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OUTBURST CHARACTERISTICS OF THREE LIKELY SU UMa-TYPE DWARF NOVAE: UV Gem, FS And AND AS Psc

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UV Gem is a dwarf nova which is given a UGSS subtype (SS Cyg-type) in the 4th Edition of General Catalogue of Variable Stars (GCVS). The GCVS lists its range of variability of 14.7–18.5 p and a mean cycle length of outbursts of 54 d. Very little information is found in the literature. Zwitter and Munari (1994) obtained a spectrum and confirmed the presence of a weak Hα emission line, suggesting that the mass-transfer rate is rather high. We observed this star in order to clarify its outburst pattern.

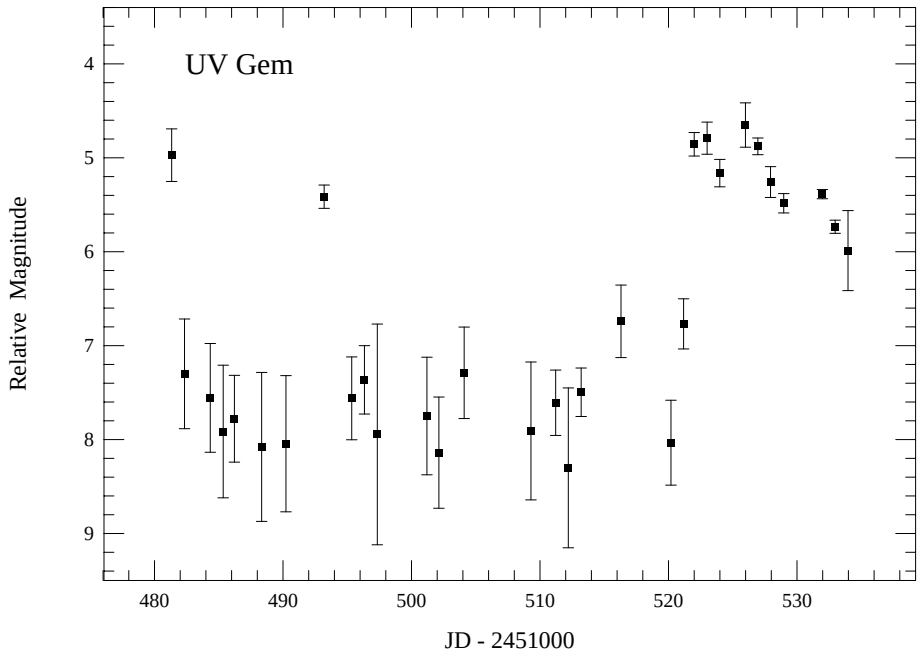

Figure 1. Overall light curve of UV Gem

The CCD observations were done using an unfiltered ST-7 camera attached to the Meade 25-cm Schmidt–Cassegrain telescope. The exposure time was 30 s. The images were dark-subtracted, flat-fielded, and analyzed using the Java^{TM}-based PSF photometry

Table 1: Outbursts of FS And

JD at max	peak mag	d[a] (d)	JD at max	peak mag	d[a] (d)
2449659	17.0	-[b]	2450040	15.8	< 3
2449681	16.7	-	2450333	15.4	-
2449694	16.5	-	2450345	15.7	-
2449997	16.6	-	2450361	15.0	-
2450005	15.5	3	2450711	15.5	-
2450016	15.6	2	2450744	15.7	-
2450026	15.8	< 6			

[a] Outburst duration.
[b] Not determined (too few data).

package developed by one of the authors (TK). The magnitudes were determined relative to GSC 1333.247, whose Tycho-2 magnitude is $V = 10.78 \pm 0.10$ and $B-V = +0.57 \pm 0.14$. The constancy of comparison star during the run was confirmed by comparison with GSC 1333.543 and GSC 1333.680. The light curve drawn from these observations is presented in Figure 1.

