*White Dwarfs as Probes of Fundamental Physics: Tracers of Planetary, Stellar and Galactic Evolution*
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# Accreting pulsating white dwarfs: Probing heating and rotation

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**Abstract.** The white dwarfs in close, interacting binaries provide a natural laboratory for exploring the effects of heating and angular momentum from the accreting material arriving on the surface from the companion. This study is even more fruitful when it involves a pulsating white dwarf, which allows an exploration of the effects of the accretion on the interior as well as in the atmosphere. The last decade has seen the accomplishment of UV (HST) and optical (ground) studies of several accreting white dwarfs that have undergone a dwarf nova outburst that heated the white dwarf and subsequently returned to its quiescent temperature. The most recent study involves V386 Ser, which underwent its first known outburst in January 2019, after 19 years at quiescence. V386 Ser is unique in that its quiescent pulsation shows a triplet, with spacing indicating a rotation period of 4.8 days, extremely slow for accreting white dwarfs. This paper presents the result of HST ultraviolet spectra obtained 7 months after its outburst that shows the first clear confirmation of shorter period modes being driven following the heating from a dwarf nova outburst.

**Keywords.** accretion, dwarf novae, white dwarfs

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## 1. Introduction

Dwarf novae are close binaries consisting of a late main sequence star that is transferring material through the Roche lobe to a white dwarf via an accretion disk. In 18 known cases, the mass transfer is low enough that the accretion disk does not totally swamp the light of the white dwarf and non-radial pulsations are viewed. These accreting pulsators differ from single ZZ Ceti stars in several ways. They are generally hotter due to the accretion (12–16,000K) compared to the instability strip for ZZ Cetis (Gianninas, Bergeron & Fontaine 2007), they have mixed compositions due to the mass transfer (0.1 solar) compared to pure hydrogen for DAs or pure helium for DBs, they rotate faster (∼200 sec) compared to the rotation of days for single white dwarfs, and they are more massive ($0.8\mathrm{M}_\odot$) compared to single white dwarfs. The temperatures determined from UV spectroscopy with HST show that the instability strip for the pulsators is wide and contains dwarf novae with comparable temperatures that are not known to pulsate (Szkody *et al.* 2010). The width of the strip was explained by Arras, Townsley & Bildsten (2006) as due to helium enrichment of the atmosphere due to the mass transfer.

**Table 1.** Known Accreting Pulsators.

| **Name** | **Year** | **$P_{orb}$ [min]** | **T[° K]** | **$P_{pulse}$ [sec]** |
|---|---|---|---|---|
| GW Lib | 1998 | 76.8 | 15,000 | 236,376,648 |
| V455 And | 2004 | 81.1 | 10,500 | 320–370 |
| GY Cnc | 2004 | 81.5 | 14,500 | 335,581,595 |
| V386 Ser | 2004 | 80.5 | 14,500 | 221,346,609 |
| SDSS2205+11 | 2004 | 82.8 | 15,000 | 330,475,575 |
| EQ Lyn | 2005 | 77.8 | 15,100 | 1192–1230 |
| PQ And | 2005 | 80.6 | 12,000 | 1358,1967,1988 |
| LV Cnc | 2005 | 81.3 | 13,500 | 214,260 |
| MT Com | 2005 | 119.5 | 12,000 | 668,1236,1344 |
| V355 UMa | 2006 | 82.5 | 12,500 | 641,1065 |
| PP Boo | 2006 | 88.8 | 10,000 | 559 |
| OV Boo | 2008 | 66.6 | 14,200 | 500,660,1140 |
| EZ Lyn | 2008 | 85.0 | 13,000 | 256,756 |
| DY CMi | 2011 | 85.6 | | 238,684 |
| BW Scl | 2012 | 78.2 | 14,800 | 618,1242 |
| 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 |

While it remains unclear why some of the pulsators appear to stop pulsating at random times, it is known that the increased accretion during a dwarf nova outburst heats the white dwarf (Sion 1995; Godon *et al.* 2006) so that it moves out of the instability strip. Subsequent cooling on a human observable timescale of months to a few years allows a unique probe of how efficiently the convection zone drives pulsations. The 18 known accreting pulsators are listed in Table 1, along with their discovery years, their orbital periods, white dwarf temperatures and observed pulsation periods at quiescence. Of these, four have been observed after a dwarf nova outburst, using HST and ground observations prior to 2019. Diverse results were obtained. EQ Lyn had one observation a year after outburst, but showed no pulsations then and returned to its quiescent pulsation period within 3 yrs (Mukadam *et al.* 2011). V455 And showed a 1 min shorter period at 2 yrs past its outburst but has complications as it contains a magnetic white dwarf (Szkody *et al.* 2013a). GW Lib is still cooling after its 2007 outburst, shows a sporadic changing mix of periods between 5 min, 19 min and 4 hrs (Toloza *et al.* 2016) and EZ Lyn only showed pulsations after its outburst (Szkody *et al.* 2013b). In 2019, V386 Ser underwent its first known dwarf nova outburst.

