UNVEILING X-RAY PROPERTIES OF NEW INTERMEDIATE POLARS

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ABSTRACT

We present first X-ray observations with the *XMM-Newton* satellite of the new magnetic Cataclysmic Variables HT Cam, UU Col and RX J2133+51. Strong rapid X-ray pulses reveal the rotational period of the accreting white dwarf thus unambiguously confirming these systems as true members of the Intermediate Polar class. These systems also reveal complex properties which make Intermediate Polars an intriguing class still to be fully explored.

Key words: Cataclysmic Variables; X-rays; Accretion.

1. INTRODUCTION

New optically identified Cataclysmic Variables (CVs) have recently increased the Intermediate Polar class (IPs) by at least a 30% (Gänsicke et al., 2005), rejuvenating the issue on the evolution and link between the two subclasses of magnetic CVs (Polars and IPs). A wide range of spin-to-orbit period ratios has also stimulated new theoretical works on the evolution of white dwarf (WD) spin equilibria (Norton et al., 2004), where the WD magnetic moment, the mass accretion rate play an essential role. Differently from optical strongly affected by X-ray reprocessing, X-ray observations are essential to identify the true WD spin period and the accretion mode. Also, a soft X-ray component similar to that observed in the synchronous and highly magnetized Polar is now being detected in an increasing number of IPs [Haberl et al. (2002); Staude et al. (2003); de Martino et al. (2004)], reinforcing the debated question on the progeny of Polars, i.e. whether IPs will synchronize during their evolution towards short orbital periods. In the framework of our programme with *XMM-Newton* aiming at determining unambiguously the IP nature of new optical candidates, we present here part of the results obtained from X-ray observations of three new systems (see Fig. 1).

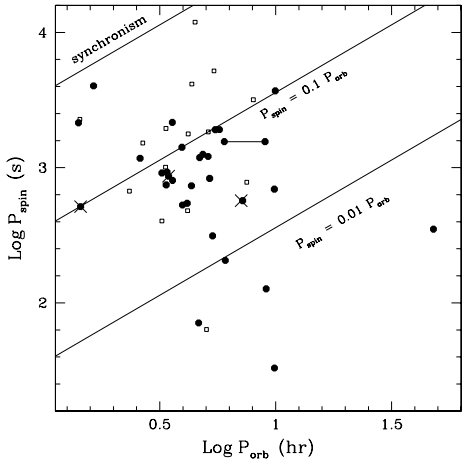

Figure 1. The spin-orbit period plane of IPs. Diagonal lines from top to bottom indicate P_{spin}/P_{orb}*=1, 0.1 and 0.01. Dots: X-ray confirmed IPs; squares: optical candidates and crosses: HT Cam (*P_{spin}*=515 s;* P_{orb}*=86 min), UU Col (*P_{spin}*=864 s;* P_{orb}*=3.5 hr) and RX J2133+51 (*P_{spin}*=571 s;* P_{orb}*=7.2 hr).*

2. HT CAM: A LOW MASS TRANSFER RATE IP

A 39 ks (EPIC) observation in March 2003 confirms the 515 s optical (Tovmassian et al., 1998) period as the true WD spin period. Discrete Fourier Transforms (DFT) in

the 0.2-15 keV range (Fig. 2) as well as in selected energy bands show the dominance of the spin frequency (ω). No signal is detected at either the beat ($\omega - \Omega$) or the orbital (Ω) frequencies, indicating that accretion occurs via a disc. Spin pulse fraction is $\sim 40\%$ with no energy dependence in the whole EPIC range. The EPIC spectra are well represented by a multi-temperature plasma with $\mathrm{kT_{max}}$=20 keV and power law index α=0.7 and metal abundance $\mathrm{A_Z}$=0.6 plus a gaussian centred at the neutral 6.4 keV iron line (EW=50 eV) plus a low ($\mathrm{N_H} = 5.7 \times 10^{20}\,\mathrm{cm^{-2}}$) total absorber. Hence HT Cam is not affected by strong absorption and the spin pulses are due to changes in the observable emitting volume. The low accretion rate of $2.4 \times 10^{-11}\,\mathrm{d^2_{100pc}\,M_\odot/yr}$ is consistent with that predicted by gravitational radiation for its short orbital period. A detailed analysis of the RGS spectra as well as of the optical/UV behaviour can be found in de Martino et al. (2005).

