Detection of the First Observed Outburst of DW Cancri

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Abstract Using data gathered by amateur astronomers from several nations, as reported to the American Association of Variable Star Observers (AAVSO), the first observed outburst of the intermediate polar DW Cancri was detected on January 25, 2007, at magnitude V ~11.36. This represented a brightening of ~4 magnitudes from both recent measurements and long term average quiescence. The outburst was of a relatively short duration, as measured from the first detection of the outburst, showing a fading of ~2.25 magnitudes in ~27 hours, and another ~1.25 magnitudes within the next ~30 hours. Follow up photometric observations show the asynchronous rotation period of the magnetic white dwarf star of this system to be 38.6 minutes, in agreement with previous studies; a strong secondary signal of ~73.7 minutes was also noted. As to whether or not the outburst was the result of disk instabilities or caused by a mass transfer event, no conclusion could be reached.

1. Introduction

Sterken and Jascheck (1996) identified Intermediate Polar (IP or DQ Her) systems as containing a non-synchronously rotating magnetized white dwarf with a cool companion (near the main sequence). These high mass transfer systems have an accretion disk near the white dwarf whose accretion activity is disrupted by the magnetic field of the white dwarf as it flows towards the magnetic poles from the accretion disk; variations in the brightness of this activity are caused by a combination of eclipsing and rotationally modulated accretion effects.

While Kholopov *et al.* (1981) gave this star its GCVS name of DW Cnc, Stepanian (1982) was the first to suggest that DW Cnc (R.A. 07^h 58^m 53.07^s, Dec. +16° 49' 26.2" (J2000)) is a dwarf nova, on the basis of its blue color and *V* magnitude variations from 15 to 17.5.

Patterson *et al.* (2004) provide an overall review of this intermediate polar. The time-series photometry in their study showed two periodic signals, over the course of a one-year baseline of measurement, of 38.6 and 69.9 minutes. The spectroscopic study detected a period of 86.1 minutes. The authors interpreted the 86.1-minute signal to be the orbital period of the binary (P_{orb}) and the 38.6-minute signal to be the spin period of the magnetic white dwarf (P_{spin}). The analysis further showed that the 69.9-minute signal was a spin-orbital beat period (lower orbital sideband) through the relationship of 1/69.9 = (1/38.6)–(1/86.1) within the limits of their measurements.

Rodríguez-Gil *et al.* (2004) noted that DW Cnc had yet to be observed undergoing an outburst (~8 years of monitoring) and that the normal range of the magnitude variations was between *V* ~14 and *V* ~15 with occasional low states ~2 magnitudes fainter.

Here we present photometry showing the first observed outburst of DW Cnc on January 25, 2007, as well as follow-up observations showing the asynchronous rotation period of the magnetic white dwarf star of this system, with additional data analysis showing a strong secondary period signal.

2. Observations

All data are from the AAVSO International Database and *V* filter with the exception of Boyd's data from February 5 and 6, 2007, which were unfiltered. Table 1 lists the equipment used by the authors.

The most recent observation of DW Cnc (within the AAVSO database) prior to the detected outburst occurred on 2007 January 21.317 UT, and was measured by MacDonald (Canada) at a magnitude *V* = 15.29. The closest previous observation to that date was on 2007 January 13.0578 UT and measured by Gualdoni (Italy) at magnitude *V* = 15.21. Gomez (Spain) measured DW Cnc at *V* = 15.48 on 2006 December 25.9913 UT.

The first observed outburst of DW Cnc was detected by MacDonald on 2007 January 25.2970 UT at *V* ~11.36; the variable was noted as being saturated in the image which places a lower limit on the brightness (just the variable was saturated, not the comparison stars, and MacDonald had to be urged to post his observation, even if the photometry was suspect once the importance of his image became more apparent). The first follow-up detections were by Crawford (USA) on 2007 January 26.4333 UT, where DW Cnc had already faded to an average magnitude *V* = 13.56, and Gualdoni (26.9839 UT) with magnitude *V* = 13.55.

The next series of observations occurred 2007 January 27.8833 UT when Boyd (England) measured the average magnitude *V* = 14.83. On 2007 January 28.8507 UT Oksanen (Finland) measured an average *V* = 14.84. Average magnitude values are referenced simply because of the large oscillations, of as much as ~0.9 magnitude occurring within the light curve as shown in Figure 2 from a 3.6-hour time series on January 29, 2007, by Crawford. The series of measurements by Boyd on January 27 showed the oscillations ranging from *V* = 14.56 to *V* = 15.37 magnitudes, which appears close to DW Cnc's recent quiescent state and with oscillations similar to those prior to the outburst.

