

# RX J2115.7–5840: a short-period, asynchronous polar<sup>\*</sup>

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**Abstract.** We report phase-resolved optical polarimetric, photometric and spectroscopic observations of RX J2115.7–5840 (= EUVE J2115–58.6, Craig 1996) which confirms the system to be a magnetic cataclysmic binary of the polar (AM Herculis) subclass. The optical light curve is sometimes flat and occasionally displays a pronounced bright phase, reminiscent of the self-eclipse of a small accretion spot by the revolving white dwarf, as seen in self-eclipsing polars. Our period search reveals ambiguous results only which can be interpreted assuming that the white dwarf is not synchronously rotating with the binary orbit. We find circularly polarized cyclotron radiation with  $V/I$  ranging from 0% to –15% on one occasion, from –8% to +15% on another occasion. Compared with other polars, the self-occulted accretion region of RX J2115.7–5840 had an extreme red cyclotron spectrum. In addition, the system has an extreme hard X-ray colour during the ROSAT all-sky survey observation. Both properties suggest a low value of the magnetic field strength, and our best estimate gives  $B = 11 \pm 2$  MG. Due to the absence of significant M-star features in our low-resolution spectra we estimate the minimum distance to RX J2115.7–5840 to be  $d > 250$  pc (for an M5<sup>+</sup> secondary star).

**Key words:** accretion – cataclysmic variables – AM Herculis binaries – stars: RX J2115.7–5840)

## 1. Introduction

EUVE J2115–58.6 was detected during the EUVE all-sky survey with a countrate of 0.05 cts s<sup>–1</sup> (Bowyer et al. 1996) and tentatively identified as a magnetic cataclysmic variable by Craig (1996) who identified strong H-Balmer, HeI, HeII and CaII emission lines. Moderate resolution spectroscopy in the blue

wavelength regime was done by Vennes et al. (1996). They observed pronounced radial velocity variations of H $\beta$  and HeII and determined the orbital period of the system of 110.8 min with a possible one-cycle-per-day alias of 102.8 min.

The source was also detected with the ROSAT-PSPC during the X-ray all-sky survey performed in 1990/1991 at a countrate of 0.380 s<sup>–1</sup> (galactic coordinates  $l^{II} = 337^\circ$ ,  $b^{II} = -41^\circ$ ). We are currently running a program in order to identify optically bright ROSAT survey sources extracted from the ROSAT All-Sky Survey Bright Source Catalog (1RXS, Voges et al. 1997) at high galactic latitudes ( $|b^{II}| > 30^\circ$ , limiting countrate 0.2 s<sup>–1</sup>). With no certain optical identification at the time, RX J2115.7–5840 entered our target list with high priority. When its nature as magnetic CV became clear from a low-resolution spectrum, phase-resolved data were collected in order to study its main characteristics. Later it became clear, that polarimetric and photometric observations has been performed coincidentally from SAAO, too. We present here the combined results of our optical observations obtained over a 70-day basis from South Africa and Chile.

## 2. Observations and analysis

### 2.1. The ROSAT all-sky survey (RASS) observations

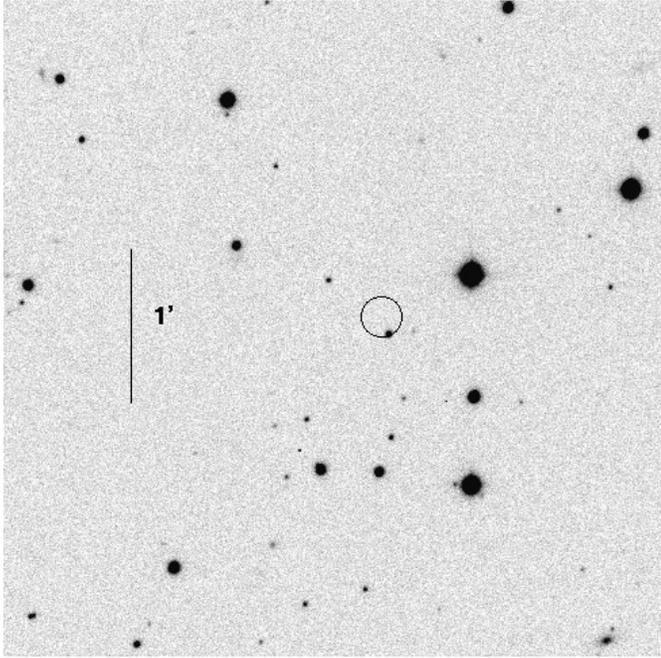
RX J2115.7–5840 was observed during the RASS for a total of 294 sec. The source was scanned 13 times with exposures ranging from 16.2 to 25.9 sec. It showed a modulation of the X-ray flux by 100% reaching a peak countrate of 1.2 s<sup>–1</sup>. The mean survey countrate was  $0.38 \pm 0.19$  s<sup>–1</sup> and the mean hardness ratio  $HR1 = (H - S)/(H + S) = -0.02 \pm 0.1$ , where  $H$  and  $S$  are the counts in the ROSAT hard (0.4 – 2.4 keV) and soft (0.1 – 0.4 keV) bands, respectively. Folded over the most likely optical period, the X-ray light curve shows a clear on/off behaviour with length of the X-ray bright phase extending for ~50% of the orbital cycle.

