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$g'r'$ CCD observations of four long-period eclipsing variables

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About 600 CCD magnitude measurements in the g', r' filters were acquired in 2022 for four long-period eclipsing binaries: V698 Cyg, V788 Cyg, EU Gem, V733 Per. The light elements for all these systems were derived using the ASAS-SN database.

1 Introduction

Long-period eclipsing binaries are interesting objects for investigation. First, their light elements are difficult to derive. Second, wide binary systems differ in their evolution from shorter-period binaries and can give interesting insight into their origin and life story.

For our study, we selected four long-period eclipsing binaries (V698 Cyg, V788 Cyg, EU Gem, V733 Per). In the GCVS (Samus et al., 2017), they have periods from $47\overset{\mathrm{d}}{.}85$ to $97\overset{\mathrm{d}}{.}74$.

V698 Cyg. This variable star was discovered by Hoffmeister (1929) as an Algol type star, with only one reliable minimum detected. Whitney (1952) presented the star's light elements with the period $97\overset{\mathrm{d}}{.}738$, reproduced in the GCVS along with a rather wide photographic range, $12\overset{\mathrm{m}}{.}2$–$14\overset{\mathrm{m}}{.}9$.

V788 Cyg. The variability discovery was announced by Geyer et al. (1955) who determined the photographic range $10\overset{\mathrm{m}}{.}0$–$10\overset{\mathrm{m}}{.}9$. The GCVS light elements with $P = 47\overset{\mathrm{d}}{.}84870$ are from Baldwin (1977).

EU Gem. The star was announced as an Algol variable by Hoffmeister (1949). Later, Hoffmeister claimed the star to be irregular, but Meinunger (1966) confirmed its Algol type with the period $52\overset{\mathrm{d}}{.}2665$. The photographic range in the GCVS is $13\overset{\mathrm{m}}{.}7$–$14\overset{\mathrm{m}}{.}9$.

V733 Per. This possible Algol was discovered by Hoffmeister (1968) but confirmed only years later by Otero et al. (2005). They found the period $77\overset{\mathrm{d}}{.}53$, reproduced in the GCVS, and reported a rather narrow visual variation range, $11\overset{\mathrm{m}}{.}89$–$12\overset{\mathrm{m}}{.}17$ ($12\overset{\mathrm{m}}{.}03$ in the secondary minimum).

2 Observations and Results

We performed CCD observations of the four long-period eclipsing binaries (V698 Cyg, V788 Cyg, EU Gem, V733 Per) in August 2022 – November 2022 (the JD range 2459813 – 2459900) at the Caucasus Mountain Observatory (CMO, Russia) with the 60-cm telescope

using an Andor iKon-L camera, 2048×2048 pixels, with a pixel size of 13.5 microns. The $g'r'$-band filters of the ZTF survey system (Masci et al., 2019) were used. Information about the CMO and description of the observing data reduction technique can be found in Berdnikov et al. (2020). We obtained a total of about 600 magnitude measurements with photometric errors close to $0\overset{m}{.}02$–$0\overset{m}{.}03$.

Observations are given in Table 1 (the complete table is presented in the html version of the paper as a text file; the table in the text is a short fragment showing its format and contents).

Table 1. Observations of eclipsing variable stars

V698 Cyg	g	r
JD 24...		
59826.25062	12.3530	-
59826.25081	12.3440	-
59826.25100	12.3350	-
59826.25124	-	11.6780
59826.25138	-	11.7020
59826.25151	-	11.6560
59826.28024	12.4023	-
59826.28043	12.4069	-
59826.28063	12.4024	-
59826.28086	-	11.7260
59826.28100	-	11.7410
59826.28113	-	11.6950

The orbital elements given in Table 2 are derived from ASAS-SN data (Kochanek et al. 2017). The coordinates, for the equinox and epoch 2000.0, are extracted from the Gaia DR3 data release. The light curves, constructed for our observations with the derived periods, are presented in Fig. 1.