Three distinct outbursts were observed during this period: short outbursts on JD 2451481 and 2451493, and a long outburst starting on JD 2451522. The interval of the first two outbursts is only 12 d. The interval between the second and third being 29 d, it is likely one outburst was missed between the second and third outbursts. The true cycle length is thus likely 1/4 of the GCVS period. The first and second outburst decayed very quickly, with a rate of decline exceeding 1 mag d^{-1}, which is characteristic of normal outbursts of SU UMa-type dwarf novae. The third outburst lasted more than 11 d, which is very characteristic of a superoutburst. The observed outburst pattern suggests that UV Gem is an SU UMa-type dwarf nova with a short cycle length. This seems to be consistent with the high mass-transfer rate inferred from spectroscopy.

FS And is a dwarf nova discovered by Hoffmeister (1967). He reported relatively frequent detections of outbursts. The object was studied by Meinunger (1986), who reported an approximate outburst cycle length of $\sim$ 10 d, and the presence of a possible standstill. The object has been classified as a possible Z Cam star based on this observation. However, the lack of detailed published photometry has made the detailed classification slightly ambiguous. Bruch (1989) obtained spectroscopy and confirmed the dwarf nova classification.

We observed FS And in order to study its outburst behavior. We took three V-band data at Ouda Station, Kyoto University (Ohtani et al. 1992), between 1996 September 10 and 17. We further studied unfiltered CCD observations reported to the public database of the VSOLJ (Variable Star Observers League in Japan), and VSNET (http://www.kusastro.kyoto-u.ac.jp/vsnet/). The former contains observations by M. Iida, and the latter those by L. T. Jensen. Although zero-point calibrations were rather uncertain for unfiltered CCD observations, the zero-point error seems to be smaller than $\sim 0\overset{\mathrm{m}}{.}3$ by comparison with the Ouda data. This degree of uncertainty will not affect the analysis of the overall outburst behavior. Table 1 lists the observed maxima of outbursts.

The shortest observed interval between successive outbursts was 8 d, which generally confirmed the cycle length reported by Meinunger (1986). All observed outbursts faded quickly. Figure 2 represents the best observed portion of the light curve. Frequent short outbursts are clearly seen on Figure 2. The mean interval between these outbursts was

10 d. The quick fade from the outburst maxima is not characteristic of a Z Cam star (or a short period SS Cyg star) having this cycle length. The characteristics of outbursts more resemble those of a frequently outbursting SU UMa-type dwarf nova, best exemplified by HS Vir (Kato 1995; Kato et al. 1998), which showed similar frequent, short outbursts recurring with a period of 8 d. From these similarities, we propose that FS And is a good candidate for an SU UMa-type dwarf nova. The possible "standstill" reported by Meinunger (1986) may have been a superoutburst. Further monitoring for outbursts is strongly recommended.

