Search for Dwarf Novae in DASCH Scans Near M44

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Abstract. Dwarf novae (DNe) are a subclass of Cataclysmic Variables (CVs) with outbursts powered by a disk instability leading to a sudden increase in the accretion rate. The Digital Access to a Sky Century at Harvard (DASCH) Collaboration is preparing to digitize over 500,000 Harvard plates from the 1880s to the 1980s with limiting magnitudes ranging from B$\sim 14-19$. As a demonstration project, we have scanned more than 500 plates in the fields centered on the galactic open cluster M44. There are 21 CVs in the fields within 10 degrees of M44 covered by the scans. Here we present the preliminary results of DN outbursts of the known CVs to derive long-term DN outburst duty cycles. In addition, a 100y lightcurve for a XMM$-$Newton source is also presented to demonstrate DASCH capabilities.

Keywords: dwarf novae; cataclysmic variables; accretion disks; binaries; M44 (Praesepe)
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INTRODUCTION

The Harvard College Observatory (HCO) maintains a collection of more than 500,000 glass astrophotographic plates that cover both the northern and southern skies from the 1880s to the 1980s. The limits of the plates range from B$\sim$14 to 19 blue magnitudes. These 8x10 & 14x17 inch Plates cover $5 \sim 25$ degrees on a side. Every point on the sky has been observed about 500-1000 times. This 100 year coverage is a unique resource for studying temporal variations in the universe on $\sim$10-100y timescales. The Digital Access to a Sky Century at Harvard (DASCH) collaboration has developed an ultra-high speed digital plate scanner (Simcoe et al. 2006) which will ultimately enable the full Harvard plate collection to be digitized. As a demonstration project for the science case and photometry development, we have scanned more than 500 plates in the fields near and including the open cluster M44. M44 (Praesepe or NGC 2632) is a well studied nearby open cluster with a distance of about 185 pc, an age of about 600-800 Myr (e.g. Claver et al. 2001), and metallicity [Fe/H] = $+0.11 \pm 0.03$ (An et al. 2007).

Here we explore the variability of Cataclysmic Variables (CVs) in the fields of M44, to measure the frequency of Dwarf Novae (DNe) outbursts. DNe are a subclass of CVs, characterized by semi-periodic outbursts caused by episodic accretion of stored gas onto the White Dwarf (WD). Outbursts are powered by a sudden increase in the accretion rate, and occur at intervals of weeks to decades, lasting for days to weeks, with brightness increases of $\sim$2-6 magnitudes. It is widely believed that the outburst is driven by the thermal$-$viscous disk instability (see e.g. Cannizzo 1993, 2000; Lasota 2001; and Buat-Menard et al. 2001), and only about 10% of the disk mass is actually accreted in an outburst.

RESULTS

Most of DN outbursts are from U Gem type CVs. The DN outburst fraction for U Gem type CVs in the fields within 10 degrees of M44 are listed in Table 1. The ourburst rates of different U Gem type CVs are very different, for example, YZ Cnc has 34 detections in outburst state (defined by at least 2 mag brighter than quiescence) among 103 detection in total, while AT Cnc only has 1 possible detection in outburst state among 247 detections in total. The frequency of DNe outbursts constrains the mean disk density - higher outburst rates correspond to the higher disk density. If there is no outburst shown in a CV, it is likely to be a polar or intermediate polar, where the magnetic field strength $> 10^6$ G either prevents an accretion disk or the disk is truncated at large radius (see e.g. a review Kuulkers et al. 2003).

Lightcurves of several interesting CVs and a XMM−Newton source KW 262 are shown in Figure 1, for which we provide more detail as follows.

U Gem: U Gem is the second best studied DN (after SS Cygni). A dozen DN outbursts are detected in DASCH scans. Note that because U Gem is $12^o34'$ away from M44 and the present plate data are centered on M44, most plates containing U Gem are not included here. Thus we get very little coverage and only ~ 30 yr data in a series of wider field plates are available from the 500 scans. This is also the reason why most CV lightcurves in Figure 1 only cover a smaller time span than 100 yr.

YZ Cnc: a U Gem (Z Cam subtype) DN with very high ourburst rate.

AT Cnc: a U Gem (Z Cam subtype) DN with very low outburst rate (only one possible 2 mag outburst point among 247 detected points). The only detection (plate rh05721, JD=2427473.5835) is close to the limiting magnitude, and the error is very large (2.3 mag), thus it remains very uncertain whether this is an outburst. Considering the extremely low outburst rate, it might be a magnetic CV. Besides, there are 3 dips detected with 4 points in the lightcurve, which might come from binary eclipses.

X Leo: a U Gem variable with high outburst rate (32%). 12 detected points ranging from 15 to 12 mag out of 58 plates. V$= 17 - 12$mag in AAVSO database.

