Is the old nova RW UMi (1956) an intermediate polar?

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ABSTRACT

From photometric observations of the old nova RW UMi (1956) we have discovered the presence of five sub-orbital periodicities. The longest period, $P_1 = 54.4$ min, always observed, could be the beat period between the orbital period and the white dwarf (WD) spin period that we assume to be $P_2 = 33.4$ min. The other suborbital periods could be orbital sidebands with respect to $P_2$ and/or correspond to Keplerian resonance radii. We suggest that in its post-outburst state, characterized by higher $M$, RW UMi is an asynchronous intermediate polar with a truncated accretion disc. If the magnetic momentum of the WD is $\mu_{34} \sim 0.8$, in its quiescent pre-outburst state, the nova would appear as a discless, synchronous intermediate polar.

Key words: Close Binaries – Cataclysmic Variables – mass transfer – stellar evolution – magnetic fields – stellar winds –

1 INTRODUCTION

Classical novae (CNe) belong to the class of Cataclysmic Variables (CVs) and are formed by a white dwarf (WD) primary accreting matter from a Roche lobe filling companion, usually a lower main sequence star. The WD is surrounded by an accretion disk, unless its magnetic field is strong enough to partially (Intermediate Polar systems) or totally (Polar systems) control the accretion geometry. Stable mass transfer is ensured by angular momentum losses from the binary system due to the magnetic braking mechanism and gravitational radiation. Thus, CVs evolve towards shorter and shorter orbital periods and lower and lower masses of the secondary.

The orbital periods of CVs show a bimodal distribution characterized by a minimum period of $P \sim 80$ min and a gap in the range $2h \leq P_{\text{orb}} \leq 3h$ (see Warner 1995 for a comprehensive review). The 3$h$ upper limit of the gap corresponds to secondary stars which are just becoming fully convective ($M_2 \approx 0.3\, M_\odot$) and in which the dynamo mechanism is partially suppressed leading to a drastic decrease of the efficiency of the magnetic braking and, consequently, of the accretion rate (Zangrilli et al. 1997). The secondary then shrinks inside its Roche lobe until gravitational radiation will bring them again in contact, which will happen when the binary has reached $P_{\text{orb}} \sim 2h$.

The accretion luminosities of old novae are at any given orbital period systematically brighter than those of dwarf novae (DNe), suggesting that the former ones have higher mass transfer rates and/or hotter white dwarfs and thermally stable accretion discs. There seems to be no systematic difference between the pre- and the post- nova luminosities, although a few old novae appear 2–4 magnitudes brighter than in their pre-nova state. Amongst these, GQ Mus, CP Pup and V1974 Cyg have orbital periods below the period gap, while V1500 Cyg is just above it (Ritter & Kolb 1998). However, while strongly magnetized systems like GQ Mus and V1500 Cyg, as ‘polars’, are expected to alternate between high and low states of their accretion rates, the explanation for the luminosity standstills of disc accreting systems like CP Pup and V1974 Cyg suggested by Retter & Naylor (2000) is that, after the outburst, they experience a constant superhump phase.

RW UMi is a high galactic latitude, probably slow, nova that brightened in 1956 reaching $m \sim 6$. It was first considered as a supernova by Kukarkin (1962) due to its unusually large outburst amplitude and because it was apparently located out of the Galactic halo. The pre-nova magnitude was estimated $\sim 21$ (Duerbeck 1987), but its post-outburst magnitude still is about $2.2$ mag brighter. Esenoglu et al. (2000) estimated the nebular parallax of the nova as $5000 \pm 800$ pc. This yields $M_V^{\text{max}} \sim -7.7$ at light maximum, and $M_V^{\text{min}} \sim 7.3$ or $\sim 5.1$ before and after the outburst, respectively. Thus the nova is located in the Galactic halo.

The first spectroscopic observation of RW UMi was ob-
of the nova from the WIRO observations. The journal of observations is given in Table 1.