Figure 1 shows the overall light curve from all AAVSO *V* filter observations of DW Cnc between the JD dates of 2454094.5756 and 2454135.3084 (December 24, 2006– February 4, 2007) which show the outburst duration to have been less than ~7 days.

3. Period analysis

An analysis of Crawford's ~3.6-hour January 29, 2007, photometric data run (Figure 2) shows a strong period signal of 0.0268 day = 38.6 minutes (Figure 3), which is the asynchronous rotation period of the magnetic white dwarf star of this system as derived from photometry. This analysis was preformed by PERANSO software (Vanmunster 2005) using the CLEANEST method.

Figure 4 (a, b) show ~25 hours of photometric time series data with ~21.5 hours of data, from five nights, being contributed by Boyd and combined with Crawford's ~3.6 hours from one night's data. A CLEANEST period analysis of the data in Figure 4, also shows the same strong period signal of 0.0268 day; however, in this analysis a relatively strong secondary signal can be readily observed as well as some obvious weaker signals (Figure 5).

When the resulting period data from the combined Boyd and Crawford observations (Figure 4 and Figure 5) were pre-whitened to remove the 0.0268-day period signal, a strong secondary period signal of 0.0512 day was detected as shown in Figure 6. This strong secondary period is 73.73 minutes.

4. Discussion

It is unfortunate that during the ~4 preceding days of the observed outburst there are no observations known to the authors or the length of the outburst could be more accurately determined.

Uemura *et al.* (2002) also showed a strong secondary quasi-periodic oscillation at 73.4 ± 0.4 minutes. This is in close agreement with our own strong secondary signal of 73.73 minutes. We note that the Patterson *et al.* (2004) study showed a spin-orbital beat period of 69.91 minutes.

Hellier *et al.* (1997), in a study of the IP XY Arieti, presented additional outburst data for six intermediate polars (V123 Sgr, TV Col, EX Hya, XX Ari, YY Dra, and GK Per), and Hellier *et al.* (2000) presented a study of the outbursts of the IP EX Hydrae and a discussion of mass-transfer events and disk instabilities. DW Cnc comes closest to EX Hya in terms of P_{orb} (98.4min) and TV Col in terms of P_{spin} (31.8 min), thereby sharing characteristics with both systems having outbursts due to disk instabilities and those having outbursts due to a mass transfer event. In addition, while DW Cnc (P_{spin} = ~55% P_{orb}) may be grouped with the majority of IP's (TV Col-V1223 Sgr grouping) with respect to having a spin period greater than five percent of the orbital period, DW Cnc appears to have a higher-amplitude outburst (~4 magnitudes) than the other members, and a longer period of duration (~2–4 days) than either TV Col or V1223 Sgr (~1–2 days).

5. Conclusions

We report the first observation of an outburst of the intermediate polar system DW Cnc. The outburst at its observed maximum V<=11.36 magnitude (qualified as star was saturated) showed a brightening of ~4 magnitudes from its previous quiescent state. The outburst was of a relatively short duration showing a fading of ~2.25 magnitudes in ~27 hours and another 1.25 magnitudes within another ~30 hours, from the time of discovery.

The rotational period of the white dwarf portion of the DW Cnc system (P_{spin}), as detected by Crawford's and Boyd's time series photometry at ~38.6 minutes, has remained the same since 2004. While Uemura *et al.* (2002) after a long term light curve study showed the strongest signal at a period ~37.5 minutes, Rodríguez-Gil *et al.* (2004) and Paterson *et al.* (2004) show the period to be ~38.6 minutes. Crawford and Boyd's data also show the rotational period to be stable over both short (3.6 hours) and longer (25.1 hours) periods of photometric time series data analysis.

No conclusion could be reached as to whether or not we are seeing a different spin-orbital beat period, a strong alias, or something else with the strong secondary period signal of 73.73 minutes.

DW Cnc does not appear to fit with either the grouping of IPs that go into outburst due to disk instabilities or those that go into outburst as a result of a mass transfer event, and no conclusion could be reached regarding the origin of this first observed outburst.

It would be desirable that both professional and amateur astronomers continue to observe and study this system, so that future outbursts can be detected and analyzed, and the question of whether or not the outburst is the result of disk instabilities, a mass transfer event, or even some other mechanism or combination can be resolved.

This is a demonstration, also, of the important role amateur astronomers from around the world can play in the collection of photometric data of variable stars, as well as the importance of the AAVSO as being a repository for those observations.

