Dwarf nova oscillations and quasi-periodic oscillations in cataclysmic variables - VII. OY Carinae and oscillations in dwarf novae in quiescence

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ABSTRACT
We have observed dwarf nova oscillations (DNOs) in OY Car during outburst, down through decline and beyond; its behaviour is similar to what we have previously seen in VW Hyi, making it only the second dwarf nova to have DNOs late in outburst that continue well into quiescence. There are also occasional examples of DNOs in deep quiescence, well away from outburst – they have properties similar to those during outburst, indicating similar physical causes and structures. We discuss the occurrence of DNOs in other dwarf novae and conclude that DNOs during quiescence are more common than often supposed and exhibit properties similar to those seen in outburst.

Key words: accretion, accretion discs – binaries: close, dwarf novae, cataclysmic variables – stars: oscillations – stars: individual: OY Car

1 INTRODUCTION
In this series of papers (Woudt & Warner 2002 (Paper I); Warner & Woudt 2002 (Paper II); Warner, Woudt & Pretorius 2003 (Paper III); Warner & Woudt 2006 (Paper IV); Pretorius, Warner & Woudt 2006 (Paper V); Warner & Pretorius 2008 (Paper VI); Woudt et al. 2009 (Paper VIII)) we have largely concentrated on the rapid oscillations in brightness that are observed in cataclysmic variables (CVs) that have accretion discs with high rates of mass transfer (\(\dot{M}\)), i.e., nova-like variables and dwarf novae in outburst. These have tended to be the most observed systems for dwarf nova oscillations (DNOs) and quasi-periodic oscillations (QPOs) because they provide the highest probability of exhibiting them (the rich phenomenology of DNOs and QPOs has been reviewed in Warner (2004)). Nevertheless, in Warner (2004) it was pointed out that there are a few reports, often isolated observations that have not been repeated, of optical and X-Ray DNOs and QPOs in dwarf novae in quiescence. An example is the 41.76 s DNO in quiescence of V893 Sco (Paper V). In addition, the independent variety of DNOs known as longer period DNOs (lpDNOs) observed at optical wavelengths (Paper III) has on one occasion been seen in quiescence in HT Cas (Patterson 1981) and once each in AQ Eri and OY Car (Paper III); we report more fully on OY Car in this paper. Examples of DNOs in early quiescence in VW Hyi, were first noted in Paper I, where QPOs in deep quiescence were also recorded.

The existence of DNOs and QPOs in quiescent dwarf novae is of considerable significance for their relevance to possible physical interpretations. For example, a belief that such DNOs only appear during outburst can influence the choice of model (e.g. Piro & Bildsten 2004).

We first give a description of the principal properties of oscillations observed during outbursts. A more thorough overview can be obtained from Warner (2004) and Warner & Woudt (2008). Standard DNOs exist in most but not all dwarf novae during outburst, with periods \(P_{\text{DNO}}\) in the range 6 – 40 s, varying systematically through each outburst and passing through minimum period at maximum luminosity. Two types of QPO are found: those related to DNOs, with \(P_{\text{QPO}}\sim 16 \times P_{\text{DNO}}\), and another kind with much longer quasi-periods, \(\sim 3000\) s. In the most studied dwarf nova, VW Hyi, frequency doubling and tripling of DNOs is observed late in outburst (Paper IV) and the fundamental period of the DNOs increases to become similar to that of the lpDNOs, which survive into the first few days after return to quiescence (Warner & Woudt 2008; Paper VIII).

The most worked on model used to explain the various kinds of oscillations is the Low Inertia Magnetic Accretor (LIMA), developed from a suggestion of Paczynski.
discuss their full evolution.

in outburst (Papers I and IV) and into quiescence, so we OY Car behave in a manner similar to those of VW Hyi
analyse the whole data set. It emerges that the DNOs in
in the SU UMa type dwarf nova OY Car (Paper III; Warner
We have previously described selected observations of DNOs
2.1 Observations during outburst and early
photometer. A log of these observations is given in Table 1.
observations obtained with the SAAO 30-inch reflector (and some
(O'Donoghue 1995) on the 40- and 74-inch reflectors. Obser-
the South African Astronomical Observatory (SAAO), us-
2 NEW OBSERVATIONS OF OY CAR
All of our observations were made at the Sutherland site of
the American Association of Variable Star Observers to produce
Figure 1. The average superoutburst light curve of OY Car (filled circles), compared to the average superoutburst profile of VW Hyi (open circles).

of 1.51 h, discovered by Vogt (1979), and has normal out-
bursts with an (uncertain) average interval of 160 d and superoutbursts that recur on a timescale of 346 d (Warner 1995). These are greater intervals than for VW Hyi, which has 28 d and 185 d respectively, suggesting that a lower mass transfer rate is operating in OY Car.

