Filling up the period gap: RX J0803.4–4748, a new 137 minute polar

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Abstract. We report the discovery of a new AM Herculis system as the counterpart of the bright and very soft X–ray source RX J0803.4–4748 found serendipitously in a ROSAT PSPC pointing. Optical photometry showed deep (2 mag) variations with a period of $\sim$ 137 min placing RX J0803.4–4748 right into the period gap. The modulation can be interpreted in terms of cyclotron beaming and is very similar to that of other non–selfeclipsing polars like e.g. V843 Cen. Such a geometry is also supported by the X–ray light curve of a later HRI pointing which was lacking any pronounced faint–phase. Phase-resolved optical spectra are charaterized by strong Balmer and He II λ4686Å line emission superimposed onto a blue continiuum, and reveal disinct cyclotron humps at certain phases. The field strength of 39 MG as derived from the separation of the harmonics is in agreement with that of other soft X–ray polars.

1. ROSAT observations

As part of a program to study newly ROSAT-discovered supersoft X-ray sources (Greiner 1996) the field of RX J0803.4–4748 was observed between December 2–4, 1991 in a short (2.3 ksec) pointing centered on RX J0800.4–4746 which later turned out to be a white dwarf (Fleming et al. 1996). RX J0803.4–4748 ($\equiv$1RXS 080346.3–474838; henceforth referred to as 0803) appeared therein as the second brightest X-ray source (average count rate 0.465 ± 0.016 cts/sec) located $\sim 37'$ off-axis. It's X-ray flux was strongly modulated ($\sim$95%) rising to a peak-rate of $\sim$1.2 cts/sec at the end of the pointing (Fig. 1; left). The X-ray spectrum is very soft, with virtually no counts above 0.5 keV as indicated by the hardness ratio HR1=-0.93 ± 0.07. The spectrum can be readily deconvolved with an absorbed blackbody model (χ^2_ν=1.04). The inclusion of an additional bremsstrahlung component (with fixed $T_{\rm br}$ = 20 keV) yields no significantly better fit (χ^2_ν=1) and only slightly alters the blackbody parameters. The best-fit range of temperature and absorbing columns is $T_{\rm bb} = 30 - 55$ eV and $N_{\rm H} = (2-8) \cdot 10^{20}$ cm^{-2} at the 95% confidence level. We can set a firm upper limit on the flux-ratio in the ROSAT band $F_{\rm br}/F_{\rm bb} \lesssim 0.01$ (with $T_{\rm bb} \equiv 25$ eV and $T_{\rm bb} \equiv 20$ keV fixed).

The positional error of $\sim 50''$ made an optical identification in this crowded galactic plane region ($b^{\rm II}$=–8°.7) difficult. We therefore obtained a ROSAT HRI pointing between May 12 and June 7, 1994 which constrained the X-ray position to $\alpha_{2000} = 08^{\rm h}03^{\rm m}45^{\rm s}.6$ and $\delta_{2000} = -47°48'42''$. The CV is the only optical

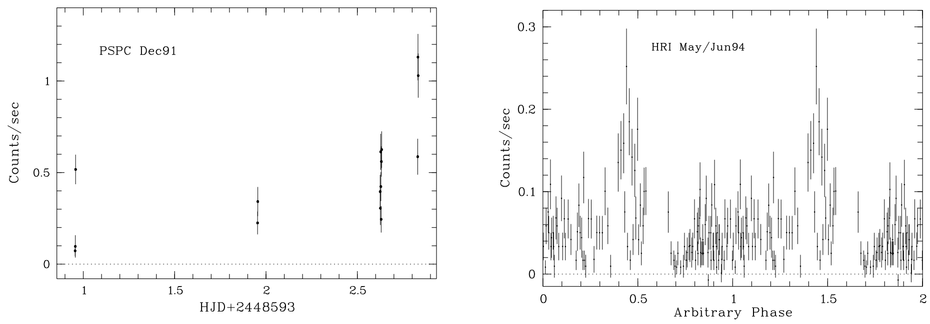

Figure 1. **Left:** X-ray light curve of RX J0803.4–4748 obtained on December 3, 1991 using the ROSAT PSPC. **Right:** The HRI X-ray light curve obtained in May/June 1994 folded with a period of 137.1 min. The phase zero offset is arbitrary.

counterpart found within the 10″ HRI error circle and has end figures 45ˢ.6 and 47″. The X-ray light-curve of the HRI observation folded on the preliminary photometric ephemeris (see below) revealed no strong orbital variations, but a non-zero count-rate at nearly all phases with an average count rate of 0.045 ± 0.007 (Fig. 1; right) consistent with the mean rate during the PSPC pointing (note the conversion factor of 7.8 between HRI and PSPC count rates for such soft X-ray spectra). only one observing interval and is thus certainly not a permanent feature.