With only 102 detected photons the X-ray spectrum of RX J2115.7–5840 is not very well constrained. It can be fitted using a single bremsstrahlung component ( $kT_{br} > 1$  keV) with

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<sup>\*</sup> Based in part on observations at the European Southern Observatory La Silla (Chile) with the 2.2m telescope of the Max-Planck-Society



**Fig. 1.** CCD-image of the field of RX J2115.7–5840 (R-filter), north is top and east to the left. The circle indicates the X-ray positional error circle, the cataclysmic binary is the star on the circle. Its coordinates are  $\alpha_{2000} = 21^h 15^m 40.6^s$ ,  $\delta_{2000} = -58^\circ 40' 52''$

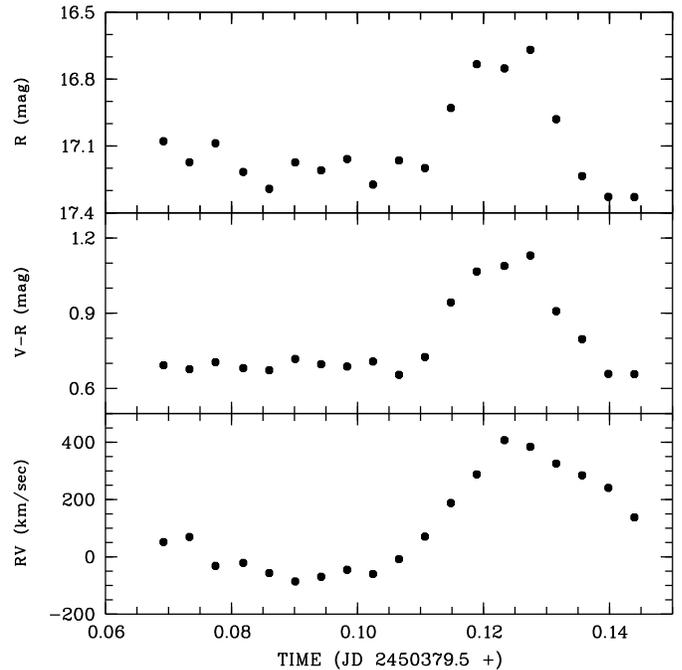
X-ray spectral flux at 1 keV of  $2 \text{ photons cm}^{-2} \text{ s}^{-1} \text{ keV}^{-1}$ . The spectrum is very weakly absorbed,  $N_H = 0.4 \pm 1.0 \times 10^{20} \text{ cm}^{-2}$ , and even compatible with zero absorption.

## 2.2. Spectroscopic observations

An *R*-band CCD image of the field of RX J2115.7–5840 is reproduced in Fig. 1. Only one possible optical counterpart of the X-ray source lies within the positional error circle of the RASS X-ray observations. A total of 21 low-resolution spectra of this star (12 Å FWHM, integration time 300 sec) and one with intermediate resolution (3 Å FWHM, integration time 600 sec) were obtained with the EFOSC2 spectrograph at the ESO/MPG 2.2m-telescope on October 23, 1996, between UT 0:19 and 3:30.

The flux-calibrated low-resolution spectra were folded through Johnson *BVR* filter curves in order to derive broadband optical light curves. These are suspected to be accurate within  $\pm 0.5 \text{ mag}$  (absolute) but variability and colours can be determined with much higher accuracy of approximately 0.1 – 0.2 mag.

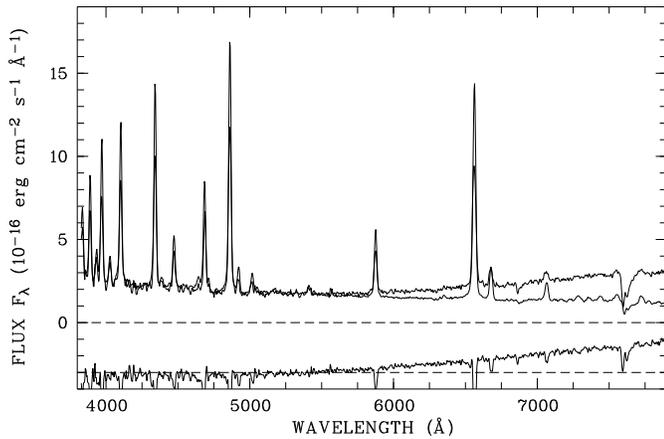
The *B*-band light curve does not show any significant variation, the *V*-band light curve displays marginal variability at a level of 0.2 mag, but the *R*-band light curve shows a pronounced orbital hump with full amplitude of about 0.5 mag centered on HJD 245 0379.6231. The optical *R*-band light curve as derived from our low-resolution spectra is shown together with the variation in *V* – *R* and the radial velocity variation of the main emission lines in Fig. 2. Two more spectra (not shown



**Fig. 2.** Optical *R*-band light curve, colour variation *V* – *R*, and mean radial velocity variation derived from low-resolution spectrophotometry obtained on October 23, 1996

in Fig. 2) were recorded during the preceding faint and bright phases, respectively. Using all the spectra, a photometric period of  $\sim 113 \text{ min}$  was derived by a period search based on Scargles (1982) algorithm.