All of the outburst DNOs observed by us and by others happen to have been made during or shortly after superoutbursts. To provide a fiducial time during outburst with which to refer the DNOs (cf. the VW Hyi outburst templates in fig 5 of Paper I) we used magnitudes available from the American Association of Variable Star Observers to produce an average superoutburst light curve, shown together with one for VW Hyi in Fig. 1 (in OY Car, T = 0 corresponds to the brightness dropping through V = 14.1). Comparison of this with the American Association of Variable Star Observers (AAVSO) observations for the appropriate individual outbursts enables us to set our observations and those of previous observers on a common evolutionary time scale. For observations made during quiescence we list time since the last reported outburst.

We have computed Fourier transforms (FTs) of the light curves, subdividing them in order to be more sensitive to the occurrence of DNOs, which can vary in period and amplitude. When present we follow the oscillations using amplitude/phase diagrams (A − ϕ), which are simply observed-calcualted values of least squares fits of short lengths of light curve to sinusoids of appropriate periods. Table 1 notes whether significant oscillations occurred during the runs and Table 2 gives details for those sections, with mean periods and amplitudes determined from the least squares fits.

We found oscillations in only one of the runs made near a maximum of outburst; the FT for the combined subsections IV, V and VI of run S6722 is shown in Fig. 2 and shows DNOs and QPOs. The FT for a part of Section I of run S6724 (which was a continuation of S6722 on the same night) showed DNOs and lpDNOs and was given in fig. 16 of Paper III. The DNOs (Table. 2) show small variations in period around ~ 17.6 s, typical of that seen in other dwarf
Table 1. An overview of our data archive of OY Carinae. Observations during superoutburst and quiescence.

| Run     | Date       | $T$ | Length | $t_{\text{on}}$ | Tel. | DNO | lpDNO | QPO | Remarks                          |
|---------|------------|-----|--------|----------------|------|-----|-------|-----|---------------------------------|
|         |            | (d) | (h)    | (s)           |      |     |       |     |                                 |
| S6722   | 2003 Feb 01| −5.9| 2.80   | 4.5           | 40-in| √   | −     | √   | DNOs at 17 – 18 s (3 – 7 mmag)   |
|         |            |     |        |               |      |     |       |     | QPOs at 278 s (11 mmag)         |
| S6724   | 2003 Feb 01| −5.7| 1.94   | 5             | 40-in| √   | √     | √   | DNOs at 17 – 18 s (3 – 6 mmag)   |
|         |            |     |        |               |      |     |       |     | lpDNO at 116 s (9 mmag)         |
| S6727   | 2003 Feb 02| −4.9| 1.39   | 5.6           | 40-in| −   | −     | −   | No DNOs > 2 mmag                |
| S6730   | 2003 Feb 02| −4.8| 1.21   | 5             | 40-in| −   | −     | −   | No DNOs > 2 mmag                |
| S5482†  | 1992 Apr 21| −2.9| 2.25   | 5             | 40-in| −   | −     | −   | No DNOs > 2 mmag                |
| S6739   | 2003 Feb 04| −2.8| 1.97   | 5             | 40-in| −   | −     | −   | No DNOs > 2 mmag                |
| S5484†  | 1992 Apr 22| −2.0| 1.20   | 5             | 40-in| −   | −     | −   | No DNOs > 4 mmag                |
| S6743   | 2003 Feb 05| −1.9| 2.47   | 5             | 40-in| −   | −     | −   | No DNOs > 3 mmag                |
| S6748   | 2003 Feb 07| 0.2 | 1.54   | 5             | 40-in| √   | −     | −   | DNOs at 29 s (12 mmag)          |
| S6752   | 2003 Feb 09| 2.0 | 1.06   | 6             | 40-in| −   | −     | −   | No DNOs > 10 mmag               |
| S6754   | 2003 Feb 09| 2.2 | 2.81   | 5             | 40-in| √   | −     | √   | QPOs at 50 – 60 s (11 – 12 mmag) |
| S6755   | 2003 Feb 10| 3.2 | 0.58   | 6             | 40-in| √   | −     | −   | DNOs at 50 s (12 mmag)          |