KW 262: it is a XMM−Newton source in a 50 ksec observation (Franciosini et al. 2003). It has a color $B-R = 1.42 \pm 0.6$ in GSC2.2 catalog (McLean et al. 2000). A ~ 2.5 mag outburst was detected in two scanned plates (plate i31229 with JD=2416455.9309, and plate i31230 with JD=2416455.9569). It is probably a flaring active binary. X-ray corona emission is a common feature among late type stars (Schmitt & Liefke 2004). It is believed that the corona magnetic activity is related to the rotation (Dempsey et al. 1993a, 1993b). Therefore, close binaries tend to emit higher X-ray flux due to their higher angular momentum.

DISCUSSION

There are many other interesting objects which can be studies using existing and future DASCH scans, such as binary systems in and out of M44, Novae, tidal disruptions of main sequence stars on supermassive black holes, AGN variabilities, supernovae, flare stars and the unexpected.

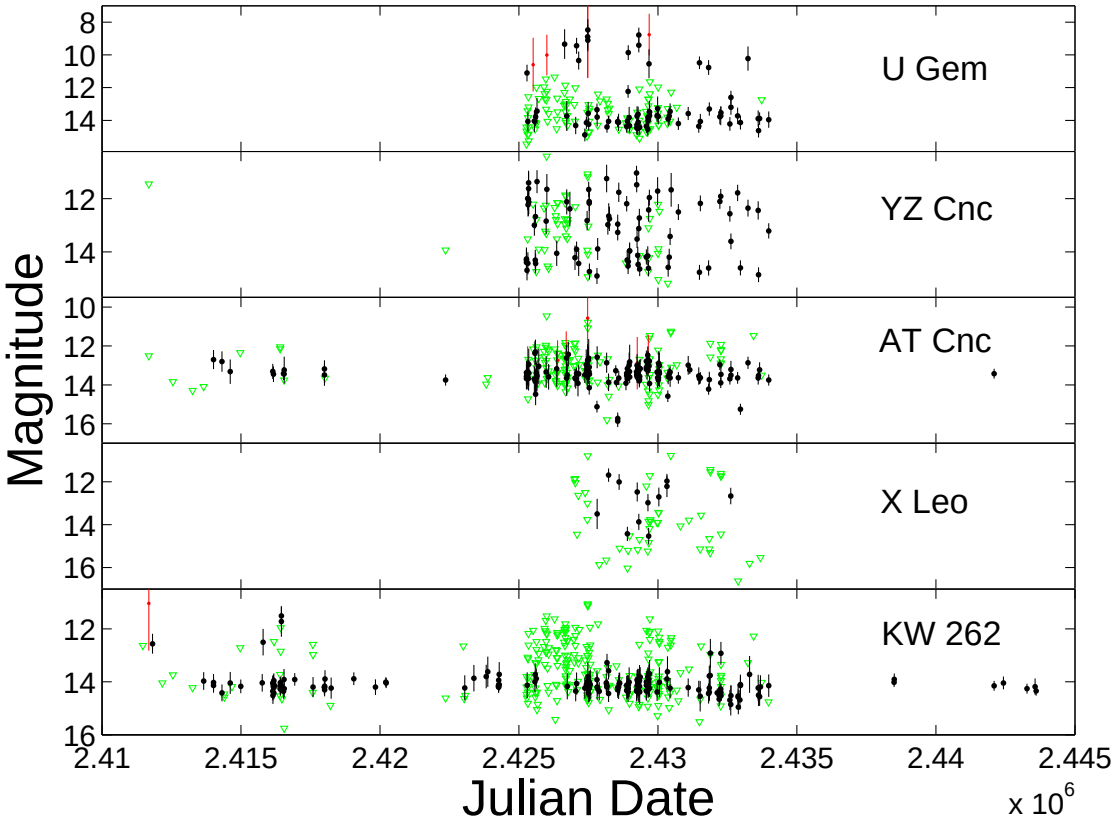

FIGURE 1. Lightcurves of CVs U Gem, YZ Cnc, AT Cnc, X Leo and XMM-Newton source KW 262. Black points with errorbars are detections with error less than 1 mag, smaller red points with errorbars are detections with error larger than 1 mag, and green open down triangles are upper limits.

TABLE 1. DN outburst fraction for U Gem type CVs in the fields within 10 degrees of M44.

Object	N_{all} *	N_{burst} †	**Outburst Rate** N_{burst}/N_{all}
AT Cnc	247	≤ 1	≤ 0.004
GY Cnc	57	4	0.07
GZ Cnc	64	13	0.20
SV CMi	10	0	0
SY Cnc	144	23	0.16
U Gem	157	20	0.13
X Leo	34	11	0.32
YZ Cnc	103	34	0.33
Total	816	106	0.13

* Points in bin 9 (at the edge of plates) and upper limits brighter than quiescence-2 mag are not included.

† A burst is defined by >2 magnitude increase of quiescent state. Upper limits fainter than quiescence-2 mag are treated as in quiescence.

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