6. Acknowledgements

We acknowledge with thanks the variable star observations from the AAVSO International Database contributed by observers worldwide and used in this research.

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Table 1. Equipment used by the Authors

Observer (AAVSO Initials)	*Telescope*	*Size*	*CCD*
Crawford (CTX)	Meade, SCT @ f/10	30.5cm	SBIG ST-9XE
Boyd (BDG)	Meade SCT @ f/5.2	35cm	StarlightXpress SXV-H9
Gualdoni (GCO)	Meade SCT	25.4cm	SBIG ST-7XME
Gomez (GOT)	Newtonian @ f/5	20cm	SBIG ST7-XME
MacDonald (MDW)	Meade SCT @ f/6.3	25.4cm	StarlightXpress SXV-H9
Oksanen (OAR)	RCOS Ritchey-Chretien	40cm	SBIG STL-1001E

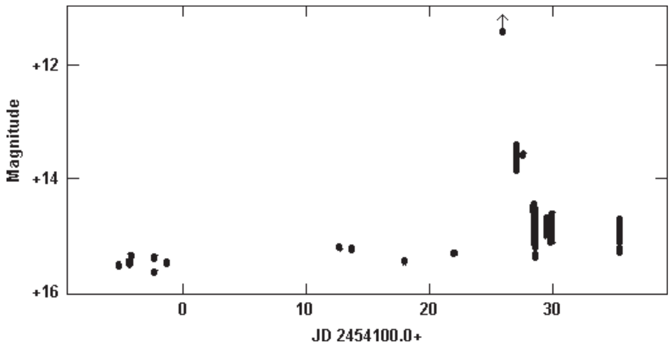


Figure 1. Photometric light curve from all AAVSO *V* filter observations of DW Cnc between the JD dates of 2454094.5756 and 2454135.3084 (2006 December 24–2007 February 04).

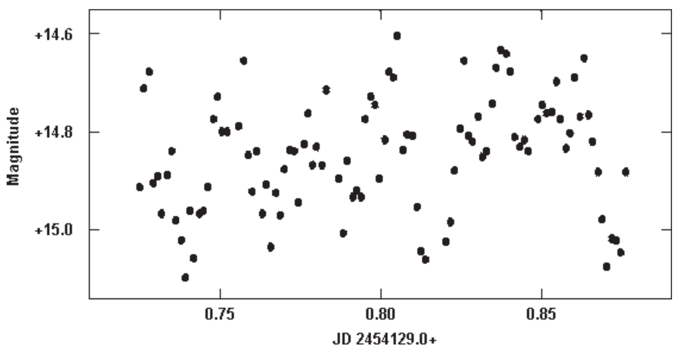


Figure 2. Time series photometry of DW Cnc obtained 2007 January 29, from *V* filter data gathered by Crawford over an approximate time period of 3.6 hours, demonstrating the frequent flickering of up to ~0.9 magnitude reported by previous observers.

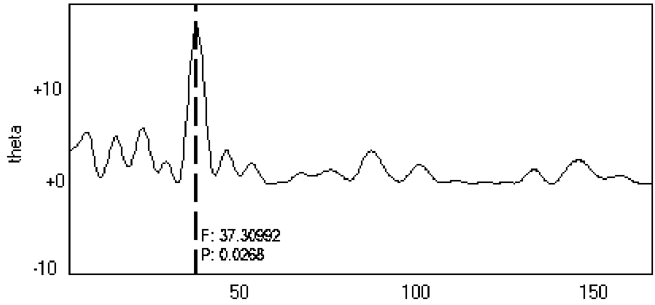
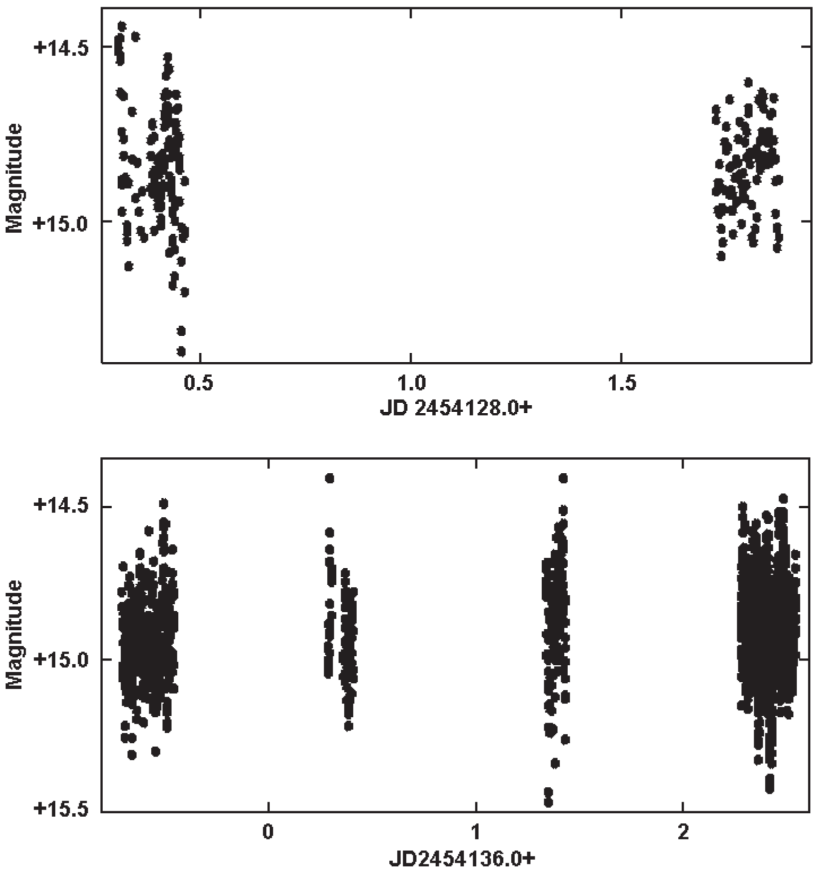


