RX J2115-5840: confirmation of a new near-synchronous Polar

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Abstract. Schwope et al (1997) suggested that the newly discovered Polar RX J2115-5840 is a near-synchronous system. We have obtained circular polarisation observations of RX J2115-5840 which show that the spin and orbital periods differ by 1.2%. We find the first direct evidence of 'pole-switching' in a near-synchronous Polar. Further our data requires that the accretion flow must be directed onto the same magnetic field line at all spin-orbit beat phases implying that at some phases the flow must follow a path around the white dwarf before accreting.

1. Introduction

RX J2115-5840 (EUVE 2116–58.6) was discovered during the *ROSAT* (Voges et al 1996) and *EUVE* (Bowyer et al 1996) all sky surveys. Subsequent ground based observations confirmed the source as a Polar. Schwope et al (1997) suggested that the orbital and spin periods of RX J2115-5840 differ by ~1%. This would make it the fourth near synchronous Polar and the first one below the 2–3 hr period gap. We obtained 2 weeks of white light polarimetric observations in July-Aug 1997 at SAAO to investigate this possibility.

2. Results

The circular polarisation data are shown in Fig. 1: the circular polarisation is generally either close to zero or shows positive excursions. However, there are occasions when negative polarisation is seen (HJD 2450000+ 659, 666 and 672). These observations suggests that RX J2115–58 is not fully synchronised.

To investigate the circular polarisation data more closely, we used a Discrete Fourier Transform to obtain an amplitude spectrum (Fig 2). The highest amplitude peak corresponds to a period of 110.889 mins – similar to the spectroscopic period of 110.8 mins reported by Vennes et al (1996). The second highest peak corresponds to a period of 109.547 mins – similar to the shorter of the two possible optical photometric periods, 109.84 and 109.65 mins, reported by Schwope et al (1997). If we assume that the binary orbital period is Ω=110.889 min and the spin period of the white dwarf is ω=109.547 min we find the following more complex frequencies in the amplitude spectrum: 3Ω, 2ω, 3ω, $\omega \pm \Omega$, $2\omega + \Omega$,

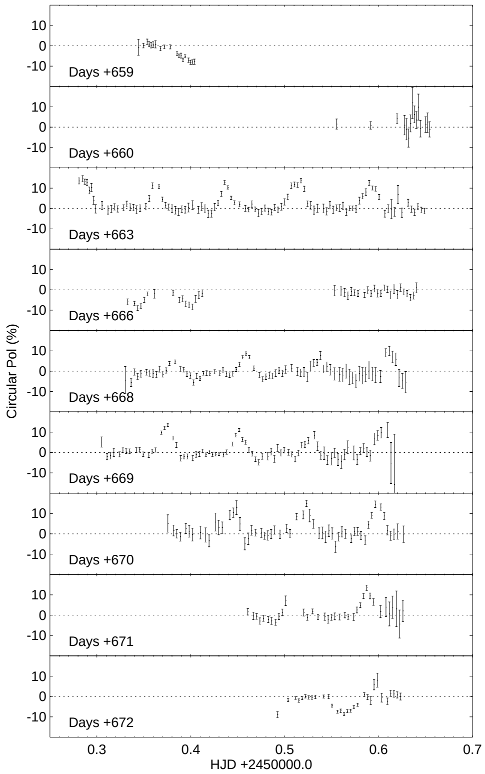

Figure 1. The circular polarisation data. The HJD is shown on the left hand side +2450000.0.

4Ω–3ω. Any other frequencies which are present have amplitudes lower than 1%. The spin-orbit beat frequency corresponds to a period of 7.1 days.

3. The spin-orbital beat period

To make a more detailed investigation of these data we folded the circular polarimetry on the proposed spin and orbital periods and the spin-orbital beat period (the left hand panel of Fig 3). Folding the data which correspond to a discrete beat phase on the proposed spin period of the white dwarf, we find that the polarisation curve shows a negative excursion lasting approximately half the spin cycle. At other spin phases the polarisation is close to zero (the right hand panel of Fig 3). At $\phi_{(\omega-\Omega)}$=0.20 the polarisation is not significantly modulated. At other beat phases a prominent positive hump is seen in the folded spin polarisation curves, the peak of which advances in phase as $\phi_{(\omega-\Omega)}$ increases.

