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High Spectral Resolution X-ray Observation of Magnetic CVs: EX Hya

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High spectral resolution X-ray observation of magnetic CVs: EX Hya

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In magnetic cataclysmic variables (CVs) the primary is a highly magnetized white dwarf (WD) whose field controls the accretion flow close to the WD, leading to a shock and accretion column that radiate chiefly in X-rays. We present preliminary results from a 500 ks Chandra HETG observation of the brightest magnetic CV EX Hya. From the observational dataset we are able to measure the temperature and density at different points of the cooling accretion column using sensitive line ratios. We also construct line-based light curves to search for rotational modulation of the X-ray emission.

EX Hya is an eclipsing, high inclination (i~78°) IP with an orbital period of 98 min and a WD spin period of 67 min. X-ray studies give a radial velocity amplitude of 58.2±3.7 km/s associated with the WD, which can be used to infer the WD mass using additional optical information (Hoogerwerf et al. 2004, Beuermann & Reinsch 2008).

Beginning on 05-13-2007 we obtained a 500 ks ACIS/HETG observation of EX Hya, covering ~125 WD spin periods. These observations allow us to test models of the spin-phased modulation, including occultation of one shock column and absorption by the accretion curtain (see fig. 1). We present a progress report on the spectral analysis (fig. 2).

- Density diagnostic:

The high SNR obtained allows us to increase the accuracy of the density derived from the Fe XXII *I*(11.92Å/*I*(11.77Å) ratio (Mauche et al. 2003). In fig. 3 we show the measured value of this ratio using our data and compare it with results obtained from previous data. We find log n_e [cm^{-3}]~13.7±0.2. With this and other accurate measurements, we will be able to determine the density as a function of temperature in the cooling column and compare to model predictions.

- Line-base light curves:

For each ion, we extract photons from the HEG and MEG (±3,2,1 orders) and construct light curves (fig. 4) using the ephemeris of Hellier et al. (1992). Fig. 4 shows features (e.g. ϕ ~ 0.9) that are statistically significant, suggesting complex structures in the accretion flow.

- The Fe Kα fluorescence line:

From the line-based periodogram and light curve (fig. 5) we can see that no modulation at the spin or orbital period is present. This suggests that Fe Kα is not formed in the accretion curtain or column. Another spectral line with approximately the same flux shows strong modulation at the WD spin (see fig. 5, Ca XIX light curve), indicating that the lack of modulation in the Fe fluorescence line is not driven by a low SNR.

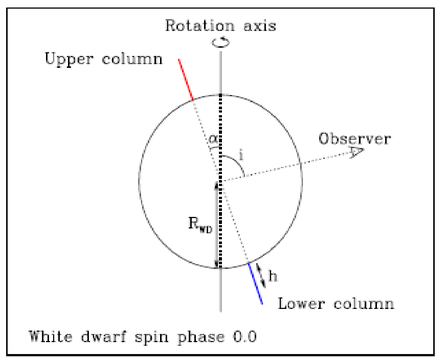

Fig. 1: Schematic of the EX Hya WD. The parameter *h* represent the height above the WD surface where the spectral line is formed.

