XMM MONITORING OF THE ECLIPSING POLAR HU AQUARII

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ABSTRACT

We present results of an ongoing XMM monitoring campaign of the bright eclipsing polar HU Aqr. During four pointings performed between 2002 and 2005 the system was found in different accretion states ranging from intermediate to very low mass-transfer rates. On the long run these data uniquely constrain the distribution of the different radiation components in the accretion zone (cyclotron, bremsstrahlung, reprocessed soft X-ray emission) as a function of the instantaneous, specific accretion rate. An interesting, first result is the equilibrium of the primary hard X-ray flux and the soft, blackbody-like component during the intermediate state (Fig. 5). The last XMM pointing was accompanied by 4 hours of truly simultaneous ULTRACAM high-speed photometry at the VLT providing additional sub-second variability information in three optical bands (Fig 1). These data resolve the eclipse ingress/egress with an unprecedented high S/N and directly determine the location of the accretion spot on the white dwarf (Fig. 2). During all states the atmosphere of the white dwarf and the heated cap surrounding the accretion spot is directly discernable from XMM-OM UV light curves and optical photometry. From our new eclipse timings we find a third case (after DP Leo and NN Ser; Schwope et al. 2002 (A&A 392, 541); Brinkworth et al. 2005, astro-ph0510331) for a strong negative period derivative in a CV (Fig. 3) of $\dot{P} = -8.1 \times 10^{-12}$, which indicates either a true decrease of the binary orbit or is mimicked by a third body.

Key words: Accretion – AM Herculis binaries – stars: binaries: eclipsing – stars: individual: HU Aqr – X-rays: stars.

ACKNOWLEDGMENTS

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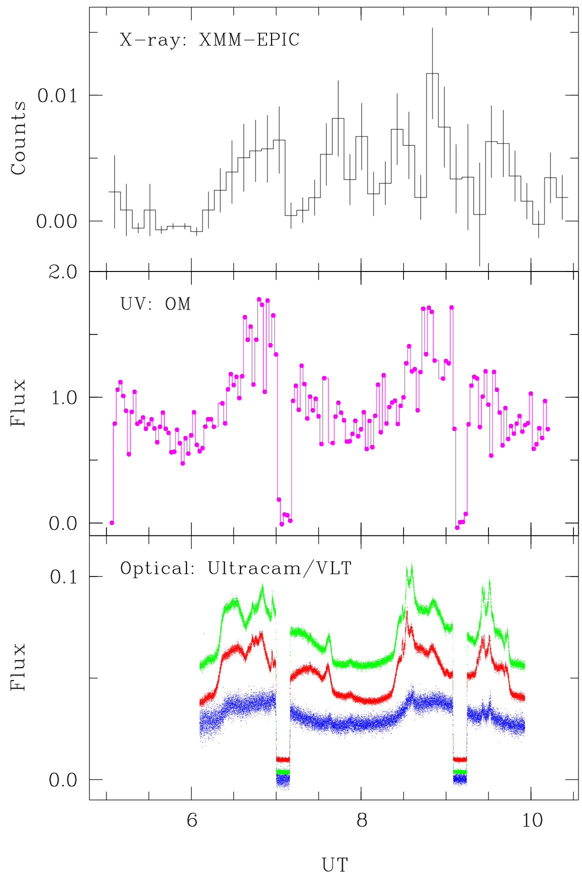

Figure 1. Simultaneous XMM and Ultracam high-speed photometry at the VLT taken in May 2005 during an episode of very low accretion activity. The top panel shows residual X-ray emission from the accretion plasma, while the UV light curve displayed in the middle panel is dominated from the heated photosphere below the acretion shock. In the lowest panel ULTRACAM ugr high-speed data at 0.5 sec resolution are shown, which is sensitive to photospheric radiation (u-band) and additional cyclotron emission (g- and r- band).

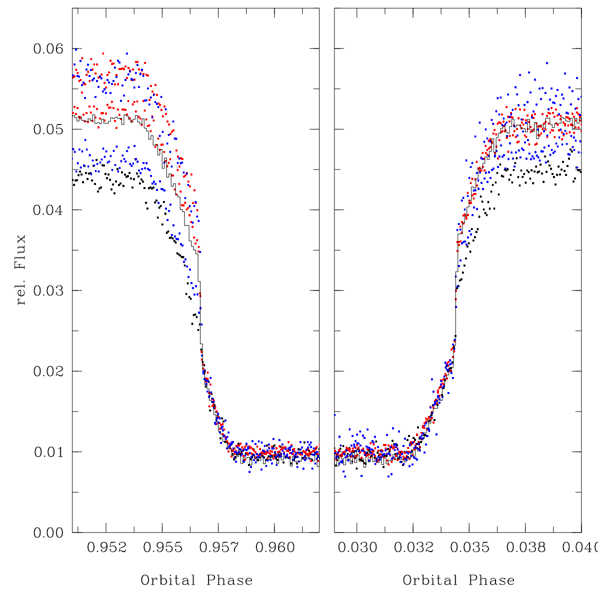

Figure 2. A blow up of the ULTRACAM r-band light curves around eclipse phase. This data resolves the egress and ingress of the white dwarf (28 sec) and the accretion spot (1.2 sec) with unrivaled high signal-to-noise and will allow to discern the linear dimensions of the emission components directly. The dots represent data from four individual runs, while the line is the resulting phase-average light curve.