4. Pole-Switching

In fully synchronous Polars, the accretion flow is locked with respect to the binary orbital rotation frame and the bulk of the accretion flow is thought to be directed onto the geometrically preferred magnetic pole of the white dwarf. However, in the case of near-synchronous Polars, the accretion flow rotates around the magnetic field of the white dwarf on the spin-orbit beat period. This has the

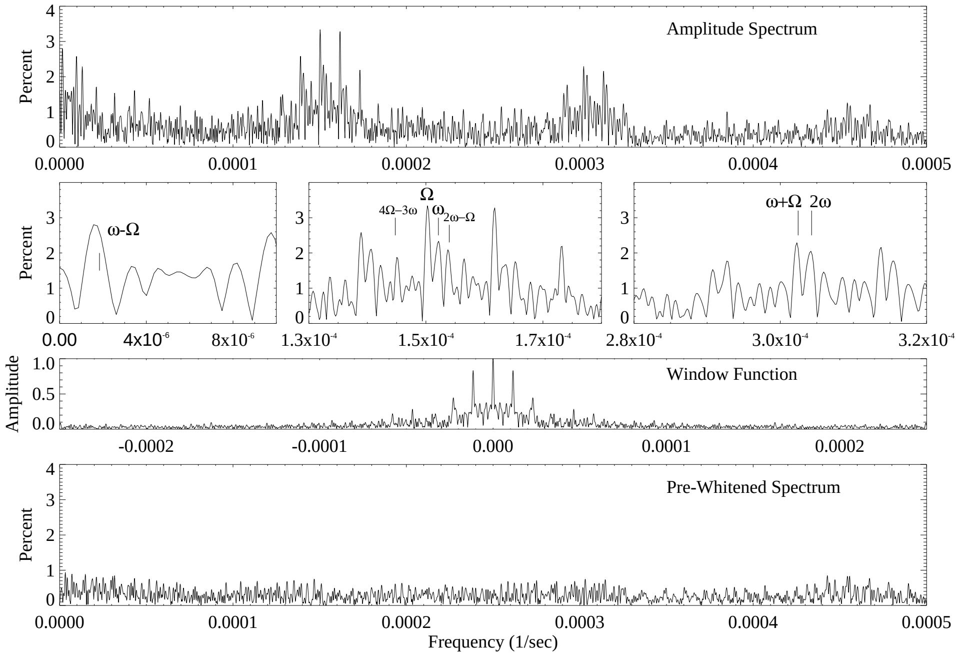

Figure 2. From the top: the amplitude spectrum of the circular polarisation data; the amplitude spectrum in greater detail over three frequency intervals; the window function and the amplitude spectrum pre-whitened using the frequencies mentioned in the text.

effect that the accretion flow will be directed preferentially onto first one then the other magnetic pole of the white dwarf. At two phases of the spin-orbit beat period we expect that the flow will be equally directed onto both poles. This 'pole-switch' will manifest itself most obviously in the circular polarisation curves where the polarisation will change sign after the accretion flow has 'switched' poles. This is seen in the right hand panel of Fig 3 where at $\phi_{(\omega-\Omega)}$ ~0.00 the polarisation is modulated with a positive hump, but at $\phi_{(\omega-\Omega)}$ ~0.07 and 0.17 it is modulated with a negative hump.

We consider two accretion scenarios which are described in Fig 4. The phasing of the data on the spin, orbital and beat phases requires that the accretion flow must be directed onto the same magnetic field line at all spin-orbit beat phases implying that at some phases the flow must follow a path around the white dwarf before accreting. This is difficult to reconcile with simple views of how the accretion stream attaches onto the magnetic field of the white dwarf. Possible reasons for this are described in a more detailed paper that has been submitted to *MNRAS*.