Table 2. Elements derived for the four observed objects

Star name	Coordinates, J2000	T_0, HJD	Period, days
V698 Cyg	$19^h59^m53.350^s$ $+36°16'40.00''$	2459339.359	97.76308
V788 Cyg	20 27 34.130 +31 51 25.12	2457770.320	47.84883
EU Gem	06 39 42.014 +17 11 31.36	2459056.027	52.26637
V733 Per	03 31 48.516 +36 12 44.85	2459266.222	77.08768

The reviewer kindly pointed out to us that EU Gem, according to Gaia data, has a comparable-luminosity companion only $4''$ away. Figure 2 shows a part of a CCD frame for EU Gem (size $3.5' \times 3.5'$) obtained with the 60-cm CMO telescope in the B filter. The comparable-brightness star, which is in $4\overset{''}{.}1$ from EU Gem, does not affect our brightness measurements of EU Gem because PSF photometry was performed.

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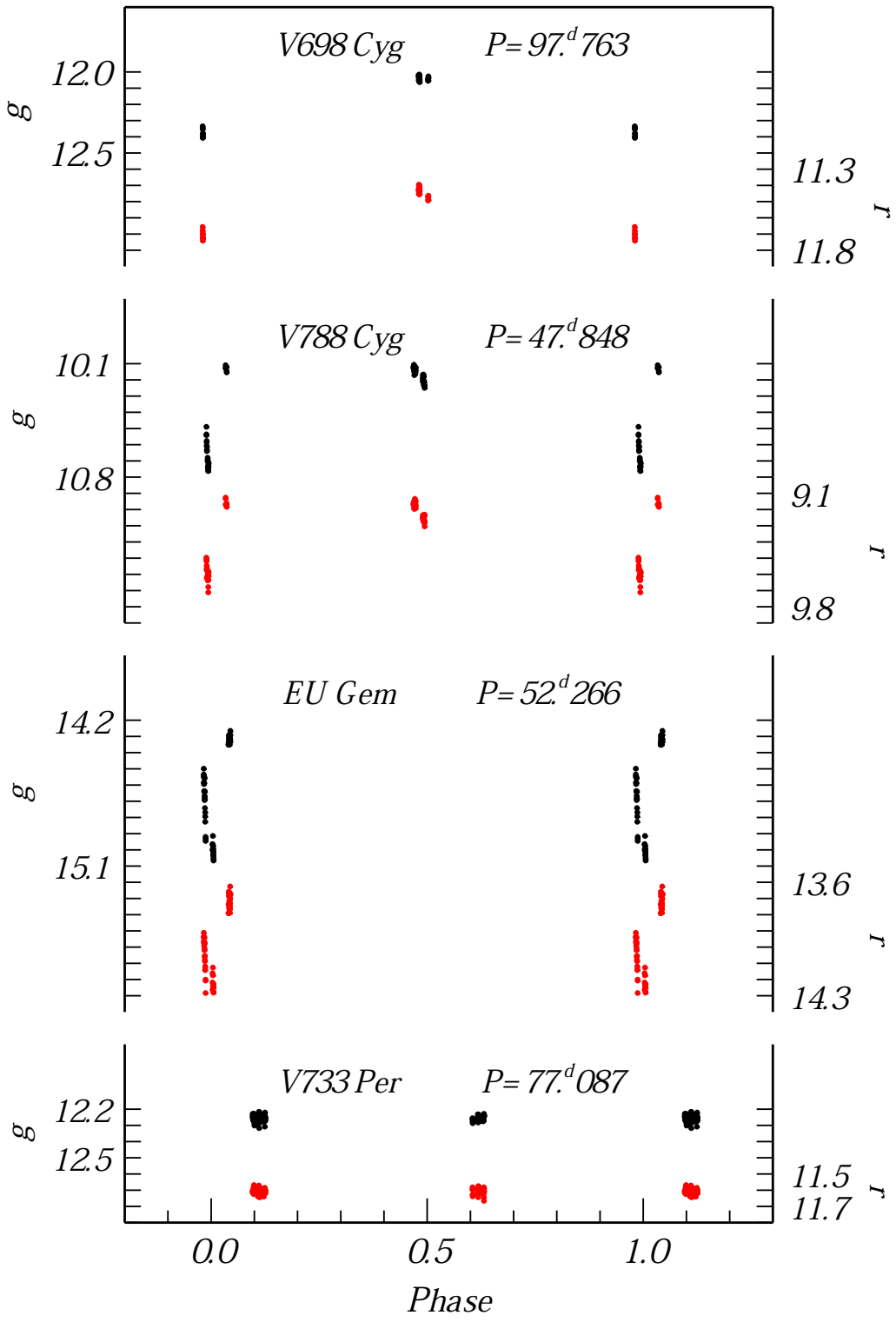

Figure 1.
Light curves for the four observed stars. Red color shows observations in the r' filter.