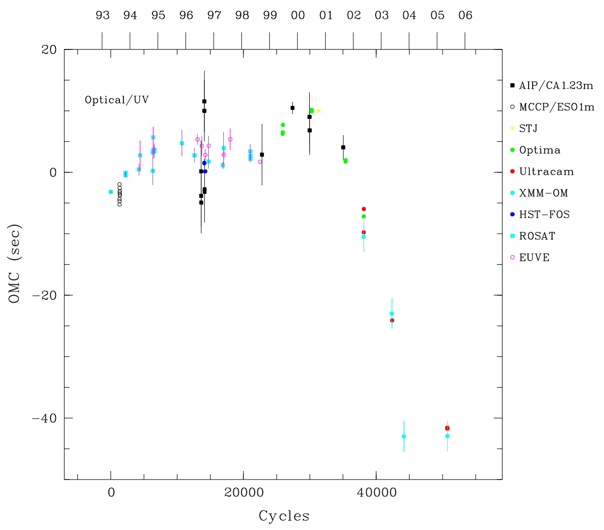

Figure 3. Monitoring of the eclipse egress of HU Aqr over a 12-years baseline using various space and ground based facilities. The new optical and X-ray timings suggest a large period derivative with respect to a linear ephemeris. This unexpected behaviour does either indicate the presence of a third body or a true period decrease of the binary. For the latter case the angular momentum loss would be a factor of 100 higher than the value expected for a short period CV where angular momentum-loss is thought to be only driven by gravitational radiation.

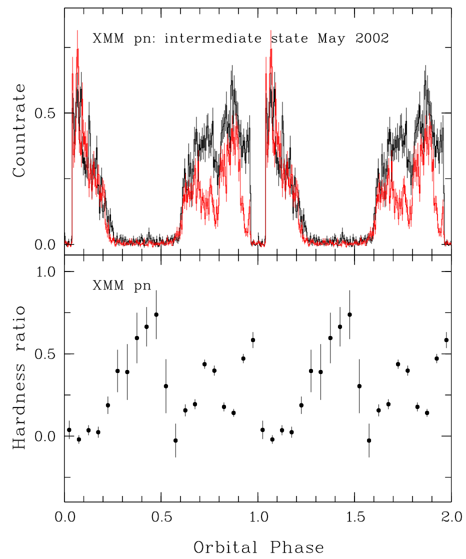

Figure 4. XMM EPIC light curve of HU Aqr taken during the intermediate state in May 2002. Count rates in the soft (<300eV, red) and hard (>0.5keV) bands are show separately. Around $\phi \sim 0.65$ and $\phi \sim 0.9$ broad and narrow absorption features are evident, which also have an impact on the hardness ratio (lower panel).

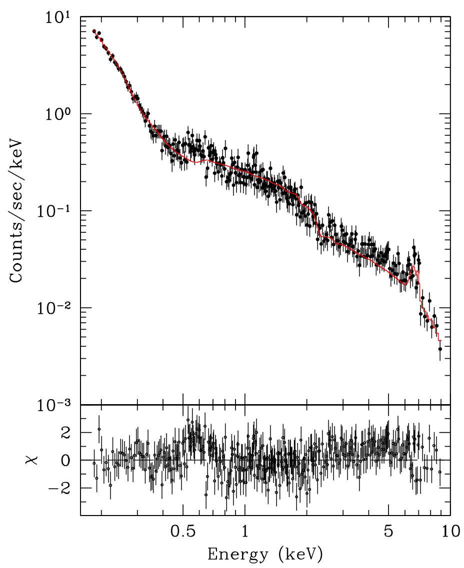

Figure 5. X-ray spectrum of HU Aqr taken during the intermediate accretion state in May 2002. Two-component blackbody and thermal plasma model with $T_{\rm bb} = 34$eV and $T_{\rm mek} = 39$keV is required to roughly fit the data. The fit residuals show hints of line emission around 0.6 and 6.4 keV, which correspond to O VII *and the fluorescence iron line. Both lines indicate presence of additional low temperature plasma and a harder reflection components. The ratio between the soft and hard bolometric fluxes is only 2, and therefore strongly reduced when compared to a ROSAT high state observation.*