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XMM OBSERVATIONS OF POLARS FROM THE SDSS

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RESUMEN

Hemos llevado a cabo observaciones *XMM* de 5 polares débiles descubiertas por el Sloan Digital Sky Survey. Los flujos de rayos X y los espectros presentan una variedad de regímenes de choque. El acrecentador más bajo posee propiedades de rayos X consistentes con un origen en la estrella secundaria. Las curvas de luz de todos los sistemas presentan una alta variabilidad, con una de ellas mostrando un profundo eclipse, y en otras dos con evidencias de variaciones relacionadas con la órbita.

ABSTRACT

We conducted *XMM* observations of 5 faint Polars discovered by the Sloan Digital Sky Survey. The X-ray fluxes and spectra show a variety of shock regimes. The lowest accretor has X-ray properties consistent with an origin on the secondary star. The light curves of all systems show large variability, with one showing a deep eclipse, and with some evidence for orbital-related variations in 2 others.

Key Words: **BINARIES: CLOSE — X-RAYS: BINARIES**

1. INTRODUCTION

The first 2 years of the Sloan Digital Sky Survey (SDSS) have revealed a variety of cataclysmic variables (Szkody et al. 2002; 2003a,b), among them several new systems containing highly magnetic white dwarfs (known as Polars or AM Her systems). Due to the faint magnitudes reached by the SDSS, the new systems include some of the the lowest mass-transfer rate systems known. For Polars, this means that many objects may be in the regime where the electrons cool primarily by cyclotron emission or where the shock degenerates into a bombardment solution (see Wickramasinghe & Ferrario (2000) for a description of these cases). To gain a better understanding of the shock regimes and accretion characteristics of these faint SDSS sources, we have used the high sensitivity and good energy coverage of the *XMM* satellite to observe 5 of these new sources. The characteristics of the 5 Polars are summarized in the Table below and a brief summary of the results follows. For brevity, we abbreviate the sources to their first few digits in RA but the full source identifications are in Szkody et al. (2002, 2003a,b).

TABLE 1

XMM OBSERVATIONS OF POLARS

SDSSJ	P(m)	V (mag)	UT Date	PN (c/s)	(ks)
0155+00	87	15.6	7-04-03	0-0.05	11.1
0729+36	120	20.6	10-31-02	0-0.08	7.5
0752+36	162	19.0	10-31-02	0.4-1.1	7.4
1553+55	263	17.6	2-17-03	0.01-0.04	10.4
1553+55	263	17.6	3-12-03	0.02-0.06	9.7
1700+40	115	18.0	8-11-03	0-0.25	9.0

2. SDSSJ1553+55

This SDSS source is one of two that were found to have extreme cyclotron harmonics (Szkody et al. 2003a) that are highly modulated in the optical throughout their orbital period (4.4 hr for SDSSJ1553) as the viewing angle of the magnetic pole changes. Fitting these harmonics indicated that SDSSJ1553 had a 60 MG field strength with a very low shock temperature (< 1 keV) and an extremely low specific accretion rate (10^{-14} $M_\odot$/yr), placing it in the bombardment accretion regime. *XMM* data is consistent with this picture, as the PN count rate is very low and there is no periodic variation evident in either of the 2 observations. The X-ray flux that is observed all comes from energies below 2 keV and the best fit to the 0.2-10 keV spectra of both observations is with a 188 eV bremsstrahlung source. As the distance to SDSS1553 is known to be about 100pc (from the identification of TiO bands of an M5V star evident in the near-IR), the X-ray luminosity comes out to be about 10^{30} ergs/s. The flux, light curve and spectrum are all consistent with an origin from the secondary star, rather than from active accretion at

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a magnetic pole. A previous *SAX* observation of AM Her during a low state had identified the X-rays as possibly having a large contribution from the activity level of the secondary, but the spectrum was too hard (>3.6 keV) to be attributed solely to a coronal source (deMartino et al. 1998). Thus, SDSSJ1553 may provide the first good evidence of the activity level of the secondary in a cataclysmic variable.

3. SDSSJ0155

The first optical observations of this bright SDSS Polar revealed deep eclipses on a period of 87 min (Szkody et al. 2002). The *XMM* data cover more than 2 orbital periods and show deep eclipses in X-rays at the same phases as the optical eclipses observed preceding and following the X-ray observations. The X-ray spectrum can be fit with both hard (14 keV bremsstrahlung) and soft (125 eV black body) components. The soft component is harder than typically found in Polars, but this may be the result of calibration problems with the *XMM* PN and MOS detectors below 0.5 keV.

4. SDSSJ1700

Optical analysis of this polar revealed a 30 MG field strength and a low inclination so that one accretion pole is viewed throughout the 115 min orbit (Szkody et al. 2003b). While the optical light curve shows a strong 2.5 mag periodic modulation throughout its orbit, the *XMM* PN light curve shows strong variability for the first few ks which does not repeat on the orbital timescale. The spectrum can be fit with a soft black-body and bremsstrahlung components, although the fit is not well-constrained. Transient flaring-like activity is common in Polars and has been observed in both active and low states of AM Her and UZ For (deMartino et al. 1998; Pandel & Cordova 2002). Thus, it appears that the variability in the mass transfer dominates the orbital variability at the time of the *XMM* observation of SDSSJ1700.

5. SDSSJ0752

Optical photometry shows a 1.5 mag modulation of this system on its 2.7 hr period, typical of the changing view of a single accretion pole. The *XMM* data only cover about 0.7 phase. There is a narrow eclipse-like feature near the start of the MOS observations, which unfortunately is not covered in the PN observation which started later. This feature looks very much like an X-ray eclipse, and it occurs at the same phase as the minima of the optical (obtained 11 hrs later), although it is much narrower than the optical minimum. However, without coverage of several complete orbits, it is impossible to tell if this is sporadic or periodic behavior. The X-ray spectrum is best fit with a combination of a 97 eV black-body and a 20 keV bremsstrahlung component.

6. SDSSJ0729

This optical (and X-ray) faint system also shows a one-mag variation in the optical throughout its 2.6 hr orbit. The *XMM* observation covered 80% of an orbit. During the first part (0.55 in phase), the X-rays are close to zero, but then there is a large rise in count rate for the last 2ks of the observation. As in the case of SDSSJ0752, we will need further data to determine if this rise is sporadic or associated with the emergence of the X-ray emitting pole from self-eclipse. In this case, there is no contemporaneous ground coverage and the Optical Monitor data have too low S/N to provide much insight into the transient accretion.

7. CONCLUSIONS

XMM is a good instrument for detecting the faint X-ray emission of low accretion rate Polars found in SDSS. The X-rays detected from the lowest accretor, SDSSJ1553 are consistent with an origin from an active late M secondary star, rather than an accretion shock. Thus, these lowest accretors can be used to probe the activity level of the secondaries in fast-rotating, short period binaries. The X-ray light curves of the other four all show large variability, although only SDSS0155 is clearly periodic, with a deep, narrow X-ray eclipse coincident with the optical eclipse. SDSSJ0752 also shows what may be an X-ray eclipse feature. SDSSJ1700 shows evidence for transient accretion variability. Except for SDSSJ1553, the sources can be fit with both a soft and hard component, indicating that there is an accretion shock which emits hard X-ray and heats the underlying white dwarf.

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