IAU Colloquium 190 on Magnetic Cataclysmic Variables
ASP Conference Series, Vol. 315, 2004
Sonja Vrielmann & Mark Cropper, eds.

The *CHANDRA* data of the Classical Nova RR Pic (1925): A possible Magnetic Cataclysmic Variable Candidate

Şölen Balman and Aybuke Küpcü-Yoldaş

Middle East Technical University, Physics Dept., Inönü Bulvarı, Ankara, Turkey

Abstract.

During 25ksec of CHANDRA ACIS-S3 observations of the old nova RR Pic 1925 a count rate of 0.067±0.0017 c/s was detected. The results show evidence (spatial and spectral) for X-ray emission from the region around the prominent SW blob in the H_α images. Shell emission is detected with count rate $\geq (1.95\pm1.33)\times10^{-3}$ c/s. The spectral analysis shows that the source spectrum can not be explained by a single or two temperature bremsstrahlung or VMEKAL models including photoelectric absorption, only models using powerlaw distribution of temperature fit the data well and indicate excess O, Al, Mg, S, and Si in the source spectrum. A soft excess in the CHANDRA data could be explained by a partial covering absorber model with covering fraction in a range 14-86 % consistent with characteristics of the Magnetic Cataclysmic Variable systems. The light curve shows significant orbital and other modulations.

1. Introduction

The classical nova RR Pic had an outburst in 1925 as a slow nova (expansion speed $\sim$ 400 km/s). The shell shows "equatorial ring and polar cap/blob" geometry. There are similarities and important differences between the spectra in the ring and blob regions (in C and O lines). The optical shell has a size of 30″x21″ and an expansion rate of 850 km/s is detected for the ring (Gill & O'Brien 1998). The distance of the nova is measured to be 600±60 pc.

2. CHANDRA Data Analysis

The source was chosen from the ROSAT archives as a candidate for an extended source. As an example for a X-ray detected nova remnant it was then studied with the aid of the CHANDRA ACIS-S (see also Balman 2002). In search for traces of extended emission around the point source in RR Pic in the CHANDRA data, several radial profiles at differing Position Angles were constructed. The results show that the shell is detected with $\geq (1.95\pm1.33)\times10^{-3}$ c/s i.e. 1.5σ above the background value. Another detailed analysis using a clipping method above 3σ variations on the average background value indicates emission 2-3σ above the background around the nova coincident with the optical shell. Extented emission exists around the central source between 0.2-2 keV; The im-

age in the 0.2-0.7 keV band indicates an emission region extending out to S and SW in the direction of the prominent SW blobs in the optical shell.

The point source spectrum could only be fitted with models like C6PMEKL or CEVMKL. (Singh et al. 1996 incl. a power law distribution of temperature and emission measures to account for the hard excess). The soft excess could be lifted by assuming a partial covering absorber yielding a covering fraction in a range 14-86 %. The N_H derived for the source is $(1\text{-}20)\times10^{22}$ cm^{-2} and T_{max} is 1.95-4.2 keV (where $(T/T_{max})^{\alpha}$ describes the models and α=1). The fits yield reduced χ^2 values of 1.27-1.6. A warm absorber model (ABSORI, Done et al. 1992) is also consistent with the data reducing the soft excess in the spectrum. The X-ray flux in the 0.2-10 keV is 3.0×10^{-13} erg/cm^2/s translating to a luminosity of 1.3×10^{31} erg/s. The variable abundance models yield fits with excess $O/O_{\odot} \sim 1.4$, $Mg/Mg_{\odot} \sim 3.1$, $Al/Al_{\odot} \sim 20.0$, $Si/Si_{\odot} \sim 1.5$, $S/S_{\odot} \sim 2.1$.

The point source RR Pic is a candidate magnetic WD with $P_{orb}=0.^d1450$ that shows up to 6 harmonics in the optical data (Kubiak 1984). There have been several different periodicities detected from the source: P$\sim$ 13-15-17 min (Kubiak 1984); flickering at 20-40 sec (Warner 1981). The CHANDRA lightcurve of the source shows significant variation on the orbital period of the system (208.8 min). The power spectrum of the source indicates existence of a consistent signal at $(1.60825\pm0.04208)\times10^{-3}$ Hz corresponding to a 621.79 sec possible period in the spectrum, however, with low significance. The signal does not exist in the DFT or in the other sources in the field or the background: it could be a candidate QPO or the spin period of the WD.

3. Discussion

The CHANDRA data of RR Pic reveals the existence of extended emission around the nova towards S and W directions at a 1.5σ confidence level as a lower limit. For a clipped background (for above 3σ), the detection is at $2\text{-}3\sigma$ level. The Spectrum of the source has a power law distribution of temperatures with kT_{max} =1.95-4.13 keV and enhanced elemental abundances of O, S, Si, Mg and particularly high Al. There is a soft excess which could be explained by a partial covering absorber or a warm absorber model. The spectrum of RR Pic resembles that of a magnetic CVs. The light curve of the source shows variation folded on the orbital period. The power spectrum reveals a possible period of 621.79 sec of a QPO or a WD spin period. Further observations of RR Pic in the optical and X-ray wavelengths are encouraged.

References

Balman, Ş. 2002, in AIP conf Ser., 637, Classical Nova Explosions, eds. M. Hernanz & J. Jose (New York: AIP), 365

Gill, C.D. & O'Brien, T.J. 1998, A&A, 300, 221

Kubiak, M. 1984, Acta Astronomica, 34, no.3, 331

Singh, K.P., White, N.E., & Drake, S.A. 1996, ApJ, 456, 766

Warner, B. 1981, MNRAS, 195, 101