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PERIOD CHANGES IN THE ECLIPSING BINARY SYSTEM V861 Her

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The variability of eclipsing binary V861 Her (GSC 3079-00201; $\alpha = 16^{\rm h}51^{\rm m}12\overset{\rm s}{.}80$, $\delta = +41^\circ17'58\overset{''}{.}2$; J2000.0) was discovered and initially investigated on the photographic plates of Moscow collection by Antipin (1996). Later, Csizmadia et al. (2004) analyzed CCD observations and times of minima published by Csizmadia et al. (2002) and Borkovits et al. (2003). The authors gave following light elements:

$$MinI = HJD2451690.5276 + 0\overset{\rm d}{.}344824 \times E \quad (1),$$

that differ considerably from the ephemeris published by Antipin (1996):

$$MinI = HJD2443684.325 + 0\overset{\rm d}{.}3446322 \times E \quad (2).$$

Assuming probable strong variations of the period, we undertook additional CCD observations.

Our CCD photometry was carried out using a Pictor 416XTE camera at the 50-cm Maksutov telescope of the Crimean Laboratory (Sternberg Astronomical Institute). The observations in the Johnson V band continued for three years. 475 brightness measurements were obtained on five nights in 2004 (JD2453195–212), 257 ones – on four nights in 2005 (JD2453561–570), and 166 more – on two nights in 2006 (JD2453552 and 53945). The images were dark subtracted, flat-fielded and analyzed with the aperture photometry package developed by V.P. Goranskij. GSC 3079-00194 was used as a comparison star, the same star was selected for comparison by Csizmadia et al. (2002) and Borkovits et al. (2003). We observed seven primary and two secondary minima, the times of minima determined from our observations (with Gaussian fitting) are marked *tp* (this paper) in the last column of Table 1.

Phased light curves for each season and for all our observations are shown in Figure 1. The curve was plotted for the elements:

$$MinI = HJD2453212.336 + 0\overset{\rm d}{.}3446322 \times E \quad (3).$$

The O'Connell effect mentioned by Csizmadia et al. (2004) is presented in our data too. The period (but not the epoch) is in agreement with that from Antipin (1996) and contradicts the ephemeris published by Csizmadia et al. (2004).

To study period changes of V861 Her in detail, we re-analyzed the photographic data (Antipin, 1996). The observations were divided in parts (seasonal in most cases), then the time of minimum for each of the parts was determined using Hertzsprung's method in conjunction with a computer algorithm developed and described by Berdnikov (1992). The same technique was used by us to determine the time of minimum from NSVS/ROTSE-I online data (Wozniak et al., 2004). Furthermore, we collected all published times of minima of the variable. The results are summarized in Table 1. The last columns of the table contains a reference to the source of information: (pg) photographic observations; (NSVS) NSVS/ROTSE-I data (Woźniak et al., 2004); (C&) Csizmadia et al. (2002); (D1) Diethelm (2002); (B&) Borkovits et al. (2003); (tp) this paper, our CCD observations; (HSW) Hübscher et al. (2009); (D2) Diethelm (2009).

The $O-C$ residuals were calculated for the linear light elements (3). The corresponding $O-C$ diagram is shown in Fig. 2. Variations of the orbital period in the binary system are clearly seen. The remarkable changes occurred between JD2445869 and JD2452344. The diagram corresponds to abrupt period changes not periodic ones. The linear ephemeris (3) can be accepted as current light elements.

Note that neither primary nor secondary minima from Csizmadia et al. (2002) and Borkovits et al. (2003) are in agreement with all other available observations. Apparently, these times of minima are erroneous.