2.1 WIRO observations

WIRO observations were secured in June 1999 using the Michigan State University visual camera attached at the prime focus of the 2.3 m telescope (WIRO) on Jelm Mountain (Laramie, WY). The space resolution was 2.3 arcsec/pixel. We observed with a time resolution of 27 s for 2.72 h on June 18, and for 2.60 h on June 19. In order to obtain a higher S/N ratio we did not use filters. We selected a small region for the CCD readout in order to improve the

![Figure 1](https://example.com/figure1.png)

Figure 1. 2.5" × 2.5" field of nova RW UMi. North is at the top, East is to the left. The position of the nova is marked by a circle but the object is invisible (m_v ≥ 21) in the POSS before its eruption in 1956. Stars a and b have been used to obtain the mean relative fluxes of the nova observed with WIRO.

![Figure 2](https://example.com/figure2.png)

Figure 2. Mean flux ratios of RW UMi with respect to field stars a and b of Fig. 1, obtained during the first night at WIRO. No filter was used. The typical error bar of individual data points is shown in the upper right of the plot.

2 THE OBSERVATIONS AND DATA REDUCTION

The 2.5" × 2.5" field centered on the nova is shown in Fig. 1. No object is seen at the position of the nova because the POSS image was taken before the 1956 outburst. However, the luminosity of the post-nova is higher than the pre-nova, and its image, together with the magnitudes and colours of two field stars, labelled b and c in Fig. 1, were provided by Kaluzny & Chlebowski (1989). These field stars allowed an absolute calibration of the Ekar V magnitudes. Stars a and b in Fig. 1 were used to obtain the mean relative fluxes of the nova from the WIRO observations. The journal of observations is given in Table 1.

![2.5" × 2.5" field of nova RW UMi. North is at the top, East is to the left. The position of the nova is marked by a circle but the object is invisible (m_v ≥ 21) in the POSS before its eruption in 1956. Stars a and b have been used to obtain the mean relative fluxes of the nova observed with WIRO.](https://example.com/figure1.png)

![Mean flux ratios of RW UMi with respect to field stars a and b of Fig. 1, obtained during the first night at WIRO. No filter was used. The typical error bar of individual data points is shown in the upper right of the plot.](https://example.com/figure2.png)
time resolution of our observations. The selected field therefore contained only RW UMi and field stars a and b (see Fig. 3). We then measured the mean flux ratios between the nova and the two nearby stars following standard photometric procedure. The light curves of the nova, expressed as flux ratio variations, for the two observing nights at WIRO are shown in Figs. 2 and 3. We note that, in spite of the fact that each run was about 1.9 times the main period, its modulation is not clearly seen in our data. The reason is that the light curve of the nova is intrinsically rather irregular which also explains why only the systematic and extended observations performed by Retter & Lipkin (2001) were able to provide a precise period.

2.2 Ekar observations

Additional observations in V were obtained in May 2000 at Asiago, Italy, using the 1.82 m Mt. Ekar telescope with the CCD of the AFOSC system as an imager. The time resolution was 430 s. Data reduction was performed with IRAF software packages. Field stars b and c of Fig. 1 allowed the calibration of the V magnitudes (Kaluzny & Chlebowski 1983). The light curves of the old nova from the two Ekar observing nights are shown in Figs. 4 and 5. The length of each observation is about 2.3 orbital periods, and in this case the orbital modulation is more evident than in the WIRO data.

2.3 The photometric periods.

As anticipated, the pathological irregularity of the light curve of this old nova makes the determination of the main period (Retter & Lipkin 2001) difficult, when only two or three cycles are observed. For example, the Fourier analysis of the WIRO data, probably due to the rather different appearance of the two data sets, would suggest a period of 0.098 d. The Ekar data, instead, show a best period at 0.06614 d, while a peak at 0.05856 d, the closest one to $P_{\text{main}}$, is only the fifth highest alias in the power spectrum.