Mean bright- and faint-phase spectra with low spectral resolution are shown in Fig. 3 and the one spectrum with higher resolution is shown in Fig. 4. RX J2115.7–5840 shows the typical features of a magnetic cataclysmic binary with strong emission lines of the H-Balmer series (including the strong Balmer jump in emission), HeI, HeII, and the CIII/NIII Bowen blend at 4640/50 Å. The lines exhibit a phase-dependent asymmetry and display pronounced radial velocity variations. We have determined the radial velocity of 5 main emission lines ( $H\alpha$ ,  $H\beta$ ,  $H\gamma$ , HeI 5876, HeII 4686) by fitting single Gaussians. No significant difference between the radial velocity variations of the different lines was found. We, therefore, show the average radial velocity of the 5 lines in the lower panel of Fig. 2. Although the emission lines are slightly asymmetric, our resolution is not high enough in order to discern between possible (likely) multiple emission components. Although not reflecting the change of the radial velocity variations very well, we used a sine approximation in order to estimate the spectroscopic period. The best fit gives  $P_{\text{orb}} = 114 \pm 4 \text{ min}$ , in agreement with the period derived from the photometric variations of our spectra, and consistent with Vennes et al. (1996) spectroscopic period.

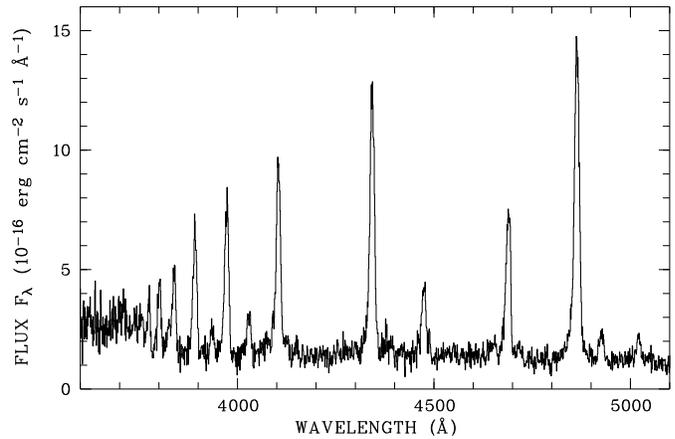


**Fig. 3.** Average bright- and faint-phase low-resolution spectra of RX J2115.7–5840 (12Å FWHM). The lower curve, which was shifted by three flux units in vertical direction is the difference of the above spectra, regarded as cyclotron spectrum

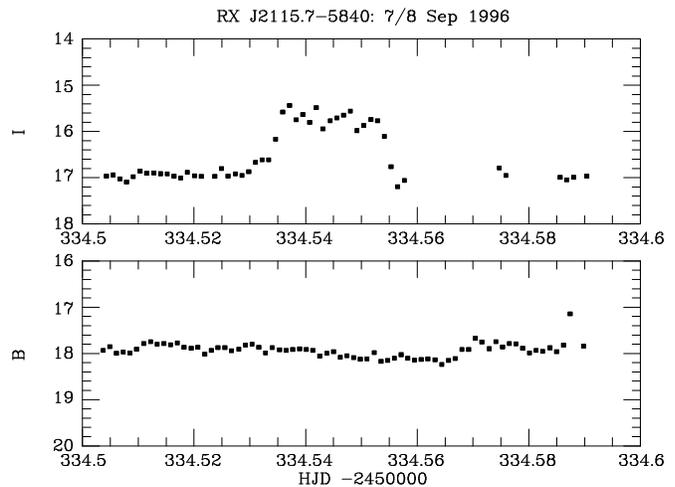
### 2.3. Photometry

CCD photometry of RX J2115.7–5840 was undertaken at SAAO over 7 nights, from 1996 September 3 to 9. The observations were made on the 0.75-m telescope with the UCT CCD camera, employing a Wright Instruments blue-sensitive EEV CCD chip operated in frame transfer mode. Observations were mostly conducted without a filter, except for those done on 7/8 September, for which alternately a B and I filter were employed. Details of the observations appear in the observing log (Table 1), suffice to say that integration times were either 20 or 30 sec for the filterless data, with no dead time between frames. The observations were obtained in both photometric and non-photometric conditions, while seeing was equally as variable, from good ( $\lesssim 1$  arcsec) to poor (2–3 arcsec). The scale of the CCD is  $0.37$  arcsec pixel $^{-1}$  in normal mode (which was used for the majority of the observations), and twice that value for  $2 \times 2$  prebinning mode, which was used when the seeing was poor. The field of the UCT CCD on the 0.75-m telescope is  $\sim 2.6 \times 1.8$  arcmin $^2$ .