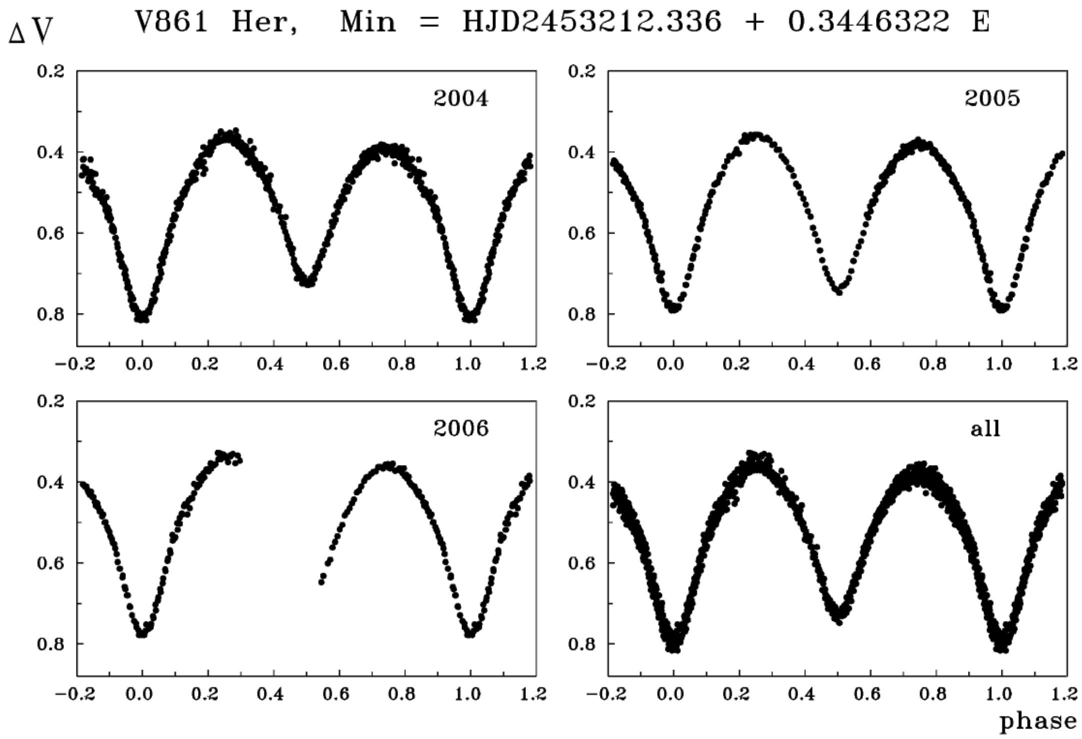

Figure 1. Phased light curves for each season and for all our CCD observations.

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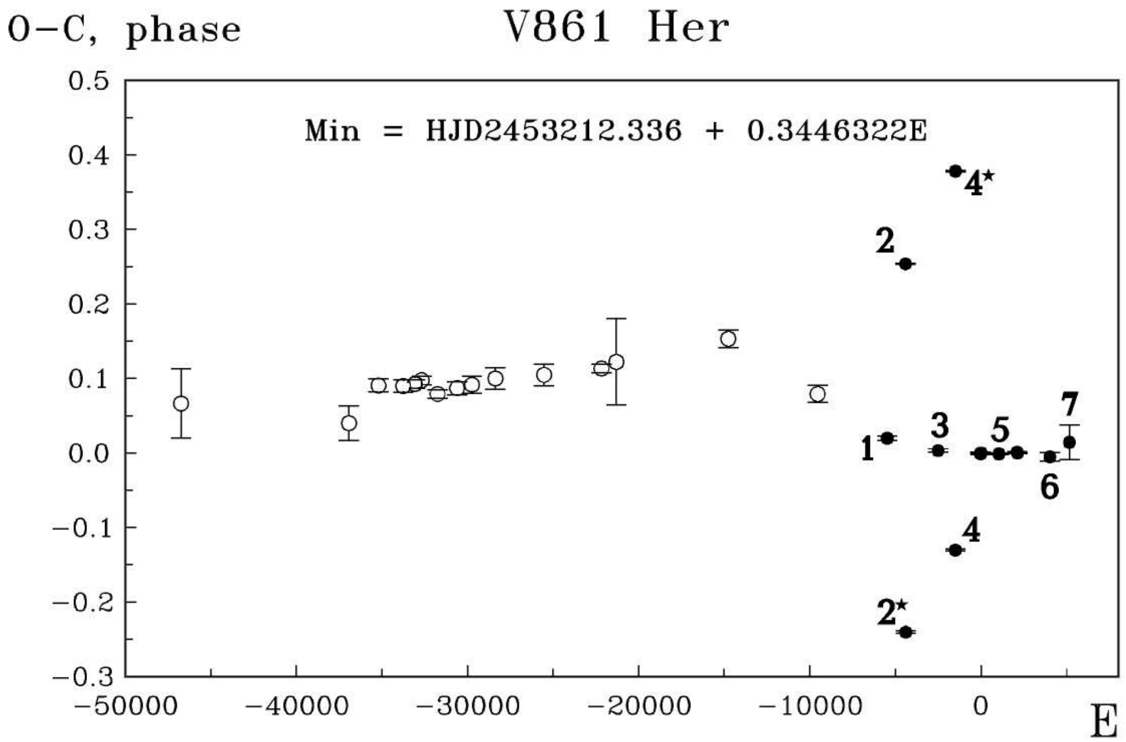

