+51	2012	77.9		582-642,1200	
SDSS0755+14	2017	84.8	15,900	257-262	
RXJ0232-37	2017	95.3	13,200	267	

corotation resonance (Whitehurst, 1988), it is hard to relate this to the disappearance of pulsations in the white dwarf. If the disk increases its extent and it then dominates the optical light to mask the white dwarf contribution, the overall brightness should increase by a noticeable amount.

5 Is 16-19 min a Preferred Pulsation Mode?

Of the 18 accreting pulsators (Table 1), 5 show a period near 19 min. In EQ Lyn, MT Com, BW Scl and SDSS1457+51, this period is a normal period during quiescence. However, in GW Lib, this period shows up only after its outburst (Bell et al., 2016; Chote et al., 2017) and appears and disappears on timescales of months. This is a relatively long period for a hot white dwarf and it is not clear what triggers this mode.

Table 2: Known Outbursts of Accreting Pulsators.

Object	Outbursts
PQ And	1938, 1967, 1988, 2010
GW Lib	1983, 2007
V455 And	2007
MT Com	1994
EQ Lyn	2006
EZ Lyn	2006, 2010
V355 UMa	2011
SDSS2205+11	2011
BW Scl	2011
OV Boo	2017

6 Are the Hrs-Days Periods Due to Pulsations?

In 6 short period ($\leq$ 1.5 hrs) accreting binaries (GW Lib, FS Aur, V455 And, V355 UMa, EZ Lyn and V406 Vir), long periods of several hours have been observed. Of these 6, four contain pulsating white dwarfs. Some of the properties of these long periods are reminiscent of the outbursts recently observed in ZZ Ceti stars in Kepler data (Bell et al., 2016, see also Bell in this conference). Those outbursts seem to occur only in ZZ Ceti stars near the red end of the instability strip. While only one (V455 And) of the accreting pulsators is near the red edge of the accreting pulsator instability strip, it is interesting to compare their general properties with those of the outbursting ZZ Ceti objects. Of course, all of the accreting pulsators have faster spins and different atmospheric compositions than the ZZ Ceti objects. Table 4 compares 3 of the accreting pulsators to the outbursting ZZ Ceti objects, as well as V406 Vir which is not known to pulsate but has very similar properties to EZ Lyn.

7 Why are There so Few Accreting Pulsators Known?

There is currently a lack of discovery of new accreting pulsators. While 11 of the 18 were found in the SDSS, the new sky surveys (CRTS, ASASSN, Kepler) are photometric. The primary way to identify candidates is through optical spectra, where the Balmer emission lines from the accretion disk are flanked by absorption

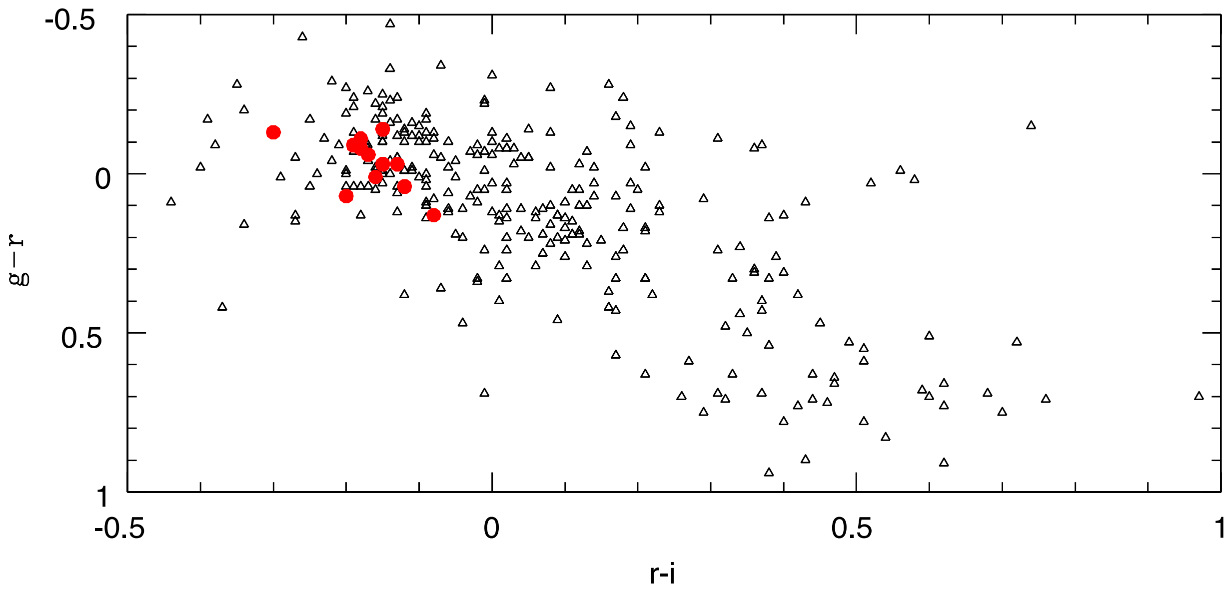

Figure 1: g-r vs r-i colors of all CVs from SDSS (Szkody et al., 2011) with objects with accreting pulsators shown in red.

Table 3: Systems Observed to Stop Pulsations Without Outbursts.

Object	T(K)	Outburst	Pulse On	Pulse Off
EQ Lyn	15,100	2006	2005/6,2010,2012,2014	2007,2011/12,2013
LV Cnc	13,500		2005,2010	2004,2007/8,2010,2012,2013
SDSS2205+11	15,000	2011	2004	2008,2012
SDSS0755+14	15,900		2015/16	2017
PP Boo	10,000		2005	2006,2012
V355 UMa	12,500	2011	2006,2014	2012

from the white dwarf. These spectra show that the white dwarf is a major contributor to the optical light and thus, pulsations from it can be detected. In general, this type of spectrum will exist for ultrashort (67-85 min) orbital period systems, where the mass accretion rate is very low, and the outbursts are large ($>$ 5mag) and the recurrence times long (years). Thus, followup spectra of these candidates from the ongoing sky surveys are needed to find more accreting pulsators.

In the early days of SDSS, Nilsson et al. (2006) suggested that the accreting pulsators might be found by color, as the 5 known at that time fell into a narrow color range in the g-r vs r-i color-color diagram. The colors of all 18 known accreting pulsators are shown along with all the known SDSS CVs from (Szkody et al., 2011) in Figure 1. While the range is larger than that found by Nilsson et al. (2006), this remains a possible way to narrow down candidates from photometric surveys.

Table 4: Accreting Pulsators Showing Long Periods.

Object	Amp(mag)	P(hr)	Repeats	T (K)
GW Lib	0.4	4	weeks	15,000
V355 UMa	0.025	5.5		12,500
EZ Lyn	0.6	1	32 day	13,000
V406 Vir	0.5	1	8.5 hr	18,000
ZZ Cet	0.1-0.4	1-24	2-10 days	11,000

8 Conclusions

It is apparent there are many unanswered questions remaining about accreting white dwarfs. To get answers, theorists are needed to provide the models for accreting objects with high temperature, spin and metal content. Spectra of objects that are being discovered in photometric surveys are needed to arrive at more pulsating candidates. Fast photometry with large telescopes for the faint objects are needed to confirm candidates as pulsators. Once a larger body of data exists, trends can be found that will aid in determining which pulsation modes are present and what causes them to change.

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