Observations during quiescence

| Run     | Date       | $T$ | Length | $t_{\text{on}}$ | Tel. | DNO | lpDNO | QPO | Remarks                          |
|---------|------------|-----|--------|----------------|------|-----|-------|-----|---------------------------------|
|         |            |     |        |               |      |     |       |     |                                 |
| S2966†  | 1982 Mar 24| ~ 46*| 2.02   | 10            | 30-in| √   | −     | −   | (lp)DNOs at 104 s (25 mmag)      |
| S2970†  | 1982 Mar 25| ~ 47*| 1.49   | 10            | 30-in| −   | −     | −   | No DNOs > 10 mmag               |
| S2974†  | 1982 Mar 28| ~ 50*| 0.95   | 10            | 30-in| −   | −     | −   | No DNOs > 10 mmag               |
| S2982†  | 1982 May 18| ~ 101*| 1.04  | 10            | 30-in| √   | −     | −   | (lp)DNOs at 130 s (17 mmag)      |
| S3273†  | 1984 Mar 03| ~ 40*| 0.25   | 1             | 30-in| −   | −     | −   | No DNOs > 20 mmag               |
| S3826†  | 1986 May 02| ~ 20*| 0.69   | 5             | 30-in| −   | −     | −   | No DNOs > 20 mmag               |
| S6050   | 2000 Feb 01| ~ 202*| 1.36  | 10            | 40-in| −   | −     | −   | No DNOs > 9 mmag                |
| S6055   | 2000 Feb 03| ~ 204*| 2.32  | 5.8           | 40-in| −   | −     | −   | No DNOs > 5 mmag                |
| S6485   | 2002 Feb 15| ~ 34*| 6.91   | 5.7           | 74-in| √   | √     | √   | (lp)DNOs at 48 – 74 s (9 – 26 mmag) |
| S6488   | 2002 Feb 16| ~ 35*| 2.88   | 7             | 74-in| √   | −     | −   | (lp)DNOs at 48, 61 s (26 – 29 mmag) |

† $T = 0$ is defined by the average superoutburst profile (see Fig. 1); † data obtained with the UCT photometer; * Time since last recorded outburst.

Figure 2. The Fourier transform of a section of run S6722. Both the QPO and DNO frequencies are marked.
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Figure 3. The $A-\phi$ diagram for run S6722, relative to a fixed period of 17.59 s; phase variations are shown in the lower panel, amplitude variations are displayed in the top panel. The dashed vertical lines in the lower panel indicate times of mid-eclipse according to the ephemeris of Greenhill et al. (2006).

Figure 4. The Fourier transform of run S6754. The 305-s QPO is marked.

outburst in run S6724 serve to indicate the lpDNO periods. In VW Hya we found that the lpDNOs only increased slightly in period through outburst and into quiescence, so by analogy we have classified the $\sim 50-70$ s oscillations seen late after outburst as lpDNOs (Table 2), but there is some ambiguity because we have not detected any ordinary DNOs in the same runs.

There have been only two previous studies of DNOs in OY Car. Schoembs (1986) caught OY Car in late superoutburst and followed it into quiescence with 1 s integration times. He was the first to detect DNOs in this object and studied in detail oscillations with periods of 19.44, 20.48 and 27.99 s during outburst, also finding periodicities at 55 and 120 s in quiescence a week later. (As can be seen in fig. 8 of Schoembs (1986) his O–C curves do not return to their initial phases, indicating use of comparison sine waves with periods too short; the optimum periods would be up to two tenths of a second longer than those quoted by Schoembs.) Marsh & Horne (1988) observed with HST for $\sim 2250$ s towards the end of a superoutburst, finding a double DNO with periods 17.94 and 18.16 s, or an implied beat period of 1480 s; these we have discussed in Paper II.