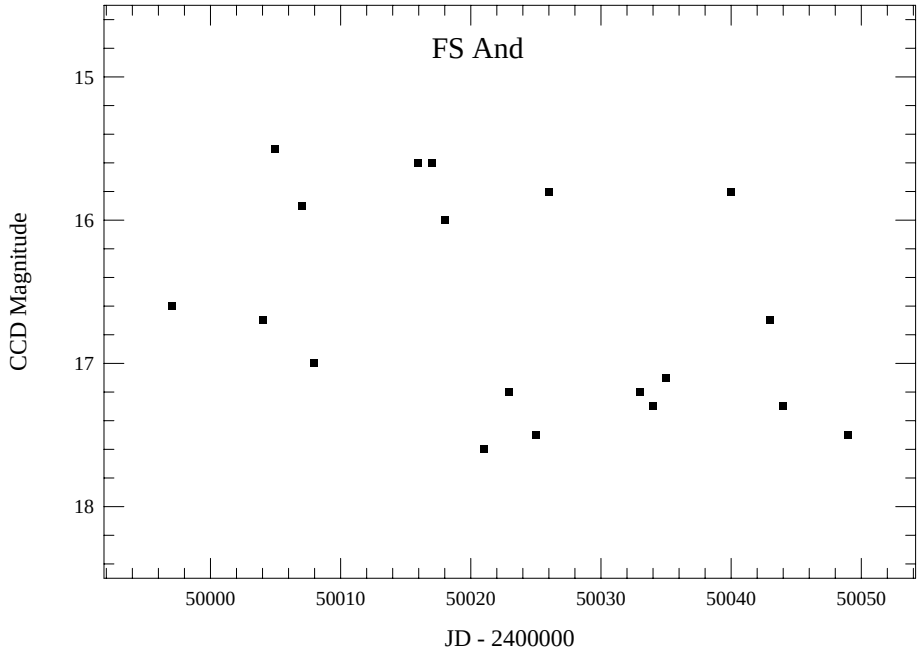

Figure 2. Light curve of FS And. Frequent, short outbursts with a recurrence time of $\sim$ 10 d are seen

AS Psc (= S 10828) was originally discovered as an eruptive variable reaching $B = 16.5$ in 1963 in the vicinity of the galaxy M33 (Richter 1979). Since no other outbursts were detected between 1963 and 1980 (Richter 1979), the star was suspected to be a nova in M33. The second outburst was detected in 1980 (Sharov 1982), which made a long-period dwarf nova more likely. However, the possibility of a recurrent nova in M33 remained (Richter 1983). Since then, three more outbursts were detected, at least one of which faded very quickly (Sharov 1988). Together with the shortest interval of 293 d between outbursts, the object is now considered to be a dwarf nova with rather infrequent outbursts (Richter 1989). Richter (1989) listed all the observations of five known outbursts. From the lack of the visible counterpart on POSS and other deep exposures, the quiescent magnitude is considered to be fainter than $B = 21.7$. Combined with the brightest observed maximum, reaching $B = 15.3$, the total amplitude of outburst is larger than 6.4, which makes AS Psc a good candidate of an SU UMa-type dwarf nova.

Further evidence for an SU UMa-type dwarf nova can be found in the extremely rapid decline (1.6 mag d^{-1}), observed on the occasion of the 1984 outburst. This rate of decline corresponds to that of a normal outburst of an SU UMa-type dwarf nova with a short orbital period. If AS Psc is indeed an SU UMa-type dwarf nova, the bimodal distribution of outbursts (normal outbursts and superoutbursts) would make the simple statistical analysis of outbursts by Richter (1989) misleading. No further outburst has been reported

both in the literature and to VSNET.

While surveying exposures taken by the members of Kyoto University Astronomy Lovers' Association, the authors found a new outburst of AS Psc occurring in 1989 October. The exposure was taken by Mr. Nishida with a hypersensitized TP 2415 film and a 13-cm reflector on JD 2447801.231. The exposure clearly showed AS Psc in outburst. Using V-magnitude comparison stars for TX Tri, we estimated the magnitude of the variable as 16.3. The outburst occurred 1028 d after the last known outburst in 1986.

Looking at available materials (summarized in Richter 1989), the existence of two types outbursts is evident: short or faint outbursts, as in JD 2444461 and 2445964, and long or bright outbursts. Such a bimodal distribution is consistent with the supposed classification of an SU UMa-type dwarf nova. By assuming that outbursts reaching $16^{\rm m}.5$ are long, bright outbursts (likely superoutbursts), there is a clear indication of regular intervals between them. The interval between the 1983 and 1986 outbursts is 1102 d, which is close to interval of 1028 d between the 1986 and 1989 outbursts. The interval of 7384 d between the 1963 and 1983 outbursts may be 7 times of this fundamental period. The available material thus suggests that the supercycle of AS Psc is 1000–1100 d, which is an intermediate value between WZ Sge-type dwarf novae and usual SU UMa-type dwarf novae (c.f. Nogami et al. 1997). Although there still remains a possibility that the true supercycle could be N-th of this value, the large outburst amplitude seems to be consistent with a long supercycle. Further observations to search for outbursts, and time-resolved photometry to search for superhumps are strongly encouraged.

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