3. UU COL: A FAINT SOFT X-RAY IP

The faint high galactic latitude UU Col was observed for 28 ks (EPIC) in September 2004. The DFT in the whole EPIC range (Fig. 2) and in selected enegy bands shows the dominance of the 864 s period dected by Burwitz et al. (1996) except in the 0.3-0.5 keV range where the second harmonic is stronger than the fundamental. This implies that the main accreting pole dominates in the hard X-rays whilst both poles, probably offset, contribute in the soft X-rays. While no orbital periodicity is observed, the signal at the beat ($\omega - \Omega$) is also detected, indicating that material accretes via a disc as well as overflows above it (hybrid accretion mode). The spin folded light curves have a complex energy dependence indicating the presence of multiple components. The EPIC spectra indeed reveal a complex spectrum which does not require a temperature stratification but two MEKAL models at 11 keV and 0.18 keV with very low abundance $\mathrm{A_Z}$=0.4 plus a black-body at 50 eV partially absorbed (50%) by a dense column with $\mathrm{N_H} = 1.0 \times 10^{23}\,\mathrm{cm^{-2}}$. The RGS spectra are also well fitted by these components. The soft-to-hard X-ray bolometric flux ratio is 0.2. A mass accretion rate of $1.5 \times 10^{-12}\,\mathrm{d^2_{100pc}\,M_\odot/yr}$ for d>740 pc is consistent with the secular value for its orbital period. A detailed analysis of the RGS, EPIC and OM data will be reported elsewhere.

4. RX J2133+51: A NEW SOFT X-RAY IP

The first 16 ks (EPIC) observation of this recently discovered IP (Bonnet-Bidaud et al., 2005) was carried out in May 2005. The DFT in the whole EPIC range (Fig. 2) reveals equal power at the fundamental and first harmonic of the optically identified 571 s period. The beat period cannot be detected and a low frequency variability is suspected and needs to be confirmed by the second observation. The power spectra in selected energy ranges reveal complex behaviour in the soft (below 0.5 keV) and

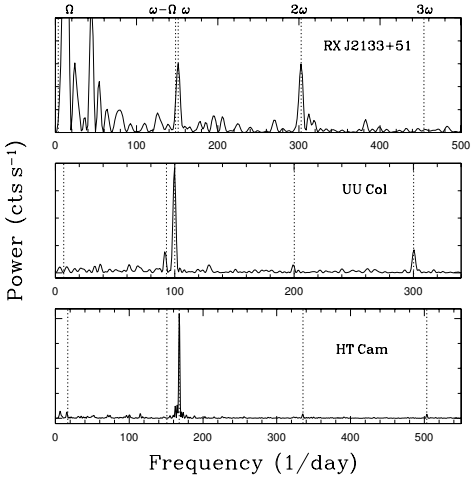

*Figure 2. The EPIC-pn DFTs of HT Cam (*bottom*), UU Col (*middle*) and RX J2133+51 (*top*). The spin (ω), the beat ($\omega - \Omega$) and the orbital (Ω) frequencies are marked with dotted vertical lines.*

hard ranges. The EPIC spectra indeed require a complex composite model consisting of a multi-temperature plasma with $\mathrm{kT_{max}}$=67 keV, α=1.0 and metal abundance $\mathrm{A_Z}$=0.8, plus a gaussian at the 6.4 keV iron line (EW=50 eV) plus a black-body at 96 eV and a total absorber ($\mathrm{N_H^1} = 1.7 \times 10^{21}\,\mathrm{cm^{-2}}$) and a second partial (48%) dense absorber ($\mathrm{N_H^2} = 1.2 \times 10^{23}\,\mathrm{cm^{-2}}$). The RGS spectra are also well represented by the same model. RX J2133+51 hence is similar to RX J1548-45 (Haberl et al., 2002) showing a strong highly absorbed hot blackbody component. The bolometric soft-to-hard flux ratios is high (0.83). This preliminar analysis hence reveals that the number of soft X-ray IPs might increase in the near future.

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