Figure 2. The $O-C$ diagram. Open circles: the photographic times of minima; filled circles: CCD times of minima: (1) NSVS data (Woźniak et al., 2004), (2) and (2*) primary and secondary minima from Csizmadia et al. (2002), (3) Diethelm (2002), (4) and (4*) primary and secondary minima from Borkovits et al. (2003), (5) this paper, (6) Hübscher, Steinbach & Walter (2009), (7) Diethelm (2009).

Table 1. Times of minima and $O-C$ residuals.

HJD(UT)24...	Err, d	Min	E	O–C, d	O–C, p	Err, p	Source
37105.9730	0.016	I	-46735	0.0229	0.0663	0.0464	pg
40484.0487	0.008	I	-36933	0.0137	0.0399	0.0232	pg
41080.2799	0.003	I	-35203	0.0312	0.0906	0.0087	pg
41578.9624	0.003	I	-33756	0.0309	0.0898	0.0087	pg
41813.3132	0.002	I	-33076	0.0319	0.0924	0.0058	pg
41950.1339	0.002	I	-32679	0.0336	0.0974	0.0058	pg
42272.0141	0.002	I	-31745	0.0273	0.0792	0.0058	pg
42665.9314	0.003	I	-30602	0.0300	0.0870	0.0087	pg
42961.9720	0.004	I	-29743	0.0315	0.0915	0.0116	pg
43431.7086	0.005	I	-28380	0.0344	0.0999	0.0145	pg
44414.6013	0.005	I	-25528	0.0361	0.1047	0.0145	pg
45571.8791	0.002	I	-22170	0.0390	0.1131	0.0058	pg
45868.9552	0.020	I	-21308	0.0421	0.1222	0.0580	pg
48124.5836	0.004	I	-14763	0.0528	0.1531	0.0116	pg
49923.1935	0.004	I	-9544	0.0272	0.0790	0.0116	pg
51322.3798	0.001	I	-5484	0.0068	0.0197	0.0029	NSVS
51690.5276	0.0002	I	-4416	0.0874	0.2536	0.0006	C&
51695.5268	0.0006	II	-4401	-0.0829	-0.2405	0.0017	C&
52344.5532	0.0008	I	-2518	0.0011	0.0031	0.0023	D1
52693.6196	0.0004	I	-1505	-0.0449	-0.1304	0.0012	B&
52696.5519	0.0004	II	-1497	0.1303	0.3781	0.0012	B&
53195.4489	0.0004	I	-49	-0.0001	-0.0003	0.0012	tp
53203.3751	0.0003	I	-26	-0.0005	-0.0013	0.0009	tp
53208.3742	0.0002	II	-11	-0.1708	-0.4957	0.0006	tp
53212.3360	0.0002	I	0	0.0000	0.0000	0.0006	tp
53564.3795	0.0003	II	1022	-0.1706	-0.4950	0.0009	tp
53569.3744	0.0002	I	1036	-0.0006	-0.0016	0.0006	tp
53570.4085	0.0002	I	1039	-0.0004	-0.0010	0.0006	tp
53937.4425	0.0003	I	2104	0.0004	0.0010	0.0009	tp
53945.3686	0.0002	I	2127	-0.0001	-0.0003	0.0006	tp
54596.3771	0.0019	I	4016	-0.0018	-0.0053	0.0055	HSW
54596.5511	0.0024	II	4017	-0.1724	-0.5004	0.0070	HSW
54990.6430	0.008	I	5160	0.0049	0.0141	0.0232	D2
54990.8089	0.0005	II	5161	-0.1739	-0.5045	0.0014	D2

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