After the usual flat-fielding and bias subtraction, batch mode DoPHOT routines (Mateo & Schechter 1989) were used to obtain both PSF profile-fitted and aperture magnitudes. Brighter stars on the frames were used as comparison stars, and differential magnitudes derived. The rms scatter of the corrected comparison stars was typically 0.006 magnitudes for the filterless photometry, and  $\sim 0.01$  mag for the B & I data. RX J2115.7–5840 exhibits a large degree of variability, up to  $\sim 1.4$  mag in I, 1 mag for filterless (“white-light”), and much less ( $\lesssim 0.4$  mag) for B. The pronounced “hump” seen in the longer wavelength light curves (I & filterless) is not seen in the B light curve (see Fig. 5). Furthermore, there are substantial night-to-night changes in the light curves, evidenced by a less pronounced hump, or even a double hump on the first night (see Fig. 6).



**Fig. 4.** Single bright-phase spectrum of RX J2115.7–5840 at intermediate spectral resolution (3Å FWHM). The spectrum shows the typical features of a magnetic cataclysmic binary, the Hydrogen Balmer lines up to the series limit as well as lines of high-ionization species as HeI, HeII and CIII/NIII



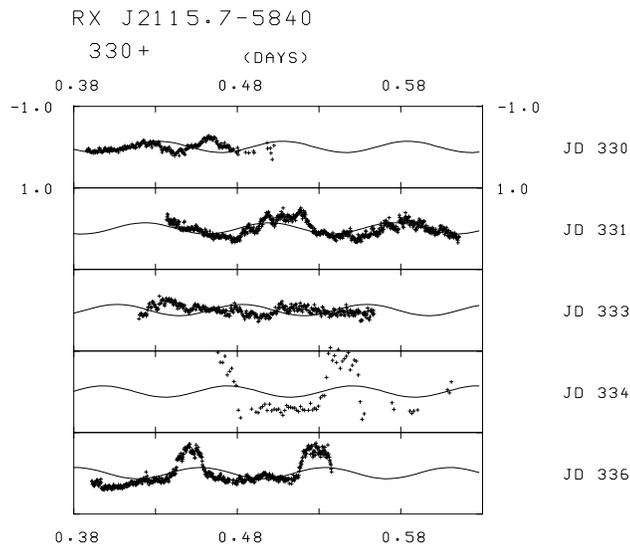
**Fig. 5.** CCD-photometry of RX J2115.7–5840 simultaneously obtained in B and I-filters

### 2.4. Polarimetry

White-light photopolarimetry of RX J2115.7–5840 was undertaken on the SAAO 1.9-m telescope using the UCT Polarimeter (Cropper 1985) on 1997 September 15/16 and November 10/11 and 11/12. The relative faintness of the object precluded any filtered observations. The instrument was run in the so-called “Stokes mode”, simultaneously measuring linear and circular polarization every 180 s, and the intensity every 10 s. Polarization standards were observed at the end of each night in order to derive the instrumental waveplate offsets, which are constant to  $\pm \sim 2^\circ$  from night to night. Sky measurement were obtained every 15 to 20 min, and the sky background values interpolated with a polynomial spline before subtraction from stellar intensity data arrays. The observations were obtained in photometric

**Table 1.** Observing Log for RX J2115.7–5840

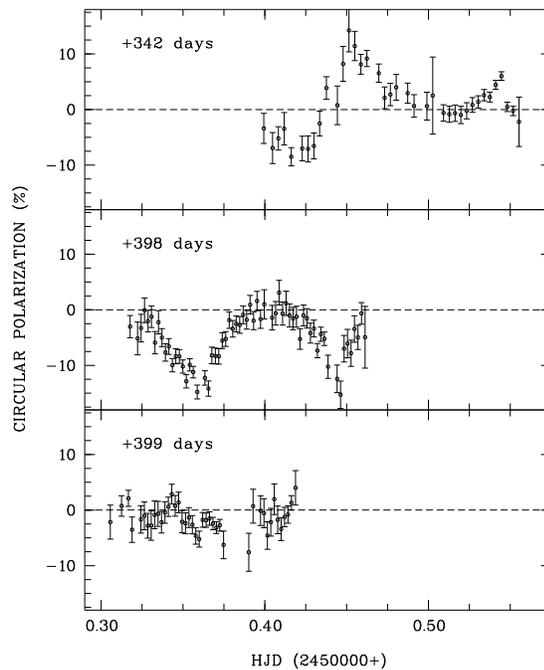
DATE			RUN	TELESCOPE	HJD START (-2450000)	LENGTH (h)	INT (s)	FILTER
(day	month	year)						
<i>CCD Photometry:</i>								
3/4	Sep	96	W002	0.75 m	330.387	2.78	30	w.l.
4/5	Sep	96	W005	0.75 m	331.436	4.32	20	w.l.
6/7	Sep	96	W007	0.75 m	333.420	3.46	30	B
7/8	Sep	96	W009,W010	0.75 m	334.467	3.46	60,30	B,I
9/10	Sep	96	W018	0.75 m	336.538	3.52	20	w.l.
<i>Polarimetry:</i>								
15/16	Sep	96	P0342	1.90 m	342.398	3.84	10,180	w.l.
10/11	Nov	96	P0398	1.90 m	398.316	3.54	10,180	w.l.
11/12	Nov	96	P0399	1.90 m	399.304	2.82	10,180	w.l.