In order to look for the presence of higher frequency secondary modulations, we have corrected our data sets subtracting the observed orbital modulation and long term trends. We performed harmonic analysis using the CLEAN program which eliminates aliases (Roberts et al. 1987). Power spectra are presented in Figs. 6-8. Fig. 6 shows that all the significant peaks in WIRO data are at frequencies below 200 d$^{-1}$. Fig. 7 shows the results for individual nights. Night 1 shows three main periods, $P_1 \sim 54$ min, $P_2 \sim 33$ min, and $P_3 \sim 17$ min; night 2 still shows $P_1$ and $P_3$, but also $P_3 \sim 24$ min.

Fourier analysis of the two Ekar runs is shown in Fig. 8. A year after WIRO observations, $P_1$ is still the more stable...
Table 2. Suborbital periodicities found in RW UMi. The specific values were determined by subtracting all other frequencies but the one under consideration. They are here presented with a precision which only reflects the resolution of the periodogram. The systematic uncertainty due to the broadness of the individual peaks is much larger and estimated to amount to $\sim \pm 2 \text{ d}^{-1}$.

The main period $P_{\text{main}}$ determined by Retter & Lipkin (2001) is also reported: according to them it corresponds to a positive superhump period.

| Telescope | Night | Peak | Frequency (d$^{-1}$) | Period (min) |
|-----------|-------|------|---------------------|--------------|
| WIRO      | 1+2   | $P_1$| 26.447              | 54.449       |
|           | 1     | $P_2$| 43.150              | 33.372       |
|           | 2     | $P_3$| 59.000              | 24.407       |
|           | 1+2   | $P_4$| 82.820              | 17.387       |
| Ekar      | 1+2   | $P_1$| 26.50               | 54.34        |
|           | 1     | $P_2$| 43.00               | 33.49        |
|           | 1     | $P_3$| 68.10               | 21.14        |
| main period | $P_{\text{main}}$ | 16.915 | 85.133 |

Figure 6. Clean power spectrum of all WIRO data up to their Nyquist frequency, after subtraction of the orbital modulation and long term trends: significant signals are below frequency 200 d$^{-1}$.

Figure 7. Clean power spectra of WIRO data after correction for the long-term trends. Upper panel: night 1 shows three main peaks, $P_1$, $P_2$ and $P_4$ at about 23, 43 and 80 d$^{-1}$, respectively; medium panel: night 2 still shows $P_1$ and $P_3$ but also another consistent signal, $P_5$, at about 60 d$^{-1}$; lower panel: in the combined data of nights 1 and 2, $P_1$ and $P_4$ appear more prominent than $P_2$ and $P_3$ because they were observed in both nights.

Each of the detected periodicities is represented by a folded light curve in Figs. 9 and 10. The periods adopted are those of Table 2 and do not coincide exactly with those of Figs. 7 and 8. They were found by performing Fourier analysis on our data sets after the subtraction of all the other periods except the one under examination. In this way, each modulation is no longer distorted by the simultaneous presence of the other periods. The small error bars suggest that the modulations are rather well defined.

3 DISCUSSION

3.1 The long term light curve

Table 3 collects some historical magnitude determinations of RW UMi, and reports, whenever possible, the range of the light modulation observed and the colours. While this list suggests a slow negative trend of the luminosity of the
old nova, the reported (mean) magnitudes all lie within the observed short-term variations of the individual runs. Thus, only future observations will be able to confirm such a possible decline.

3.2 Physical parameters of the binary

Assuming that the period derived by Retter & Lipkin (2001) is very close to the actual orbital period (see next section), and taking the recent correlation between the orbital period and the mass of the secondary star presented by Howell (2001), we may estimate the mass of the secondary in RW UMi as $q = 0.16$ well satisfies the condition $q \leq 0.22$ for the formation of positive superhumps. This might favour the interpretation of the positive superhump period $P_{\text{SH+}}$ as

$$P_{\text{SH+}} = \frac{1 + q}{1 + 0.74q} P_{\text{orb}},$$

(1)

With $q = 0.16$, we obtain a positive superhump period 4% larger than the orbital one.