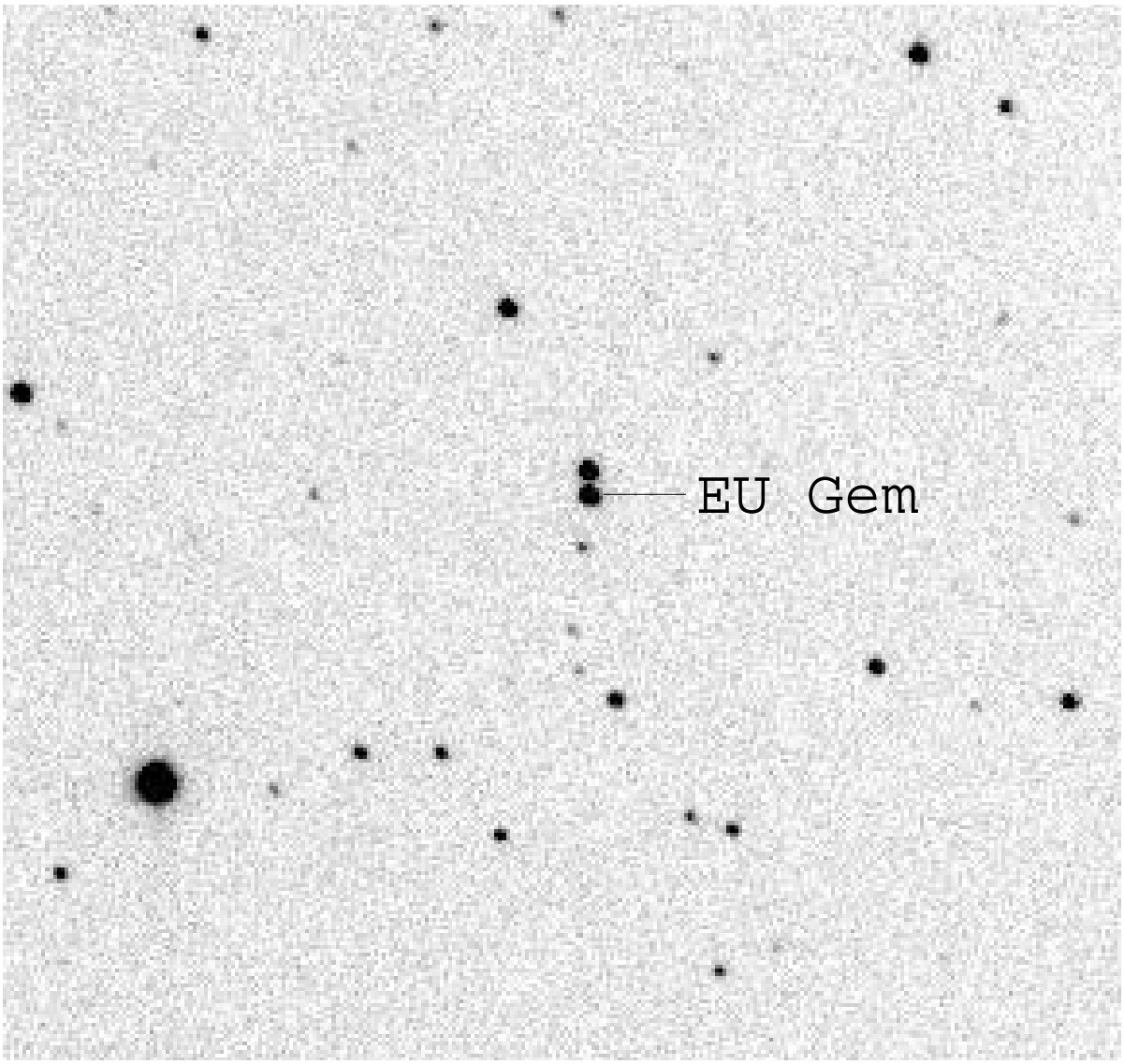

Figure 2.
CCD frame of EU Gem.