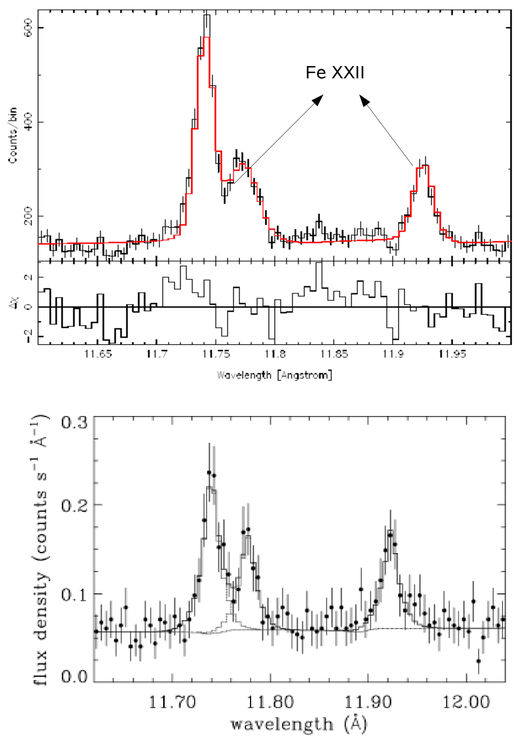

Fig. 2: Chandra/HETG spectra of EX Hya. Top panel shows the spectrum from a 500 ks (05-13-2007) observation in the Fe XXII region . Bottom panel shows previous 60 ks (05-18-2000) observation on the same object (from Mauche et al 2003). The significant improvement in the SNR will allow us to model the density and temperature distribution of the accretion column in detail.

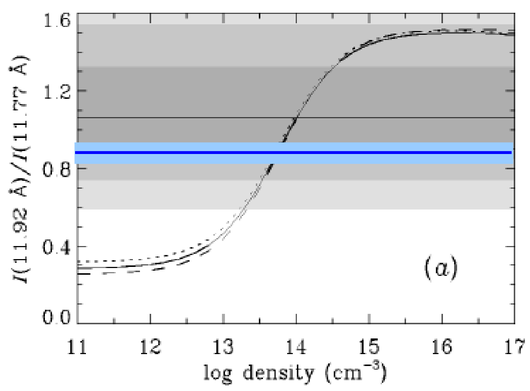

Fig. 3: Fe XXII density diagnostic line ratio applied to EX Hya. Gray shaded region represent 68%,90% and 99% confidence error envelopes calculated from previous ACIS/HETG observations (see Mauche et al. 2003 for details). Blue line and light blue strip represent measured value and its 90% confidence error from our data.

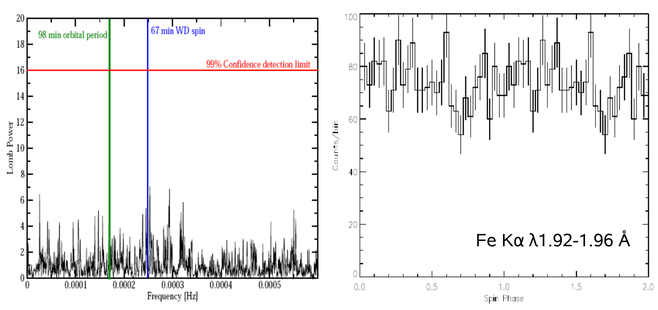

Fig. 5:*Left Panel*: Lomb periodogram of the Fe Kα line region (6.4 keV). The red line show the 99% confidence detection limit. Blue and green lines indicates the frequencies where the WD spin and orbital periods are located. Right panel: ACIS/HETG light curve folded at a 67 min WD spin period of EX Hya. The bin size is 0.0334 spin period, error bars represent 1σ errors.