We can combine the DNOs listed in Schoembs, Marsh & Horne and this work into two informative diagrams. A commonly plotted variation is the period-luminosity relationship, as seen in Fig. 5. The comparable plot for VW Hya is given in fig. 8 of Paper I, for which we made the comment that from maximum down almost to quiescence the slope is typical of dwarf novae during decline; but then, in VW Hya, there is a section where the period changes very rapidly without much drop in brightness. We found in VW Hya (Paper IV) that this phase of rapid deceleration of the oscillations is also where frequency doubling and tripling occurs. In OY Car the same large reduction of slope in the $V-log P_{DNO}$ diagram is discernable, even though poorly observed, but is recognizable through direct comparison with VW Hya.

The second diagram shows the evolution of DNO and lpDNO periods with time: Fig. 6. Again there is similarity to the behaviour of VW Hya, but without evidence yet for frequency multiplication. The fundamental periods of the VW Hya DNOs increase from 20.0 s at $T \sim 0$ to $\sim 90$ s at $T \sim 1.2$ d and then appear to stabilize at the latter period, which is similar to its lpDNOs (see Paper IV and fig. 2 of Warner & Woudt 2009). In the case of OY Car the DNOs increase from 17.6 s and stabilize at $\sim 60$ s.

### 2.2 Observations during deep quiescence

Schoembs (1986) was the first to observe DNOs in OY Car at quiescence – he found oscillations at 55 s and at 122 s in a light curve obtained 8 days after the end of a superoutburst. For our observations, returning to Tables 1 and 2, of 10 runs of sufficient length and quality to detect oscillations, made in quiescence well away from outbursts, we have three positive identifications. Run S2966 shows a very strong oscillation at 104 s for about 40 min; but it is in runs S6485 and S6488, made on consecutive nights, that we have a more informative haul. We have already illustrated a short section of S6488, showing large amplitude oscillations at $\sim 48$ s directly visible in the light curve (Paper III); here we analyse these quiescent DNOs in detail. An aspect that is conducive to detecting rapid oscillations is that the quiescent light curves of OY Car have unusually low flickering activity.

For these runs S6485 and S6488 Table 2 shows occa-
Table 2. DNOs, lpDNOs and QPOs in OY Carinae.

| Run No. | O/Q† | HJD start (2440000 +) | Length (s) | DNOs (periods in seconds) [amplitude in mmag] | lpDNOs (periods in seconds) [amplitude in mmag] | QPOs (period in seconds) [amplitude in mmag] |
|---------|------|----------------------|------------|-----------------------------------------------|-----------------------------------------------|------------------------------------------|
| S6722   | O    | 12672.36511          | 761        | 17.84 (0.05)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.37662          | 1326       | 17.56 (0.03)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.39202          | 1377       | 17.37 (0.02)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.42741          | 1260       | 17.82 (0.05)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.44205          | 2325       | 17.61 (0.01)                                  | –                                             | 278 (1)                                 |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.46907          | 1005       | –                                              | –                                             |                                          |
| S6724   | O    | 12672.54502          | 3445       | 17.80 (0.01)                                  | 116.3 (0.9) 63.9 (1.2)                         | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.58501          | 1550       | 17.61 (0.02)                                  | –                                             | 315 (1)                                 |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.60301          | 945        | 17.44 (0.07)                                  | 67.7 (0.5)                                   | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12672.61401          | 940        | 17.80 (0.04)                                  | –                                             | –                                        |
| S6748   | O    | 12678.42970          | 1790       | 28.89 (0.06)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
| S6754   | Q    | 12680.42688          | 990        | 42.85 (0.22) 48.91 (0.31)                      | –                                             | 346                                      |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12680.44714          | 2395       | 51.90 (0.20) 60.89 (0.27)                      | –                                             | 352                                      |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12680.47491          | 2441       | 48.68 (0.14)                                  | –                                             | 305 (1)                                 |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12680.51156          | 2266       | 52.48 (0.23)                                  | –                                             | 571 (2)                                 |
|         |      |                      |            |                                               |                                               |                                          |
| S6755   | Q    | 12681.46269          | 2106       | 49.68 (0.19)                                  | –                                             | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
| S2966   | Q    | 5053.32008           | 2320       | –                                              | 104.4 (0.4)                                  | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
| S2982   | Q    | 5108.21176           | 3760       | –                                              | 130.4 (0.7)                                  | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
| S6485   | Q    | 12321.32548          | 4360       | –                                              | 66.99 (0.20)                                  | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12321.38501          | 1120       | –                                              | 74.20 (0.61)                                  | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12321.44501          | 860        | –                                              | 61.39 (0.37) 74.26 (0.55)                      | 354                                      |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12321.48902          | 1898       | –                                              | 56.92 (0.20) 69.71 (0.23)                      | 310                                      |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12321.54198          | 1120       | –                                              | 48.35 (0.23)                                  | 585 (3)                                 |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12321.55500          | 1728       | –                                              | 50.71 (0.15)                                  | –                                        |
| S6488   | Q    | 12323.50036          | 1088       | –                                              | 60.52 (0.59)                                  | –                                        |
|         |      |                      |            |                                               |                                               |                                          |
|         |      | 12323.51303          | 1120       | –                                              | 47.84 (0.16)                                  | –                                        |

