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HIP 60725 AND CU CVn: TWO NEW δ Sct STARS

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In the period from 1996 to 1998, a few δ Sct stars were observed from Monegrillo and Mollet del Valles Observatories in Spain while monitoring a small set of selected HIPPARCOS variable stars. In both cases a 40cm Newtonian telescope was used. The telescopes were also equipped with a Johnson V filter and a SX Starlight CCD camera with a Sony ICX027BL chip cooled by a Peltier system to about -25°C. Dark frames and flat fields were obtained and used to perform image cleaning. Photometric reductions were carried out using a synthetic aperture differential magnitude extraction method and the software package LAIA (Laboratory for Astronomical Image Analysis).

The HIPPARCOS variables, discovered by the satellite mission, were selected on the basis of a reanalysis of the satellite data, which suggested that the actual variable type for some objects could be different from the one assigned in the HIPPARCOS and TYCHO catalogues (ESA, 1997). This new analysis was based on a search for periodicities in the satellite photometric data and on inspection of the light-curve morphology. We present here our observations and results for two of these HIPPARCOS variables HIP 60725, and CU CVn (HIP 67357), which are shown to be new δ Sct stars. `Period98` (Sperl, 1998) was used to analyse our photometric and the Hipparcos Epoch Photometry data series. Table 1 shows the observational log, and Table 2 gives some additional basic information on these objects. The spectral types were retrieved from the HIC (Turon et al., 1993), and equatorial coordinates from the Hipparcos Catalogue (ESA, 1997).

Table 1. Observational log

Star	Observation period	Comp. star	Check star	Data points	Remarks
HIP 60725	13 Mar-11 Jul 1998	SAO 002046	GSC 4556-800	607	1
HIP 67357	16 Feb-27 Feb 1998	HIP 67327	–	467	2

[1] Monegrillo Observatory, 40-cm telescope

[2] Mollet del Valles Observatory, 40-cm telescope

Table 2. Basic data

Star	GCVS Name	Spectral type	Equatorial coordinates (epoch 2000)
HIP 60725	–	F0	$\alpha = 12^{\rm h}26^{\rm m}43\overset{\rm s}{.}735$ $\delta = +81°28'26\overset{''}{.}27$
HIP 67357	CU CVn	F0	$\alpha = 13^{\rm h}48^{\rm m}20\overset{\rm s}{.}117$ $\delta = +31°24'03\overset{''}{.}80$

HIP 60725 (= SAO 2041 = GSC 04557-09079) is listed in the HIPPARCOS catalogue as an unsolved variable (ESA, 1997). Our analysis of the Hipparcos data shows a main frequency at 7.5306±0.0004 c/d, or a 0.13279 day period. The new photometric data show that HIP 60725 is actually a small amplitude variable (maximum amplitude of 0.1 mag in the V band), which displays strong amplitude changes from night to night. Its F0 spectral type as well as the short period and the multiperiodic character of the light-curve are good indicators of light variations due to δ Sct pulsations.

A Fourier analysis of the ground-based data indicates that there are two pairs of strong frequencies at 7.512 and 7.530 c/d, and at 7.655 and 7.673 c/d, with a typical error for all of them of ±0.003 c/d. As there is a strong 7-day feature in the spectral window, these pairs are clearly 7-day aliases of each other. Among the detected frequencies in these data, the frequency at 7.530 c/d corresponds to the main frequency detected in the satellite photometry with a semi-amplitude of 27 mmag (25 mmag in the ground based data). As an additional test, our photometric data and the HIPPARCOS data were merged after removing their respective average values. A subsequent frequency analysis revealed that all the data could be folded on a 0.132792 ± 0.000001 day period, showing that this period is real and stable within the given errors since the HIPPARCOS era (mean epoch of 1991.25) until our 1998 observations (Fig. 1). The 7.673 c/d frequency is then its 7-day alias.

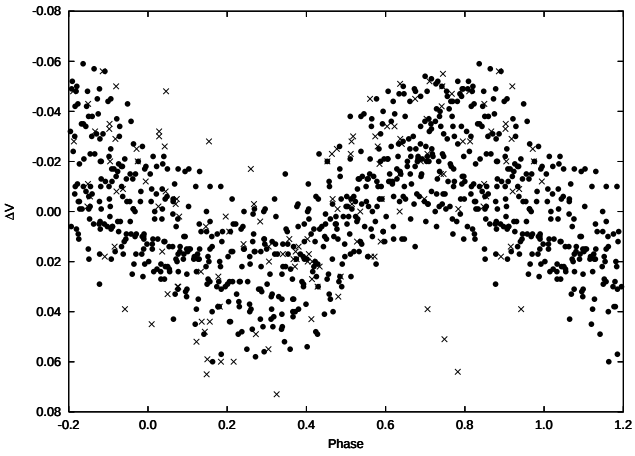

Figure 1. HIP 60725 satellite (crosses) and new photometric data (points) folded on the 0.132792 day period. Phase zero is assigned arbitrarily.

