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THE PRIMARY MINIMUM OF OW GEMINORUM IN 2002

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The light variation of the long-period eccentric Algol-type eclipsing binary OW Geminorum (=HDE 258878=BD+17°1281, sp. type F2 Ib-II, $V_{\rm max}$=8.2 mag, ΔV=1.8 mag, P≈1260 days) was discovered in 1988 by D.H. Kaiser during his photographic nova search (Kaiser et al. 1988). The first period determination was given by Kaiser (1988), while the high eccentricity was indicated for the first time by the secondary minimum observations of Williams (1989). Since the discovery, two primary minima, the first in 1991 (Williams & Kaiser 1991, Pravec 1992, Hanzl et al. 1993) and the second in 1995 (Hager 1996) were covered by visual, photoelectric and CCD observations. The most thorough analysis of the system was presented by Griffin & Duquennoy (1993, hereafter referred to as GD93), mostly based on radial velocity measurements. There is very few multicolour photometry in the literature and this fact initiated our observational efforts addressing the primary minimum in early 2002.

The ephemeris given by Williams & Kaiser (1991) predicted this year's minimum to occur on January 3, 2002. Our CCD photometric observations were carried out on 13 nights between Dec. 17, 2001 and Jan. 11, 2002. The data were obtained in two observatories. $BV(RI)_C$ photometry was done at Szeged Observatory with the 0.4-m Cassegrain telescope equipped with an SBIG ST–9E CCD camera (512×512 pixels). The exposure times were between 5 and 60 seconds, depending on the actual filter and target brightness. The majority of the data was recorded with the 60/90/180 cm Schmidt telescope mounted at the Piszkéstető Station of the Konkoly Observatory. The detector was a Photometrics AT200 CCD camera (1536×1024 pixels, KAF-1600 chip). Here the exposure times ranged from 2 to 20 seconds.

All data were reduced with standard tasks in IRAF[1]. We made aperture photometry with IRAF/DAOPHOT. Two nearby stars, already suggested for comparisons by Terrell et al. (1994), were chosen as comparison and check stars (comp = GSC 1332-0578, V=9.90 mag, $B-V$=+0.30 mag, check = SAO 95777, V=9.05, $B-V$=+0.230 mag, Hanzl et al. 1993). We used the fainter star as comparison because a 6-hour long continuous B-band photometry on Dec. 17, 2001 suggested slight (and ambiguous) changes of the brighter

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Table 1: Differential magnitudes of OW Gem relative to GSC 1332-0578 (MJD=Hel.JD−2450000). "Sz" and "Pi" denote Szeged Observatory and Piszkéstető Station, respectively.

MJD	ΔB	ΔV	ΔR_C	ΔI_C	Obs.
2261.462	−1.25	−1.71	−1.90	−2.20	Sz
2266.349	−1.31	−1.65	−1.88	−2.13	Pi
2267.453	−1.32	−1.66	−1.88	−2.13	Pi
2271.528	−1.23	−1.57			Pi
2274.321	−0.78	−1.14			Pi
2275.498	−0.32	−0.80	−1.11	−1.41	Pi
2276.235	−0.07	−0.59	−0.90	−1.22	Pi
2277.273	0.41	−0.30	−0.61	−0.97	Pi
2278.189	0.44	−0.28	−0.64	−1.08	Sz
2278.387	0.45	−0.29	−0.66	−1.07	Sz
2279.240	0.05	−0.59	−0.92	−1.26	Sz
2279.320	0.03	−0.59	−0.94	−1.29	Sz
2281.303	−0.69	−1.19	−1.46	−1.78	Sz
2285.478	−1.31	−1.64		−2.14	Pi
2286.461	−1.32	−1.66		−2.12	Pi

star at a level of 0.02-0.03 mag. Although later data did not confirm this suspected variability, we have preferred the fainter star as the main comparison. To determine the standard transformation coefficients for both instruments, we obtained $BV(RI)_C$ band images of the open cluster M67, containing a widely used photometric standard sequence (Chevalier & Ilovaisky 1991). The estimated photometric accuracy based on the scatter of the standardized "comp minus check" data is ±0.03 mag in B, ±0.02 mag in V and ±0.01 mag in R_C and I_C bands. The whole dataset consists of 15 points in B and V, 11 points in R_C and 13 points in I_C band. All photometric data are presented in Table 1 and the light curves are plotted in Fig. 1.

We have determined the epoch of minimum by fitting low-order polynomials to the lower part of the light curves. Unfortunately, the weather did not permit observations on every night, thus the gaps make the epoch determination uncertain. The derived epoch is Hel.JD 2452277.73±0.20 giving $O-C$=$-0\overset{d}{.}29$ (with the ephemeris given below). More accurate moment requires more data obtained at different geographic longitudes which bridge the daily gaps in our light curves.

We have collected all available times of minimum from Williams & Kaiser (1991), Hanzl et al. (1993) and Hager (1996) in order to construct the updated $O-C$ diagram. It is completely linear and the points scatter around a straight line which has a non-significant slope of 0.01±0.02. Therefore, we conclude that the present ephemeris

$$\text{Hel.JD}_{\text{min}} = 2449760.857 + 1258.59 \times E$$

can be used to predict further minima.