## 2. V386 Ser

V386 Ser was first discovered in the SDSS by Szkody *et al.* (2002) and pulsations were found by Woudt & Warner (2004). An international campaign over 11 nights showed the dominant pulsations period at 609 sec was an evenly spaced triplet, implying a very slow rotation of 4.8 days (Mukadam *et al.* 2011). A low resolution UV spectrum obtained with the Solar Blind Channel on HST could be fit with a quiescent white dwarf of about 14,000K, while simultaneous optical data showed the identical periods as in the UV with a UV/opt amplitude ratio of 6 indicating a low order mode (Szkody *et al.* 2007).

A mid-cycle proposal for UV spectra with COS on HST was approved to determine the heated temperature of the white dwarf, the pulsation mode during this heated interval, and whether the atmosphere was rotating as slowly as the quiescent mode splitting implied. An early attempt to observe failed due to spacecraft jitter but was successfully redone on August 15, 7 months after outburst. The AAVSO data showed V386 Ser had declined to about 0.5 mag above quiescence. The resulting spectrum can be generally fit with a white dwarf near 20,000±2000K, about 6000K hotter than at quiescence. However, the blue wing of Ly$\alpha$ is lower than models predict. If this is not due to calibration issues with the new grating setting of the G140L, it implies a high helium abundance, exactly what is predicted by Arras, Townsley & Bildsten (2006). The fit also shows that the outer layer of the white dwarf atmosphere is rotating at a fast rate, about 150±50 km/s, similar to most accreting white dwarfs, and not at the very slow rate implied by the pulsation splitting.

Using the time-tag data acquisition, a light curve was constructed by summing and binning the spectral data for the two HST orbits. The power spectrum of this light curve reveals a very strong signal at 104.28±0.05 sec with an amplitude of 2.5%. Ground based photometry obtained at McDonald Observatory on July 25 shows a similar period of 104.01±0.08 sec with an amplitude of 0.6%. After more than a decade of trying, this is the first clear confirmation of the driving of shorter period modes after a dwarf nova outburst. The period of 100 sec is also interesting in that it is what Arras, Townsley & Bildsten (2006) show to be driven for a temperature of ∼19,000K and a helium abundance $Y = 0.58$.

## 3. Conclusions

Our recent HST and ground observations of the accreting pulsating white dwarf in V386 Ser 7 months after its large amplitude dwarf nova outburst reveal a temperature about 6000K hotter than quiescence, a pulsation period about 6 times shorter than quiescence and an atmospheric rotation rate comparable to other accreting white dwarfs and much faster than the slow rotation rate implied from asteroseismology. Future observations as it continues to cool to its quiescent temperature can track how a deepening convection zone begins to drive pulsation modes with longer periods.

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## References

Arras, P., Townsley, D., & Bildsten, L. 2006, *ApJ*, 643, L119
Gianninas, A., Bergeron, P., & Fontaine, G. 2007, *ASP-CS.*, 372, 577
Godon, P. *et al.* 2006, *ApJ*, 642, 1018
Mukadam, A. S. *et al.* 2010, *ApJ*, 714, 1702
Mukadam, A. S. *et al.* 2011, *ApJ*, 728, L33
Sion, E. M. 1995, *ApJ*, 438, 876
Szkody, P. *et al.* 2002, *AJ*, 123, 430
Szkody, P. *et al.* 2007, *ApJ*, 658, 1188
Szkody, P. *et al.* 2010, *ApJ*, 710, 64
Szkody, P. *et al.* 2013a, *ApJ*, 775, 66
Szkody, P. *et al.* 2013b, *AJ*, 145, 121
Toloza, O. *et al.* 2016, *MNRAS*, 459, 3929
Woudt, P. & Warner, B. 2004, *MNRAS*, 348, 599