References

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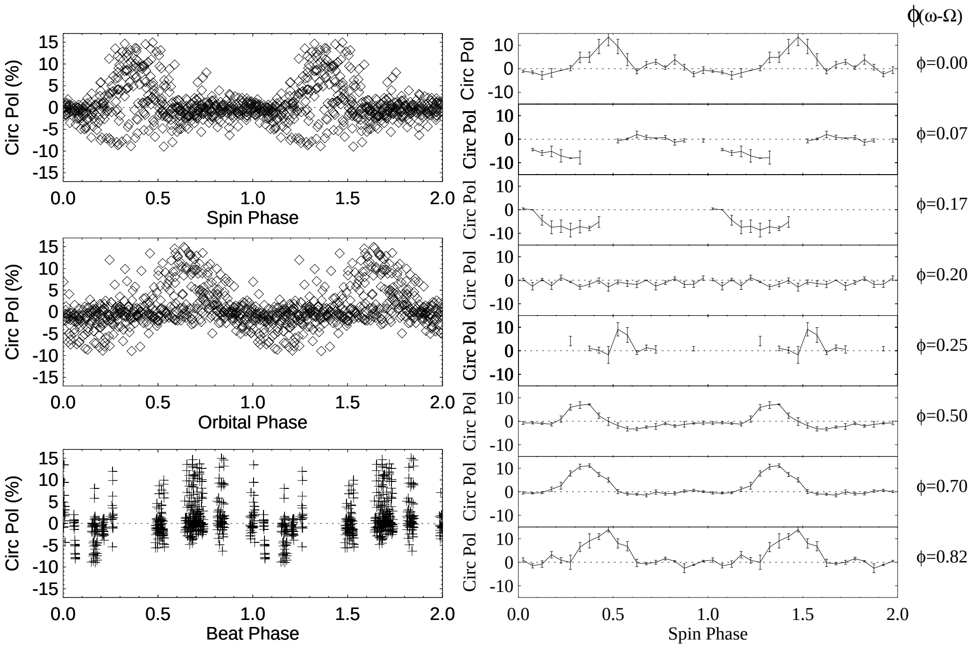

Figure 3. Left panel: The circular polarisation folded on the spin period (top panel); folded on the orbital period (middle panel), folded on the orbital-spin beat period, $\omega - \Omega$. Phase zero was arbitrarily chosen. Right panel: The circular polarisation data folded and binned on the proposed spin period of the white dwarf, as a function of the spin-orbital beat period. The beat phase is shown at the right hand side.

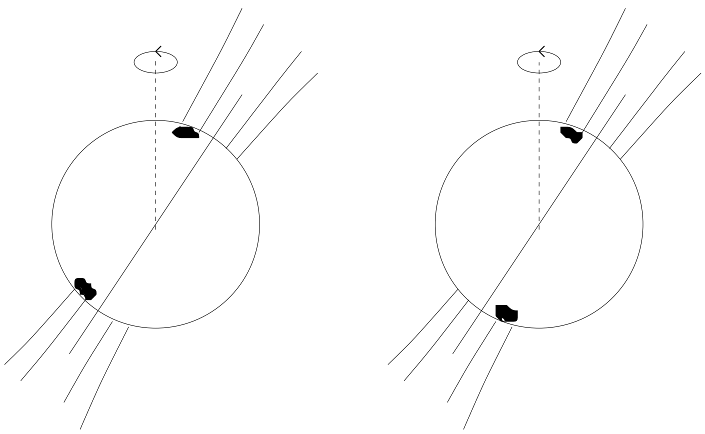

Figure 4. Our two accretion scenarios. In the left hand panel the accretion flow is directed onto one or other footprint of the same set of magnetic field lines at all spin-orbit beat phases. In the right hand panel the flow is directed onto a diametrically opposite set of field lines at different beat phases. The spin axis of the white dwarf is shown as a dotted vertical line. We favour the scenario described in the left hand diagram.