This situation corresponds to the scenario suggested by Retter & Lipkin (2001). They also suggested that, similarly to the other two short-orbital-period old novae CP Pup and V1974 Cyg, the presence of positive superhumps might be a consequence of the post-outburst higher accretion luminosity.

b) Negative superhumps. A few CVs are known to show cyclical brightness modulations with periods shorter than the orbital one. This phenomenon is generally interpreted as the result of a precessing disc. The precession of the outer anulus of a tilted disc in this case is retrograde. From Warner’s (1995) equation (2.62c) we obtain for the negative superhump period $P_{\text{SH-}}$:

$$P_{\text{SH-}} = \left(1 + 0.35 \frac{q}{(1 + q)^2}\right)^{-1} P_{\text{orb}} = \left(1 + 0.35 \frac{q}{(1 + q)^2}\right)^{-1} P_{\text{orb}}.$$  

(2)

For RW UMi this results in $P_{\text{SH-}}$ being 4% shorter than $P_{\text{orb}}$.

We conclude that the period observed by Retter & Lipkin (2001) should represent the orbital period within 4% uncertainty. We furthermore note that our derived mass ratio $q = 0.16$ well satisfies the condition $q \leq 0.22$ for the formation of positive superhumps. This might favour the interpretation by Retter & Lipkin (2001) that $P_{\text{main}}$ represents a positive superhump period.

3.3 Superhumps and the orbital period

CVs can show several photometric periods, the most important ones are related to the orbital period. The most obvious case is that of CVs at sufficiently high inclination showing eclipses and/or luminosity bumps due to the hot spot. Other important photometric modulations, which do not seem to be strongly related with the inclination of the binary system, are called ‘superhumps’ and may differ by a few percent from the orbital period. Actually, two opposite cases are observed:

a) Positive superhumps. They mostly characterize SU UMa DN systems during super outbursts and are thought to be produced at relatively large mass transfer rates, when the outer edge of the accretion disc expands reaching the 3:1 resonance radius. Positive superhumps then represent the beat period between the apsidal prograde precession of the eccentric outer edge of the disc and the orbital motion of the secondary.

Taking equations (3.34) and (3.42) from Warner (1995) we find a relation between the positive superhump period $P_{\text{SH+}}$ and the orbital one $P_{\text{orb}}$:

$$P_{\text{SH+}} = \frac{1 + q}{1 + 0.74q} P_{\text{orb}}.$$  

(1)

We furthermore note that our derived mass ratio $q = 0.16$ well satisfies the condition $q \leq 0.22$ for the formation of positive superhumps. This might favour the interpretation by Retter & Lipkin (2001) that $P_{\text{main}}$ represents a positive superhump period.

3.4 The suborbital photometric periods

Besides the superhumps, which periods are close to the orbital one, CVs may show other periodic or quasi-period oscillations (QPOs) in their light curves. These phenomena might be similar to those observed in LMXBs. However, probably due to the longer timescales in CVs, they have not been studied as thoroughly. The secondary, suborbital, periodicities found in RW UMi are listed in Table 3.

Lai (1999) has shown that the inner region of the accretion disc around a rotating magnetized collapsed object.

Table 3. Historical magnitude determinations for RW UMi.

| JD      | $V$  | $\pm \Delta V$ | $B$  | $\pm \Delta B$ | $B - V$ | $V - R$ | Ref.       |
|---------|------|----------------|------|----------------|---------|---------|------------|
| 2246778.05 | 18.70 |               |      |                |         |         | Kaluzny & Chlebowski (1980) |
| 2447744.30 | 18.72 |               |      |                |         |         | Szkody (1994) |
| 2447451.35 | 18.5  | 0.2            |      |                |         |         | Szkody et al. (1995) |
| 2447452.25 | 18.8  | 0.2            |      |                |         |         | Szkody et al. (1995) |
| 2447797.7 | 18.9  | 0.13           | 18.9 | 0.13           |         |         | Howell et al. (1991) |
| 2448117.5 | 18.90 |               |      |                |         |         | Ringwald et al. (1996) |
| 2450962.0 | 18.95 |               |      |                |         |         | WIRO data (white light) |
| 2451347.72 | 18.9  | 0.23           |      |                |         |         | Howell et al. (1991) |
| 2451348.65 | 18.9  | 0.23           |      |                |         |         | Szkody et al. (1989) |
| 2451695.52 | 18.93 | 0.27           |      |                |         |         | Ekar data   |
| 2451696.52 | 18.94 | 0.24           |      |                |         |         | Ekar data   |