Notes: Uncertainties in the periods are quoted after the periods in parentheses; † O/Q = Outburst/Quiescence.
sional simultaneous presence of two DNOs, separated by $\sim 12$ s with beat period $\sim 330$ s, and also a tendency to switch between two similarly spaced periods. This is very similar to the simultaneous or alternating presence of direct and reprocessed beams mentioned in Section 1 and discussed in Paper VI. Therefore in OY Car we see, for the first time, an aspect of outburst behaviour also present in quiescence. Fig. 7 shows a section of S6485 in which DNOs at 61 s and 74 s are present with sufficient amplitude that the beats between them can be seen. Fig. 8 shows an $A - \phi$ diagram for part of run S6485 in which the abrupt shift from one DNO period to another is seen as a change of slope in the phases.

Fig. 9 shows the 74 s lpDNO emerging from eclipse. It appears after the central part of the disc has been uncovered but before the bright spot has reappeared, which is consistent with the lpDNO source being close to the primary. Fig. 9 is very similar to the run 2290 eclipse of HT Cas shown in fig 8 of Patterson (1981), which was used to deduce that the flickering source in HT Cas is located near the centre of the disc - we suggest that it was not flickering but the $\sim 100$ s lpDNO in HT Cas that was active at that time.

The last two sections of S6485 show a QPO with period 585 s, which is roughly twice the period inferred from the double DNOs in the earlier part of the run. A similar effect was seen in run S6754 (Table 2). Switches between a QPO and its harmonic are commonly seen in VW Hyi (figure 10 of paper IV).

Despite the various similarities between OY Car and VW Hyi we found no DNOs in the latter during quiescence to much lower amplitude limits than those we have observed in OY Car (table 1 of Paper I).

2.3 DNOs during eclipse
Schoembs (1986) found that the amplitude of DNOs in two of his light curves obtained near supermaximum peaked somewhat after eclipse minimum. The phase variations did not show any definite variation through eclipse, but the
DNO periods were not sufficiently stable to give reliable results. Our superoutburst run S6724 is of high quality and possesses two eclipses that are suitable for analysis. The light curve was smoothed by subtracting a 15 bin running average before determining the $A - \phi$ diagram. The basic light curve and the amplitudes and phases of the DNOs are shown in Fig. 10. As can be seen from the phase diagram, there were changes of DNO period through the run (see Table 2); these prevent confident detection of systematic phase shifts through eclipse, but, as previously found by Schoembs, there are maxima in the DNO oscillation amplitudes well after eclipse minimum. In Fig. 11 we show the $A - \phi$ diagrams in the vicinity of the two eclipses, folded on orbital phase. Schoembs noted that in his runs maximum DNO amplitude corresponded to maximum of superhumps, but that may have been only a coincidence because this does not appear to be the case in our run. It is possible that the offset of pulse amplitude relative to mid-eclipse is caused by a strong reprocessing signal coming from the thickened disc in the vicinity of the impact of the accretion stream, as has recently been found for DQ Her (Saito & Baptista 2009).