**Fig. 6.** CCD-photometry of RX J2115.7–5840 in white light and *I*-filter (JD 334). Time along the abscissa is given in fractional days, brightness values were normalized to the mean brightness of each night. Differential white-light magnitudes with respect to the comparison star directly to the southwest of RX J2115.7–5840 for runs 2, 5, 7, and 18 on JD 330, 331, 333, and 336, are  $-3.541^m$ ,  $-3.138^m$ ,  $-3.210^m$ , and  $-3.201^m$ , respectively. A sine curve connecting all data sets with  $P = 109.84$  min, one of our possible photometric periods, is shown for reference

conditions with  $\sim 1$  arcsecond seeing, except for the last night (11/12 Nov), for which the seeing was worse ( $\gtrsim 2$  arcseconds).

RX J2115.7–5840 shows clearly detectable circular polarization, ranging from  $\sim -15$  to  $+15\%$  (Fig. 7). The accuracy of our linear polarization measurement was  $\sim 3\%$  and within this accuracy no clear detection of the linear polarisation is seen. The various circular polarization curves are quite dissimilar, indicating that large changes in the accretion geometry between the different observations took place. The most simple curve at JD 398 is reminiscent of a one-pole accreting AM Herculis star with extended self-eclipses of the accretion region by the



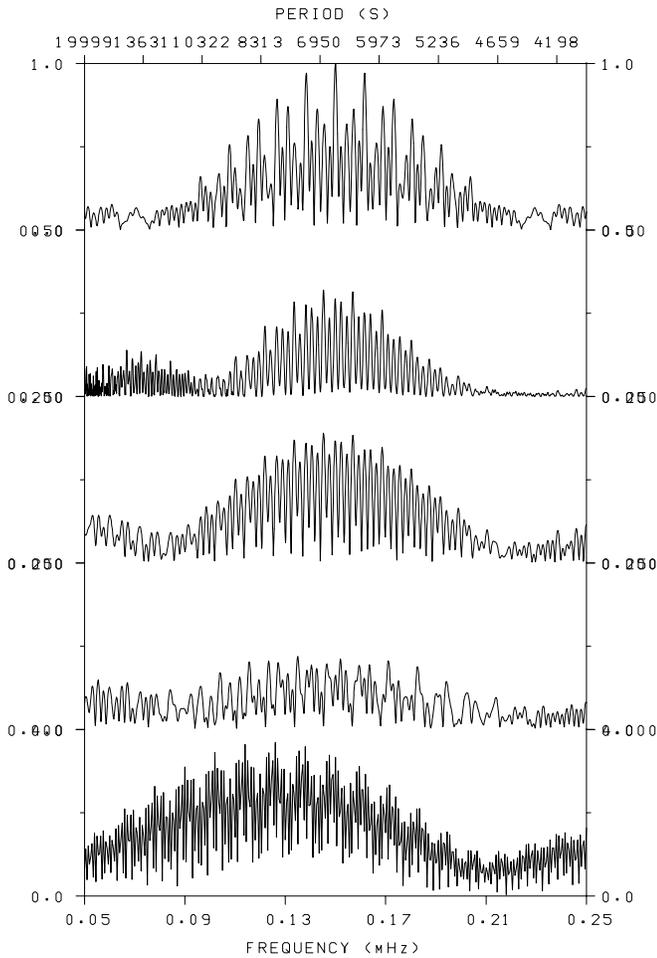
**Fig. 7.** Degree of circular polarization of RX J2115.7–5840 at the specified days measured in white light

revolving white dwarf. The large positive circular polarization seen for a rather short phase interval at JD 342 then indicates that also a second accretion region on the opposite hemisphere (with opposite circular polarization polarity) became active.

The light curves recorded simultaneously displays no pronounced orbital hump, and resemble those seen at JD 330 and 331 (see Fig. 6).

### 3. Results and discussion

The polarimetric observations confirm beyond doubt that RX J2115.7–5840 is indeed a magnetic cataclysmic binary, probably of AM Herculis type (polar). The borders between



**Fig. 8.** Results of period search of RXJ2115.7–5840 using all CCD-data shown in Fig. 5. Shown are from top to bottom the window function, the PDM and DFT periodograms, the DFT periodogram of the photometry after prewhitening by the dominant period (114.74 min), and the DFT periodogram of the circular polarization data

polars and intermediate polars (IPs) were blurred by the discovery of soft X-ray emitting polarized IPs like PQ Gem (other ‘soft IPs’ are discussed by Haberl & Motch 1995) on the one hand and asynchronous polars like BY Cam on the other hand. However, the degree of synchronism between the white dwarf and the binary rotation is still an important parameter and we start our analysis therefore by a period search using our photometric, polarimetric and spectroscopic data and compare them with the results of Vennes et al. (1996).