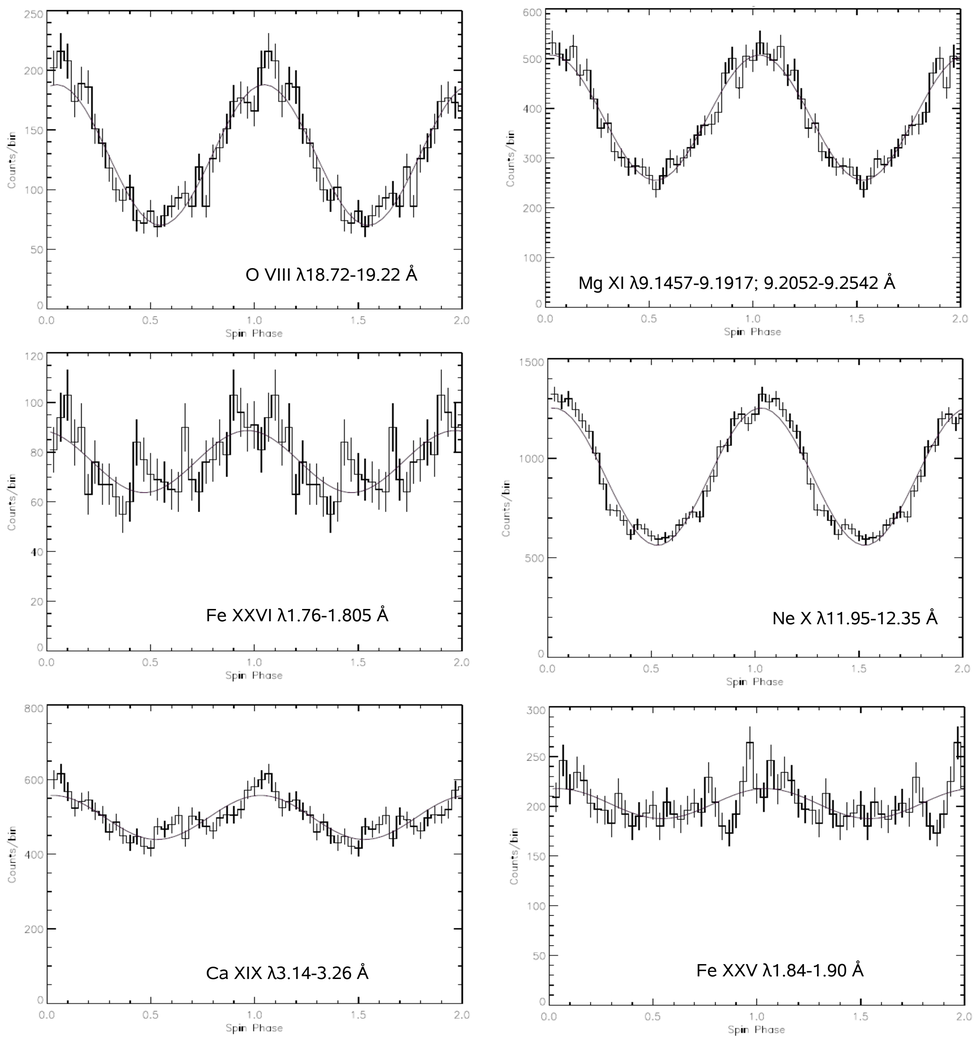

Fig. 4: Line-based light curves folded at a 67 min WD spin period of EX Hya. The bin size represent 0.0334 spin period, error bars represent 1σ. Each plot contains the best fit of a sinusoidal curve (except Fe Kα where no satisfactory fit was found) .

-Changes in the structure of the accretion columns?:

ACIS/HETG observations in May 2000 showed two remarkable features in the MgXI light curves, which are explained as emission from the accretion columns (see fig. 1 and 6).

During our observation, those features are not reproduced in any line-based light curves, probably due to changes in the accretion rate (i.e. shock height), asymmetries between both accretion columns or some other effect to be investigated.

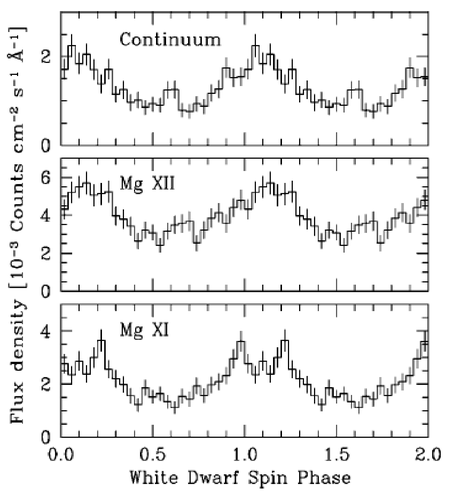

Fig. 6: Line-based light curves folded at a 67 min WD spin period of EX Hya from previous ACIS/HETG observations (from Hoogerwerf et al. 2006). The bin size represent 0.04 spin period, error bars represent 1σ errors.

References

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