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Figure 8. CLEAN power spectra of Ekar observations after correction for the long-term modulation. Upper panel: night 1 shows peaks around 28 d$^{-1}$, relatively close to $P_1$, at 43 d$^{-1}$, which is $\sim P_2$, and around 67 d$^{-1}$ ($P_5$); medium panel: on night 2 only a broad peak around 25 d$^{-1}$, that is $P_1$, is relevant; lower panel: in the combined data of nights 1 and 2, $P_1$ and $P_2$ are still prominent.

Table 4. Dynamical and geometrical parameters of the binary system.

| $P_{\text{main}}^{(1)}$ (d) | $M_1^{(2)}$ ($M_\odot$) | $q^{(3)}$ | $a^{(4)}$ (10$^{10}$ cm) |
|-----------------------------|------------------------|----------|---------------------|
| 0.05912                     | 0.7                    | 0.16     | 4.16                |

| $R_{L1}^{(5)}$ (10$^{10}$ cm) | $P_{\text{WD}}^{(6)}$ (10$^8$ cm) |
|-------------------------------|-------------------------------|
| 2.83                          | 5.655                         |

1) is in all cases close to $P_{\text{orb}}$ (see text); 2) tentatively assumed for a slow nova; 3) $M_2$ is derived from Howell (2001); 4) $a$ is the orbital separation; 5) Roche lobe radius of the WD (Warner 1995); 6) from Hamada & Salpeter (1961).

Figure 9. WIRO data folded with the four main signals detected. For the folding we used the peak values of the periodogram indicated in each panel. Note that the given precision only corresponds to the resolution of the periodogram (see also Table 4). Individual points and error bars refer to the means within each 0.1P phase interval. Phase zero refers to the first datapoint (see Table 4); $P_1$ and $P_2$ are the more stable signals (see also their smaller errorbars).

Table 5. Radii corresponding to the observed secondary periods.

| Period (min) | Symbol | Radius (10$^{10}$ cm) | Notes |
|--------------|--------|------------------------|-------|
|              | $r_1$  | 2.924                  | 1     |
|              | $r_2$  | 2.113                  | 2     |
|              | $r_3$  | 1.714                  | 3     |
|              | $r_5$  | 1.557                  | 4     |
|              | $r_4$  | 1.367                  | 5     |

1) larger than $R_{L1}$; possible beat period between $P_2$ and $P_{\text{main}}$; 2) close to $r_{\text{max}}$; possible spin period of the WD; 3) close to the superhump resonance 3:1, i.e. the (3,2) resonance radius; 4) close to the (4,3) resonance radius; 5) $\sim 0.5 \times P_2$. 

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The intermediate polar RW UMi

(neutron star, white dwarf) is subject to magnetic torques that induce warping and precession of the disc. The result is that a number of magnetically driven resonances between the disc and the rotating central dipole will arise. In some intermediate polar systems (IPs) the spin period of the WD is the same as that of the Keplerian orbit at the magnetosphere radius, so the two rotational motions are equal. In this case, the magnetic field will easily produce a warped inner disc which rotates with the spin period of the WD. However, in order to produce observable interferences with the orbital motion, the warped structure must extend to a large fraction of the disc, so that its variable geometry can interact with the accretion stream from the secondary. This possibility will depend on the viscosity inside the disc and the intensity of the magnetic field of the primary. In general, outside some critical radius, viscous forces will overcome the magnetic torque and warping will be destroyed (Lai 1999).

However, since RW UMi is a short orbital period system, which can host only a very small accretion disc, even a modest magnetic field might produce a warping that extends to a considerable portion of the disc. Still, most IPs are not synchronous rotators, so that the warping will be a much more complicated process, in which the outer parts of the disc might switch between prograde and retrograde precession. Thus, RW UMi might display both positive and negative superhumps, perhaps in a rather complex and unstable fashion.