Figure 3. PERANSO software period analysis, using the CLEANEST method applied to Crawford's January 29, 2007, photometric data run as shown in Figure 2.



Figures 4a, 4b. ~25 hours of photometric time series data with ~21.5 hours of data from five nights, contributed by Boyd and combined with Crawdord's ~3.6 hours from one night's data. A CLEANEST period analysis of the data in Figures 4a and 4b, combined, also shows the same strong period signal of 0.0268 day.

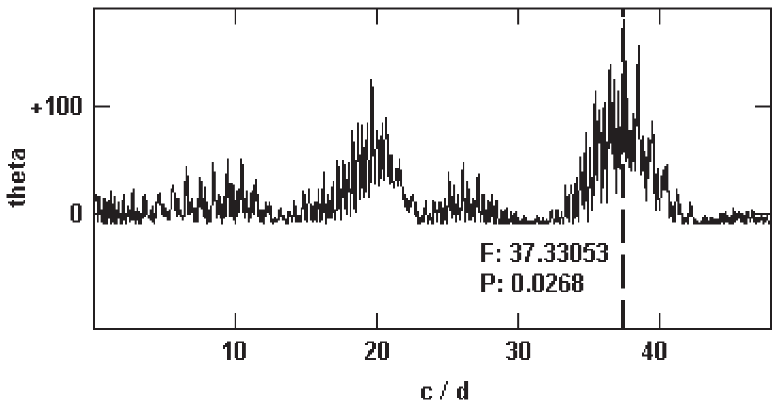


Figure 5. PERANSO software period analysis, using the CLEANEST method applied to ~25 hours of time series photometry. A relatively strong secondary signal can be readily observed as well as some obviously weaker signals.

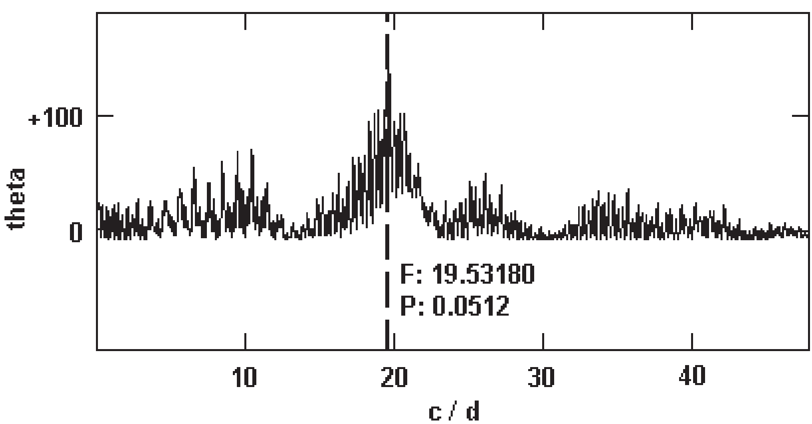


Figure 6. This presents the data from Figure 5 after a CLEANEST period analysis, after being prewhitened to remove the primary detected period signal of 38.6 minutes and leaving a strong secondary signal of .0512 d = 73.73 minutes.