Since the light-curve of HIP 60725 shows a strong amplitude modulation, a second period was searched for. The satellite and ground-based data sets were prewhitened to remove the 0.13279 day period component and its alias forest. The ground-based prewhitened data showed two strong peaks at 7.656 c/d and 7.798 c/d in the frequency domain, which again are two 7-day aliases of the same frequency (the abovementioned 7.512 c/d alias also appears but with a lower amplitude). The frequency at 7.798 c/d can

also be identified in the HIPPARCOS data. If both prewhitened data sets are merged, the 7.798 c/d frequency becomes the dominant one with a semi-amplitude of 16 mmag and all observations can be folded on a 0.128233 ± 0.000001 day period (Fig. 2). Its presence in the two independent data sets suggests that is a genuine frequency. Table 3 summarizes our results of the frequency analysis.

Table 3. Results of detected frequencies in the satellite data

Data set	Name	Frequency (c/d)	Semi-ampl. (mag)	Period (days)	S/N	Ground-based detection?
HIP 60725	f_1	7.530	0.027	0.1328	5.5	y
	f_2	7.798	0.020	0.1282	5.5	y
CU CVn	f_1	14.742	0.023	0.0678	10.3	y
	f_2	12.561	0.009	0.0821	4.8	n

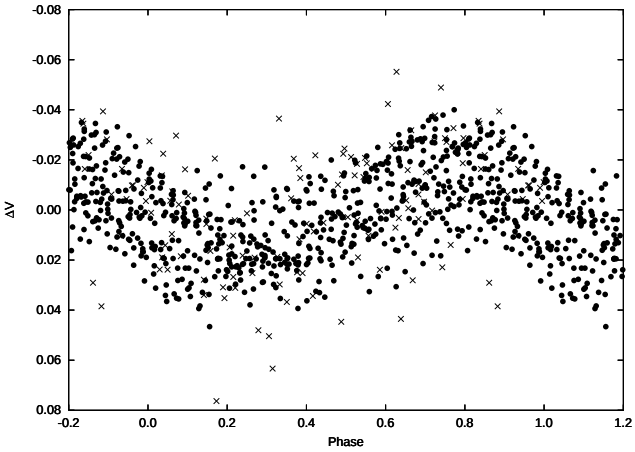

Figure 2. HIP 60725 satellite (crosses) and new photometric data (points) folded on the 0.128233 day period after removing the main 0.132792 day component.

CU CVn (HIP 67357) is listed as a periodic variable in the HIPPARCOS catalogue with a mean period of 0.1356670 days (ESA, 1997) and was classified as an EW: in the 74th Special Name-List (Kazarovets et al. 1999). A period analysis of the Hipparcos Epoch Photometry data shows a dominant frequency at 14.7419 ± 0.0004 c/d (period of 0.067834 ± 0.000002 days). Our photometric observations in the V band show that this object is a small-amplitude variable star with a maximum total amplitude of 0.06 mag, and rapid as well as irregular light-curve changes (Fig. 3). As for HIP 60725, its F0 spectral type, the short period as well as the rapid modulation probably caused by multiperiodicity are indicators of pulsation of the δ Sct type.

Although the small number of observed nights, only six, makes it difficult to obtain a reliable Fourier analysis of the new data for CU CVn, the frequency at 14.742 c/d is present, but only as part of a forest of 1 day aliases and not as the strongest component. As a matter of fact, even a satisfactory folded light-curve based on the 0.067834 day period could not be achieved after merging all available (ground-based and satellite) photometric data. The rapid modulation of the light-curve indicates that this object is a

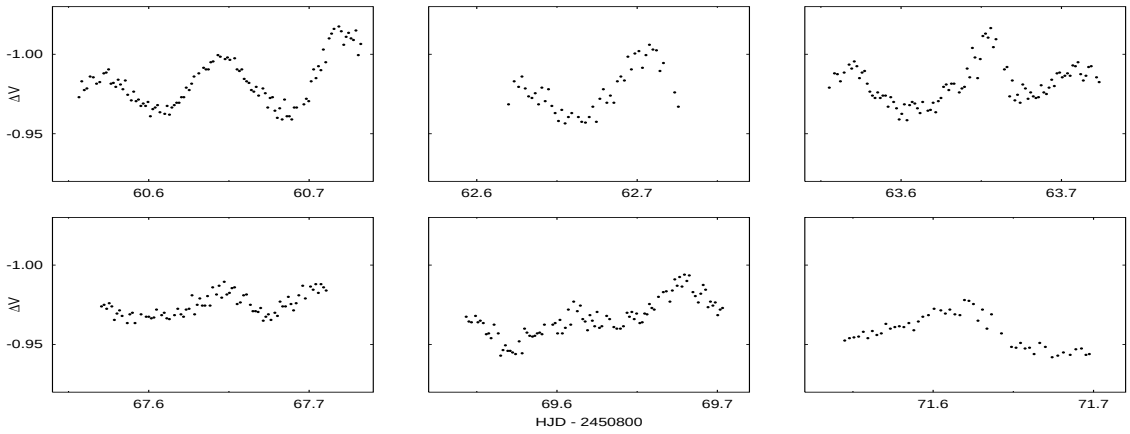

Figure 3. Ground-based light-curve in V light of CU CVn.

probable multiperiodic variable. Prewhitening of the satellite data suggests the presence of at least another frequency at 12.5606 ± 0.0004 c/d, which is very close to the frequency at 12.5869 ± 0.0004 detected in the prewhitened ground-based data. However, both cannot be unambiguously identified as corresponding to the exact same frequency. Table 3 illustrates the results for the HIPPARCOS data only. It is obvious that larger data sets spread over many nights are needed - especially in the case of CU CVn - to have a better knowledge of all the frequencies that are excited in these new δ Sct variables.

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