2. Optical Photometry

Follow-up CCD-photometry was obtained on March 26-27, 1995 and January 17-18, 1998 at La Silla using the 2.2 m+EFOSC and the 1.5 m-Danish+DFOSC, respectively. We carried out a period search on the individual data sets using the analysis-of-variance method (Schwarzenberg-Cerny 1989). Both periodograms (Fig. 2; right) are consistent with a best-fit period of ∼137 min, although one-day aliases at 122 and 145 min are quite prominent. The latter are definitively ruled out by a χ^2 calculation applied to the timings of the four minima observed (Fig. 2; right, lower panel). This shows a fine alias structure (due to the 3 year separation) around the best guess period at 137.1 min which is used to define a preliminary ephemeris of

$$\mathrm{HJD}(T_{\mathrm{min}}) = 245\,0832.7476 + E \times 0.09523. \tag{1}$$

Due to the aliasing the estimated uncertainty is still high ($\pm 0^{\mathrm{d}}.0003$).

The folded light curves (Fig. 2; left) are characterized by a V-shaped minimum with 2 mag amplitude ($B = 16^{\mathrm{m}}.2 - 18^{\mathrm{m}}.5$) followed by a double-humped bright phase. The overall appearance is similar to that of V834 Cen (Schwope & Beuermann 1990), suggesting a geometry where the main accreting pole is permanently in view ($i + \beta < 90°$) and closest to the observer at optical minimum. Accretion rate and/or geometry may vigorously change on rather small time