### 3.1. Period search

We subjected the filterless and I-band CCD light curves (Figs. 5 and 6) to a period analysis, using both discrete Fourier transform (DFT) and phase dispersion minimization (PDM) periodograms. The power spectra show no significant features for periods <1000 sec, up to the Nyquist frequency.

Pronounced power appears at  $\sim 1.5$  mHz (110 min), and at the first and second harmonics, particularly for the DFT, which is more susceptible to non-sinusoidal waveforms than the PDM periodogram. An inspection of the periodograms near the dominant frequency indicates that there is not a “clean” distribution of frequency peaks with the usual 1 cycle  $d^{-1}$  alias structure. This is not surprising given the previously mentioned nightly changes to the shape of the light curve. In Fig. 8 we show the periodograms centered near the dominant frequency at  $\sim 0.15$  mHz. The strongest peaks in both the DFT and PDM power spectra occurs at a period corresponding to 114.74 min (or its alias at 106.27 min), although other nearby peaks are only mildly less significant. Pre-whitening by the dominant period removes most of the power at 0.15 mHz (see 4th panel from the top in Fig. 8), indicating that the complex period structure is likely an artefact of the data sampling. The highest peak for the prewhitened data occurs at 124 min, far away from other period estimates, the second highest peak at 110 min is close to the spectroscopic period.

After the photopolarimetry runs, we included those intensity data in our period analysis. Some of these data have poor quality due to mediocre seeing, and the consequent loss of light from the small aperture we were forced to use. Inclusion of the polarimetric intensities did not resolve the ambiguity over the photometric period, and the periodogram of all the combined photometry (CCD and polarization intensities) was rather different, with the dominant peak occurring at 98.6 min, and its aliases, none of which coincide with either the spectroscopic or previously determined photometric periods. A periodogram of only the  $V/I$  circular polarization data (lowest panel of Fig. 8) shows highest power at a period of 131.3 min, which is inconsistent with all other period determinations. However, it may be significant that one of the aliases (at 111.8 min) is very close to the purported orbital spectroscopic period (110.8 min) reported by Vennes et al. (1996).

The periodograms are clearly affected by the coming and going of the bright phase. This becomes evident if one uses for the period search only those datasets, where an orbital hump is clearly detectable (JD 334, 336, and 379, the times of hump center at these three occasions can be found in Tab. 2). The corresponding periodogram has power mainly at 109.84 min (566 cycles between days 336 and 379).

If one tentatively assumes that the accretion geometry is the same when the circular polarization curve looks most simple (JD 398) and when the photometric light curve pattern shows a pronounced hump (JD 334, 346, and 379) and performs a period search for the times of mid-hump at these four occasions, a period of 109.65 min emerges as a possible solution (567 cycles between days 336 and 379).

The different period estimates can be compared to the spectroscopic period, as derived from the emission line radial velocities by Vennes et al. (1996), which shows two strongly aliased peaks corresponding to periods of 110.8 and 102.8 min. Neither of our estimates coincides exactly with either possible value of the spectroscopic period.

**Table 2.** Times of mid-hump of RX J2115.7–5840 at specified dates

Date	HJD (-2450000)
7/8 Sept 1996	334.5444
9/10 Sept 1996	336.4513
9/10 Sept 1996	336.5282
23 Oct 1996	379.6231

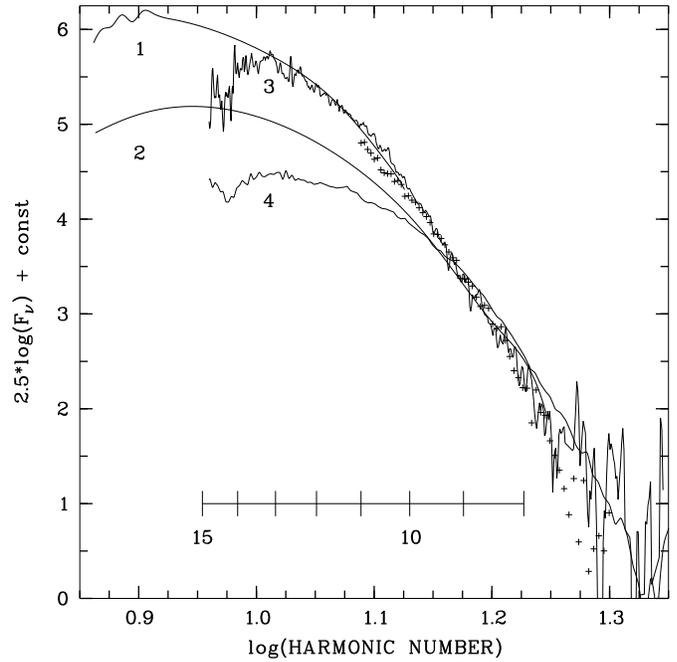
On the basis of the present photometric and polarimetric data, it seems that the photometric and spectroscopic periods could be discordant, indicating that the system is asynchronous to a small degree ( $\sim 1\%$ ). The changing shape of the light curve may indicate a pole-swapping accretion mode. If the far (‘southern’) pole is accreting, selfeclipses by the revolving white dwarf occur, leading to pronounced orbital modulation of the optical light. If the near (‘northern’) pole accretes, the accretion region possibly never becomes eclipsed and orbital photometric modulations are smoothed, also the changes in polarity of  $V/I$  supports the accretion region moving from one pole to the other.