In order to gain some insight into the physical nature of the components, we have tried to fit the observed light curves with a simple model. GD93 presented a detailed analysis of the system, including a light curve fit of the primary minimum observed by visual observers. We wanted to check whether their model can be extended to describe multicolour data, too. For this purpose, we computed model light curves with a programme written by LLK. The programme was not developed to match a light curve by

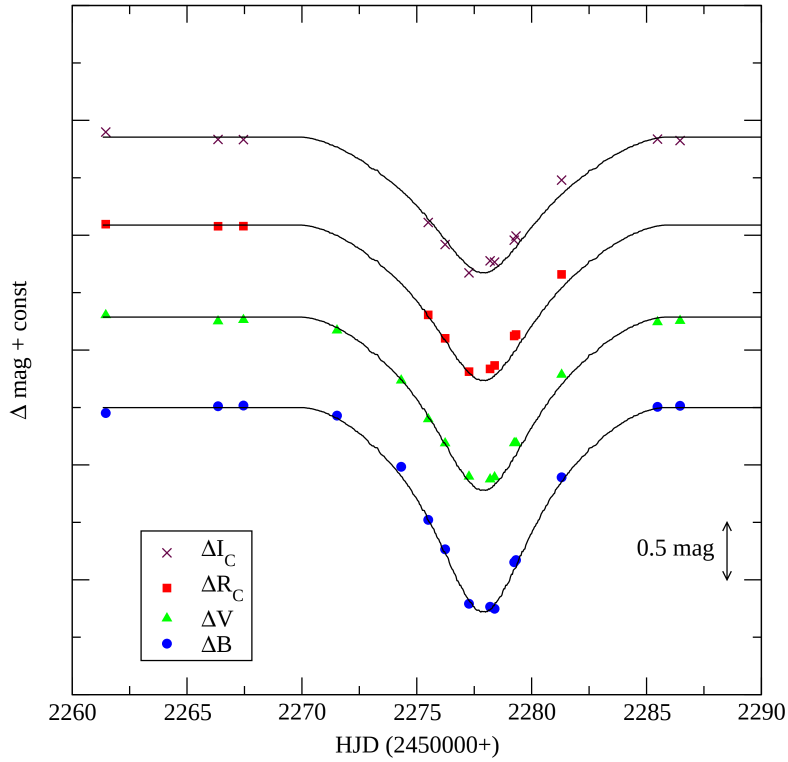

Figure 1. Standardized differential light curves of OW Gem with the adopted model light curves.

automatic iteration, but calculates light variations for a given model and enables the user to adjust the parameters of the model until a satisfactory convergence toward the observed curves are not found. The adjustable parameters include the sizes (under spherical assumption) and temperatures (assuming black-body radiation) of the two stars, and the minimum projected distance between the centers of the model stars ("impact parameter"). The relative transverse velocity is fixed by the known orbital elements. Standard linear limb-darkening coefficients for log g = 1.0, T_{eff}=7250 K and 4500 K, computed for the $BV(RI)_C$ photometric bands, were taken from Diaz-Cordoves et al. (1995) and Claret et al. (1995). Standard $BV(RI)_C$ magnitudes were calculated by multiplying the computed fluxes with the filter transmission functions (Bessell 1990) and integrating over wavelength.

The spectral types of the components are known fairly accurately thanks to this direct detection in the spectrum (GD93). The brighter primary is of spectral type F2 Ia-II, while the secondary is a late G-type star (G8 according to GD93). We have adopted the following geometric parameters determined by GD93: R_1=30 $R_\odot$, R_2=35 $R_\odot$. The secondary moves with 66 km s^{-1} relative to the primary and the impact parameter is 10 $R_\odot$. The initial temperatures were T_1=7300 K and T_2=4600 K, corresponding to F2 and G8 of luminosity class I-II (Carroll & Ostlie 1996, Appendix E). Good fits (solid lines in Fig. 1) could be obtained for the same geometry with slightly different temperatures: T_1^{fit}=7000±100 K, T_2^{fit}=4900±100 K. (We noticed some asymmetry in the ascending branches of the light curves, most visible in R_C and I_C. Independent data are needed to decide whether it is real.) The corresponding luminosities are L_1 ≈1950 $L_\odot$, L_2 ≈ 640 $L_\odot$, giving visual absolute magnitudes M_V^1 = −3.5 mag and M_V^2 = −2.0 mag. These values are in good agreement with those of GD93, the only difference is the slightly hotter secondary. We conclude that presently available data are compatible with an F2-3 Ib-II primary and G4-5 IIb secondary.

The next secondary minimum will occur between Oct. 8 and Nov. 7, 2002. We urge CCD observers to follow this event by observing in as many photometric bands as possible. It is expected that multicolour coverage of both minima would improve the photometric modelling of the components giving a more accurate physical description of this interesting system.

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