A key problem in the analysis of the suborbital periods is to detect the spin period of the WD. From our data we note that the period $P_1$ (Table 2) is the most stable one: at least one year. In terms of Keplerian velocities, it would correspond to an orbit with a radius $r_1 > R_{L1}$, which is obviously impossible. We however note that $P_1$ fits quite well with the beat period between $P_2$ and $P_{\text{main}}$. Rather curiously, this match is better than the one obtained using the two possible alternative values for the orbital period $P_{\text{orb}} = P_{\text{main}} \pm 4\%$ (see Section 3.3), although our precision does not really allow to conclusively decide between those possibilities.

$P_2$ was observed only during one night at WIRO and during one at Ekar. Although it is not the shortest of the detected periods, for the above reasons we tentatively assume it as the spin period of the magnetic WD. In the most general case of an inclined rotator, the inner disc region truncated by the magnetosphere of the primary should be warped and precess with the WD spin period. However, the most easily observable effect is the direct interaction of the mass stream from the secondary with the rotating magnetosphere of the WD. The changing inclination of the magnetic axis with respect to the stream produces a periodic modulation of the accretion rate onto the polar caps. In this way $P_1$ results as the beat period between the orbital and the rotational one ($P_2$).

Following this scenario, we should also look for other optical orbital sidebands like $\omega_{\text{rot}} + \Omega_{\text{orb}}$ and $\omega_{\text{rot}} \pm 2 \Omega_{\text{orb}}$, where $\omega_{\text{rot}} = P_2^{-1}$ and $\Omega_{\text{orb}} = P_{\text{main}}^{-1}$. We find that

- $\omega_{\text{rot}} + \Omega_{\text{orb}} = 60 \sim P_3^{-1}$;
- $\omega_{\text{rot}} + 2 \Omega_{\text{orb}} = 77$, between $P_4^{-1}$ and $P_5^{-1}$;
- $\omega_{\text{rot}} - 2 \Omega_{\text{orb}} = 9$.

The latter, low frequency value corresponds to the time length of our observations, and is therefore not detectable.

Table 6. Critical radii in the accretion disc of RW UMi.

| Symbol | Radius  | Notes |
|--------|---------|-------|
| $r_{\text{circ}}$ | 0.780 | 1 |
| $r_{43}$ | 1.571 | 2 |
| $r_{32}$ | 1.903 | 3 |
| $r_{21}$ | 2.494 | 4 |
| $r_{\text{max}}$ | 2.152 | 5, 6 |

1) circularization radius (Hessman & Hopp 1990);
2) (4,3) resonance radius;
3) (3,2) resonance radius responsible for superhumps;
4) (2,1) outer resonance radius; it is larger than $r_{\text{max}}$;
5) last outer stable orbit (Paczynski 1977);
6) positive superhumps require that the outer disc radius reaches $r_{32}$.

Figure 10. Ekar data folded with the three main periods detected and reported in Table 2. $P_1$ is observed in both nights; $P_2$ is detected only in night 1 as well as period $P_5$. See also comments to Fig. 9.
roughly 8.6 d

However, we note that a peak of minor significance at

Table 6 lists the main critical radii of the accre-

metric, and look for correlations with those radii where mat-

Radii labeled as $r_{*2}$ refer to resonances between the radial excursion of a test particle and the position of the secondary star [Whitehurst & King 1993].

Periods $P_2$ and $P_3$ would indicate Keplerian radii $r_3$ and $r_5$ which are close to resonance radii $r_{*2}$, where superhumps are thought to be produced, and $r_{43}$, respectively. Finally, we note that $P_4$ is about $0.5 \times P_2$ and could be its second harmonic.

If we assume that, in its steady quiescent state, the nova is a synchronous rotator and take $P_2$ as the spin period of the WD, then $r_2$ should coincide with the Alfvén radius. However, this would suggest Keplerian orbits beyond the last stable orbit of the disc $r_{\text{max}}$, and no disc could form at all. As a result, if we assume that some disc does presently exist, then RW UMi, in its post-outburst state, cannot be a synchronous rotator.