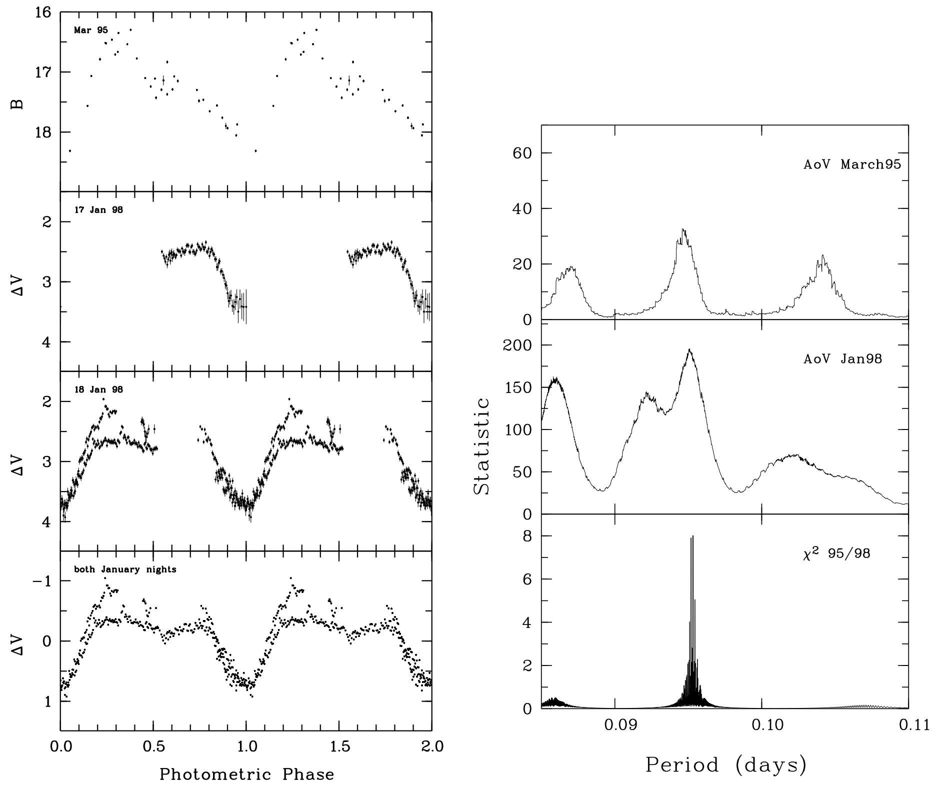

Figure 2. **Left:** Light curves of RX J0803.4–4748 obtained in March 1995 and January 1998 folded with a period of 137.1 min. **Right** AoV-periodograms calculated from the optical photometry using the data from March 1995 (upper panel) and January 1998 (middle panel). The lower panel shows a weighted χ^2_ν-calculation applied to the timings of the minima of both runs.

scales causing the large cycle-to-cycle variations (of about 0.5 mag) as observed on January 18, 1998.

3. Optical Spectroscopy

Our 1995 photometry was complemented by 8 low-resolution spectra covering approximately one orbital cycle with a time resolution of 15 min. Fig. 3 (left) shows a subset of consecutive spectra. The spectra are dominated by intense emission lines of the Balmer series, He II λ4686Å, and He I superimposed on a blue continuum. The inverted Balmer decrement and the strength of the He II λ4686Å line being about 2/3 of Hβ suggest a magnetic CV classification. This is directly confirmed by the detection of cyclotron lines at phases 0.7–0.8. The separation of the 4th/5th/6th harmonics (seen at λ6100, λ5000 and λ4300Å) of the cyclotron fundamental suggest a magnetic field strength of 39±3 MG depending on the plasma temperature and the viewing angle θ. A corresponding

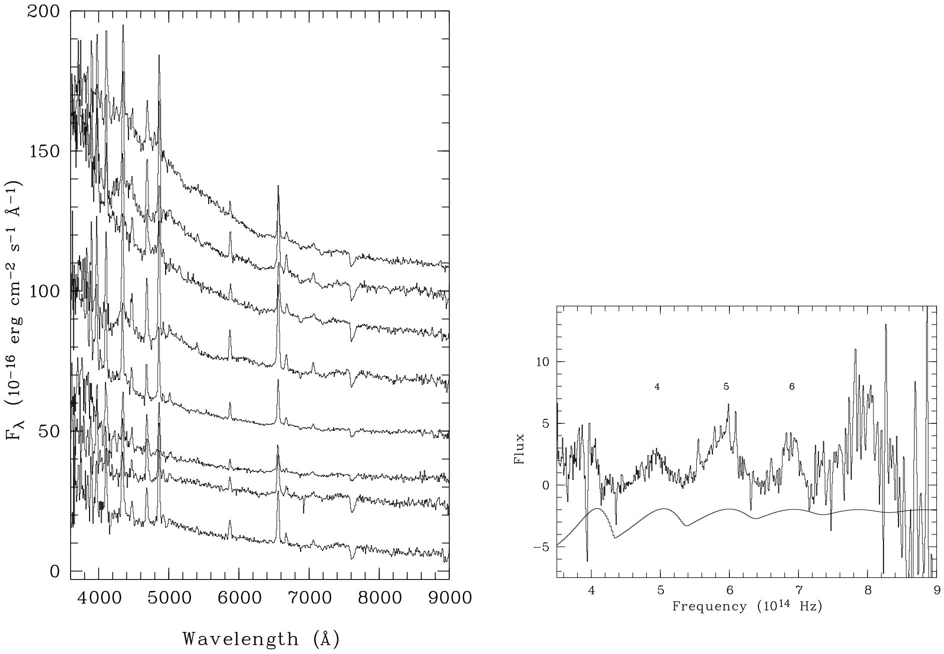

Figure 3. **Left:** Phase resolved spectra of 0803 obtained in March 1995. Spectra are shifted by 10 flux units each and run from phase ~0.0 (bottom) to ~0.95 (top). **Right:** Continuum and emission line subtracted spectrum taken at phase 0.82 together with a cyclotron model of $B = 39 \pm 3$ MG with $kT = 10$ keV and $\theta = 80°$.

cyclotron model is shown in Fig. 3 (right) together with the continuum and emission line subtracted spectrum taken at phase 0.82.

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