The difference between the orbital period  $P_{\text{orb}}$  and the spin period of the white dwarf  $P_{\text{wd}}$  might be estimated assuming that  $P_{\text{orb}}$  is represented by the spectroscopic period of 110.8 min and that  $P_{\text{wd}}$  is represented by one of the photometric periods derived for far-pole accretion, 109.84 min or 109.65 min. Hence, the degree of asynchronism is of the order of  $\sim 1\%$ . A unique determination of this quantity requires photometric monitoring of the system over one beat cycle (which is  $\sim 7$  days).

### 3.2. The cyclotron spectrum of the far pole

As in other selfeclipsing polars (e.g. Schwope et al. 1995), the difference spectrum between the bright and the faint phase can be regarded as the cyclotron spectrum originating from the accreting spot active at that time. This spectrum is shown on a linear scale in the lower panel of Fig. 3 and on a logarithmic scale in Fig. 9. Also included in Fig. 9 are suitably scaled cyclotron spectra of other polars which have measured magnetic field strengths. The cyclotron spectrum of RX J2115.7–5840 rises steeply towards long wavelength with peak wavelength clearly longward of  $8000 \text{ \AA}$ . It does not show any sign of modulation by cyclotron harmonics. Since also no Zeeman lines were observed, no direct measurement of the field strength in RX J2115.7–5840 seems to be possible. The colour of the cyclotron spectrum indicates that we are observing the high-harmonic optically thin part of the spectrum which is determined only by the strong frequency-dependence of the cyclotron absorption coefficient  $\kappa_{\text{cyc}}$ . Thus at least an estimate for the field strength can be derived, assuming that the cyclotron spectra of low-field polars in the optically thin regime are similar.

In order to test this hypothesis and use it as tool for the field determination of RX J2115.7–5840 we synthesized a common cyclotron spectrum from low-field polars with measured field strengths (Fig. 9). The absorption coefficient  $\kappa_{\text{cyc}}$  in dimensionless frequency units, i.e. normalized to the cyclotron fundamental, is a function of the plasma temperature and the projection



**Fig. 9.** Normalized cyclotron spectra of low-field AM Herculis stars with measured field strengths (labelled 1–4) and cyclotron spectrum of RX J2115.7–5840 (represented by small crosses) for an assumed field strength of 11 MG. Ticks along the horizontal line indicate, where the cyclotron spectrum of RX J2115.7–5840 would have started for field strengths  $B = 15 \dots 8$  MG. The identification of published cyclotron spectra of the other AM Hers is: (1) EP Dra – 16 MG (Schwope & Mengel 1997), (2) RXJ1957-57 – 16 MG (Thomas et al. 1996), (3) and (4) low and high states of BL Hyi – 12 MG (Schwope, Beuermann & Jordan 1995)

angle only (the latter is the angle between the magnetic field and the propagation vectors). The spread of these parameters must not be too large among the different objects for a reliable comparison of their spectra. The plasma temperatures of the different objects are not yet measured. Parameters influencing the plasma temperature are the mass of the white dwarf, the field strength and the specific mass accretion rate. The former two are known to be more or less the same for the objects concerned with here, while the latter is widely unknown. For the time being we assume similar values for the different objects. We used BL Hyi (Schwope et al. 1995), EP Dra (Schwope & Mengel 1997) and RX J1957-57 (Thomas et al. 1996), all of which have field strengths in the range 12–16 MG. The projection angle at the particular phases of the spectra used in the construction of the common cyclotron spectrum correspond to  $\sim 70\text{--}80^\circ$ . With the known field strength, the observed spectra were transformed from wavelength to the dimensionless frequency, normalized to the cyclotron fundamental frequency. The observed spectra peak at harmonic numbers 8–11, the optically thick Rayleigh-Jeans component lies in each case in the unobserved infrared spectral regime. The different observed turnover frequencies (from being optically thick to optically thin) reflect different sizes of and densities in the emission regions. The different spectra were

then translated to each other by shifting them vertically until they agree at a certain frequency (or harmonic number  $m_H$ ). Constraints for the choice of the finally adopted number,  $m_H = 14$ , were sufficient low optical thickness (shifts  $m_H$  to large values) and sufficient high flux in the observed spectra (shifts  $m_H$  to small values). The agreement between the different spectra in their usable (optically thin) part is surprisingly good, thus justifying our assumptions on plasma temperature and orientation.