In order to have a standard disc, the stream from the secondary should be able to penetrate the magnetosphere of the primary down to the circularization radius $r_{\text{circ}}$. Our data do not give us any clear indication about what the inner radius of the disc can be. However, we might reasonably assume that some material is presently orbiting around the WD at least between radii $r_3$ and $r_{*2}$ which accounts for the probable presence of superhumps.

### 3.5 Pre-nova and post-nova state of RW UMi

In the previous subsection we have tentatively assumed $P_2$ as the spin period of the WD. If its Keplerian radius, $r_2$, is also the Alfvén radius for the stream, $r_{\mu,\text{stream}}$, then, as $r_{\mu,\text{stream}} > r_{\text{circ}}$, no disc can form.

However, it appears plausible that a sort of an equilibrium status, with no disc formation, might have been achieved by the fainter pre-nova, while the stream was carrying only $\dot{M} \sim 10^{-9} M_{\odot} \text{yr}^{-1}$. Using equations (6.5) and (7.6) from Warner (1995) we may write

$$r_{\mu,\text{stream}} = 3.66 \times 10^{10} \mu_{34}^{4/7} M_1^{-1/7} \dot{M}_2^{-2/7} \text{ cm}. \quad (3)$$

Thus, within our hypothesis we derive $\mu_{34} \approx 0.84$, or, consequently, $B \approx 1.5 \times 10^7 \text{ G}$.

The post-nova is however brighter than the pre-nova. Again we use equation (3) to derive $r_{\mu,\text{stream}}$ for the high state of the nova, characterized by $\dot{M} \sim 10^{-8} M_{\odot} \text{yr}^{-1}$, which would account for yielding $M_{\text{min}} \sim 5.1 \text{ mag}$. We find that the stream can now penetrate the magnetosphere down to a radius

$$r_{\mu,\text{stream}} \sim 1 \times 10^{10} \text{ cm}$$

This radius is probably not close enough to the circularization radius to allow for the formation of a standard disc, but material can finally penetrate the magnetosphere ensuring stable accretion and also the formation of a probably chaotic disc. Note that the resonance radii of Table 6 are now populated by streaming gas. All intermediate polars have $r_{\text{inner}} < r_{\text{corotation}}$, so they are asynchronous rotators. The gas between the inner disc radius and the corotation radius might be rather turbulent and instability phenomena at the resonance radii could be enhanced.

In conclusion, if we assume $P_2$ as the spin period of the WD, we find that RW UMi in its steady quiescent state should be a discless intermediate polar, while in its post-outburst state it appears as an intermediate polar with a somewhat unstable truncated accretion disc. The magnetic moment of the primary $\mu_{34} \approx 0.84$ is rather large for short orbital period intermediate polars. RW UMi should then tend with time to go back to a pure discless state.

### 4 SUMMARY

1. We have presented new photometric time-series of the old nova RW Umi.
2. The data revealed the presence of several suborbital periods. The most stable one of these is $P_1 \sim 54 \text{ min}$, which is detected in all data sets. We find that $P_1$ agrees well with a beat period between our period $P_2 \sim 43 \text{ min}$ and the period found by Retter & Lipkin (2001) $P_{\text{main}} = 85 \text{ min}$, which is assumed to be very close to the orbital period.
3. The most probable explanation for the presence of $P_2$ is that it represents the spin period of the white dwarf. The other suborbital periods can then be found as being orbital sidebands with respect to $P_2$ and/or correspond to Keplerian resonance radii.
4. Assuming a mixture of ‘disc’ and ‘magnetic’ periods we find that RW UMi, in its post-nova state, must be an asynchronous intermediate polar, as the Keplerian radius of the assumed spin period $P_2$, i.e. the Alfvén radius, is larger than the circularization radius.
5. Comparing the mass-transfer rates from the pre- and the post-nova, we conclude that RW UMi in its quiescent, i.e. pre-nova, state is a discless intermediate polar.

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