Our analysis of the quiescent DNOs during eclipse, which is made difficult because of variable periods of the lpDNOs, shows no systematic phase changes and in particular no peak amplitude after mid-eclipse as is seen in outburst (Fig. 11).

3 OTHER OSCILLATIONS IN QUIESCENCE
3.1 Other DNOs observed in quiescence

In addition to the quiescent DNOs or lpDNOs discussed in the previous Section there are reports of hard X-Ray DNOs in other quiescent dwarf novae. Cordova & Mason (1984) and Eracleous, Patterson & Halpern (1991), from the same half an hour length of data, find a period at 21.83 s in HT Cas. Although intrinsically of weak statistical significance this is close to the 20.2 – 20.4 s range of DNOs observed during outburst (Patterson 1981) and therefore gains credibility. Pandel, Cordova & Howell (2003) found a 62 s modulation in quiescence in VW Hyi, with an amplitude of 6% and of similar strengths in hard and soft X-Rays. From the width of the signal in the Fourier transform they deduced a coherence length of only 2 cycles, but the spectral broadening is certainly due to a steady change of period and alternating direct and reprocessed contributions of a far more coherent DNO (Paper VI). U Gem showed periods of 121 and 135 s (table 3(a) of Cordova & Mason (1984)) in quiescence, the beat period between which is 1166 s, which is almost exactly twice the 585 s QPO period seen in hard X-rays during an outburst of U Gem (Cordova & Mason 1984), suggesting that the shorter periods are lpDNOs and that frequency doubling (Section 1) of the QPO had taken place. This is also consistent with ∼ 25 s DNOs observed in soft X-Rays during outbursts of U Gem (Mason et al. 1988). One other claim is a statistically significant 33.9 s DNO in SU UMa (Eracleous et al. 1991), which has had no optically detected DNOs even during outburst to compare with it.

3.2 QPOs in quiescence

Although rare, there are previous observations of optical QPOs in the quiescent state of some dwarf novae. The earliest was of 1200 – 1800 s modulation in SS Aur with amplitude up to 0.5 mag (Tovmassian 1987, 1988). Recently RAT J1953+1859 was initially discovered to be a CV through the presence of 0.3 mag QPOs at ∼ 1200 s, and later found to outburst as a dwarf nova (Ramsay et al. 2009). Between
these dates a QPO at 343 s and amplitude 0.03 mag, with a possible orbital sideband, was found in V893 Sco (Bruch, Steiner & Gneiding 2000; Paper III) and a QPO at 190 s in WX Hyi, reported in Paper V, is similar to one seen in outburst. These latter are probably lpDNOs. QPOs at 1000 s were found to be quite common in VW Hyi at quiescence (Paper I).

There are also two observations of quiescent QPOs made in the X-ray region: 290 s in AB Dra (Cordova & Mason 1984), which is possibly also an lpDNO, and a pair at 2193 and 3510 s in OY Car (Ramsay et al. 2001; Hakala & Ramsay 2004).

4 DISCUSSION

Our observations of OY Car during outburst show that it shares many behavioural properties with the more comprehensively studied VW Hyi. As with VW Hyi its DNOs can be followed into quiescence for a few days after outburst, but in addition it can show occasional DNOs in quiescence at any time between outbursts. Our analysis indicates that the quiescent DNOs in many ways resemble outburst DNOs, and therefore require similar physical explanations.

The notion that a LIMA model is applicable in the low $M$ state is supported by the conclusion of Wheatley & West (2003) from hard X-Ray observations of OY Car during quiescence. They find that eclipse of the emitting source is of much shorter duration than that of the white dwarf and is displaced such that the X-Rays evidently arise in a small region at high latitude on the surface of the primary. This is what is expected from magnetically controlled accretion onto an underlying inclined dipole field of the primary, rather than onto a stronger field generated during outburst by the differentially rotating equatorial belt.

We have presented observations that suggest that, although rarer than some of those seen during outburst, DNOs during quiescence are present in a number of dwarf novae, should be searched for more assiduously, and need to be accommodated in any general model of CV oscillations.

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