We compared the observed cyclotron spectrum of RX J2115.7–5840 with those of the other polars by shifting it along both axes of Fig. 9 until best agreement was reached. A shift along the abscissa corresponds to a change of the adopted value of the field strength  $B$ . A shift along the ordinate gives just the normalization of the spectrum. Our best estimate for the field strength thus achieved is 11 MG. We believe that the field strength cannot be much in excess of  $\sim 13$  MG, because of the observed steepness of the cyclotron spectrum of RX J2115.7–5840. The field strength is probably not much lower than  $\sim 9$  MG. The blue end of the cyclotron spectrum would then correspond to harmonic numbers as high as and in excess of  $m_H \simeq 20$ , which has never been observed in any polar (due to the negligible power radiated in these high harmonics). We thus regard  $B = 11 \pm 2$  MG as a reasonable estimate of the magnetic field strength.

### 3.3. A distance estimate

Our faint-phase low-resolution spectrum does not show any prominent feature originating from the secondary star. We estimate its contribution to this spectrum to be less than 30% ( $\lesssim 0.55 \times 10^{-16}$  erg cm $^{-2}$  s $^{-1}$  Å $^{-1}$  at 7540Å). On the assumption that it is a main sequence star, which is generally accepted for cataclysmic binaries just below the period gap, we may estimate its distance using Bailey’s (1981) method together with the improved calibration by Ramseyer (1994). The major uncertainty in this procedure comes from our photometric accuracy and the poorly known mass-radius relation of main-sequence stars of late spectral type. Using e.g. either the calibration by Caillault & Patterson (1990) or Neece (1984) we obtain the possible spectral type (mass), scaled K-brightness (using M-dwarf template spectra), surface brightness  $S_K$  and stellar radius as (Sp,  $K$ ,  $S_K$ ,  $\log(R_2/R_\odot)$ ) = (M5 $^+$ , 15.3, 5.3, -0.61) and (M4.5, 16.1, 4.7, -0.73), respectively. With  $\log d = ((K - S_K + 5)/5 - \log(R_2/R_\odot))$  this yields a lower limit distance estimate of  $d > 250$  pc for the former, and  $d > 350$  pc for the latter case. Should the spectral type of the secondary be later than we have assumed the lower limit distance would be smaller.

### 3.4. RX J2115.7–5840 as X-ray and EUV-emitter

Although RX J2115.7–5840 is a bright, variable source at X-ray wavelengths, it was missed by previous identification programmes (soft survey: e.g. Beuermann & Burwitz 1995, hard survey: Hasinger et al. 1996) due to its unusual hard X-ray spectrum which places it between the selection boundaries of these

previous identification programmes. One may thus speculate about some more low-field polars as counterparts of relatively hard ROSAT survey sources.

The X-ray spectral shape as seen with ROSAT (although not well determined) does not make the assumption of a soft blackbody component necessary, unless in the case of all other AM Herculis stars. This makes the system similar to the ‘classical’ intermediate polars (known before ROSAT), which have hard thermal bremsstrahlung spectra only. The EUV-detection on the other hand clearly shows the presence of a soft component. It is not clear, however, if both components originate from the same accretion spot. Perhaps the system has one IP-like pole emitting predominantly hard X-ray bremsstrahlung which was active during the RASS and a second polar-like accretion region emitting soft and hard X-rays which was active during the EUVE sky survey? With the present very limited observational data we clearly cannot answer these questions and we need more EUV- and X-ray observations with full phase coverage in both modes of accretion.

### 3.5. Conclusions

We have found clear and unique evidence for the magnetic nature of the new cataclysmic variable RX J2115.7–5840 by the detection of strong and variable circular polarization. In addition, the radial velocity pattern and the shape of the optical light curve (when showing the pronounced hump) suggest an AM Herculis type nature of this object. We found, however, some features which do not fit in the most simple picture of a synchronously rotating polar: (1) there is no consistent photometric and spectroscopic period; (2) the optical lightcurve is sometimes flat and sometimes strongly modulated, which is not related to changes in the mass accretion rate; (3) the circular polarization curve is not repeatable, showing either only one or both signs of polarization. One possible explanation for these deviations is the presence of a small asynchronism ( $\sim 1\%$ ) between the orbital and the spin periods of the white dwarf. The origin of such an asynchronism is unknown. Other polars with comparable orbital period (hence, mass accretion rate and thus accretion torque) and field strength (hence, synchronisation torque) are not known to show this behaviour, they are synchronized. There are three more asynchronous polars known, V1500 Cyg (Stockman et al. 1988), BY Cam (e.g. Mouchet et al. 1997), and RXJ1940–10 (Patterson et al. 1995) with orbital periods of 197, 201, and 202 min, beat periods between spin and orbital period of  $\sim 14$ , 7.8, and -49.5 days, respectively. All these systems are long-period polars, i.e. they have orbital periods above the 2-3 hour period gap. For V1500 Cyg the reason for the asynchronism was found in its 1975 nova explosion. The mechanism behind for the two other systems are unknown. If confirmed, RX J2115.7–5840 would be the first asynchronous polar below the period gap. To confirm its nature is a challenge for observers, to understand its physics a challenge for theorists.

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